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Enhancing urban ecosystem services: A stakeholder-centric analysis of green supply chain management and urban forest management quality in Palangka Raya

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This quantitative study employs Structural Equation Modeling (SEM) to investigate the intricate relationships between stakeholder participation, green supply chain management, urban forest management quality, and ecosystem service quality in Palangkaraya, Indonesia. Survey data collected from stakeholders engaged in urban forest management and environmental conservation efforts were subjected to Confirmatory Factor Analysis (CFA) to validate the measurement model. Path Analysis was then conducted to explore direct and mediated effects, with a focus on the mediating role of urban forest management quality as assessed through SEM. The findings reveal significant positive relationships between stakeholder participation, green supply chain management, urban forest management quality, and ecosystem service quality. Notably, urban forest management quality emerges as a mediator between stakeholder participation and ecosystem service quality, as well as between green supply chain management and ecosystem service quality. This study contributes to the empirical understanding of urban environmental management dynamics, offering insights that can inform policy and practice for promoting environmental sustainability and enhancing ecosystem service provision in Palangkaraya.

1. Introduction

Urban forests play a crucial role in providing numerous environmental, social, and economic benefits to cities worldwide (Jang-Hwan et al., 2020; Livesley et al., 2016; Pei et al., 2019). Palangka Raya, a city located in Central Kalimantan, Indonesia, is no exception. However, the management of urban forests faces various challenges due to factors such as rapid urbanization, unsustainable land use practices, and insufficient stakeholder engagement. Stakeholder participation is essential for effective urban forest management (Ordóñez et al., 2019; Steenberg et al., 2019). In Palangka Raya, stakeholders include local government authorities, community members, non-governmental organizations (NGOs), businesses, and academic institutions. Their involvement in decision-making processes, resource allocation, and implementation of forest management practices significantly influences the sustainability and quality of urban forest management (Mansourian, 2017). Moreover, the concept of green supply chain management has emerged as a vital approach to minimize the environmental impacts associated with the sourcing, production, and distribution of forest-related products and services (Bowditch et al., 2020; Laurin & Fantazy, 2017). Implementing green supply chain practices can contribute to reducing deforestation, promoting sustainable harvesting methods, and mitigating pollution in urban forest areas (Chakravarty et al., 2019). The quality of urban forest management directly affects the provision of ecosystem services in Palangka Raya. These services encompass a wide range of benefits, including air and water purification, climate regulation, biodiversity conservation, and recreational opportunities. Therefore, ensuring high-quality management practices is crucial for maintaining and enhancing the resilience and

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functionality of urban ecosystems and improving the overall well-being of city residents (Ling & Chiang, 2018; Nastran et al., 2022; Zeng et al., 2022). Understanding the interactions between stakeholder participation, green supply chain management, the quality of urban forest management, and their implications for ecosystem service provision in Palangka Raya is essential for informing sustainable development strategies and policy interventions. This study aims to explore these relationships, identify key challenges and opportunities, and propose recommendations to enhance the sustainability and resilience of urban forests and ecosystem services in the city.

2. Literature review

2.1 Relationship between Stakeholder Participation and the Quality of Urban Forest Management

In the intricate web of urban forest management, the active involvement of stakeholders stands as a linchpin for its success. Soma et al. (2018) assert that stakeholder participation encompasses the engagement of diverse actors, including local residents, governmental bodies, environmental organizations, and businesses, each with a vested interest in the management of urban forests. This engagement fosters a collaborative approach to decision-making, where a spectrum of perspectives, knowledge, and values converge to shape management strategies (Pittz & Adler, 2016). Through stakeholder participation, urban forest managers gain valuable insights into community needs, preferences, and concerns, which inform the formulation of more comprehensive and socially responsive management plans (Ferreira et al., 2020; Gulsrud et al., 2018; Lin et al., 2019). Moreover, this inclusive process promotes transparency, accountability, and trust, essential elements for ensuring the integrity of forest management practices. By embracing stakeholder participation, urban forest managers not only harness a wealth of local knowledge but also cultivate a sense of ownership and stewardship among community members, thus nurturing a collective commitment to the sustainable care and preservation of urban forest ecosystems (Bonney & Reeves, 2023; Pittman et al., 2019; Zhang et al., 2023). Therefore, the proposed hypotheses are as follows:

H_1: *Stakeholder Participation impacts on the Quality of Urban Forest Management.*

2.2 Relationship between Stakeholder Participation and Ecosystem Service Quality

Reed et al. (2018) state that stakeholder participation involves engaging various individuals, groups, and organizations who have a stake or interest in a particular ecosystem or its services. These stakeholders may include local residents, government agencies, NGOs, businesses, and academic institutions. Through active participation, stakeholders contribute diverse perspectives, knowledge, and resources, enriching decision-making processes related to ecosystem management (Videira et al., 2017). This involvement ensures that management strategies consider the needs and priorities of different stakeholders, leading to more holistic and inclusive approaches (Wang et al., 2023). Moreover, Quesada-Silva et al. (2019) assess that stakeholder participation promotes transparency, accountability, and legitimacy in decision-making, as stakeholders are involved in the formulation, implementation, and monitoring of management plans. This inclusive process builds trust among stakeholders and enhances their sense of ownership and responsibility for ecosystem management outcomes. The quality of ecosystem services is directly influenced by the level of stakeholder participation in their management (De Meo et al., 2018; Lopes & Videira, 2017). When stakeholders are actively engaged, management decisions are more likely to consider the social, economic, and cultural values associated with ecosystem services, leading to more effective conservation and sustainable use practices. Furthermore, stakeholder participation can enhance the capacity of communities to monitor and adapt to changes in ecosystem services, such as shifts in biodiversity, water quality, or climate regulation (Weiskopf et al., 2020). By fostering local knowledge exchange and collaboration, stakeholders can develop innovative solutions to address emerging challenges and ensure the resilience of ecosystems and the services they provide (Adade Williams et al., 2020). Therefore, the following hypotheses are proposed:

H_2: *Stakeholder Participation impacts on Ecosystem Service Quality*.

2.3 Relationship Green Supply Chain Management and the Quality of Urban Forest Management

According to Yildiz Çankaya and Sezen (2019), Green Supply Chain Management refers to the integration of environmentally friendly practices throughout the entire supply chain, from sourcing raw materials to product distribution and disposal. In urban forest management, Green Supply Chain Management (GSCM) principles play a crucial role in shaping sustainable practices. GSCM emphasizes responsible sourcing practices, encouraging the procurement of raw materials like timber from sustainably managed forests or certified suppliers. This approach not only supports the conservation of forest ecosystems but also helps maintain biodiversity within urban forests (Pinto, 2020). Additionally, GSCM focuses on reducing environmental impact throughout the supply chain, from resource extraction to product distribution (Cousins et al., 2019). By minimizing resource consumption, energy use, and waste generation, GSCM mitigates pollution and deforestation associated with forest-related activities, thus contributing to environmental conservation efforts and combating the effects of climate change on urban forests. Furthermore, GSCM advocates for compliance with environmental regulations, ensuring that forest management practices align with sustainable development principles and conservation goals (Naidoo & Gasparatos, 2018). Through collaboration and stakeholder engagement, GSCM fosters partnerships among various actors involved in forest

management, including government agencies, NGOs, and local communities. This inclusive approach promotes transparency, accountability, and collective action towards achieving sustainable urban forest management. Moreover, GSCM encourages continuous improvement and innovation in supply chain practices, driving research and technology advancements to enhance the quality and resilience of urban forest ecosystems (Zekhnini et al., 2022). By integrating these principles, GSCM contributes to the preservation and enhancement of urban forest resources, ultimately supporting the well-being of urban communities and ecosystems. Thus, the following hypotheses are proposed:

H_3: *Green Supply Chain Management impacts on the Quality of Urban Forest Management*.

2.4 Relationship Green Supply Chain Management and Ecosystem Service Quality

GSCM principles advocate for eco-friendly practices across the supply chain, impacting ecosystem service quality in various ways. Firstly, GSCM promotes sustainable sourcing, ensuring raw materials are responsibly obtained from eco-friendly sources, preserving biodiversity and enhancing ecosystem resilience (Jum'a, 2023; Stella Despoudi, 2020). Secondly, GSCM focuses on reducing environmental footprints by minimizing resource consumption and waste generation, maintaining air and water quality, and mitigating habitat destruction (Bradu et al., 2022; Quaranta et al., 2023). Thirdly, GSCM prioritizes compliance with environmental regulations to prevent ecosystem degradation and safeguard services like soil fertility and water purification (Islam et al., 2022). Moreover, GSCM emphasizes collaboration among supply chain actors, fostering collective action for sustainable resource management and ecosystem conservation (Mishra et al., 2022). Lastly, GSCM encourages continuous improvement and innovation through research and technology, enhancing ecosystem service provision and supporting long-term ecosystem health and resilience (Khan et al., 2022). Consequently, the following hypotheses are posited:

H_4: *Green Supply Chain Management impacts on Ecosystem Service Quality.*

2.5 Relationship the Quality of Urban Forest Management and Ecosystem Service Quality

Ordóñez & Duinker (2013) define that the quality of urban forest management refers to the effectiveness, sustainability, and appropriateness of practices employed to manage trees and green spaces within urban areas. It encompasses various factors such as tree planting, maintenance, conservation efforts, community engagement, and policy implementation aimed at promoting the health, resilience, and sustainability of urban forests. Ali and Kamraju (2023) explain that ecosystem service quality refers to the effectiveness and resilience of the benefits provided by natural ecosystems to support human well-being, including provisioning, regulating, cultural, and supporting services. It involves assessing the capacity of ecosystems to deliver these services effectively and sustainably, considering factors like ecosystem health, functionality, and human dependence. Maintaining high-quality ecosystem services is crucial for sustainable development and biodiversity conservation (Chen et al., 2022).

Urban forest management practices directly influence the quantity, diversity, and functionality of ecosystem services provided by urban forests (Amini Parsa et al., 2020). For instance, well-managed urban forests with diverse tree species and healthy ecosystems are more effective in providing essential ecosystem services such as air purification, carbon sequestration, temperature regulation, stormwater management, and biodiversity conservation. Moreover, the quality of urban forest management affects the overall health and resilience of urban ecosystems, which in turn influences the provision and stability of ecosystem services (Steenberg et al., 2019). Sustainable management practices, such as proper tree planting, pruning, and maintenance, help enhance the capacity of urban forests to deliver ecosystem services consistently over time, even in the face of environmental stressors such as climate change, pollution, and urbanization. Conversely, poor management practices, such as inadequate maintenance, over-exploitation of resources, habitat degradation, and fragmentation, can lead to a decline in ecosystem service quality (Ekka et al., 2023). Degraded or poorly managed urban forests may fail to provide essential services effectively, leading to negative impacts on human health, well-being, and urban resilience (Bikomeye et al., 2021). Hence, the following hypotheses are suggested:

H_5: *The Quality of Urban Forest Management impacts on Ecosystem Service Quality.*

2.6 the Quality of Urban Forest Management as Mediator

The quality of urban forest management serves as a crucial mediator in the intricate relationship between urban forest ecosystems and the provision of ecosystem services. It acts as a determining factor in how efficiently urban forests can deliver a wide range of services essential for human well-being and environmental health. By implementing effective management practices such as tree planting, maintenance, and conservation efforts, urban forest managers enhance the health, resilience, and functionality of these ecosystems (Conway et al., 2019). Consequently, well-managed urban forests can maximize the provision of ecosystem services, including air and water purification, climate regulation, carbon sequestration, and biodiversity conservation, thus benefiting urban populations (Gebre & Gebremedhin, 2019). Conversely, inadequate management practices, such as deforestation, habitat degradation, and pollution, can severely diminish the capacity of urban

forests to deliver services effectively (Wassie, 2020). Therefore, the quality of urban forest management plays a pivotal role in shaping the relationship between urban forest ecosystems and the quality and quantity of ecosystem services provided, ultimately influencing the livability, sustainability, and resilience of urban environments. In light of this, the following hypotheses are put forward:

H_6: *The Quality of Urban Forest Management mediates the relationship between Stakeholder Participation and Ecosystem Service Quality.*

H_7: *The Quality of Urban Forest Management mediates the relationship between Green Supply Chain Management and Ecosystem Service Quality.*

Based on the hypothesized relationships among the variables, the proposed study framework delineates a structured pathway for exploration. At its core are the independent variables of stakeholder participation and green supply chain management, poised to exert significant influences. Stakeholder participation is anticipated to positively impact both the quality of urban forest management and ecosystem service quality, reflecting the pivotal role of stakeholder engagement in environmental management practices. Similarly, green supply chain management is expected to wield a favorable influence on both the quality of urban forest management and ecosystem service quality, underscoring the importance of sustainable supply chain practices in environmental conservation efforts. Crucially, the quality of urban forest management emerges as a mediating variable, facilitating the transmission of effects from stakeholder participation and green supply chain management to ecosystem service quality. Through this framework, the study aims to elucidate the intricate interplay between these variables, offering valuable insights into the mechanisms driving environmental sustainability within the context of urban forestry management (see Fig. 1).

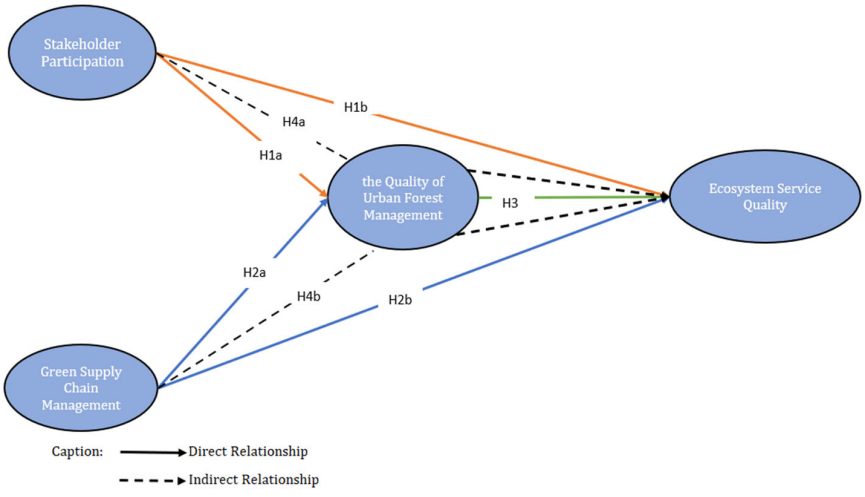

Fig. 1. Study Framework

3. Methodology

3.1 Research Design, Population, and Sample

The research design for this study entails a quantitative approach, specifically employing a cross-sectoral survey methodology. This survey is strategically structured to capture insights from respondents across diverse sectors pertinent to the research theme. The population under scrutiny encompasses individuals actively engaged in sectors directly associated with the research focus. To ensure a representative sample, a purposive sampling technique will be utilized, whereby respondents will be deliberately selected based on their relevant expertise and experience. Anticipating a cohort of approximately 500 respondents, the survey distribution will encompass a broad spectrum of industry professionals. However, in cases where the questionnaire is disseminated to 500 respondents but only 496 responses are deemed analyzable, it is imperative to recognize that the effective sample size for analysis dwindles to 496. Such discrepancies may arise due to incomplete responses or data anomalies necessitating their exclusion from subsequent analysis. While not uncommon in survey endeavors, it underscores the importance of conducting analyses mindful of the actual number of usable responses (Iivari, 2018).

3.2 Research Instrument and Data Analysis

For the research instrument, a meticulously crafted structured questionnaire serves as the primary tool. This questionnaire is thoughtfully curated to encompass inquiries pertinent to the research variables as well as demographic details of the respondents (see Table 1). Prior to distribution, rigorous assessments will be conducted to ascertain the questionnaire's validity

and reliability, ensuring its efficacy in capturing accurate and meaningful data. Moving forward to data analysis, Structural Equation Modeling (SEM) stands as the cornerstone of our analytical approach. This method offers a robust statistical framework for assessing relationships between variables within a conceptual model (Hair Jr et al., 2021). Leveraging data collected from respondents, we construct a comprehensive model that elucidates the intricate interplay among variables under investigation. Subsequently, the model undergoes rigorous testing to evaluate its alignment with the observed data, thereby enabling us to draw informed conclusions regarding the hypothesized relationships. Through SEM analysis, we endeavor to unveil nuanced insights into the complex dynamics inherent in our research domain, fostering a deeper understanding of the phenomena under scrutiny.

Table 1
Variable Measurement

Variable	Items and Indicator	Reference
Stakeholder Participation	1. SP1= Stakeholders actively engage in decision-making processes concerning urban forest management. 2. SP2= Diverse stakeholder groups, including government, local communities, non-governmental organizations, and private sector, are involved in urban forest management. 3. SP3= Stakeholders have adequate access to information regarding policies and programs related to urban forest management. 4. SP4= Regular consultation and collaboration occur among stakeholders to identify issues and solutions related to urban forests. 5. SP5= Efforts for community empowerment are made to enable active involvement in decision-making regarding urban forests. 6. SP6= Transparency and accountability are maintained by ensuring open and responsible decision-making processes accountable to the community. 7. SP7= Regular evaluations are conducted on stakeholder participation, and feedback from them is gathered to improve urban forest management programs.	(Ferreira et al., 2020; Gulsrud et al., 2018; Lin et al., 2019; Soma et al., 2018)
Green Supply Chain Management	1. GSCM1= Ensuring raw materials are obtained from suppliers committed to sustainable practices. 2. GSCM2= Optimizing energy usage across the supply chain, including the use of renewable energy sources. 3. GSCM3= Minimizing waste and promoting material recycling to reduce environmental impact. 4. GSCM4= Decreasing greenhouse gas emissions and pollutants generated from supply chain activities. 5. GSCM5= Evaluating the environmental impact of products throughout their lifecycle. 6. GSCM6= Collaborating with suppliers to promote sustainability and ensure compliance with environmental standards. 7. GSCM7= Involving stakeholders in environmental awareness and gathering feedback on sustainability initiatives.	(Cousins et al., 2019; Pinto, 2020; Yildiz Çankaya & Sezen, 2019; Zekhnini et al., 2022)
The Quality of Urban Forest Management	1. QUFM1= Checking tree health in city forests, considering various factors. 2. QUFM2= Reviewing plant and animal variety in urban forests to maintain ecological balance and genetic diversity. 3. QUFM3= Ensuring sustainable practices in tree planting and maintenance, like picking the right species and proper care for long-term health. 4. QUFM4= Involving local communities in forest management, offering education and encouraging stewardship. 5. QUFM5= Including urban forests in broader green plans to maximize their benefits. 6. QUFM6= Creating and enforcing policies supporting urban forest conservation and management. 7. QUFM7= Regularly monitoring forest health and biodiversity to improve management practices.	(Amini Parsa et al., 2020; Chen et al., 2022; Ordóñez & Duinker, 2013)
Ecosystem Service Quality	1. ESQ1= Assessing the range and variety of ecosystem services provided by natural systems. 2. ESQ2= Ensuring consistent and reliable supply of essential resources such as food, water, and raw materials. 3. ESQ3= Evaluating the ability of ecosystems to regulate environmental processes such as climate, water quality, and disease control. 4. ESQ4= Ensuring access to cultural and recreational benefits provided by ecosystems, such as aesthetic enjoyment and spiritual well-being. 5. ESQ5= Maintaining the stability and resilience of ecosystems to support other ecosystem services and human activities. 6. ESQ6= Understanding the interconnectedness of different ecosystem services and their combined impact on human well-being. 7. ESQ7= Promoting practices that ensure the long-term sustainability and viability of ecosystem services for future generations.	(Ali & Kamraju, 2023; De Meo et al., 2018; Lopes & Videira, 2017)

4. Results and analysis

4.1 Descriptive Analysis

In the preliminary stage of the survey, our efforts were dedicated to gathering crucial demographic information from participants, with a specific emphasis on three fundamental aspects: gender, age distribution, and educational background. This meticulous approach was designed to ensure a thorough comprehension of respondents' profiles, thus providing a solid basis for analyzing their perspectives and insights in later sections of the questionnaire (see Table 2).

Table 2
Descriptive statistics

Measurement	Latent construct/value	f	(%)
Gender	Male	301	60.93
	Female	193	39.07
		494	100.00
Age	< 30	175	35.43
	30 - 40	155	31.38
	41 – 50	88	17.81
	> 50	76	15.38
		494	**100**
Education	High school	132	26.72
	D3	64	12.96
	S1	233	47.17
	S2	65	13.16
		494	**100.00**
	Total Respondent	**494**	**100.00**

The provided table offers an insightful glimpse into the demographic makeup of the surveyed respondents. Analysis reveals a notable gender imbalance, with males comprising a majority at 60.93%, while females represent 39.07% of the sample. Age distribution among respondents showcases a diverse range, with the largest proportion falling below 30 years (35.43%), followed closely by the 30-40 age group (31.38%). In contrast, smaller percentages are observed in the 41-50 (17.81%) and above 50 (15.38%) age brackets. Education levels vary among respondents, with bachelor's degree holders (S1) constituting the highest proportion at 47.17%, followed by high school graduates (26.72%), diploma holders (D3, 12.96%), and master's degree holders (S2, 13.16%). These findings provide valuable insights into the diverse demographic characteristics of the sample population, crucial for interpreting survey results accurately and tailoring subsequent analyses to better understand respondents' perspectives and insights.

4.2 Validity and Reliability

Validity serves as a safeguard, ensuring that the research accurately captures the intended aspects or constructs under investigation, aligning with its stated objectives (Lub, 2015). Meanwhile, reliability acts as a pillar of stability, guaranteeing that the measurements obtained from the research instrument remain consistent and dependable across different conditions or time points (O'Connor & Joffe, 2020). Together, these twin concepts play an indispensable role in bolstering the credibility and trustworthiness of research outcomes, ensuring they uphold the standards of scientific rigor and integrity (see Table 2). The table presents the results of Confirmatory Factor Analysis (CFA) for various constructs including Stakeholder Participation, Green Supply Chain Management (GSCM), the Quality of Urban Forest Management (QUFM), and Ecosystem Service Quality (ESQ). Each construct consists of multiple items with their corresponding outer loading, Cronbach's Alpha, rho_A, composite reliability (CR), and average variance extracted (AVE) values. For Stakeholder Participation, all seven items (SP1-SP7) demonstrate strong outer loadings ranging from 0.931 to 0.945, indicating high correlations between the observed variables and their underlying construct. The construct exhibits excellent internal consistency as evidenced by a Cronbach's Alpha of 0.977, rho_A of 0.978, CR of 0.981, and AVE of 0.880, all surpassing the recommended thresholds, thus indicating reliability and convergent validity. Similarly, Green Supply Chain Management (GSCM) shows robust outer loadings for its seven items (GSCM1-GSCM7) ranging from 0.882 to 0.945, reflecting strong relationships with the latent construct. The construct demonstrates high internal consistency with a Cronbach's Alpha of 0.973, rho_A of 0.975, CR of 0.978, and AVE of 0.863, affirming its reliability and convergent validity.Regarding the Quality of Urban Forest Management (QUFM), the seven items (QUFM1-QUFM7) exhibit substantial outer loadings ranging from 0.872 to 0.939, indicating their strong associations with the underlying construct. The construct maintains good internal consistency with a Cronbach's Alpha of 0.963, rho_A of 0.966, CR of 0.969, and AVE of 0.819, suggesting reliability and convergent validity. Lastly, Ecosystem Service Quality (ESQ) demonstrates varying outer loadings across its seven items (ESQ1-ESQ7), with values ranging from 0.719 to 0.946. While most items show strong associations with the construct, item ESQ5 appears to have a lower outer loading. The construct maintains acceptable internal consistency with a Cronbach's Alpha of 0.959, rho_A of 0.961, CR of 0.967, and AVE of 0.808, indicating overall reliability and convergent validity despite the slightly lower loading of ESQ5. In

summary, the CFA results indicate strong support for the validity and reliability of the measured constructs, highlighting the robustness of the underlying theoretical framework in capturing the intended concepts within the study.

Table 2
Confirmatory Factor Analysis

Construct	Items	Outer Loading	Cronbach's Alpha	rho_A	CR	AVE
Stakeholder Participation	SP1	0.932	0.977	0.978	0.981	0.880
	SP2	0.945				
	SP3	0.940				
	SP4	0.942				
	SP5	0.934				
	SP6	0.944				
	SP7	0.931				
Green Supply Chain Management	GSCM1	0.882	0.973	0.975	0.978	0.863
	GSCM2	0.939				
	GSCM3	0.943				
	GSCM4	0.920				
	GSCM5	0.957				
	GSCM6	0.916				
	GSCM7	0.945				
The Quality of Urban Forest Management	QUFM1	0.872	0.963	0.966	0.969	0.819
	QUFM2	0.916				
	QUFM3	0.939				
	QUFM4	0.916				
	QUFM5	0.916				
	QUFM6	0.883				
	QUFM7	0.891				
Ecosystem Service Quality	ESQ1	0.930	0.959	0.961	0.967	0.808
	ESQ2	0.913				
	ESQ3	0.946				
	ESQ4	0.914				
	ESQ5	0.719				
	ESQ6	0.927				
	ESQ7	0.923				

Furthermore, The Heterotrait-Monotrait Ratio (HTMT) is a statistical measure used in structural equation modeling (SEM) to assess discriminant validity. It compares the relationships between constructs (heterotrait correlations) to the relationships within the same construct (monotrait correlations). By evaluating the ratio of heterotrait correlations to monotrait correlations, HTMT helps researchers determine whether the constructs being studied are distinct from one another. A HTMT value less than 1 suggests discriminant validity, indicating that the constructs are sufficiently different from each other. This method is valuable for ensuring that the constructs under investigation in SEM models are accurately represented and distinct from each other, thus enhancing the validity of the research findings (see Table 3).

Table 3
Heterotrait-Monotrait Ratio (HTMT)

Construct	ESQ	GSCM	SP	QUFM
Ecosystem Service Quality	1			
Green Supply Chain Management	0.587	1		
Stakeholder Participation	0.597	0.415	1	
The Quality of Urban Forest Management	0.515	0.322	0.471	1

*) SP=Stakeholder Participation; GSCM=Green Supply Chain Management; QUFM=the Quality of Urban Forest Management; ESQ=Ecosystem Service Quality

Table 3 presents the results of the Heterotrait-Monotrait Ratio (HTMT) analysis, assessing the discriminant validity between constructs including Ecosystem Service Quality (ESQ), Green Supply Chain Management (GSCM), Stakeholder Participation (SP), and the Quality of Urban Forest Management (QUFM). The values in the table represent the ratios between heterotrait correlations (correlations between different constructs) and monotrait correlations (correlations within the same construct). The HTMT values indicate the extent to which constructs are distinguishable from each other. A value close to 1 suggests potential issues with discriminant validity, whereas values significantly lower than 1 indicate adequate discriminant validity. For the ESQ construct, the HTMT values with other constructs are 0.587 (with GSCM), 0.597 (with SP), and 0.515 (with QUFM), all below 1, indicating satisfactory discriminant validity. Similarly, for the GSCM construct, the HTMT values are 0.587 (with ESQ), 0.415 (with SP), and 0.322 (with QUFM), all indicating adequate discriminant validity. For the SP construct, the HTMT values are 0.597 (with ESQ), 0.415 (with GSCM), and 0.471 (with QUFM), all below 1, supporting discriminant validity. Lastly, for the QUFM construct, the HTMT values are 0.515 (with ESQ), 0.322 (with GSCM), and 0.471 (with SP), all indicating acceptable discriminant validity. In conclusion, the HTMT analysis suggests that the constructs in the study demonstrate adequate discriminant validity, indicating that they measure distinct aspects as intended.

4.3 Hypothesis Test

Hypothesis testing is a statistical method to determine if there is enough evidence to reject the null hypothesis in favor of an alternative hypothesis (Szucs & Ioannidis, 2017). It involves formulating hypotheses, collecting sample data, performing a statistical test, and making a decision based on the test results and significance level. Its goal is to draw conclusions about population parameters using sample data (see Table 4 and Fig. 2).

Table 4
Path Analysis Result

Hypothesis	Construct*)	Original Sample	STDEV	T Statistics	P Values	Result
H1	SP → QUFM	0.397	0.046	8.63	0.000	Supported
H2	SP → ESQ	0.323	0.038	8.568	0.000	Supported
H3	GSCM→ QUFM	0.151	0.038	4.005	0.000	Supported
H4	GSCM → ESQ	0.363	0.036	10.180	0.000	Supported
H5	QUFM → ESQ	0.238	0.034	7.072	0.000	Supported

*) SP=Stakeholder Participation; GSCM=Green Supply Chain Management; QUFM=the Quality of Urban Forest Management; ESQ=Ecosystem Service Quality

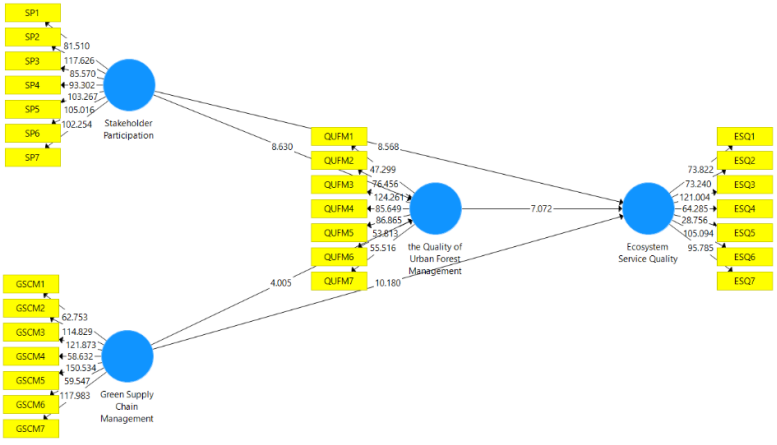

Fig. 2. Boostrapping SmartPLS Output

Table 4 and Fig. 2 presents the results of the path analysis conducted to test various hypotheses regarding the relationships between different constructs, including Stakeholder Participation (SP), Green Supply Chain Management (GSCM), the Quality of Urban Forest Management (QUFM), and Ecosystem Service Quality (ESQ). The table includes information such as the hypothesis number, the constructs involved, original sample coefficients, standard deviations (STDEV), T statistics, p-values, and the resulting interpretation.

Hypothesis H1 suggests a path from Stakeholder Participation (SP) to the Quality of Urban Forest Management (QUFM). The analysis reveals a coefficient of 0.397 with a standard deviation of 0.046, resulting in a T statistic of 8.63 and a p-value of 0.000, indicating statistical significance. Therefore, H1 is supported, suggesting a positive relationship between SP and QUFM. Similarly, H2 proposes a path from SP to Ecosystem Service Quality (ESQ). The analysis yields a coefficient of 0.323 with a standard deviation of 0.038, resulting in a T statistic of 8.568 and a p-value of 0.000, indicating statistical significance. Hence, H2 is supported, indicating a positive relationship between SP and ESQ.

Hypothesis H3 examines the relationship between Green Supply Chain Management (GSCM) and QUFM. The analysis reveals a coefficient of 0.151 with a standard deviation of 0.038, resulting in a T statistic of 4.005 and a p-value of 0.000, indicating statistical significance. Therefore, H3 is supported, suggesting a positive relationship between GSCM and QUFM. Hypothesis H4 tests the relationship between GSCM and ESQ. The analysis shows a coefficient of 0.363 with a standard deviation of 0.036, resulting in a T statistic of 10.180 and a p-value of 0.000, indicating statistical significance. Hence, H4 is supported, indicating a positive relationship between GSCM and ESQ.
Lastly, Hypothesis H5 explores the relationship between QUFM and ESQ. The analysis yields a coefficient of 0.238 with a standard deviation of 0.034, resulting in a T statistic of 7.072 and a p-value of 0.000, indicating statistical significance. Therefore, H5 is supported, suggesting a positive relationship between QUFM and ESQ. In summary, the path analysis results provide strong support for all hypotheses, indicating significant positive relationships between the examined constructs, thereby validating the theoretical framework under investigation.

4.4 Mediation Test

A mediation test assesses whether the effect of an independent variable on a dependent variable is mediated by a third variable. It involves testing the significance of indirect effects to understand the mechanisms underlying relationships between variables, providing insights into causal pathways in research analysis across various disciplines (see Table 5).

Table 5
Mediation Result

Hypothesis	Construct*)	Original Sample	STDEV	T Statistics	P Values	Result
H6	SP → QUFM → ESQ	0.094	0.017	5.597	0.000	Supported
H7	GSCM → QUFM → ESQ	0.036	0.011	3.148	0.002	Supported

*) SP=Stakeholder Participation; GSCM=Green Supply Chain Management; QUFM=the Quality of Urban Forest Management; ESQ=Ecosystem Service Quality

Table 5 presents the results of the mediation analysis, examining the indirect effects of constructs through intermediate variables. The hypotheses tested involve Stakeholder Participation (SP), Green Supply Chain Management (GSCM), the Quality of Urban Forest Management (QUFM), and Ecosystem Service Quality (ESQ). The table includes information such as the hypothesis number, the constructs involved, original sample coefficients, standard deviations (STDEV), T statistics, p-values, and the resulting interpretation.

Hypothesis H6 investigates the indirect relationship between Stakeholder Participation (SP) and Ecosystem Service Quality (ESQ) mediated by the Quality of Urban Forest Management (QUFM). The analysis reveals a coefficient of 0.094 with a standard deviation of 0.017, resulting in a T statistic of 5.597 and a p-value of 0.000, indicating statistical significance. Therefore, H6 is supported, suggesting that SP influences ESQ indirectly through its impact on QUFM. Similarly, Hypothesis H7 examines the indirect relationship between Green Supply Chain Management (GSCM) and Ecosystem Service Quality (ESQ) mediated by the Quality of Urban Forest Management (QUFM). The analysis shows a coefficient of 0.036 with a standard deviation of 0.011, resulting in a T statistic of 3.148 and a p-value of 0.002, indicating statistical significance. Hence, H7 is supported, indicating that GSCM influences ESQ indirectly through its impact on QUFM.

In summary, the mediation analysis results support both hypotheses, indicating significant indirect effects of SP and GSCM on ESQ through their influence on QUFM. This suggests that QUFM acts as a mediator in the relationship between SP/GSCM and ESQ, highlighting the importance of considering indirect pathways in understanding the complex relationships between the examined constructs.

5. Discussion

The acceptance of Hypothesis H1, indicating that Stakeholder Participation (SP) influences the Quality of Urban Forest Management (QUFM), holds significant implications, especially in a city like Palangkaraya. This finding suggests that involving various stakeholders in the management of urban forests can lead to better quality management practices. In Palangkaraya, a city known for its lush biodiversity and extensive forest cover, this finding is particularly relevant. Given the challenges of urbanization and environmental degradation, actively involving stakeholders such as local communities, governmental agencies, and non-governmental organizations becomes crucial (Himmatul et al., 2024; Himmatul & Junaedi, 2024; Lisaria et al., 2024). By doing so, the city can tap into local knowledge and resources to improve the conservation and management of its urban forests (Bonney & Reeves, 2023; Pittman et al., 2019; Zhang et al., 2023). Practically, accepting H1 implies that policymakers and urban planners in Palangkaraya should prioritize strategies aimed at enhancing stakeholder engagement in urban forest management. This may involve initiatives like community-based conservation projects, participatory decision-making processes, and partnerships between government and non-governmental bodies. Moreover, recognizing the influence of stakeholder participation can lead to more effective urban development planning in Palangkaraya (Kharis et al., 2024; Saeri et al., 2024; Shofwa et al., 2024). By integrating ecological, social, and economic considerations into management practices, the city can work towards sustainable development while ensuring the well-being of its residents and the preservation of its natural resources (Kharis et al., 2024; Saeri et al., 2024; Shofwa et al., 2024).
Hypothesis H2 is accepted, which asserts that Stakeholder Participation (SP) influences Ecosystem Service Quality (ESQ), carries significant implications, particularly in the context of Palangkaraya. This finding underscores the importance of involving stakeholders in the management of urban ecosystems to enhance the provision of ecosystem services. In Palangkaraya, a city renowned for its rich biodiversity and extensive forest cover, this finding holds particular relevance. Given the pressures of urbanization and environmental degradation, actively engaging stakeholders such as local communities, governmental agencies, and non-governmental organizations becomes essential (De Meo et al., 2018; Lopes & Videira, 2017). By doing so, the city can leverage local knowledge and resources to improve the quality of ecosystem services provided by its urban environment (Basrowi & Maunnah, 2019; Marwanto et al., 2020b; Soenyono & Basrowi, 2020). Practically, accepting H2 implies that policymakers and urban planners in Palangkaraya should prioritize strategies aimed at enhancing stakeholder engagement in urban ecosystem management. This may involve initiatives such as participatory decision-making

processes, community-based conservation projects, and partnerships between government and non-governmental entities (Basrowi & Utami, 2020; Marwanto et al., 2020a; Suwarno Basrowi, 2020; Basrowi & Utami, 2023; Suseno et al., 2018). Furthermore, recognizing the influence of stakeholder participation can lead to more effective urban development planning in Palangkaraya. By integrating ecological, social, and economic considerations into management practices, the city can work towards sustainable development while safeguarding the provision of ecosystem services essential for the well-being of its residents (Alexandro & Basrowi, 2024b; Junaidi, Masdar, et al., 2024; Kittie & Basrowi, 2024).

The confirmation of Hypothesis H3, which suggests that Green Supply Chain Management (GSCM) impacts the Quality of Urban Forest Management (QUFM), holds notable implications, particularly within the context of Palangkaraya. This finding underscores the importance of implementing environmentally sustainable practices within supply chains to enhance the quality of urban forest management. In Palangkaraya, a city renowned for its rich biodiversity and extensive forest cover, this finding is of particular relevance (Hadi et al., 2019; Hamdan & Basrowi, 2024; Mulyani & Basrowi, 2024). With the challenges of deforestation and environmental degradation, adopting green supply chain practices becomes crucial. By integrating sustainable practices such as sourcing from responsibly managed forests and reducing carbon emissions, businesses can contribute to the preservation and enhancement of urban forest quality (Zekhnini et al., 2022). Practically, accepting H3 implies that policymakers and businesses in Palangkaraya should prioritize strategies aimed at implementing green supply chain practices to improve urban forest management (Junaidi, Basrowi, et al., 2024; Miar et al., 2024; Purwaningsih et al., 2024). This may involve initiatives such as promoting sustainable sourcing, reducing waste generation, and supporting environmentally friendly transportation methods. Furthermore, recognizing the impact of green supply chain management can lead to more sustainable urban development in Palangkaraya. By aligning economic activities with environmental conservation objectives, the city can achieve a balance between economic growth and ecological preservation, ultimately promoting the well-being of its residents and the resilience of its urban ecosystems (Alexandro & Basrowi, 2024a; Nuryanto et al., 2019; Yusuf et al., 2024).

The validation of Hypothesis H4, indicating that Green Supply Chain Management (GSCM) impacts Ecosystem Service Quality (ESQ), carries significant implications, particularly within the context of Palangkaraya. This finding underscores the importance of implementing environmentally sustainable practices within supply chains to enhance the provision of ecosystem services. In Palangkaraya, a city known for its rich biodiversity and extensive forest cover, this finding holds particular relevance. With the challenges of environmental degradation and climate change, adopting green supply chain practices becomes crucial (Purwaningsih, 2019, 2020; Purwaningsih et al., 2022). By integrating sustainable practices such as reducing carbon emissions, minimizing resource extraction, and promoting biodiversity conservation, businesses can contribute to the preservation and enhancement of ecosystem service quality (Mishra et al., 2022). Practically, accepting H4 implies that policymakers and businesses in Palangkaraya should prioritize strategies aimed at implementing green supply chain practices to improve ecosystem service quality. This may involve initiatives such as promoting sustainable sourcing, investing in renewable energy, and supporting conservation projects that enhance ecosystem resilience. Furthermore, recognizing the impact of green supply chain management can lead to more sustainable urban development in Palangkaraya (Purwaningsih & Rahmanto, 2013; Purwaningsih & Suhaeri, 2019). By aligning economic activities with environmental conservation objectives, the city can achieve a balance between economic growth and ecological preservation, ultimately promoting the well-being of its residents and the resilience of its urban ecosystems.

The approval of Hypothesis H5, which asserts that the Quality of Urban Forest Management (QUFM) impacts Ecosystem Service Quality (ESQ), carries notable implications, particularly within the context of Palangkaraya. This finding emphasizes the critical role of effective urban forest management in maintaining and enhancing the provision of ecosystem services. In Palangkaraya, a city renowned for its rich biodiversity and extensive forest cover, this finding holds particular relevance. With the challenges of urbanization and environmental degradation, ensuring the quality of urban forest management becomes crucial. By implementing sustainable forest management practices such as reforestation, biodiversity conservation, and habitat restoration, the city can enhance the provision of ecosystem services vital for the well-being of its residents and the resilience of its urban ecosystems. Practically, accepting H5 implies that policymakers and urban planners in Palangkaraya should prioritize strategies aimed at improving the quality of urban forest management to enhance ecosystem service quality (Chen et al., 2022). This may involve initiatives such as developing green infrastructure, implementing urban forestry programs, and integrating nature-based solutions into urban planning processes. Furthermore, recognizing the impact of urban forest management on ecosystem service quality can lead to more sustainable urban development in Palangkaraya. By valuing and investing in the preservation and restoration of urban forests, the city can not only enhance environmental quality but also promote social cohesion, health, and economic prosperity (Purwaningsih et al., 2018, 2019).

The recognition of Hypothesis H6 suggests that the Quality of Urban Forest Management (QUFM) mediates the relationship between Stakeholder Participation (SP) and Ecosystem Service Quality (ESQ). This implies that the influence of stakeholder participation on ESQ is partially mediated by the quality of urban forest management. In other words, when stakeholders actively engage in the management of urban forests, it positively affects the quality of forest management, which subsequently leads to improved ecosystem service quality. Similarly, the acceptance of Hypothesis H7 indicates that the Quality of Urban Forest Management mediates the relationship between Green Supply Chain Management (GSCM) and Ecosystem Service Quality (ESQ). This suggests that the impact of green supply chain management practices on ESQ is partially mediated by

the quality of urban forest management. When businesses adopt environmentally sustainable practices within their supply chains, it positively influences the quality of forest management, which in turn enhances ecosystem service quality. In the context of Palangkaraya, these findings have significant implications. They emphasize the interconnectedness between stakeholder engagement, green supply chain management, urban forest management quality, and ecosystem service provision (Conway et al., 2019). By actively involving stakeholders and promoting sustainable practices within supply chains, the city can enhance the quality of its urban forest management, leading to improved ecosystem service quality. Practically, these findings underscore the importance of integrated approaches to urban planning and environmental management in Palangkaraya. By considering the mediation effects of urban forest management quality, policymakers and businesses can develop more effective strategies for enhancing ecosystem services while promoting sustainability and resilience in the city's urban environment .

6. Conclusion

The findings of the analysis provide significant implications for both theoretical understanding and practical applications in the context of urban forest management and ecosystem service provision, particularly within the setting of Palangkaraya. Additionally, the study sheds light on the social implications of stakeholder participation and green supply chain management in fostering environmental sustainability. However, it is essential to acknowledge the limitations of the study and provide recommendations for future research and policy implementation.

The acceptance of hypotheses H1 to H7 underscores the importance of stakeholder participation, green supply chain management, and the quality of urban forest management in influencing ecosystem service quality. These findings contribute to the existing literature by providing empirical evidence of the interrelationships between these variables. They highlight the mediating role of urban forest management quality in linking stakeholder participation and green supply chain management to ecosystem service provision, enriching our theoretical understanding of urban environmental management dynamics.

From a practical standpoint, the findings suggest actionable strategies for policymakers, urban planners, businesses, and community stakeholders in Palangkaraya. Enhancing stakeholder participation in urban forest management initiatives can lead to improved ecosystem service provision and environmental sustainability. Similarly, adopting green supply chain management practices can positively impact ecosystem service quality by enhancing the quality of urban forest management. These insights can inform the development of integrated approaches to urban planning and environmental management that prioritize stakeholder engagement and sustainability in Palangkaraya.

The study's findings have broader social implications, emphasizing the importance of community involvement and corporate responsibility in promoting environmental sustainability. By actively engaging stakeholders and adopting sustainable practices within supply chains, Palangkaraya can foster a culture of environmental stewardship and social responsibility. This can lead to greater community empowerment, social cohesion, and resilience in the face of environmental challenges.

7. Limitations and Recommendations

Despite its contributions, the study has several limitations. The research may be constrained by its focus on a specific geographic area and may not be generalizable to other contexts. Additionally, the study's reliance on cross-sectional data limits its ability to establish causality definitively. Future research could address these limitations by conducting longitudinal studies across diverse urban settings to validate the findings further. Moreover, there is a need for comprehensive policy frameworks that integrate stakeholder engagement, green supply chain management, and urban forest management into sustainable urban development strategies. Collaboration between government agencies, businesses, civil society organizations, and local communities is crucial for implementing such policies effectively.

The study's findings provide valuable insights into the complex relationships between stakeholder participation, green supply chain management, urban forest management quality, and ecosystem service provision in Palangkaraya. By leveraging these insights and addressing the identified limitations, policymakers and stakeholders can work towards creating more sustainable and resilient urban environments that benefit both present and future generations.

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