SOCIAL LIFE CYCLE ASSESSMENT OF ARABICA COFFEE PRODUCTION BASED ON ITS MANAGEMENT SYSTEM IN SAMOSIR REGENCY, NORTH SUMATRA PROVINCE, INDONESIA

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ABSTRACT

The growing global demand for coffee has heightened concerns about its social sustainability, particularly in smallholder-based production systems where empirical evidence remains limited. This study assesses the social impacts of Arabica coffee production in Samosir Regency, North Sumatra Province, Indonesia, using the Social Life Cycle Assessment (S-LCA) framework and the 2020 United Nations Environment Programme (UNEP) reference-scale approach. Six micro-scale Arabica coffee enterprises representing three management systems private enterprises, middlemen, and a farmer group were evaluated across six stakeholder categories and 26 social subcategories. All management systems achieved a "highly sustainable" rating, with social sustainability index scores of 0.88 for private enterprises, 0.87 for the farmer group, and 0.86 for middlemen. Key social hotspots were identified in occupational health and safety, the absence of written employment contracts, and limited employer-provided social security coverage. The findings indicate that targeted, low-cost interventions such as basic OHS provision, simple employment contract templates, and facilitated enrolment in social security schemes could significantly strengthen social outcomes without imposing excessive financial burdens on micro-enterprises, thereby enhancing social equity and resilience within Indonesia's Arabica coffee value chain.

Keywords : Arabica coffee, rural development, social life cycle assessment, social sustainability

INTRODUCTION

Coffee is one of the most widely traded agricultural commodities and supports millions of smallholder farmers in tropical regions (De Felice et al., 2025). Coffee also has social, cultural, and environmental dimensions that shape rural livelihoods and global consumption. As demand grows, concerns are rising about how coffee is produced and who gains from it (Wright et al., 2024). Ensuring that production is both environmentally and socially sustainable has become a central concern for researchers, policymakers, and industry actors.

Indonesia is a key player in this context. It is the second largest coffee producer in Asia after Vietnam and among the top five globally. Between 2022 and 2023, national production rose by 2.4 percent to around 12 million bags, while domestic consumption increased by 18.2 percent (International Coffee Organization, 2023). Most of Indonesia's roughly 1.27 million hectares of coffee plantations are managed by smallholders, and 2023 production is estimated at about 790 thousand tons (Badan Pusat Statistik, 2023). These figures underline both the strategic importance of coffee for Indonesia's agricultural sector and the central role of smallholder farmers. Yet farmers and workers still face unstable prices, limited financial services, and weak bargaining positions in the value chain, raising questions about how fairly the benefits of coffee production are shared.

Samosir Regency, located in the highlands of North Sumatra Province, is a key Arabica-producing area. Fertile volcanic soils and a growing tourism sector make Samosir both an agricultural hub and a center of community-based livelihoods rooted in coffee farming, post-harvest processing, and trading. Despite this dependence, issues such as fair wages, safe working conditions, and broader community well-being remain

underexplored, even though they are crucial for ensuring that coffee-driven growth translates into equitable and inclusive development. Sustainability is commonly framed around three interconnected pillars: environmental protection, economic viability, and social welfare (Tragnone et al., 2022) (dos Muchangos et al., 2025).

Research on coffee has paid considerable attention to environmental aspects such as deforestation, carbon emissions, and waste management (Gosalvitr et al., 2023), but the social dimension is less developed. Social sustainability centers on people's well-being by addressing human rights, fair labor practices, equality, and empowerment (Barreto Peixoto et al., 2023). It requires that benefits are distributed fairly and that affected communities can participate meaningfully in decision making. The Social Life Cycle Assessment (S-LCA) framework offers a structured way to evaluate these social aspects. Developed by the United Nations Environment Programme, S-LCA examines social and socioeconomic impacts across a product's life cycle, from raw material extraction to consumption and disposal (Benoît Norris et al., 2020). In contrast to environmental or economic assessments, S-LCA focuses explicitly on people workers, local communities, consumers, and value chain actors helping to identify social hotspots and guide improvements in corporate responsibility and public policy (UNEP, 2021).

Although S-LCA has been applied to various agricultural sectors worldwide, its use in Indonesia's coffee industry is still limited. A study in West Java showed clear differences in social performance among coffee enterprises managed privately, by middlemen, and by farmer groups (Rahmah et al., 2023). Management systems shape how benefits, responsibilities, and risks are distributed: private enterprises often have stronger organization and capital; farmer groups rely on collective participation but face resource constraints; and middlemen connect farmers to markets while sometimes reinforcing income disparities. Understanding these governance structures is vital for designing fair and inclusive systems that support smallholders. In Samosir, however, the social impacts of different coffee management systems have not been systematically assessed. Local development plans have focused more on environmental and technical aspects such as soil quality and processing standards while human and social dimensions remain largely undocumented. This information gap constrains efforts to design policies and programs that integrate social considerations into sustainable coffee development.

This study addresses these gaps by applying the S-LCA framework to Arabica coffee production in Samosir Regency. It has three main objectives. First, it assesses the social impacts of coffee production across three management systems private enterprises, middlemen, and farmer groups using six stakeholder categories: workers, local communities, value chain actors, consumers, society, and children. Second, it identifies social hotspots within the value chain, such as labor conditions, community relations, and the distribution of welfare. Third, it formulates recommendations to improve social performance through fair labor practices, stronger community participation, and institutional strengthening. The approach combines quantitative and qualitative assessments to capture both compliance with social standards and the lived experiences of stakeholders. In doing so, the study reveals the strengths and weaknesses of each management system and identifies strategies for enhancing social outcomes in the coffee sector.

RESEARCH METHODS

This study was conducted on six coffee businesses in Samosir Regency, North Sumatra Province, Indonesia, from May to December 2024. Samosir Regency was

selected because it is a key Arabica coffee production area and a major tourist destination, with the local population largely dependent on coffee as farmers, traders, or small business owners. No previous study has applied Social Life Cycle Assessment (S-LCA) to Arabica coffee businesses in this region. Purposive sampling was used to select six Arabica coffee micro-enterprises representing the main management systems in Samosir. The sampling frame was prepared with the local agricultural office and the Synergy Community, a local coffee stakeholder network. Inclusion criteria were: (i) micro-scale enterprises operating for at least three years; (ii) involvement in post-harvest processing and direct interaction with consumers (e.g. coffee shops, tourism-oriented outlets); and (iii) willingness to participate in interviews and observations. The final sample consisted of three privately managed enterprises, two middlemen, and one farmer group. Due to the small number of eligible enterprises and the purposive sampling, results are not statistically generalizable to all Indonesian coffee businesses, but provide an in-depth case study of micro-scale Arabica coffee enterprises in Samosir Regency.

Goal definition: The study addresses three S-LCA questions: (1) Do coffee production activities, from upstream to downstream and under different management systems (farmer groups, middlemen, private enterprises), generate social benefits for all stakeholders? (2) Which aspects require improvement based on identified social impacts? and (3) Are there differences in social impacts between farmer-group, middlemen, and privately managed coffee production? The management system classification follows characteristics described by Rahmah et al. (2023). Accordingly, the study objectives are:

1. To assess social impacts generated by coffee industries managed by farmer groups, middlemen, and private enterprises.
2. To identify main social hotspots in the coffee industry. Social hotspots are specific process aspects in particular locations that represent problems, risks, or opportunities related to social issues that may threaten or enhance social well-being (Benoît Norris et al., 2020).
3. To explore potential social improvement options throughout the coffee product life cycle.

Scope definition: The functional unit is one year of operation of an Arabica coffee micro-enterprise that purchases cherries from local farmers, processes them into green or roasted beans, and sells coffee products to consumers on-site or via small-scale distribution channels. The system boundary includes purchase of cherries at the enterprise gate, post-harvest processing, on-site service to consumers, and packaging disposal at the point of sale. Upstream farm production and downstream waste management beyond the consumer are not explicitly modelled. Because the analysis focuses on enterprises rather than a specific amount of product, the study is best described as an organizational S-LCA with product-related elements.

This phase includes selecting stakeholder categories, defining subcategories and indicators, and choosing the impact assessment approach and reference scale (Benoît Norris et al., 2020). Stakeholders are defined as groups affected by activities along the coffee life cycle. The stakeholders in this study are workers, local community, value chain actors, consumers, society, and children. The social sustainability indicators follow the 2020 UNEP guidelines for Social Life Cycle Assessment (S-LCA) of products, which provide a comprehensive methodology for assessing social impacts across the entire life cycle (UNEP, 2021) (Table 1).

Table 1. Indicators used to evaluate social impacts for each stakeholder category

Stakeholders	Subcategory	Social Impact Indicators
Worker	Child labor	Compliance of coffee enterprises' policies with national regulations concerning child labor
		The presence or absence of child labor
		The presence or absence of policies to prevent child labor practices
	Fair salary	Wage payment system
		Punctuality of wage payments
		Minimum wage received by workers
		Presence or absence of wage payment documentation
		Completeness of wage payment documentation components
		Presence of suspicious deductions on wages
		Presence or absence of bonuses
		Wage equality between men and women
	Working hours	Number of hours effectively worked by employees
		Weekly time off
		Break time between working hours
		Overtime compensation
		Presence or absence of documentation regarding work hour and time off regulations
	Forced labor	Presence or absence of withholding of personal documents
		Freedom to terminate employment in accordance with applicable regulations
		Presence or absence of practices related to the withholding and non-payment of wages
		Presence or absence of forced labor under specific threats
	Equal opportunities/discrimination	Equal opportunities for employment
		Total number of discrimination cases
		Fair treatment in the workplace
	Health and safety	Number of injuries or fatal accidents
		Presence or absence of formal policy to prevent accidents
		Presence or absence of educational/training programs to prevent accidents
		Presence or absence of emergency protocols
	Social benefit/social security	Presence or absence of social security program
		Presence or absence of religious holiday allowances
		Presence or absence of other social benefits
	Employment relationship	Presence or absence of employment agreement documentation
	Sexual harassment	Total number of sexual harassment cases
		Presence or absence of grievance helpline
		Efforts by the organization to reduce the risk of sexual harassment
Local community	Access to material resources	The presence or absence of difficulties experienced by local communities in accessing material resources.
	Delocalization and migration	The presence or absence of workers from outside the region.
		The relationship between local residents and external workers.
		The presence or absence of delocalization caused by coffee business activities.
	Respect of indigenous rights	The presence or absence of discriminatory actions against indigenous communities.
		Respect by workers and business owners for indigenous rights.
	Community engagement	The presence or absence of meetings between business owners and local communities
		The presence or absence of programs/activities involving local communities
	Local employment	The presence or absence of workers originating from the local community
	Safe and healthy living conditions	The presence or absence of environmental pollution caused by coffee businesses

	Secure living conditions	The presence or absence of efforts to improve security at business sites The number of community complaints related to security issues caused by the coffee business The presence or absence of cases related to security/criminality due to the coffee business.
Value chain actor	Fair competition	Existence of partnership agreements between coffee businesses and suppliers The presence or absence of anti-competitive behavior
	Supplier relationship	Adequacy of time to meet demand Reasonability of demand volume fluctuations Communication between business owners and suppliers The presence or absence of training programs
	Wealth distribution	Fairness of selling prices Terms and conditions for termination/extension of partnerships.
	Decision-making involvement	The presence or absence of investor or supplier involvement in decision-making processes.
Consumer	Health and safety	The presence or absence of consumer complaints related to consumed products The presence or absence of nutritional information label The presence or absence of composition and warning labels (allergenic substance) The presence or absence of halal certification labels
	Feedback mechanism	The presence or absence of feedback mechanisms
	Transparency	Transparency regarding product information (price, promotions, etc.)
	End-of-life responsibility	The presence or absence of information on product disposal, reuse, or recycling
Society	Corruption	The presence or absence of involvement of the coffee business in corruption cases. The presence or absence of anti-corruption prevention programs. The presence or absence of actions taken to mitigate corruption risks
	Poverty alleviation	The presence or absence of programs implemented by business owners to help alleviate poverty.
Children	Health issues for children as consumers	The presence or absence of reports related to children's health issues after consuming coffee products.
	Children concern regarding marketing practices	The presence or absence of marketing practices that are inappropriate for children The presence or absence of non-compliance related to marketing/labeling codes of ethics

The impact assessment methodology in this study employed a reference scale approach, wherein social impacts were evaluated based on a specific reference scale. The procedure, as detailed by Hossein et al. (Hossain et al., 2018), involved a benchmarking process, scoring (for each subcategory and stakeholder categories), and calculation of a social sustainability index. Data for this study were obtained from interviews with stakeholders, field observations, and a review of relevant documents.

***Benchmarking*:** During the benchmarking process, each indicator will be assigned a score ranging from 0.00 to 1.00 based on its compliance with national regulations. The criteria for score allocation are presented in Table 2. These benchmarking scores (denoted as Ii for indicator 'i') will serve as the basis for calculating the overall impact scores for each subcategory, stakeholder category, and ultimately, the social sustainability index (Hossain et al., 2018).

Table 2. Indicator scoring scale of responses

Point	Response category
1.00	Best practice: Strongly positive/fully agreed/very highly related/highly compatible with national law
0.75	Beyond compliance: Mostly positive/moderately agreed/highly related/moderately compatible with national law
0.50	Basic compliance: Neutrally affected/agreed/neutrally related/compatible with national law
0.25	Slightly below compliance: Mostly negative/partially disagreed/moderately negative/negatively compatible
0.00	Well below compliance: Strongly negative/fully disagreed/highly unrelated/incompatible with national or international law

***Net score calculation for each subcategory*:** The net score for each subcategory is calculated according to Equation (1). In this calculation, each subcategory is assigned a specific weight based on its level of importance as determined by experts. The criteria for weight assignment are detailed in Table 3 (Hossain et al., 2018).

$$ss_a = \frac{\sum_{n=i}^{I} I_i x COI}{I_n} \quad (1)$$

SS_a = net score for subcategory 'a' (score range of 0.00 to 1.00)
I_i = score obtained from benchmarking as outlined in Table 2.
I_n = total number of indicators within subcategory 'a'
COI = coefficient of indicator, which represents the weight assigned to subcategory 'a' based on Table 3.

Table 3. Prioritization scale for each subcategory according to its importance

Weighting factor	Priority Scale
1.00	Very important
0.75	Important
0.50	Neutral
0.25	Less important
0.00	Not important/irrelevant

***Calculation of net score for each stakeholder category*:** The normalized net score for each stakeholder category is calculated according to Equation (2) (Hossain et al., 2018).

$$SE_a = \frac{\sum_{n=i}^{S_c} SSa}{\sum_{n=i}^{S_c} COI} (2)$$

SEa = net score for stakeholder category 'a' (score range of 0.00 to 1.00)
$\sum_{n=i}^{S_c} SSa$ = sum of the total score of all subcategories for stakeholder category 'a'
$\sum_{n=i}^{S_c} COI$ = sum of the total coefficient of indicator for all subcategories within stakeholder category 'a'.

***Calculation of the social sustainability index*:** The net score of the social sustainability index is calculated according to Equation (3) (Hossain et al., 2018).

$$SSS = \frac{\sum_{n=i}^{S_E} SEa}{\sum_{n=i}^{S_E} (Ia \times W_f)} \quad (3)$$

SSS= Social sustainability index (score range of 0.00 to 1.00, see Table 4)
$\sum_{n=i}^{S_E} SEa$ = Sum of the total normalized score of all stakeholders

$\sum_{n=i}^{S_E}(Ia \times W_f)$= The number of stakeholder categories multiplied by the weighting factor (Wf is assumed to be 1)

Table 4. Social sustainability index

Sustainability Index	Grade	Level of Sustainability	Significance
0.81-1.00	A	Highly sustainable	Strongly positive/strongly satisfied
0.61-0.80	B	Sustainable	Highly positive/highly satisfied
0.41-0.60	C	Neutral	Moderately positive/satisfied
0.21-0.40	D	Unsustainable	Negative/unsatisfied
0.00-0.20	E	Highly unsustainable	Strongly negative/highly unsatisfied

The social sustainability indices for all three management systems fall within the "A" range (0.81–1.00), indicating highly positive performance. While this suggests that the sampled Arabica coffee enterprises perform well on most social indicators, the narrow spread between 0.86 and 0.88 also points to potential ceiling effects. This pattern may reflect the reference-scale design, where basic legal compliance is already scored in the mid-range, as well as the tendency of respondents to emphasize positive aspects of their enterprises. A simple threshold sensitivity check in which basic compliance was hypothetically scored one level lower reduced absolute index values but did not change the relative ranking of private enterprises, farmer group, and middlemen. Nevertheless, the results should be interpreted as indicating relative rather than absolute excellence in social performance.

RESULTS AND DISCUSSION

This study assesses the social sustainability of the coffee industry in Samosir, North Sumatra, across different management systems. It focuses on six micro-scale Arabica coffee enterprises in rural villages: three privately owned businesses, two middlemen purchasing cherries and reselling processed beans, and one farmer group managing collective processing and marketing. All enterprises source cherries from local smallholders and conduct post-harvest activities such as pulping, drying, hulling, and roasting, selling green or roasted beans and brewed coffee. They rely heavily on local and family labor, with some operating in tourist areas. Overall, social impacts across private, middlemen, and farmer-group systems are similar, with only minor differences among stakeholder groups.

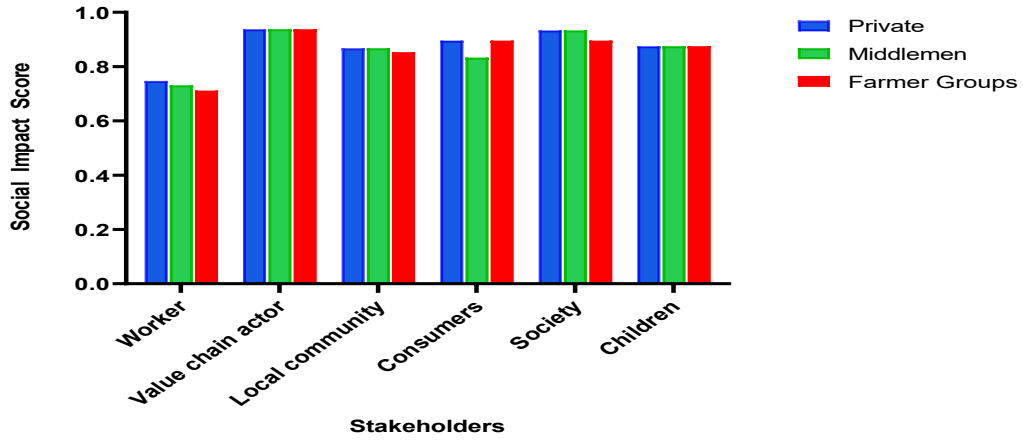

Figure 2. Social impact scores for each stakeholder based on management systems

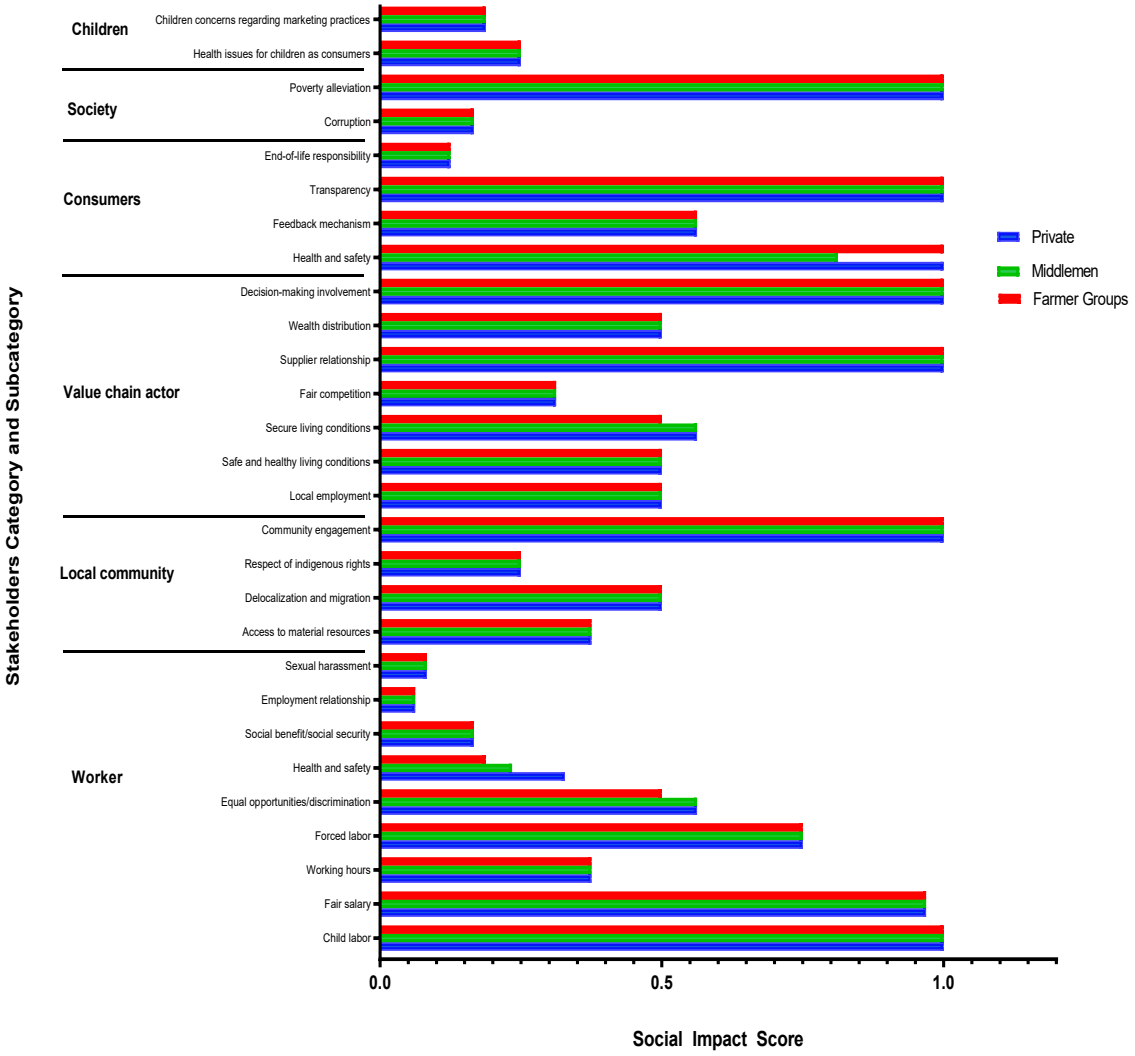

Figure 3. Comparison of social impacts for each indicator and management system

Coffee enterprises managed by farmer groups exhibited the lowest social impact scores for several indicators, such as occupational health and safety, as well as equal opportunities for the worker stakeholder, and secure living conditions for the local community stakeholder (Figure 3). Meanwhile, coffee enterprises managed by middlemen showed the lowest social impact scores for the consumer health and safety indicator and ranked second for the occupational health and safety indicator for workers. A more detailed explanation of each indicator will be provided in the following section. In general, based on the social sustainability index calculations, all coffee enterprises fall within category A (highly sustainable). Privately managed coffee enterprises demonstrated the highest index value, followed by farmer group-managed enterprises, and those managed by intermediaries (Table 5).

Table 5. Social sustainability index of coffee enterprises based on their management systems

Management system	Social Sustainability Index	Grade	Sustainability Status
Private	0.88	A	Highly sustainable
Middlemen	0.86	A	Highly sustainable
Farmer group	0.87	A	Highly sustainable

Source: Processed Primary Data (2024)

The S-LCA results for Samosir show that Arabica coffee enterprises achieve relatively high levels of social performance across multiple stakeholder groups, but they also reveal several social hotspots that require policy and management attention. The following section discusses these findings for each stakeholder category while maintaining the specific indicators used in the assessment.

Social Impacts on Workers

Child Labor

The child labor indicator was evaluated using three parameters: (1) compliance with national regulations on child labor, (2) the presence or absence of child workers, and (3) the existence of explicit policies to prevent child labor. Across all management systems private enterprises, middlemen, and the farmer group the results indicate strong compliance with Indonesian regulations. All enterprises apply a minimum recruitment age of 18 years and explicitly state that only adult applicants are eligible to work. Interviews with owners, managers, and workers, as well as field observations, confirmed that all employees are over 18 and that no workers bring children to assist them. Thus, there is no evidence of child labor within the studied enterprises.

Fair Salary

Fair salary was assessed using eight parameters: wage payment system, punctuality, minimum wage level, salary documentation, unjustified deductions, availability of bonuses, and gender pay equity. All enterprises show a high level of compliance with national regulations on wage practices (Pemerintah Republik Indonesia, 2021b). Average monthly wages vary by management type: Private enterprises: IDR 1,000,000–2,500,000, Middlemen: IDR 2,000,000–2,500,000 and Farmer group: IDR 1,000,000–1,500,000. Wages are time-based, paid monthly, and, according to workers, always disbursed on time. National regulations for micro and small enterprises allow wages to be determined by agreement between employer and worker, but stipulate that they must be at least 50% of average provincial consumption and 25% above the provincial poverty line (Pemerintah Republik Indonesia, 2021b). In North Sumatra, average monthly per capita expenditure in 2023 was IDR 1,305,339, and the poverty line in 2024 was IDR 642,423 per capita per month (Badan Pusat Statistik, 2024). The reported wages fall within or above these thresholds, indicating compliance with the regulation. Workers also receive payslips detailing wage components, reflecting adherence to legal requirements for transparent wage documentation (Pemerintah Republik Indonesia, 2021b). No unjustified deductions were reported, and bonuses are provided when sales targets are met. For positions with similar responsibilities, both workers and management reported no wage differences between male and female employees. Overall, workers expressed satisfaction with their earnings.

Working Hours

In Samosir Regency, all enterprises apply an 8-hour workday with a 1-hour break, which is not counted as working time, and provide at least one day off per week. This arrangement meets legal requirements for rest periods and weekly time off (Pemerintah Republik Indonesia, 2023). Workers occasionally perform overtime, averaging about 2 hours per day and occurring infrequently. Overtime is compensated, consistent with regulations that require overtime pay and limit daily overtime to 4 hours (Pemerintah Republik Indonesia, 2021b). However, these working time arrangements are not formalized in written contracts or company regulations, despite legal provisions that working hours should be regulated through employment agreements, company rules, or collective agreements (Pemerintah Republik Indonesia, 2023). This lack of documentation constitutes a social hotspot.

Forced Labor

The forced labor indicator considered document retention, freedom to resign, and other coercive practices such as wage withholding or threats. International Labour Organization (ILO) conventions define forced labor as work performed under threat of penalty and without voluntary consent. Interview data show that no enterprise retains workers' personal documents, withholds wages, or forces workers to perform tasks under threat. Workers stated that they can leave their jobs if they wish. These practices are consistent with ILO conventions, which Indonesia has ratified (Pemerintah Republik Indonesia, 1999a), suggesting low risk of forced labor in the studied enterprises.

Equal Opportunities and Discrimination

Non-discrimination was assessed through equal access to employment, reported discrimination cases, and perceptions of fair treatment. National law states that all workers have the right to equal opportunities and non-discriminatory treatment (Pemerintah Republik Indonesia, 2003). In practice, most recruitment is informal and limited to family members, reflecting the micro-scale and family-based nature of the enterprises. Only one private enterprise and one middleman-managed enterprise recruit publicly through social media. Despite the limited openness of recruitment channels, workers reported no experiences of discrimination and felt that they were treated fairly, including being allowed to participate in training activities. From an S-LCA perspective, this suggests positive outcomes in daily treatment, even though more inclusive recruitment mechanisms could strengthen equal opportunity in the longer term.

Health and Safety

Coffee workers face occupational health risks, particularly during roasting, which can release diacetyl, 2,3-pentanedione, CO, and CO_2. Studies in coffee processing facilities have documented diacetyl exposure above recommended limits, reaching 8.4 ppb among roaster, grinder, and packaging operators (Lebouf et al., 2017). In this study, health and safety were assessed through four parameters: accident incidence, preventive measures, training, and emergency protocols. No work-related accidents were reported in any enterprise. However, the level of preventive action varies by management system. Middlemen- and farmer-group-managed enterprises do not provide personal protective equipment (PPE) and lack emergency procedures or safety training. Two out of three private enterprises provide basic PPE, such as gloves and aprons, and only one conducts training on accident prevention and response. These practices fall short of national requirements that every worker is entitled to occupational health and safety protection (Pemerintah Republik Indonesia, 2003). Thus, occupational health and safety is one of the main social hotspots identified.

Social Benefits and Social Security

Social security was assessed by examining employer-provided social insurance, religious holiday allowances (THR), and other benefits. Workers across all management types reported having social security coverage, but these schemes are self-enrolled and not provided by the enterprises. This contradicts legal provisions that every worker and their family are entitled to labor social security through the employer (Pemerintah Republik Indonesia, 2003). On the other hand, workers do receive THR and other benefits such as barista training, in accordance with regulations on religious holiday allowance (Pemerintah Republik Indonesia, 2021b). The absence of employer-provided social security is therefore a key gap in otherwise positive wage and benefit practices.

Employment Relationship

The employment relationship indicator focused on the existence of written agreements. While national law allows verbal agreements, employers are required to

provide a letter of appointment in cases of open-ended verbal contracts, specifying at least the employee's name and address, start date, job type, and wage (Pemerintah Republik Indonesia, 2003). In the Samosir enterprises, all employment relationships are based on verbal agreements, and no appointment letters are issued. This creates legal and social vulnerabilities, especially regarding dispute resolution and clarity of rights, and is another identified hotspot.

Sexual Harassment

National regulations guarantee workers' rights to protection of moral integrity and require companies to establish a task force for preventing and handling sexual harassment at work (Pemerintah Republik Indonesia, 2003). The corresponding S-LCA indicator considered the incidence of cases, the existence of complaint mechanisms, and preventive measures. Workers and managers in all enterprises reported that no sexual harassment incidents have occurred. However, none of the enterprises has a formal complaint mechanism, task force, or written procedures. Owners often justify this absence by referring to the family-like atmosphere, open workspace, and absence of past cases. While the current risk is perceived as low, the lack of formal preventive measures and complaint structures indicates a potential vulnerability if circumstances change.

Social Impacts on The Local Community

Access to material resources

The local community reported no difficulties accessing land, water, or other ecological resources as a result of coffee operations. Coffee enterprises are relatively small and do not significantly compete for key resources, suggesting limited risk of conflict over material resources.

Delocalization and Migration

This indicator considered the employment of workers from outside the region, relations between locals and migrants, and displacement. All enterprises employ some workers from outside Samosir, which is consistent with legal guarantees of equal access to employment (Pemerintah Republik Indonesia, 2003). Local residents maintain good relations with both local and non-local workers, and there is no evidence that people have been forced to relocate due to coffee business activities.

Respect of Indigenous Rights

Tourism-related enterprises in Indonesia are required to respect local religious norms, customs, and culture (Pemerintah Republik Indonesia, 2003). Interviews show that indigenous residents feel their rights, customs, and identity are respected by both business owners and workers. No discriminatory acts against indigenous people were reported.

Community Engagement

National regulations also encourage tourism enterprises to contribute to infrastructure development and community empowerment (Pemerintah Republik Indonesia, 2023). In Samosir, all coffee enterprises participate in a multi-stakeholder network known as the Synergy Community, active since 2021 and composed of farmers, processors, roasters, café owners, government agencies, and NGOs. The community aims to promote Samosir coffee at the national level. Enterprises support community development by distributing free coffee seedlings, offering training on good agricultural and post-harvest practices, and engaging farmers in quality improvement initiatives. This indicates a high level of community engagement across management types.

Local Employment

All enterprises employ workers from the surrounding villages, contributing directly to local employment creation. This aligns with regulations requiring tourism

businesses to prioritize local products and labor (Pemerintah Republik Indonesia, 2023) and strengthens the role of coffee enterprises as engines of rural livelihood in Samosir.

Safe and Healthy Living Conditions

Coffee processing generates by-products such as silver skin and spent coffee grounds. If poorly managed, these wastes can release NOx and CO_2 during combustion and contain compounds such as caffeine, tannins, and chlorogenic acid that may create ecological problems (Janissen & Huynh, 2018). Indonesian law recognizes the right to a good and healthy environment as a human right (Pemerintah Republik Indonesia, 2009). Despite these potential risks, local residents reported no cases of environmental pollution attributable to coffee enterprises. Given the small scale of operations, current environmental impacts appear limited from the community's perspective, though continued monitoring remains important.

Secure Living Conditions

Tourism enterprises are also required to help prevent indecent or illegal activities in their surroundings (Pemerintah Republik Indonesia, 2023). None of the coffee businesses has dedicated security staff, but owners and residents reported no security incidents or complaints linked to the enterprises. Two businesses (one private, one middleman-operated) have installed CCTV as a preventive measure. Community members emphasized that maintaining a safe environment is essential because Samosir is a tourist destination, encouraging shared responsibility for security.

Social Impacts on Value Chain Actors

Fair Competition

Fair competition was assessed through the existence of partnership agreements and anti-competitive practices. All enterprises maintain partnerships with farmers, typically purchasing coffee cherries outright. However, none of these relationships is formalized through written contracts, despite national provisions requiring partnership agreements for micro, small, and medium enterprises (Pemerintah Republik Indonesia, 2021a) . At the same time, there were no reports of anti-competitive behavior, and business practices comply with national law on the prohibition of monopolistic practices and unfair competition (Pemerintah Republik Indonesia, 1999b).

Supplier Relationships

Supplier relations were evaluated based on delivery time, demand fluctuations, communication, and training. Farmers reported that they are given sufficient time to collect cherries and that changes in order volumes are reasonable. Communication between business owners and suppliers is generally good. Many enterprises also provide training or sharing sessions for farmers on topics such as quality standards and harvesting practices, strengthening long-term relationships.

Wealth Distribution

This indicator assessed whether prices paid to suppliers are perceived as fair and whether terms of partnership continuation are clear. Farmers stated that prices are profitable and cover production costs while providing reasonable profit. However, neither farmers nor business owners reported clear rules regarding partnership termination or extension, and no formal contracts exist. In practice, partnerships continue informally as long as farmers can supply cherries, indicating functional but weakly institutionalized arrangements.

Decision-Making Involvement

Suppliers and investors across management systems reported being involved in decision-making processes and expressed satisfaction with their level of participation.

This suggests a relatively inclusive governance structure within the micro-enterprises, facilitated by small scale and close personal relationships.

Social Impacts on Consumers

Health and Safety

Consumer health and safety were assessed through complaints, the presence of labels (nutritional, composition, allergen, halal), and compliance with food labeling regulations. Indonesian law requires processed food producers to include detailed information on product labels, including ingredients, manufacturer identity, halal certification if relevant, production and expiry dates, distribution permits, and specific warnings (Badan Pengawas Obat Dan Makanan Republik Indonesia, 2018).

In Samosir, reported consumer complaints mainly related to supporting facilities (Wi-Fi, waiting time) and taste preferences rather than health problems. Only one middleman-managed café received a complaint about a coffee product with an inadequate seal. Overall, there is little evidence of serious consumer health and safety issues.

Feedback Mechanisms

Consumers have the right to express opinions and complaints regarding goods and services (Pemerintah Republik Indonesia, 1999b). Private coffee businesses in Samosir provide online feedback channels via Instagram and Google reviews. In farmer-group and middlemen-managed cafés, feedback is usually delivered directly to owners in person. While mechanisms are informal, they allow consumers to voice concerns and suggestions.

Transparency

Transparency allows consumers to make informed choices. National consumer protection law prohibits deceptive practices and misleading information (Pemerintah Republik Indonesia, 1999b). Consumers reported that all businesses list prices clearly on menus, including taxes, and that there is no discrepancy between listed and charged prices. Products served match the menu descriptions, suggesting adequate transparency in pricing and product information at the point of sale (Putra et al., 2024).

End-of-Life Responsibility

End-of-life responsibility concerns how enterprises address disposal, reuse, or recycling of products and packaging, and whether they inform consumers about appropriate options (UNEP, 2021). There are currently no specific national regulations mandating such responsibilities for micro-enterprises. In Samosir, none of the businesses informs customers about end-of-life options or organizes take-back or recycling initiatives. This subcategory therefore appears as an emerging area for future improvement, especially as waste and packaging volumes grow with tourism.

Social Impacts on Society

Corruption

The corruption indicator focused on past involvement in corruption cases, the presence of anti-corruption programs, and measures to reduce corruption risks. None of the enterprises has been implicated in corruption. They also lack formal anti-corruption programs, largely because they rarely participate in government tenders and operate with simple ownership structures in which investors are also the shop owners. Digital financial systems provide transaction records and reduce opportunities for misreporting or money laundering. Overall, the corruption risk is perceived as low, though more formal policies could be considered if enterprises grow or engage more with public procurement.

Poverty Alleviation

Poverty alleviation was assessed through the existence of enterprise-led initiatives that contribute to reducing poverty. Local residents perceive that coffee businesses help

alleviate poverty by offering local employment opportunities and strengthening partner farmers' livelihoods. The combination of wage employment, skill development, and stable demand for coffee cherries supports household income diversification and resilience.

Social Impacts on Children

Health Issues for Children as Consumer

This indicator examined whether there were any reported health problems among children after consuming coffee products. No such cases were reported in any of the enterprises. This suggests that, although children occasionally visit cafés with their families, the products and serving practices have not generated reported negative health outcomes for children, in line with consumer rights to safety and security (Pemerintah Republik Indonesia, 1999b).

Marketing Practices and Children's Exposure

Children are particularly vulnerable to marketing because they lack experience as consumers and are not considered fully able to make responsible decisions (Benoît Norris et al., 2020). The study evaluated whether marketing practices were child-friendly and complied with advertising ethics. Indonesian Advertising Ethics, issued by the Indonesian Advertising Council, explicitly prohibit advertisements that encourage disobedience to parents, promote dangerous behavior, use inappropriate language, or normalize unhealthy habits (Dewan Periklanan Indonesia, 2020). All enterprises reported implementing child-friendly marketing and had no record of violating advertising or labeling ethical codes. Their marketing targets adult consumers and coffee enthusiasts rather than children, which aligns with ethical guidelines and reduces the risk of negative impacts on children.

Comparative Reflection

Overall, the pattern of results in Samosir suggests that micro-scale Arabica coffee enterprises can achieve high social sustainability scores across diverse stakeholder groups. The strongest performance is observed in dimensions such as community engagement, local employment, and supplier relationships, reflecting the close integration of coffee businesses within local social networks and the tourism economy. These findings are broadly consistent with the S-LCA study of rural coffee industries in West Java by Rahmah et al. (2023), which also reported positive social impacts for workers, local communities, and suppliers across different management systems. However, there are notable differences in the ranking of management systems. Rahmah et al. (2023) found that farmer-group-managed enterprises achieved the highest social sustainability index and were classified as "sustainable," while private enterprises and middlemen were only "neutral or sufficient." In contrast, the present study indicates that all three management systems in Samosir private enterprises, middlemen, and the farmer group are classified as "highly sustainable," with private enterprises achieving the highest index values. Possible explanations include stronger linkages between coffee businesses and the tourism sector, closer collaboration within the Synergy Community, and the very small scale of enterprises, which facilitates direct interaction and trust between owners, workers, farmers, and residents.

CONCLUSIONS AND SUGGESTION

In This study applied the UNEP (2020) Social Life Cycle Assessment framework to six Arabica coffee micro-enterprises in Samosir Regency, comparing private enterprises, middlemen, and a farmer group across six stakeholder categories. All three management systems achieved a "highly sustainable" rating, with social sustainability

indices between 0.86 and 0.88, and private enterprises scoring slightly higher than the farmer group and middlemen. The main social hotspots identified across systems include occupational health and safety (limited use of personal protective equipment and safety training), the absence of written employment contracts and clear job descriptions, and low coverage of employer-provided social security for workers. Additional weaknesses were observed in consumer information on end-of-life management and formal mechanisms to prevent sexual harassment.

From a practical standpoint, the findings suggest that relatively low-cost, targeted measures could further strengthen the social performance and business resilience of Arabica coffee enterprises in Samosir. Priority actions include providing basic OHS kits and regular safety briefings for workers, developing simple contract templates that clarify rights and responsibilities, facilitating enrolment in national social security schemes (BPJS) for permanent and long-term workers, and integrating supplier training on good agricultural and social practices into purchasing arrangements with farmer groups. By documenting their social performance using S-LCA results, micro-enterprises can also strengthen their market positioning, negotiate with buyers, and promote Samosir Arabica coffee as a socially responsible specialty product that aligns with emerging environmental, social, and governance (ESG) expectations.

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