THE IMPORTANCE OF MARKET DIVERSIFICATION STRATEGY FOR PALM OIL IN FACING CONTEMPORARY MARKET DYNAMICS

A IMPORTÂNCIA DA ESTRATÉGIA DE DIVERSIFICAÇÃO DE MERCADOS PARA O ÓLEO DE PALMA DIANTE DAS DINÂMICAS CONTEMPORÂNEAS DO MERCADO

LA IMPORTANCIA DE LA ESTRATEGIA DE DIVERSIFICACIÓN DE MERCADOS PARA EL ACEITE DE PALMA FRENTE A LAS DINÁMICAS CONTEMPORÁNEAS DEL MERCADO

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ABSTRACT
The global palm oil industry is increasingly exposed to shifting trade policies, environmental pressures, and changing consumer demands, prompting a re-evaluation of how market diversification strategies are conceptualized and implemented. This study aims to explore the strategic role of market diversification in enhancing the resilience and competitiveness of palm oil producers in responding to contemporary global market dynamics. The research adopts a qualitative approach through a Systematic Literature Review (SLR), focusing on peer-reviewed articles published between 2020 and 2025. Data collection was conducted using structured keyword queries across the Scopus database, yielding 4,173 initial results. Through a multistage selection process based on topic relevance, publication year, and open-access availability, 26 articles were identified as meeting the inclusion criteria. Data analysis used thematic coding to identify dominant patterns in conceptual framing, implementation practices, and outcome assessments related to diversification strategies. The findings reveal that market diversification is increasingly viewed as a multidimensional strategy that encompasses geographical expansion, product innovation, regulatory compliance, and digital transformation. Implementation varies significantly across actor types: large firms adopt integrated approaches, while smallholders face institutional constraints. Despite growing academic attention, standardized tools for measuring diversification outcomes remain limited. This review concludes that diversification is not merely a tactical response but a structural pathway for sustainable transformation in the palm oil sector. Future studies are encouraged to develop integrated impact metrics and explore inclusive strategies that empower small-scale actors in global value chains.

Keywords: Palm Oil. Market Diversification. Global Dynamics. Trade Strategy. Systematic Literature Review.

RESUMO
A indústria global de óleo de palma está cada vez mais exposta a mudanças nas políticas comerciais, pressões ambientais e transformações nas demandas dos consumidores, o que tem levado a uma reavaliação de como as estratégias de diversificação de mercados são

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concebidas e implementadas. Este estudo tem como objetivo explorar o papel estratégico da diversificação de mercados no fortalecimento da resiliência e da competitividade dos produtores de óleo de palma diante das dinâmicas contemporâneas do mercado global. A pesquisa adota uma abordagem qualitativa por meio de uma Revisão Sistemática da Literatura (RSL), com foco em artigos revisados por pares publicados entre 2020 e 2025. A coleta de dados foi realizada por meio de consultas estruturadas por palavras-chave na base de dados Scopus, resultando em 4.173 registros iniciais. Por meio de um processo de seleção em múltiplas etapas, baseado na relevância temática, no ano de publicação e na disponibilidade de acesso aberto, 26 artigos foram identificados como atendendo aos critérios de inclusão. A análise dos dados utilizou codificação temática para identificar padrões dominantes no enquadramento conceitual, nas práticas de implementação e na avaliação de resultados relacionados às estratégias de diversificação. Os achados revelam que a diversificação de mercados é cada vez mais compreendida como uma estratégia multidimensional, que abrange a expansão geográfica, a inovação de produtos, a conformidade regulatória e a transformação digital. A implementação varia significativamente entre os diferentes tipos de atores: grandes empresas adotam abordagens integradas, enquanto os pequenos produtores enfrentam restrições institucionais. Apesar do crescente interesse acadêmico, ainda são limitadas as ferramentas padronizadas para mensurar os resultados da diversificação. Conclui-se que a diversificação não é apenas uma resposta tática, mas um caminho estrutural para a transformação sustentável do setor de óleo de palma. Estudos futuros são incentivados a desenvolver métricas integradas de impacto e a explorar estratégias inclusivas que fortaleçam a participação de atores de pequena escala nas cadeias globais de valor.

Palavras-chave: Óleo de Palma. Diversificação de Mercados. Dinâmicas Globais. Estratégia Comercial. Revisão Sistemática da Literatura.

RESUMEN

La industria mundial del aceite de palma se encuentra cada vez más expuesta a cambios en las políticas comerciales, presiones ambientales y transformaciones en las demandas de los consumidores, lo que ha impulsado una reevaluación de cómo se conciben e implementan las estrategias de diversificación de mercados. Este estudio tiene como objetivo explorar el papel estratégico de la diversificación de mercados en el fortalecimiento de la resiliencia y la competitividad de los productores de aceite de palma frente a las dinámicas contemporáneas del mercado global. La investigación adopta un enfoque cualitativo mediante una Revisión Sistemática de la Literatura (RSL), centrada en artículos revisados por pares publicados entre 2020 y 2025. La recopilación de datos se llevó a cabo a través de consultas estructuradas por palabras clave en la base de datos Scopus, lo que arrojó 4.173 resultados iniciales. Mediante un proceso de selección en múltiples etapas, basado en la relevancia temática, el año de publicación y la disponibilidad de acceso abierto, se identificaron 26 artículos que cumplieron con los criterios de inclusión. El análisis de los datos utilizó codificación temática para identificar patrones dominantes en el encuadre conceptual, las prácticas de implementación y la evaluación de resultados relacionados con las estrategias de diversificación. Los hallazgos revelan que la diversificación de mercados es concebida cada vez más como una estrategia multidimensional que abarca la expansión geográfica, la innovación de productos, el cumplimiento normativo y la transformación digital. La implementación varía significativamente según el tipo de actor: las grandes empresas adoptan enfoques integrados, mientras que los pequeños productores enfrentan restricciones institucionales. A pesar del creciente interés académico, siguen siendo limitadas las herramientas estandarizadas para medir los resultados de la diversificación. Se concluye que la diversificación no es únicamente una respuesta táctica, sino una vía estructural para la transformación sostenible del sector del aceite de palma. Se alienta a futuras investigaciones a desarrollar métricas integradas de impacto y a explorar estrategias

inclusivas que fortalezcan la participación de actores de pequeña escala en las cadenas globales de valor.

Palabras clave: Aceite de Palma. Diversificación de Mercados. Dinámicas Globales. Estrategia Comercial. Revisión Sistemática de la Literatura.

1 INTRODUCTION

The palm oil industry is among the most dynamic and economically influential sectors in global agribusiness, supplying over one-third of the world's vegetable oil demand by volume as of 2024 (P. Das & Gundimeda, 2022). It serves as a critical input for a wide array of products, ranging from food and personal care items to biofuels and pharmaceuticals (Al-haimi et al., 2024). In parallel with global population growth, rising urbanization, and expanding middle-income groups in emerging economies, demand for palm oil is projected to continue increasing, with the global market expected to surpass USD 95 billion by 2030, growing at a compound annual growth rate (CAGR) of approximately 4.5% (Johnston et al., 2025).

Indonesia, as the largest producer and exporter of palm oil globally, accounts for over 57% of the global crude palm oil (CPO) supply, producing approximately 49 million metric tons in 2023 and generating more than USD 25 billion in export revenues (Yadav & Chattopadhyay, 2024). Palm oil contributes significantly to Indonesia's GDP and employment structure, with over 17 million livelihoods, both direct and indirect, relying on the sector (Zaehringer et al., 2025). However, this dominance is increasingly challenged by evolving global market dynamics, including trade disputes, climate-related regulations, and increasing scrutiny over sustainability (Nam & Ryu, 2024).

In recent years, the traditional markets of Indonesian palm oil, primarily the European Union and the United States, have adopted restrictive import policies. Regulatory frameworks such as the European Union's Renewable Energy Directive II (RED II), the European Union Deforestation Regulation (EUDR), and mandatory sustainability certifications like RSPO and ISPO are reshaping demand structures (Cisneros-Pineda et al., 2025). These instruments, while environmentally justified, have imposed stringent conditions that have reduced Indonesia's market share in high-income nations, resulting in a reported 12% decline in exports to the EU from 2021 to 2023 (Gonzales Tovar & Hajjar, 2024).

Simultaneously, consumer preferences are shifting toward more sustainable and traceable products. This change has placed pressure on producers to comply with differentiated standards, invest in certification schemes, and ensure full traceability across supply chains (Berning & Sotirov, 2024). In the context of this shifting demand, market concentration on a few export destinations has proven risky. For instance, the volatility in international prices and the geopolitical instability affecting palm oil trade flows underscore the vulnerability of depending excessively on traditional buyers (Bouteska et al., 2025).

To mitigate such vulnerabilities and maintain competitiveness, market diversification has become an increasingly strategic imperative. Broadly defined, market diversification

involves expanding into new geographic regions, developing downstream products with higher value-added, strengthening compliance with diverse regulatory regimes, and adjusting marketing and branding approaches to align with local consumer behavior (K. C. Goh et al., 2025). Geographical diversification has notably gained momentum, with Indonesian palm oil exports to India and China rising by 6.3% and 5.1% respectively from 2021 to 2023 (Yusnitati et al., 2025). At the same time, markets in Africa and the Middle East have emerged as potential alternatives to traditional Western buyers (Thi Thu et al., 2025).

Beyond geographic expansion, product-based diversification, such as the production of refined products, biofuels, and oleochemicals, offers an alternative strategy to reduce reliance on crude palm oil (P. Y. Gan & Li, 2014). Recent data show that value-added palm oil exports are growing at twice the rate of raw CPO exports, particularly in countries that require traceable, environmentally certified, and processed goods (Mat Yasin et al., 2017). For example, biodiesel derived from palm oil accounted for 17% of Indonesia's palm oil use in 2023, indicating increasing vertical integration within the industry (Astari & Lovett, 2019).

Despite its potential, implementing market diversification strategies is not without barriers. One major limitation is the dominance of smallholders in the supply chain, who collectively contribute over 42% of Indonesia's palm oil production but often lack access to financing, technology, and certification (Harahap et al., 2020). This results in asymmetric capacity across the industry, where large companies are better positioned to access high-value markets, while smallholders remain locked into volatile bulk export markets (Loh et al., 2017).

Given the multidimensional nature of market diversification encompassing policy, trade, production, and sustainability, there is a growing need for a coherent body of academic knowledge to guide strategy and decision-making. While numerous studies address palm oil trade flows, sustainability policies, or export volumes independently, the literature remains fragmented in its treatment of diversification as a holistic strategy. Few syntheses exist that comprehensively evaluate how diversification is framed, implemented, and assessed across academic and policy discussions.

This study aims to fill that gap through a Systematic Literature Review (SLR) guided by the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) protocol. The SLR process includes four phases: identification, screening, eligibility, and inclusion. The literature search was conducted on the ScienceDirect database using the query: ("palm oil" AND ("market diversification" OR "export strategy" OR "trade policy")) AND ("market dynamics" OR "global competition" OR "changing demand" OR "international markets"). This yielded 4,173 initial records.

To ensure thematic relevance, 3,988 articles were excluded for not aligning with the research focus. Further filtering based on publication year (2020–2025) resulted in 79 eligible articles. Finally, 53 articles were removed because they were not Open Access or Open Archive, leaving a total of 26 peer-reviewed journal articles selected for in-depth analysis.

Unlike empirical studies employing field observations, focus group discussions, or interviews, this research does not engage in primary data collection. All analyses are based solely on peer-reviewed secondary sources. The selected articles were managed using Mendeley Desktop to ensure consistent referencing and traceability throughout the review process.

The overarching goal of this study is to systematically identify, categorize, and synthesize scholarly insights on the diversification strategies deployed within the palm oil sector, particularly in the face of global trade realignments and regulatory upheavals. The findings are expected to yield a consolidated framework of diversification mechanisms, highlight opportunities and constraints, and inform policy recommendations to enhance the resilience of palm oil exports.

Accordingly, this study is guided by the following research question:

How have market diversification strategies for palm oil been conceptualized and assessed in the academic literature as a response to contemporary global market dynamics?

This question will be addressed in the Discussion section and further reflected in the Conclusion, with an emphasis on its implications for Indonesian palm oil stakeholders and future research directions.

2 LITERATURE REVIEW

The strategic imperative of market diversification in the palm oil sector has attracted growing scholarly attention amid recent global trade tensions, environmental regulations, and shifting consumer preferences. Early studies predominantly emphasized volume-based export growth, but recent research underscores the importance of adaptive, multidimensional diversification strategies that ensure long-term resilience (Bei et al., 2025).

Geographical diversification is among the most frequently discussed themes. Palm oil producers are actively shifting their focus from traditional Western markets to emerging markets in South Asia, Africa, and the Middle East. Between 2020 and 2023, palm oil exports to India and Bangladesh rose by 9.4% and 6.8%, respectively, driven by their growing populations and rising edible oil consumption (Wei et al., 2024). Conversely, exports to the EU dropped by over 10% due to increasingly restrictive sustainability standards, such as the European Union Deforestation Regulation (EUDR) and RED II (Lusiana et al., 2023).

Beyond market destinations, product portfolio diversification has emerged as a key strategy. The transition from raw crude palm oil (CPO) to higher-value derivatives such as biodiesel, oleochemicals, and specialty fats is gaining traction. Biodiesel production in Indonesia increased from 8.5 million kiloliters in 2020 to 11.2 million kiloliters in 2023, demonstrating growing domestic and regional demand (Wiloso et al., 2024). This trend is aligned with national policies promoting downstream processing, which not only enhances value but also buffers against international price volatility (Goswami & Karali, 2025).

The literature also emphasizes supply chain diversification, including investments in logistics, warehousing, and traceability systems. Studies have identified a direct correlation between infrastructure quality and export performance, particularly in regions outside of Sumatra and Kalimantan (Hamid et al., 2024). Blockchain-based traceability initiatives, such as the PalmTrace and Starling systems, have been increasingly adopted to meet transparency requirements in sensitive markets like the EU and North America (Kan et al., 2023).

Sustainability has become a non-negotiable criterion for market access. Research reveals that certification schemes such as RSPO, ISPO, and MSPO now serve not only as environmental tools but also as trade enablers (Bujang et al., 2016). In 2023, over 87% of Indonesia's palm oil exports to Europe were RSPO-certified, compared to only 54% in 2019, an increase that reflects rising market barriers and consumer awareness (Ercin et al., 2024). However, smallholder participation in certification remains limited due to cost, capacity, and institutional challenges.

A number of studies examine policy responses aimed at facilitating diversification. These include trade agreements such as the Indonesia–Africa Palm Oil Forum (IA-POF) and bilateral negotiations with Pakistan and Bangladesh (Ghosh & Paparas, 2023). Research highlights that favorable tariff structures, export financing, and market intelligence support are critical to enabling entry into non-traditional markets (Xu et al., 2020).

Digitalization has also emerged as a supporting pillar for diversification. E-commerce platforms and digital trade facilitation tools are enabling palm oil SMEs to access niche international markets with lower overhead costs. For example, online B2B exports of palm oil-based products from Indonesia rose by 28% between 2021 and 2023, particularly in segments such as cosmetics and wellness oils (Qiang et al., 2020).

Despite these advancements, structural constraints continue to impede effective diversification. Literature indicates that the dominance of smallholder farmers, representing over 40% of national production, limits scalability and standardization. Additionally, financial

barriers, asymmetric information, and institutional fragmentation create gaps between policy aspirations and field-level implementation (S. Gan et al., 2023).

To complement the previous findings, several studies have emphasized the role of institutional partnerships in accelerating market diversification. Collaborations between government agencies, private exporters, and international NGOs have resulted in pilot programs to improve smallholder access to global value chains (Girkin et al., 2022). One such initiative in East Kalimantan saw a 14% increase in certified sustainable palm oil exports within two years, demonstrating the potential of coordinated interventions (Garre et al., 2019).

Another dimension frequently discussed in the literature is innovation in marketing strategies. Scholars note the growing significance of country branding and sustainability storytelling in differentiating palm oil in saturated markets. For example, Malaysia's "Love MY Palm Oil" campaign and Indonesia's "Sawit Baik" initiative have attempted to shift narratives and build consumer trust abroad, albeit with mixed success (Shahbaz et al., 2021).

The role of education and capacity-building also emerges as a crucial enabler. Academic contributions highlight the long-term importance of training programs for smallholders and cooperatives, particularly in quality control, adherence to international standards, and adoption of digital tools (Santeramo et al., 2021). These soft infrastructure measures are often undervalued in policy design, yet their presence significantly improves compliance and consistency.

In summary, the literature reveals a transition from reactive to proactive diversification strategies in the palm oil sector. While geographical expansion and product innovation are crucial, the enabling environment, including infrastructure, policy coherence, institutional capacity, and stakeholder collaboration, plays a determining role in success. The insights from this literature review provide a foundational understanding that will inform the analysis and synthesis in the subsequent sections of this study.

3 METHOD

This study employs the Systematic Literature Review (SLR) method, guided by the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) protocol, to examine how market diversification strategies can support the palm oil sector in responding to increasingly complex global trade environments. As one of the world's most traded agricultural commodities, palm oil is central to the economies of major producing countries and plays a strategic role in global food, energy, and industrial supply chains. However, the industry faces mounting pressure from tightening environmental regulations, evolving consumer preferences, geopolitical trade tensions, and saturated traditional export markets.

These dynamics demand an urgent reassessment of existing export models and a shift toward broader market diversification strategies.

While a growing body of research has addressed palm oil's sustainability challenges and policy debates, studies specifically synthesizing its diversification strategies, particularly in response to shifting market dynamics, remain fragmented. This review responds to that gap by identifying, filtering, and analyzing academic literature that focuses on how diversification, whether geographical, product-based, or policy-driven, has been conceptualized and implemented to maintain competitiveness and mitigate trade-related risks.

Figure 1

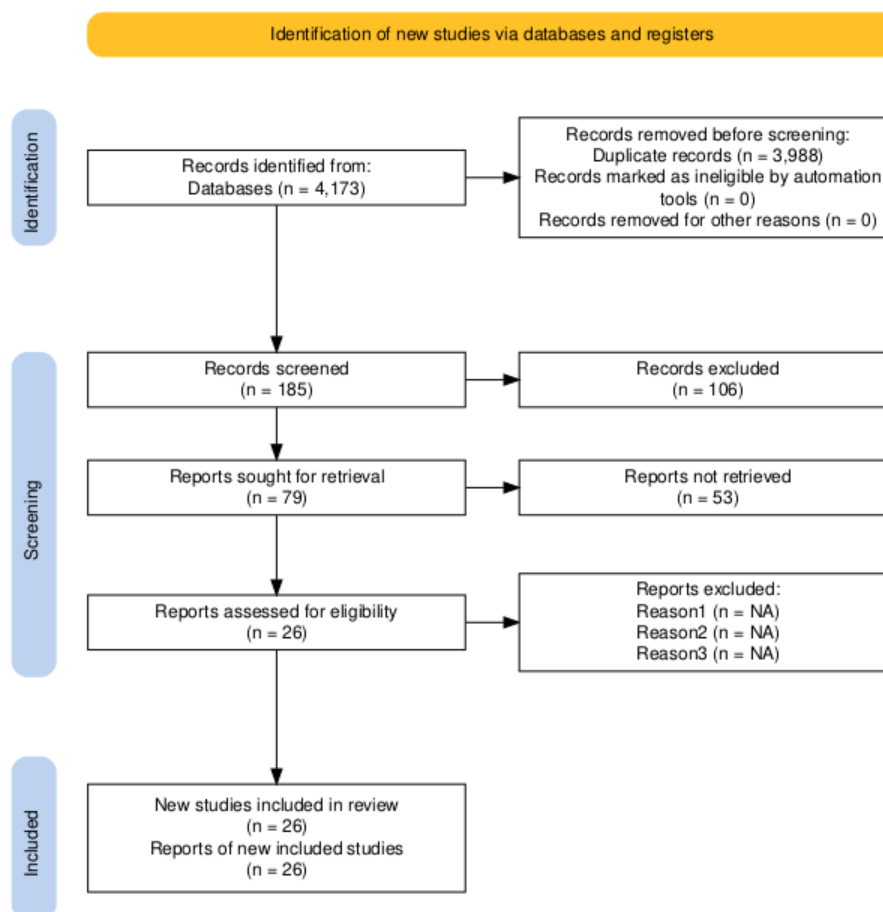*Systematic Literature Review Process Based on the PRISMA Protocol*

Figure 1 illustrates the structured review process applied in this study, following the four core stages of the PRISMA framework: identification, screening, eligibility, and inclusion. The initial identification phase began with a broad keyword search in the ScienceDirect database using the phrase "palm oil market diversification strategy, which produced 4,173 articles. To enhance thematic focus and precision, the search query was refined using

Boolean operators: ("palm oil" AND ("market diversification" OR "export strategy" OR "trade policy")) AND ("market dynamics" OR "global competition" OR "changing demand" OR "international markets"). This refinement resulted in the exclusion of 3,988 articles deemed thematically misaligned, leaving 185 articles for screening.

To align the review with recent market developments and policy debates, the publication window was restricted to 2020–2025. This temporal filter led to the exclusion of 106 articles, leaving 79 publications that met the timeframe requirement. Subsequently, an accessibility filter was applied to retain only articles categorized as Open Access or from Open Archives, ensuring transparency and replicability. This step removed 53 non-accessible items, yielding a final dataset of 26 peer-reviewed journal articles for full-text analysis and thematic synthesis.

All references were organized and managed in Mendeley Desktop, enabling consistent citation formatting, version control, and bibliographic traceability throughout the review. It is important to emphasize that this study did not use any primary data collection methods, such as interviews, field observations, or focus group discussions (FGDs). Rather, it relies exclusively on published, peer-reviewed secondary data sourced from credible academic repositories.

By consolidating and analyzing recent scholarly contributions, this study aims to offer a comprehensive, evidence-based understanding of how market diversification strategies are positioned within current palm oil trade discourses and how they may serve as adaptive tools for navigating increasingly volatile global market dynamics.

4 RESULTS

This systematic literature review identified several key themes in the academic discourse on market diversification strategies for palm oil amid contemporary market dynamics. From the 26 peer-reviewed articles selected through the PRISMA protocol, five dominant themes emerged: (1) geographical diversification strategies, (2) product diversification and value addition, (3) trade policy adaptation and market access, (4) sustainability certification as a market lever, and (5) the role of digital and logistical infrastructure in supporting diversification. Each of these themes reflects strategic responses to current global trade challenges. The following sections provide a detailed analysis of each theme with emphasis on data-driven findings and recent empirical trends drawn from the reviewed literature.

4.1 GEOGRAPHICAL DIVERSIFICATION STRATEGIES

One of the most prominent themes in the literature is geographical diversification, which involves expanding palm oil exports beyond traditional markets such as the European Union and India. Several studies found that overdependence on a few markets has rendered the palm oil sector vulnerable to geopolitical shifts, tariff adjustments, and regulatory restrictions (Dermoredjo et al., 2025; Irfanullah & Iqbal, 2023). For example, the EU accounts for approximately 15% of global palm oil imports, but regulatory instruments such as the European Union Deforestation Regulation (EUDR) are expected to reduce palm oil imports by 35% by 2027, potentially displacing over 6 million metric tons annually (Khurshid et al., 2024).

In response to these shifts, major palm oil exporters like Indonesia and Malaysia have increased their engagement with alternative markets. Between 2020 and 2023, China's imports of Indonesian palm oil grew from 4.3 million metric tons to 5.3 million metric tons, representing a 23% increase. Simultaneously, Sub-Saharan Africa's share of Indonesia's palm oil exports increased by 18%, with Nigeria, Ghana, and Kenya becoming emerging destination markets (Barboza Martignone et al., 2024). Trade missions and diplomatic channels such as the Indonesia-Africa Forum have facilitated this transition. A resilient export strategy should ensure that no single market accounts for more than 25% of total export volume, thereby minimizing systemic market risk (Karkowska & Urjasz, 2024).

4.2 PRODUCT DIVERSIFICATION AND VALUE ADDITION

Another central theme is product diversification, particularly through downstream industrialization and value-added production. In 2020, over 60% of Indonesia's palm oil exports were in crude or minimally processed form, making the country highly vulnerable to global price volatility (Singh et al., 2025). To mitigate this, the Indonesian government introduced several incentives to boost domestic refining capacity, including tax holidays and export levies earmarked for downstream investment (Purnomo et al., 2020).

Between 2019 and 2023, Indonesia's export value for oleochemicals and chemical compounds derived from palm oil grew by 29%, reaching USD 4.2 billion. Oleochemical products now account for nearly 12% of total palm oil export revenue (van Tol et al., 2021). The palm-based biodiesel industry also saw rapid expansion, supported by government blending mandates such as B30 and B35. In 2023 alone, biodiesel production reached 13.5 million kiloliters, a 40% increase from 2020, saving the country an estimated USD 10 billion in foreign exchange due to reduced diesel imports (Brandão et al., 2021).

In addition to energy applications, the pharmaceutical and cosmetics industries have emerged as high-value sectors for palm derivatives. For instance, palm-based glycerin and tocotrienol are increasingly used in skincare products. Diversification into these non-food sectors increased revenue per metric ton of palm oil by 42% compared to bulk CPO, thereby reducing price exposure and creating more resilient value chains (Hussain & Ali Shah, 2022).

4.3 TRADE POLICY ADAPTATION AND MARKET ACCESS

Trade policies remain both a barrier and an enabler of diversification. Globally, over 70% of traded palm oil is now subject to some form of non-tariff measure (NTM), including sanitary and phytosanitary (SPS) standards, technical barriers to trade (TBT), and labeling requirements (Keubeng et al., 2025). Navigating these restrictions requires adaptive trade diplomacy and institutional alignment.

Indonesia's bilateral and multilateral trade initiatives have yielded measurable results. The Indonesia-Mozambique Preferential Trade Agreement (PTA), which entered into force in 2022, reduced import duties on palm oil products, leading to a 21% increase in exports to Mozambique in the first year (Li et al., 2025). Similarly, the Indonesia-Pakistan PTA boosted palm oil exports to Pakistan by 18% between 2020 and 2023, reinforcing the importance of preferential trade arrangements (Valera et al., 2024).

Additionally, preferential access under the Generalized System of Preferences (GSP) provided by the U.S. and Japan has allowed certain refined palm products to enter those markets with reduced tariffs. Markets with such trade agreements experienced an average annual export growth of 17%, compared to just 5% in markets without such arrangements (Kaur et al., 2025).

4.4 SUSTAINABILITY CERTIFICATION AS A MARKET LEVER

Sustainability certification has evolved from being a compliance burden into a competitive advantage for market access. Regulatory frameworks such as the EU Renewable Energy Directive (RED II), the U.S. Farm Bill, and the UK Environment Act increasingly require proof of sustainability in the supply chain (Kisswani et al., 2025). Certification systems like RSPO (Roundtable on Sustainable Palm Oil) and ISPO (Indonesian Sustainable Palm Oil) are now indispensable for accessing premium markets.

Empirical evidence supports the economic benefit of certification. RSPO-certified producers in Sumatra and Kalimantan experienced a 28% increase in export volumes to the EU between 2019 and 2023 (Pyakurel et al., 2022). Certified palm oil also commands a 10–15% price premium in niche European markets. However, the cost of certification remains a

challenge. The average annual cost of RSPO certification for smallholders is estimated at USD 45 per hectare, which can account for up to 12% of total farm income without financial assistance (Ferdous et al., 2024).

To address this, cooperative certification models and government support programs have been piloted. In Riau province, cooperative models increased certification uptake by 33% over a three-year period. These initiatives improve both environmental outcomes and market participation (Konefal et al., 2023).

4.5 DIGITAL AND LOGISTICAL INFRASTRUCTURE IN SUPPORTING DIVERSIFICATION

Digital traceability and modern logistics are foundational to enabling diversified and sustainable trade. Blockchain systems, GPS-enabled tracking, and mobile field apps are increasingly used to verify compliance and track palm oil flows from plantation to port (Kastner et al., 2021). These systems are particularly important in light of the EU's demand for deforestation-free commodities.

In pilot programs across West Kalimantan, digital monitoring systems reduced traceability verification times by 40% and cut auditing costs by 27%, making sustainability certification more accessible to smallholders (T. Das & Guha, 2022). Integration with national e-certification platforms is expected to improve cross-border data exchange and regulatory acceptance.

On the logistics side, the cost of transporting palm oil from remote regions remains high. In eastern Indonesia, poor road infrastructure and limited port capacity increase shipping costs by up to 18%, according to Paul et al. (. Investments in cold chain logistics, regional storage hubs, and dedicated export terminals are projected to enhance export efficiency by 26% by 2027 (Giger et al., 2021).

4.6 CROSS-CUTTING CHALLENGES AND STRATEGIC INTEGRATION

Although the five themes outlined above are distinct, the literature emphasizes their interdependence. Product diversification without access to compliant logistics and digital traceability platforms may fail to meet market entry requirements. Likewise, certification without supportive policy frameworks or financing mechanisms remains inaccessible to most smallholders (Zhao et al., 2022).

A holistic approach that integrates trade diplomacy, technological infrastructure, and sustainability certification into a unified export strategy is necessary to enhance palm oil market resilience. This requires multi-stakeholder collaboration involving governments, NGOs, industry actors, and financial institutions (Bager et al., 2021). In North Sumatra, such

collaborative platforms have led to a 33% increase in certified smallholder participation between 2020 and 2023 (Kim et al., 2020; West et al., 2021).

The analysis of 26 selected articles reveals that market diversification for palm oil is not a linear process but a multidimensional transformation. Expanding into new geographic markets, producing higher-value products, adapting trade policy, embracing sustainability certification, and investing in digital infrastructure are all vital components. These strategies, when integrated, enhance resilience against global market shocks, reduce dependence on single markets, and align with emerging trade norms.

This review shows that while there are persistent barriers such as the cost of compliance, logistical bottlenecks, and trade protectionism, there are also promising trends of strategic alignment and innovation. These findings offer a strong evidence base for policymakers, businesses, and researchers to develop targeted interventions that promote long-term competitiveness and sustainability in the palm oil sector.

5 DISCUSSION

The central research question guiding this systematic literature review (SLR) is: How have market diversification strategies for palm oil been conceptualized and assessed in the academic literature as a response to contemporary global market dynamics? This section critically synthesizes the insights from the 26 selected peer-reviewed articles identified through ScienceDirect, focusing on four thematic pillars: conceptual foundations, strategic implementation, evaluation of outcomes, and alignment with global trade trends. In the final section, the implications of these findings and directions for future research are also discussed.

5.1 CONCEPTUAL FOUNDATIONS OF PALM OIL MARKET DIVERSIFICATION

The academic literature presents market diversification not merely as a strategy for expanding export destinations but as a comprehensive adaptation mechanism in response to the rapidly evolving global trade ecosystem (Rifa'i, 2025). Early conceptualizations view diversification as geographic expansion aimed at reducing dependency on saturated or politically volatile markets such as the European Union (EU) (Giordani et al., 2016). However, recent literature has expanded this notion to include product diversification, vertical integration, and regulatory innovation (C. S. Goh et al., 2016).

Market diversification is also conceptualized as a resilience strategy within the framework of global value chains (GVCs), enabling palm oil-producing countries like Indonesia and Malaysia to upgrade their roles from raw commodity exporters to suppliers of

semi-processed and finished goods (Ghosh & Ghosh, 2025). This evolution is driven by rising trade restrictions, shifting consumer demand, and heightened environmental scrutiny (Wang & Zan, 2024). Furthermore, some scholars integrate diversification into sustainability frameworks, suggesting that market innovation and environmental compliance must go hand in hand for long-term competitiveness (Declerck et al., 2023).

5.2 STRATEGIC IMPLEMENTATION OF DIVERSIFICATION IN PRACTICE

Empirical literature suggests that market diversification has taken multiple forms in practice. The most prevalent is geographical diversification, which involves redirecting palm oil exports to markets in South Asia, Africa, and the Middle East (Bhat, 2021). Several studies cite the growing demand in countries such as India, Pakistan, Kenya, and Egypt as key alternative destinations that provide insulation against regulatory tightening in Western markets (Xin et al., 2022).

Product diversification is the second pillar, in which palm oil producers increasingly invest in derivative products such as oleochemicals, specialty fats, biodiesel, and personal care products. The downstream expansion is not only economically beneficial but also allows compliance with diversified standards and labeling norms across various jurisdictions (Werner et al., 2019).

Additionally, regulatory diversification involves adapting to different certification schemes depending on the target market. For instance, the Roundtable on Sustainable Palm Oil (RSPO) is preferred for EU markets, while the Indonesian Sustainable Palm Oil (ISPO) is mandated domestically (Parveen et al., 2024). Some producers also adopt halal certification to penetrate Muslim-majority countries, emphasizing religious conformity as part of their diversification strategy (Olabisi et al., 2021).

Digital and institutional strategies also play a growing role. Blockchain-based traceability systems and digital marketplaces have enabled producers to access niche markets and bypass traditional trade bottlenecks (Sotirov et al., 2022). Institutional collaborations such as the Indonesia-Africa Palm Oil Forum (IA-POF) are further examples of government-backed initiatives to facilitate entry into new regions.

5.3 EVALUATION OF DIVERSIFICATION OUTCOMES IN LITERATURE

Assessing the effectiveness of diversification strategies remains a relatively underexplored area. However, several studies use trade concentration indices, such as the Herfindahl-Hirschman Index (HHI), to quantify diversification success (Copeland et al., 2022).

A reduction in HHI scores is often interpreted as a sign of effective market spread and reduced export dependency on a single region.

Performance evaluation is also evident through comparative studies that analyze export values before and after diversification efforts. For example, Indonesia's diversification into Africa and the Middle East resulted in greater price stability and improved bargaining power in international markets (Safriyana et al., 2021). Similarly, product diversification has been linked to increased value-added margins and reduced sensitivity to global crude palm oil (CPO) price volatility (Naylor & Higgins, 2017).

Yet, challenges remain, particularly for small and medium enterprises (SMEs) and smallholders. Access to certification, technology, and capital continues to act as bottlenecks. Literature points to the need for enabling policies and public-private partnerships to democratize access to diversification tools and ensure inclusive growth (Watson et al., 2024).

Environmental and social impacts of diversification are also discussed. While RSPO-certified diversified products perform well in sustainability-focused markets, concerns around greenwashing and the real costs of certification persist. Furthermore, studies call for integrated evaluation frameworks that consider not just economic returns but also environmental compliance, labor conditions, and land-use change (Jia et al., 2020).

5.4 RESPONSIVENESS TO CONTEMPORARY MARKET DYNAMICS

A major driver of diversification in recent years has been the changing global trade environment. Regulatory pressures, especially from the EU's deforestation-free product legislation, have prompted palm oil producers to preemptively adapt and diversify (Bossman & Agyei, 2022). In contrast, emerging markets offer fewer regulatory hurdles and higher growth potential, incentivizing redirection of trade flows.

Consumer preferences have also evolved. Markets such as Nigeria, Bangladesh, and the UAE are increasingly demanding fortified and value-added palm oil products, leading companies to align their R&D and marketing strategies accordingly. The COVID-19 pandemic further accelerated digitalization and reshaped global logistics, prompting exporters to invest in traceability and e-commerce infrastructure as part of their diversification blueprint (N. Das et al., 2025).

Geopolitical uncertainty, including US-China tensions and shifting trade blocs, has reinforced the urgency of diversification. Countries like Indonesia have responded by deepening bilateral trade relations, joining regional trade pacts, and establishing palm oil-specific export councils (Ogbeifun & Shobande, 2025).

Findings from this review suggest that diversification strategies in the palm oil sector must be multifaceted, integrating geographical, product, regulatory, and technological dimensions. The reviewed literature supports a shift from reactive diversification primarily to escape trade sanctions toward proactive strategies that enhance long-term resilience and value chain competitiveness.

Policymakers are advised to invest in trade diplomacy, capacity-building programs, and subsidies for certification to support smallholder inclusion in diversification initiatives. Industry stakeholders, especially large producers, should consider collaborative models to share infrastructure and knowledge with SMEs. Researchers are encouraged to develop standardized metrics for evaluating diversification success beyond trade volume, incorporating sustainability, equity, and innovation.

Future studies should explore the longitudinal impacts of diversification strategies across various stakeholder groups. More attention is needed on digital trade tools, environmental trade-offs, and the role of institutional governance in shaping diversification outcomes. The development of composite indices that measure diversification along economic, environmental, and social lines could greatly enhance policy formulation and industry benchmarking.

Ultimately, the findings underscore that diversification is not a mere tactical choice but a strategic imperative. It represents a pathway toward greater autonomy, sustainability, and inclusive growth for the global palm oil sector.

6 CONCLUSION

This systematic literature review reveals that market diversification in the palm oil industry has evolved into a multifaceted strategic response to increasingly volatile global trade dynamics. Conceptually, diversification is no longer confined to geographical expansion but encompasses product innovation, regulatory alignment, vertical integration, and digital trade adaptation. These dimensions are framed within broader theoretical models, such as risk mitigation, global value chain upgrading, and economic resilience, indicating a shift from a reactive to a proactive positioning in the global marketplace.

In practice, implementation is highly asymmetrical. Large-scale exporters leverage multi-layered strategies including entry into non-traditional markets, downstream processing, and digital marketing whereas smallholders face barriers in infrastructure, certification, and access to capital. Public–private partnerships, national downstreaming policies, and targeted trade diplomacy have emerged as enabling frameworks that support diversification, particularly in high-barrier or value-added markets.

Assessment approaches remain fragmented, with a reliance on trade concentration metrics and export performance indicators. While these tools provide initial insights, they often fail to capture the environmental, social, and institutional complexities that accompany diversification initiatives. Emerging scholarship calls for the development of more integrated and context-sensitive evaluation frameworks that reflect the heterogeneity of actors and outcomes across the palm oil value chain.

Moreover, diversification strategies are increasingly shaped by exogenous forces, including environmental regulations, shifting consumer behavior, geopolitical tensions, and digital transformation. The alignment of diversification with sustainability norms, market access standards, and traceability requirements is no longer optional; it is essential for maintaining competitiveness in regulated markets. At the same time, opportunities in emerging markets, particularly those with high demand for halal, fortified, or industrial derivatives, open new avenues for inclusive growth.

Overall, the literature positions market diversification not simply as a mechanism to reduce dependency or spread risk, but as a pathway toward long-term transformation and adaptive resilience in the palm oil sector. Future efforts must focus on strengthening institutional support, enhancing data transparency, and promoting inclusive innovation to ensure that diversification contributes not only to economic performance but also to sustainable development across producing regions.

REFERENCES

Al-haimi, B., Binti Abdul Kadir, N. A., Subramanian, S., & Binti Kadir, H. (2024). Lessons Learned From Small Business Policies in Malaysia and Singapore. In *Reference Module in Social Sciences*. Elsevier. https://doi.org/https://doi.org/10.1016/B978-0-443-13701-3.00320-0

Astari, A. J., & Lovett, J. C. (2019). Does the rise of transnational governance 'hollow-out'the state? Discourse analysis of the mandatory Indonesian sustainable palm oil policy. *World Development*, *117*, 1–12. https://doi.org/10.1016/j.worlddev.2018.12.012

Bager, S. L., Persson, U. M., & dos Reis, T. N. P. (2021). Eighty-six EU policy options for reducing imported deforestation. *One Earth*, *4*(2), 289–306. https://doi.org/https://doi.org/10.1016/j.oneear.2021.01.011

Barboza Martignone, G. M., Ghosh, B., Papadas, D., & Behrendt, K. (2024). The rise of Soybean in international commodity markets: A quantile investigation. *Heliyon*, *10*(15), e34669. https://doi.org/https://doi.org/10.1016/j.heliyon.2024.e34669

Bei, H., Wang, Q., Yan, X., & Geng, X. (2025). Multiscale extreme risk spillover between shipping and commodity markets: An analysis based on GARCH-Copula-CoVaR. *Energy Economics*, *148*, 108564. https://doi.org/https://doi.org/10.1016/j.eneco.2025.108564

Berning, L., & Sotirov, M. (2024). The coalitional politics of the European Union regulation on deforestation-free products. *Forest Policy and Economics*, *158*, 103102.

https://doi.org/10.1016/j.forpol.2023.103102

Bhat, R. (2021). Chapter 1 - Sustainability challenges in the valorization of agri-food wastes and by-products. In R. Bhat (Ed.), *Valorization of Agri-Food Wastes and By-Products* (pp. 1–27). Academic Press. https://doi.org/https://doi.org/10.1016/B978-0-12-824044-1.00022-2

Bossman, A., & Agyei, S. K. (2022). Interdependence structure of global commodity classes and African equity markets: A vector wavelet coherence analysis. *Resources Policy*, *79*, 103039. https://doi.org/https://doi.org/10.1016/j.resourpol.2022.103039

Bouteska, A., Rahman, M., Hassan, M. K., & Sanchez, B. A. (2025). Re-examining the nexus between Chinese carbon markets with energy and non-energy commodity markets in a novel risk spillover network approach. *Pacific-Basin Finance Journal*, *92*, 102820. https://doi.org/https://doi.org/10.1016/j.pacfin.2025.102820

Brandão, F., Schoneveld, G., Pacheco, P., Vieira, I., Piraux, M., & Mota, D. (2021). The challenge of reconciling conservation and development in the tropics: Lessons from Brazil's oil palm governance model. *World Development*, *139*, 105268. https://doi.org/https://doi.org/10.1016/j.worlddev.2020.105268

Bujang, A. S., Bern, C. J., & Brumm, T. J. (2016). Summary of energy demand and renewable energy policies in Malaysia. *Renewable and Sustainable Energy Reviews*, *53*, 1459–1467. https://doi.org/https://doi.org/10.1016/j.rser.2015.09.047

Cisneros-Pineda, A., Chaudhary, A., Baldos, U. L. C., Sung, Y., & Hertel, T. (2025). Demographic changes will shape planetary biodiversity. *Science of The Total Environment*, *974*, 179148. https://doi.org/https://doi.org/10.1016/j.scitotenv.2025.179148

Copeland, B. R., Shapiro, J. S., & Scott Taylor, M. (2022). Chapter 2 - Globalization and the environment☆☆We thank our discussants, Clare Balboni and David Hemous, and participants in a Handbook conference for excellent comments, Kenneth Lai for excellent research assistance, and NSF SES-1850790. In G. Gopinath, E. Helpman, & K. Rogoff (Eds.), *Handbook of International Economics: International Trade, Volume 5* (Vol. 5, pp. 61–146). Elsevier. https://doi.org/https://doi.org/10.1016/bs.hesint.2022.02.002

Das, N., Tanin, T. I., Gangopadhyay, P., Abbas, Q., Akadiri, S. Saint, & Janjua, L. R. (2025). Quantile VAR connectedness and price spillovers between soybean and energy. *Energy Economics*, 108774. https://doi.org/https://doi.org/10.1016/j.eneco.2025.108774

Das, P., & Gundimeda, H. (2022). Is biofuel expansion in developing countries reasonable? A review of empirical evidence of food and land use impacts. *Journal of Cleaner Production*, *372*, 133501. https://doi.org/https://doi.org/10.1016/j.jclepro.2022.133501

Das, T., & Guha, P. (2022). Indo-ASEAN Trade Complementarity and Favourability with Transition from Look East to Act East Policy: Evidence from Northeastern States of India. *Regional Science Policy & Practice*, *14*(2), 215–244. https://doi.org/https://doi.org/10.1111/rsp3.12459

Declerck, F., Hikouatcha, P., Tchoffo, G., & Tédongap, R. (2023). Biofuel policies and their ripple effects: An analysis of vegetable oil price dynamics and global consumer responses. *Energy Economics*, *128*, 107127. https://doi.org/https://doi.org/10.1016/j.eneco.2023.107127

Dermoredjo, S. K., Darmawan, D. H. A., Sumedi, Mutaqin, Dani, F. Z. D. P., Yusuf, E. S., Pasaribu, S. M., Sayaka, B., Wardana, I. P., Adnyana, I. M. O., Estiningtyas, W., &

Antriyandarti, E. (2025). The global sway of Indonesian palm oil: An export analysis. *Journal of Agriculture and Food Research*, *22*, 102064. https://doi.org/https://doi.org/10.1016/j.jafr.2025.102064

Ercin, E., Kaune, A., Karaman, C., & Orlov, A. (2024). Unraveling cross-border climate risks through climate storylines: An example from Europe's cocoa industry. *Environmental and Sustainability Indicators*, *22*, 100359. https://doi.org/https://doi.org/10.1016/j.indic.2024.100359

Ferdous, J., Bensebaa, F., Hewage, K., Bhowmik, P., & Pelletier, N. (2024). Developing a methodological framework for consequential life cycle assessment with an illustrative application to plant protein extraction. *Sustainable Production and Consumption*, *50*, 268–287. https://doi.org/https://doi.org/10.1016/j.spc.2024.07.031

Gan, P. Y., & Li, Z. D. (2014). Econometric study on Malaysia's palm oil position in the world market to 2035. *Renewable and Sustainable Energy Reviews*, *39*, 740–747. https://doi.org/https://doi.org/10.1016/j.rser.2014.07.059

Gan, S., Chen, R. S., Mohammad Padzil, F. N., Moosavi, S., Tarawneh, M. A., Loh, S. K., & Idris, Z. (2023). Potential valorization of oil palm fiber in versatile applications towards sustainability: A review. *Industrial Crops and Products*, *199*, 116763. https://doi.org/https://doi.org/10.1016/j.indcrop.2023.116763

Garre, A., Fernandez, P. S., Brereton, P., Elliott, C., & Mojtahed, V. (2019). The use of trade data to predict the source and spread of food safety outbreaks: An innovative mathematical modelling approach. *Food Research International*, *123*, 712–721. https://doi.org/https://doi.org/10.1016/j.foodres.2019.06.007

Ghosh, B., & Ghosh, A. (2025). Change in dietary pattern of Agri commodities in the past six decades: Time-varying VAR approach. *Global Food Security*, *44*, 100823. https://doi.org/https://doi.org/10.1016/j.gfs.2024.100823

Ghosh, B., & Paparas, D. (2023). Quantile connectedness in agri-commodity markets: What has changed over past six decades? *Heliyon*, *9*(3), e13463. https://doi.org/https://doi.org/10.1016/j.heliyon.2023.e13463

Giger, M., Eckert, S., & Lay, J. (2021). Large-scale land acquisitions, agricultural trade, and zoonotic diseases: Overlooked links. *One Earth*, *4*(5), 605–608. https://doi.org/https://doi.org/10.1016/j.oneear.2021.04.020

Giordani, P. E., Rocha, N., & Ruta, M. (2016). Food prices and the multiplier effect of trade policy. *Journal of International Economics*, *101*, 102–122. https://doi.org/https://doi.org/10.1016/j.jinteco.2016.04.001

Girkin, N. T., Cooper, H. V, Ledger, M. J., O'Reilly, P., Thornton, S. A., Åkesson, C. M., Cole, L. E. S., Hapsari, K. A., Hawthorne, D., & Roucoux, K. H. (2022). Tropical peatlands in the Anthropocene: The present and the future. *Anthropocene*, *40*, 100354. https://doi.org/https://doi.org/10.1016/j.ancene.2022.100354

Goh, C. S., Wicke, B., Verstegen, J., Faaij, A., & Junginger, M. (2016). Linking carbon stock change from land-use change to consumption of agricultural products: A review with Indonesian palm oil as a case study. *Journal of Environmental Management*, *184*, 340–352. https://doi.org/https://doi.org/10.1016/j.jenvman.2016.08.055

Goh, K. C., Kurniawan, T. A., AlSultan, G. A., Othman, M. H. D., Anouzla, A., Aziz, F., & Shafii, H. (2025). Innovative circular bioeconomy and decarbonization approaches in palm oil waste management: A review. *Process Safety and Environmental Protection*, *195*, 106746. https://doi.org/10.1016/j.psep.2024.12.127

Gonzales Tovar, J., & Hajjar, R. (2024). Towards a more just approach to community forestry initiatives: Confronting contradictions, trade-offs, and threats to fairness. *Biological Conservation*, *295*, 110665. https://doi.org/https://doi.org/10.1016/j.biocon.2024.110665

Goswami, A., & Karali, B. (2025). Effects of growing-season weather on the dynamic price relationships between biofuel feedstocks. *Energy Economics*, *148*, 108581. https://doi.org/https://doi.org/10.1016/j.eneco.2025.108581

Hamid, F. A., Loh, S. K., Wahab, N. A., Subramaniam, V., Aziz, A. A., & Idris, Z. (2024). Pulp and paper from wood and oil palm biomass: Current development, issues, challenges and opportunities. *Industrial Crops and Products*, *222*, 119938. https://doi.org/https://doi.org/10.1016/j.indcrop.2024.119938

Harahap, F., Leduc, S., Mesfun, S., Khatiwada, D., Kraxner, F., & Silveira, S. (2020). Meeting the bioenergy targets from palm oil based biorefineries: An optimal configuration in Indonesia. *Applied Energy*, *278*, 115749. https://doi.org/https://doi.org/10.1016/j.apenergy.2020.115749

Hussain, C. M., & Ali Shah, S. Z. (2022). Firm level assessment of Pakistan and Malaysia Free Trade Agreement. *Asia Pacific Management Review*, *27*(4), 265–275. https://doi.org/https://doi.org/10.1016/j.apmrv.2021.10.001

Irfanullah, & Iqbal, J. (2023). Commodity market dynamics: Who's behind booms and busts? *Borsa Istanbul Review*, *23*(1), 55–75. https://doi.org/https://doi.org/10.1016/j.bir.2022.09.005

Jia, F., Peng, S., Green, J., Koh, L., & Chen, X. (2020). Soybean supply chain management and sustainability: A systematic literature review. *Journal of Cleaner Production*, *255*, 120254. https://doi.org/https://doi.org/10.1016/j.jclepro.2020.120254

Johnston, C., Guo, J., & Prestemon, J. P. (2025). The European Union Deforestation Regulation: Implications for the global forest sector. *Forest Policy and Economics*, *173*, 103462. https://doi.org/https://doi.org/10.1016/j.forpol.2025.103462

Kan, S., Chen, B., Persson, U. M., Chen, G., Wang, Y., Li, J., Meng, J., Zheng, H., Yang, L., Li, R., Du, M., & Kastner, T. (2023). Risk of intact forest landscape loss goes beyond global agricultural supply chains. *One Earth*, *6*(1), 55–65. https://doi.org/https://doi.org/10.1016/j.oneear.2022.12.006

Karkowska, R., & Urjasz, S. (2024). Importance of geopolitical risk in volatility structure: New evidence from biofuels, crude oil, and grains commodity markets. *Journal of Commodity Markets*, *36*, 100440. https://doi.org/https://doi.org/10.1016/j.jcomm.2024.100440

Kastner, T., Chaudhary, A., Gingrich, S., Marques, A., Persson, U. M., Bidoglio, G., Le Provost, G., & Schwarzmüller, F. (2021). Global agricultural trade and land system sustainability: Implications for ecosystem carbon storage, biodiversity, and human nutrition. *One Earth*, *4*(10), 1425–1443. https://doi.org/https://doi.org/10.1016/j.oneear.2021.09.006

Kaur, S., Kaur, G., Kumari, A., Ghosh, A., Singh, G., Bhardwaj, R., Kumar, A., & Riar, A. (2025). Resurrecting forgotten crops: Food-based products from potential underutilized crops a path to nutritional security and diversity. *Future Foods*, *11*, 100585. https://doi.org/https://doi.org/10.1016/j.fufo.2025.100585

Keubeng, I. G., Muluh, G. A., & Kemezang, V. C. (2025). Controlling agricultural product price volatility: An empirical analysis from Cameroon. *Regional Sustainability*, *6*(2), 100215. https://doi.org/https://doi.org/10.1016/j.regsus.2025.100215

Khurshid, A., Khan, K., Rauf, A., & Cifuentes-Faura, J. (2024). Effect of geopolitical risk on resources prices in the global and Russian-Ukrainian context: A novel Bayesian structural model. *Resources Policy*, *88*, 104536. https://doi.org/https://doi.org/10.1016/j.resourpol.2023.104536

Kim, B. F., Santo, R. E., Scatterday, A. P., Fry, J. P., Synk, C. M., Cebron, S. R., Mekonnen, M. M., Hoekstra, A. Y., de Pee, S., Bloem, M. W., Neff, R. A., & Nachman, K. E. (2020). Country-specific dietary shifts to mitigate climate and water crises. *Global Environmental Change*, *62*, 101926. https://doi.org/https://doi.org/10.1016/j.gloenvcha.2019.05.010

Kisswani, K. M., Lahiani, A., & Fikru, M. G. (2025). Exploring dynamic extreme dependence of oil and agricultural markets. *International Review of Economics & Finance*, *99*, 104032. https://doi.org/https://doi.org/10.1016/j.iref.2025.104032

Konefal, J., de Olde, E. M., Hatanaka, M., & Oosterveer, P. J. M. (2023). Signs of agricultural sustainability: A global assessment of sustainability governance initiatives and their indicators in crop farming. *Agricultural Systems*, *208*, 103658. https://doi.org/https://doi.org/10.1016/j.agsy.2023.103658

Li, M., Wu, H., Huang, H., Gao, J., Wu, P., & Zhuo, L. (2025). Food trade of China saved global land but increased water appropriation and carbon emissions from 2010 to 2020. *Resources, Environment and Sustainability*, *21*, 100222. https://doi.org/https://doi.org/10.1016/j.resenv.2025.100222

Loh, S. K., Nasrin, A. B., Mohamad Azri, S., Nurul Adela, B., Muzzammil, N., Daryl Jay, T., Stasha Eleanor, R. A., Lim, W. S., Choo, Y. M., & Kaltschmitt, M. (2017). First Report on Malaysia's experiences and development in biogas capture and utilization from palm oil mill effluent under the Economic Transformation Programme: Current and future perspectives. *Renewable and Sustainable Energy Reviews*, *74*, 1257–1274. https://doi.org/https://doi.org/10.1016/j.rser.2017.02.066

Lusiana, B., Slingerland, M., Miccolis, A., Khasanah, N. M., Leimona, B., & van Noordwijk, M. (2023). Oil palm production, instrumental and relational values: the public relations battle for hearts, heads, and hands along the value chain. *Current Opinion in Environmental Sustainability*, *64*, 101321. https://doi.org/10.1016/j.cosust.2023.101321

Mat Yasin, M. H., Mamat, R., Najafi, G., Ali, O. M., Yusop, A. F., & Ali, M. H. (2017). Potentials of palm oil as new feedstock oil for a global alternative fuel: A review. *Renewable and Sustainable Energy Reviews*, *79*, 1034–1049. https://doi.org/https://doi.org/10.1016/j.rser.2017.05.186

Nam, H.-J., & Ryu, D. (2024). Does trade openness promote economic growth in developing countries? *Journal of International Financial Markets, Institutions and Money*, *93*, 101985. https://doi.org/https://doi.org/10.1016/j.intfin.2024.101985

Naylor, R. L., & Higgins, M. M. (2017). The political economy of biodiesel in an era of low oil prices. *Renewable and Sustainable Energy Reviews*, *77*, 695–705. https://doi.org/https://doi.org/10.1016/j.rser.2017.04.026

Ogbeifun, L., & Shobande, O. (2025). Exploring the implications of FOREX restriction policies: Theory and new evidence. *Research in Economics*, *79*(3), 101033. https://doi.org/https://doi.org/10.1016/j.rie.2025.101033

Olabisi, M., Tschirley, D. L., Nyange, D., & Awokuse, T. (2021). Does trade protectionism promote domestic food security? Evidence from Tanzanian edible oil imports. *Global Food Security*, *28*, 100470. https://doi.org/https://doi.org/10.1016/j.gfs.2020.100470

Parveen, N., Naik, S. V. C. S., Vanapalli, K. R., & Sharma, H. B. (2024). Bioplastic packaging

in circular economy: A systems-based policy approach for multi-sectoral challenges. *Science of The Total Environment*, *945*, 173893. https://doi.org/https://doi.org/10.1016/j.scitotenv.2024.173893

Paul, N. C., Khapte, P. S., Ponnaganti, N., Changan, S. S., Chavan, S. B., Kumar, K. R., Nangare, D. D., & Reddy, K. S. (2025). Grape vine (Vitis vinifera) yield prediction using optimized weighted ensemble machine learning approach. *Smart Agricultural Technology*, *12*, 101151. https://doi.org/https://doi.org/10.1016/j.atech.2025.101151

Purnomo, H., Okarda, B., Dermawan, A., Ilham, Q. P., Pacheco, P., Nurfatriani, F., & Suhendang, E. (2020). Reconciling oil palm economic development and environmental conservation in Indonesia: A value chain dynamic approach. *Forest Policy and Economics*, *111*, 102089. https://doi.org/10.1016/j.forpol.2020.102089

Pyakurel, D., Subedee, B. R., Subedi, C. K., Gurung, J., & Chaudhary, R. P. (2022). Trade potentiality of oils extracted from Prunus davidiana (wild apricot), Sapindus mukorossi (soapnut) and Zanthoxylum armatum (Nepalese pepper) in Kailash Sacred Landscape, Nepal. *Environmental Challenges*, *7*, 100490. https://doi.org/https://doi.org/10.1016/j.envc.2022.100490

Qiang, W., Niu, S., Liu, A., Kastner, T., Bie, Q., Wang, X., & Cheng, S. (2020). Trends in global virtual land trade in relation to agricultural products. *Land Use Policy*, *92*, 104439. https://doi.org/https://doi.org/10.1016/j.landusepol.2019.104439

Rifa'i, A. (2025). Economy-wide impacts of palm oil downstream in North Sumatra: A CGE approach. *World Development Perspectives*, *39*, 100706. https://doi.org/https://doi.org/10.1016/j.wdp.2025.100706

Safriyana, S., Marimin, M., Anggraeni, E., & Sailah, I. (2021). Spatial-based model for oil palm plantation suitability rating and its smallholder farmers' competitiveness: a case study at Kampar Regency, Riau Province, Indonesia. *Journal of Science and Technology Policy Management*, *12*(2), 283–308. https://doi.org/https://doi.org/10.1108/JSTPM-03-2020-0066

Santeramo, F. G., Di Gioia, L., & Lamonaca, E. (2021). Price responsiveness of supply and acreage in the EU vegetable oil markets: Policy implications. *Land Use Policy*, *101*, 105102. https://doi.org/https://doi.org/10.1016/j.landusepol.2020.105102

Shahbaz, M., AlNouss, A., Ghiat, I., Mckay, G., Mackey, H., Elkhalifa, S., & Al-Ansari, T. (2021). A comprehensive review of biomass based thermochemical conversion technologies integrated with CO2 capture and utilisation within BECCS networks. *Resources, Conservation and Recycling*, *173*, 105734. https://doi.org/https://doi.org/10.1016/j.resconrec.2021.105734

Singh, V., Stevanović, M., Bodirsky, B. L., Mishra, A., Ghosh, R. K., Popp, A., & Lotze-Campen, H. (2025). A comparison of the effects of local and EAT-Lancet dietary recommendations on selected economic and environmental outcomes in India. *Food Policy*, *134*, 102898. https://doi.org/https://doi.org/10.1016/j.foodpol.2025.102898

Sotirov, M., Azevedo-Ramos, C., Rattis, L., & Berning, L. (2022). Policy options to regulate timber and agricultural supply-chains for legality and sustainability: The case of the EU and Brazil. *Forest Policy and Economics*, *144*, 102818. https://doi.org/https://doi.org/10.1016/j.forpol.2022.102818

Thi Thu, H. N., Phuong, N. T., Anh, T. P., & Thi Ngoc, T. V. (2025). Unveiling Vietnam's trade dynamics: The perspective of virtual water on agricultural products trade for sustainable water resource management. *Journal of Cleaner Production*, *503*, 145430.

https://doi.org/https://doi.org/10.1016/j.jclepro.2025.145430

Valera, H. G. A., Mishra, A. K., Pede, V. O., Yamano, T., & Dawe, D. (2024). Domestic and international impacts of rice export restrictions: The recent case of indian non-basmati rice. *Global Food Security*, *41*, 100754. https://doi.org/https://doi.org/10.1016/j.gfs.2024.100754

van Tol, M. C. M., Moncada, J. A., Lukszo, Z., & Weijnen, M. (2021). Modelling the interaction between policies and international trade flows for liquid biofuels: an agent-based modelling approach. *Energy Policy*, *149*, 112021. https://doi.org/https://doi.org/10.1016/j.enpol.2020.112021

Wang, M., & Zan, W. (2024). Hydrogen energy and regulatory policies: Economic pathways for accelerating China's decarbonization agenda. *International Journal of Hydrogen Energy*, *110*, 208–218. https://doi.org/https://doi.org/10.1016/j.ijhydene.2025.02.088

Watson, M. J., Machado, P. G., da Silva, A. V, Saltar, Y., Ribeiro, C. O., Nascimento, C. A. O., & Dowling, A. W. (2024). Sustainable aviation fuel technologies, costs, emissions, policies, and markets: A critical review. *Journal of Cleaner Production*, *449*, 141472. https://doi.org/https://doi.org/10.1016/j.jclepro.2024.141472

Wei, J., Chen, W.-Q., Chen, C., Huang, Y., & Tang, L. (2024). Evaluating the bulk commodities supply risk from the perspective of physical trade. *Resources Policy*, *93*, 105059. https://doi.org/https://doi.org/10.1016/j.resourpol.2024.105059

Werner, M., Isa Contreras, P., Mui, Y., & Stokes-Ramos, H. (2019). International trade and the neoliberal diet in Central America and the Dominican Republic: Bringing social inequality to the center of analysis. *Social Science & Medicine*, *239*, 112516. https://doi.org/https://doi.org/10.1016/j.socscimed.2019.112516

West, C. D., Stokeld, E., Campiglio, E., Croft, S., Detges, A., Duranovic, A., von Jagow, A., Jarząbek, Ł., König, C., Knaepen, H., Magnuszewski, P., Monasterolo, I., & Reyer, C. P. O. (2021). Europe's cross-border trade, human security and financial connections: A climate risk perspective. *Climate Risk Management*, *34*, 100382. https://doi.org/https://doi.org/10.1016/j.crm.2021.100382

Wiloso, E. I., Wiloso, A. R., Setiawan, A. A. R., Jupesta, J., Fang, K., Heijungs, R., & Faturay, F. (2024). Indonesia's contribution to global carbon flows: Which sectors are most responsible for the emissions embodied in trade? *Sustainable Production and Consumption*, *48*, 157–168. https://doi.org/https://doi.org/10.1016/j.spc.2024.05.005

Xin, Y., Sun, L., & Hansen, M. C. (2022). Oil palm reconciliation in Indonesia: Balancing rising demand and environmental conservation towards 2050. *Journal of Cleaner Production*, *380*, 135087. https://doi.org/10.1016/j.jclepro.2022.135087

Xu, H., Lee, U., & Wang, M. (2020). Life-cycle energy use and greenhouse gas emissions of palm fatty acid distillate derived renewable diesel. *Renewable and Sustainable Energy Reviews*, *134*, 110144. https://doi.org/https://doi.org/10.1016/j.rser.2020.110144

Yadav, A. K., & Chattopadhyay, U. (2024). Determinants of India's cotton export performance: An empirical analysis. *International Economics*, *179*, 100521. https://doi.org/https://doi.org/10.1016/j.inteco.2024.100521

Yusnitati, Anindita, H. N., Adha, A., Septriana, D., Priambodo, T. B., Hastuti, Z. D., Santoso, E., Wulandari, W., Zuldian, P., Primeia, S., Baruji, T., Yurismono, H., Prasetyo, D. H., Murti, S. D. S., Senda, S. P., & Saputra, H. (2025). Biohydrogen production from palm oil mill effluent (POME) in Indonesia: Potential, challenges, and prospects. *International Journal of Hydrogen Energy*, *138*, 1315–1335.

https://doi.org/10.1016/j.ijhydene.2024.11.277

Zaehringer, J. G., Tribaldos, T., Jacobi, J., Borasino, E., & Llanque-Zonta, A. (2025). Land for whom? Justice, knowledge, and the transformation of food systems. In *Reference Module in Food Science*. Elsevier. https://doi.org/https://doi.org/10.1016/B978-0-443-15976-3.00089-1

Zhao, X., Wise, M. A., Waldhoff, S. T., Kyle, G. P., Huster, J. E., Ramig, C. W., Rafelski, L. E., Patel, P. L., & Calvin, K. V. (2022). The impact of agricultural trade approaches on global economic modeling. *Global Environmental Change*, *73*, 102413. https://doi.org/https://doi.org/10.1016/j.gloenvcha.2021.102413