

*Sustainable Supply Chains
at the Intersection of
Information Technology and Regulation*

**Dissertation zur Erlangung des Grades eines
Doktors der Wirtschaftswissenschaft
eingereicht an der Fakultät für Wirtschaftswissenschaften
der Universität Regensburg**

vorgelegt von: Sarah Katharina Kraft

Berichterstatter:

Prof. Dr. Andreas Otto

Prof. Dr. Florian Kellner

Tag der Disputation: 17. Juli 2026

Acknowledgements

I would like to express my sincere gratitude to my doctoral supervisor, Prof. Dr. Andreas Otto, for his dedicated mentorship, insightful discussions, and the opportunity to work as a research associate at his chair. This experience has given me the freedom to pursue my own research interests and has profoundly shaped my academic and professional path. I am equally grateful to my second supervisor, Prof. Dr. Florian Kellner, for his valuable guidance and continued support throughout this process.

I owe my deepest thanks to my parents, my brother, and my husband for their unwavering belief in me and their constant encouragement throughout this journey. Above all, I would like to thank my husband for his endless love, patience, and support, and for always motivating me. I am also grateful to my friends and colleagues, whose support, motivation, and perspectives have enriched both this work and my time throughout this journey.

Table of Contents

List of Figures	v
List of Tables	vii
List of Abbreviations	ix
1 The Imperative for Sustainable Supply Chains	1
2 Sustainable Supply Chains: Fundamentals, Enablers, and Drivers	3
2.1 Sustainability	3
2.1.1 Managing Scarcity and Intergenerational Equity	3
2.1.2 The Triple Bottom Line as a Balancing Framework	4
2.1.3 Sustainability on the Global Political Agenda	5
2.1.4 Sustainability across Scholarly Disciplines	6
2.1.5 Understanding of Sustainability	6
2.2 Supply Chains	6
2.3 Supply Chain Management	7
2.3.1 The Concept of Supply Chain Management	7
2.3.2 Core Activities and Objectives	8
2.3.3 Value Creation and growing Complexity	8
2.4 Structural Characteristics of High-Risk Supply Chains	8
2.4.1 Geographic-Governance Risk	9
2.4.2 Multi-Tier Opacity	9
2.4.3 Synthesis	10
2.5 Sustainable Supply Chains	11
2.6 Sustainable Supply Chain Management	11
2.6.1 The Concept of Sustainable Supply Chain Management	11
2.6.2 The Non-Compensability of Sustainability Violations	12
2.6.3 Risk-Based Transparency in Supply Chains	12
2.6.4 Accountability Beyond Tier-1	13
2.7 Research Landscape of Sustainable Supply Chains	13

2.7.1	Information Technology	14
2.7.2	Circular Economy	14
2.7.3	Sustainable Supplier Evaluation	14
2.7.4	Supply Chain Regulations	14
2.7.5	Underrepresented Perspectives	15
2.8	Information Technology as an Enabler for Sustainable Supply Chains .	15
2.8.1	Information Technology Requirements	15
2.8.2	Relevant Information Technologies	16
2.8.3	Limitations and Structural Challenges	16
2.9	Regulation as a Driver for Sustainable Supply Chains	17
2.9.1	Early Normative Foundations	17
2.9.2	The Emergence of Corporate Due Diligence Expectations	17
2.9.3	Disclosure-Based Approaches	18
2.9.4	Mandatory Due Diligence	18
2.9.5	The European Union as a Regulatory Driver	18
2.10	Summary	19
2.11	Research Overview	20
3	Can Blockchain be a Basis to Ensure Transparency in an Agricultural Supply Chain?	23
3.1	Introduction	23
3.2	Literature Review	25
3.2.1	About the Potential of Blockchain Technology in Supply Chains	25
3.2.2	Blockchain Applications in Agri-food Supply Chains	26
3.2.3	Blockchain Applications in the Cocoa Supply Chain	27
3.3	Blockchain-Enabled Traceability in the Cocoa Supply Chain: A Case Study of Cocoa Farmers in Ghana	28
3.3.1	Overview of the Cocoa Supply Chain	28
3.3.2	The Cocoa Supply Chain Process in Ghana: from Beans to Export	29
3.3.3	Difficulties faced by the Cocoa Farmers	30
3.3.4	A Blockchain-Based Solution for the Cocoa Supply Chain in Ghana	31
3.4	Discussion	34
3.5	Conclusion	37
4	Assessing the German Act on Corporate Due Diligence Obligations in Supply Chains: A Perspective from the Smallholder Cocoa Farmer	39
4.1	Introduction	39
4.2	Literature Review	41
4.2.1	Fundamentals on Impact Assessments	41
4.2.2	Assessments of the LkSG on Developing Countries	42
4.3	Comprehending the LkSG and the Cocoa Supply Chain	43
4.3.1	German Act on Corporate Due Diligence Obligations in Supply Chains (LkSG)	43

4.3.2	The Cocoa Supply Chain in light of the LkSG	44
4.4	Assessment of the LkSG from the Perspective of Smallholder Cocoa Farmers	45
4.4.1	Scope of the LkSG with regard to Smallholder Cocoa Farmers	45
4.4.2	Relevant Risks for the Smallholder Cocoa Farmers addressed in the LkSG	46
4.4.2.1	Child Labor under 15 Years (§ 2 para. 2 no. 1 LkSG)	46
4.4.2.2	Worst Form of Child Labor (§ 2 para. 2 no. 2 LkSG)	47
4.4.2.3	Employment in Forced Labor (§ 2 para. 2 no. 3 LkSG)	48
4.4.2.4	Occupational Safety and Health Obligations (§ 2 para. 2 no. 5 LkSG)	48
4.4.2.5	Withholding an Adequate Living Wage (§ 2 para. 2 no. 8 LkSG)	49
4.4.2.6	Remarks on the relevant Risks from the Perspective of Smallholder Cocoa Farmers	50
4.4.3	Procedural Implications of the LkSG for affected Companies in Germany	50
4.4.3.1	Risk Management and Risk Analysis	50
4.4.3.2	Preventive and Corrective Measures	52
4.4.3.3	Complaints Procedure	52
4.4.3.4	Annual Report	53
4.4.3.5	Remarks on the Procedural Implications	53
4.4.4	The Role of NGOs	53
4.4.5	The Role of Media	54
4.4.6	Remarks on the Effects of the LkSG on Smallholder Cocoa Farmers	54
4.5	Conclusion and Recommendation	56
5	Sustainable Supplier Evaluation under Due Diligence Acts	59
5.1	Introduction	59
5.2	Literature Review	61
5.2.1	Sustainable Supply Chains and Supplier Evaluation	61
5.2.2	Sustainability Criteria for Supplier Evaluation	62
5.2.3	Gaps in the Literature	63
5.3	Research Methodology and Data Collection	63
5.3.1	Systematic Literature Review	64
5.3.1.1	Descriptive Analysis	66
5.3.1.2	Categorization and Validation of the identified Sustainability Criteria	67
5.3.2	Expert Survey	67
5.4	Analysis and Results	68
5.4.1	Systematic Literature Review	69
5.4.2	Expert Survey	72
5.5	Discussion	74

5.5.1	Findings from Systematic Literature Review and Expert Survey	74
5.5.2	Alignment with LkSG: Recommendation for Sustainability Criteria	75
5.6	Conclusion	77
6	Final Conclusion	81
6.1	Theoretical and Practical Contribution	82
6.2	Limitations and Further Research	83
7	Closing Remarks on the Topic of Sustainable Supply Chains	85
	Appendix A: Detailed SMS Process	xi
	Appendix B: List of Sustainability Criteria	xiii
	References	xvii

List of Figures

3.1	Cocoa supply chain.	29
3.2	New process with the blockchain-based solution.	33
3.3	Infrastructure of the blockchain-based solution.	34
4.1	Overview of the research methodology.	43
4.2	Generalized cocoa supply chain from the perspective of the LkSG . .	45
4.3	Proactive and event-driven risk analysis along the supply chain . . .	51
5.1	Research process.	64
5.2	Articles published per year.	66
5.3	Branch distribution of survey experts.	72

List of Tables

2.1	Overview of the Three Articles in this Dissertation	21
3.1	Examples of blockchain use cases in agri-food supply chains.	27
5.1	Overview of sample selection.	65
5.2	Journal distribution.	66
5.3	Most relevant sustainability criteria according to literature.	70
5.4	Distribution of experts by years of experience.	73
5.5	Main criteria identified by experts as most relevant.	73
5.6	Relevance of sustainability criteria for supplier evaluation, based on surveyed experts.	73
5.7	Most relevant main sustainability criteria and instruments for supplier evaluation.	76

List of Abbreviations

AI	artificial intelligence
CCC	Conseil du Café-Cacao
CMC	Cocoa Marketing Company
COCOBOD	Ghana Cocoa Board
CSDDD	Corporate Sustainability Due Diligence Directive
CSRD	Corporate Sustainability Reporting Directive
DEA	Data Envelopment Analysis
DPP	Digital Product Passport
DTL	Distributed Ledger
ESPR	Ecodesign for Sustainable Product Regulation
EU	European Union
EUDR	EU Deforestation Regulation
EUFLR	EU Forced Labour Regulation
HRDD	Human Rights Due Diligence
ILO	International Labour Organization
IoT	Internet of Things
IT	information technology
LBC	Licensed Buying Company
LID	Living Income Differential
LkSG	Lieferkettensorgfaltspflichtengesetz
MCDM	multi-criteria decision-making
NAP	National Action Plan
NGO	Non-Governmental Organisation
OECD	Organisation for Economic Co-operation and Development
QCC	Quality Control Company
RFID	Radio Frequency Identification
RQ	research question
SCM	supply chain management
Scopus	Elsevier's Scopus
SDGs	Sustainable Development Goals
SDK	Software Development Kit
SLR	systematic literature review
SSCM	sustainable supply chain management
TBL	Triple Bottom Line
TOC	Take-Over Center

UN	United Nations
UNGPs	UN Guiding Principles on Business and Human Rights
WCED	World Commission on Environment and Development
WFCL	Worst Form of Child Labor
WoS	Clarivate Analytic's Web of Science

The Imperative for Sustainable Supply Chains

Global supply chains face growing scrutiny regarding their environmental and social impacts, as various stakeholder groups, including consumers, suppliers, employees, investors, and governments, increasingly demand sustainable practices [1–3]. Human rights violations remain prevalent across supply chains, including forced labor, child labor, unsafe working conditions, and unfair wages [4, 5]. Additionally, supply chain operations are linked to critical environmental challenges such as climate change, resource scarcity, biodiversity loss, and pollution [5, 6].

However, voluntary corporate sustainability initiatives have failed to achieve widespread adoption across supply chains [7]. Consequently, the regulatory landscape is shifting from voluntary approaches towards mandatory due diligence and disclosure requirements [7–9]. In parallel, information technology (IT) offers capabilities for advancing sustainable supply chains, such as transparency and risk management [10–12], yet adoption barriers remain substantial, particularly in developing countries [13, 14].

Therefore, this cumulative dissertation examines the intersection of IT and regulation as mechanisms for advancing sustainability in supply chains. Three articles address distinct aspects of this comprehensive research field: the first article explores the technological potential by examining blockchain technology as a mechanism for enhancing transparency in agricultural supply chains in developing countries. The second article assesses the regulatory impact by analyzing the potential effects of mandatory due diligence legislation on cocoa smallholder farmers. The third article addresses sustainable supplier evaluation by identifying and validating sustainability criteria for supplier evaluation under mandatory due diligence legislation, with a focus on suppliers facing heightened human rights and environmental risks.

The dissertation is structured as follows: Chapter 2 establishes the fundamentals, enablers and drivers of sustainable supply chains and concludes with an overview of the three articles presented in Chapter 3 - 5. Chapter 6 synthesizes the contributions across all three articles and discusses their collective implications, limitations, and future research directions. Chapter 7 provides concluding observations and remarks.

Sustainable Supply Chains: Fundamentals, Enablers, and Drivers

This chapter first introduces the fundamental concepts of sustainability (Section 2.1), supply chains (Section 2.2), and supply chain management (SCM) (Section 2.3), before addressing the characteristics of high-risk supply chains (Section 2.4). Building on these foundations, it explores sustainable supply chains (Section 2.5) and sustainable supply chain management (SSCM) (Section 2.6), followed by an overview of the sustainable supply chain research landscape (Section 2.7). Afterwards, this chapter presents IT as an enabler (Section 2.8) and regulation as a driver (Section 2.9) for sustainable supply chains. The chapter concludes with a summary (Section 2.10) and an overview of the three articles (Section 2.11).

2.1 Sustainability

The concept of sustainability, while now a cornerstone of global discourse, has undergone significant evolution, shaped by historical, political, and scholarly influences. This section examines this development and derives the understanding of sustainability that underpins this dissertation.

2.1.1 Managing Scarcity and Intergenerational Equity

The first milestone was set by the German von Carlowitz in 1713 [15]. Driven by severe timber scarcity resulting from late 17th-century forest overexploitation, von Carlowitz's *Sylvicultura Oeconomica* established the foundation of German forestry on the principle of sustainability: harvesting only as much timber as can be replenished through planned reforestation.

The second defining milestone came in 1987, when *Our Common Future*, a report of the World Commission on Environment and Development (WCED) chaired by Norwegian Prime Minister Gro Harlem Brundtland, defined sustainable development as development that "meets the needs of the present without compromising the ability of future generations to meet their own needs" [16, p. 24]. The report, which called for "a global agenda for change", became known as the *Brundtland Report* [16, p. 11].

The Brundtland Report emphasizes that sustainable development requires meeting basic human needs and aspirations in pursuit of a better life for all, both presently

and for future generations, a goal undermined by poverty, resource overexploitation, and misaligned technological advancements. Furthermore, the report addresses the challenges of meeting the demands of an expanding and developing global population. This calls for innovation approaches that reflect the specific socio-economic and environmental conditions of developing countries, rather than transferring technologies designed for industrialized contexts [16].

While the Brundtland Report succeeded in establishing sustainable development as a global priority, it has faced scholarly criticism. Hueting [17] criticizes the Brundtland Report for adhering to conventional concepts of economic growth despite its stated goal of sustainable development. He argues that the report inadequately addresses the fundamental conflict between increased production and environmental preservation, potentially fostering further environmental degradation. In turn, Keeble [18] acknowledges the report as a remarkable work, yet fears that it may fail to catalyze necessary action, observing that it had already created little political resonance at the time of publication, while those currently holding power are unlikely to witness the long-term consequences of present unsustainable practices. While also acknowledging it as a crucial report, Haland [19] criticizes its imprecise conceptualization of needs, which notably fails to explicitly address the necessity of consumption reduction in prosperous countries. Furthermore, she emphasizes that human needs are not fixed but contingent on cultural context and external threats. Notwithstanding these criticisms, the Brundtland Report remains a foundational document that significantly shaped global discourse on sustainability and established the conceptual basis for subsequent frameworks and policies [20–22].

As Hart [23, p. 67] observed, "in meeting our needs, we are destroying the ability of future generations to meet theirs". Building on this, he argues that achieving a truly sustainable global economy poses a complex challenge that reaches far beyond pollution control, touching on broader political and societal issues. While public policy and personal consumption must evolve, corporations are uniquely positioned to lead this transition, leveraging their resources, technological capacity, and global influence [23].

2.1.2 The Triple Bottom Line as a Balancing Framework

Ten years after the release of *Our Common Future*, Elkington [21] proposed the Triple Bottom Line (TBL), a sustainability framework designed to encourage companies to move beyond a narrow focus on financial profit. It considers performance and impacts across three interconnected dimensions: "economic prosperity" (profit), "environmental quality" (planet), and "social justice" (people) [21, p. 70]. Elkington [21] emphasizes the interdependency of these dimensions and highlights that they are dynamic and subject to constant pressure from social, political, economic, and environmental factors, making sustainability particularly complex.

Therefore, following Elkington, a company is *economically sustainable* if it generates long-term economic value while maintaining and developing the financial, human, and intellectual capital required for future value creation, ensuring competitive costs, sustainable profit margins, and continuous innovation capacity. This perspective aligns with strategic management literature (e.g., 24–26), which likewise emphasizes that long-term viability and survival of the company have long been core concerns. A company is *environmentally sustainable* if it manages its environmental impacts responsibly by minimizing resource consumption, emissions, and waste throughout its operations and product life cycle while supporting the long-term preservation of ecological systems [21]. A company is *socially sustainable* if it respects and promotes

fundamental social standards, including fair and safe working conditions, human rights, and product responsibility, and if it actively builds social capital by fostering trust and cooperative capacity by engaging responsibly with employees, customers, and local communities, thereby reducing social friction and enabling collective action toward common purposes [21].

While the TBL framework has been widely adopted [27–29], it has not escaped scholarly scrutiny. For instance, Milne and Gray [30] and Nursimloo et al. [31] argue that TBL reporting often leads to selective disclosure, whereby companies strategically report favorable information rather than fostering genuine accountability. Similarly, Norman and MacDonald [32] criticize the TBL for its problematic use as a reporting tool, arguing that, unlike financial accounting, the social and environmental dimensions lack a common unit of measure, making non-financial impacts impossible to meaningfully aggregate and compare.

Elkington [33] himself has expressed fundamental concerns about the framework's application. Reflecting on the TBL 25 years after its proposal, he announced a symbolic recall, arguing that the framework had been diluted into a mere accounting tool rather than serving as a catalyst for the deeper systemic change and rethinking of capitalism he had originally envisioned. He further contended that the TBL had failed to displace the single bottom line paradigm, as company leaders consistently prioritize financial targets over environmental and social ones.

2.1.3 Sustainability on the Global Political Agenda

Nearly two decades after Elkington's TBL, the global sustainability agenda took a more comprehensive form. In 2015, all United Nations (UN) member states adopted the *Sustainable Development Goals* (SDGs), which form the core of the 2030 Agenda for Sustainable Development [34]. The SDGs are built upon a history of international cooperation, originating with the 1992 UN Earth Summit in Rio de Janeiro, where Agenda 21 was established as a comprehensive blueprint for global partnership aimed at integrating environmental protection and human development [22]. The 2030 Agenda seeks to eradicate poverty in all its forms, enhance health and education, reduce inequality, foster economic growth, address climate change, and protect the planet. The agenda comprises 17 SDGs and 169 associated targets addressing the three dimensions of sustainability: economic, environmental, and social [34]. While primary responsibility for implementation rests with national governments, the 17 SDGs are addressed equally to the private sector, the scholarly community, and civil society, with the 2030 Agenda emphasizing broad-based partnerships that mobilize all available resources [34]. Germany, for instance, anchored the SDGs within its Sustainable Development Strategy, in place since 2002, assigning concrete measures to each of the 17 Goals with equal priority [35].

According to the *Sustainable Development Goals Report 2025*, despite measurable progress, the pace of change remains insufficient to meet the 2030 commitments. Basic needs such as food security and access to clean water and sanitation remain out of reach for large parts of the global population, and structural inequalities continue to limit human potential. These social challenges are further compounded by accelerating climate change and a substantial financing gap that constrains development progress worldwide [36].

2.1.4 Sustainability across Scholarly Disciplines

Sustainability attracts scholarly attention across a wide range of disciplines [37–39]. Studies can be categorized according to the three dimensions of sustainability: economic, environmental, and social, or may address all three simultaneously. Since sustainability encompasses a wide range of topics [37, 40], only selected examples are provided to illustrate the scope of this extensive research field. Within the economic dimension is explored through investigations of circular economy models (e.g., 41, 42), sustainable finance (e.g., 43, 44), corporate sustainability management practices (e.g., 45, 46), and sustainable supply chains (e.g., 1, 47). The environmental dimension, research addresses themes such as climate change and climate protection (e.g., 48, 49), biodiversity and ecosystem preservation (e.g., 50, 51), resource management (e.g., 52, 53), and the transition to renewable energy (e.g., 54, 55). Finally, the social dimension encompasses research on consumption patterns (e.g., 56, 57), education for sustainability (e.g., 58, 59), health (e.g., 60, 61), and social justice considerations (e.g., 62, 63). As illustrated, sustainability is an intricate and interconnected framework [21, 34]. Consequently, research on one dimension should not be considered in isolation, as the dimensions often influence one another. For instance, while the study of sustainable supply chains is typically categorized under the economic dimension, it frequently incorporates environmental and social aspects as well [64–66].

2.1.5 Understanding of Sustainability

The TBL has achieved widespread recognition and acceptance across diverse research fields, being extensively applied and validated [67–69]. Indeed, it has evolved into such a foundational framework that its three dimensions are now commonly understood as intrinsic to sustainability itself [34, 70–72]. This dissertation therefore concludes that a company can be considered sustainable when it maintains a balanced integration of the three interdependent dimensions of the TBL: economic prosperity, environmental quality, and social justice. This integrated and balanced-oriented understanding of the economic, environmental, and social dimensions of sustainability forms the foundation throughout this dissertation.

2.2 Supply Chains

The roots of the concept of supply chain can be traced back to Forrester’s [73] 1958 work on industrial dynamics. Although he did not coin the term *supply chain*, he provided a crucial conceptual foundation by modeling production and distribution systems as interconnected flows, particularly of materials and information, governed by feedback loops and time delays that often extend beyond functional boundaries within the company [73].

During the 1980s and 1990s, key contributions by Stevens [74] and Christopher [75] helped to formalize the idea of the supply chain as an integrated system. Stevens defines it as an interconnected set of activities managing the flow of materials and information from supplier to end customer, encompassing not only physical distribution but also activities such as procurement, manufacturing, customer service, and information management [74]. Building on this, Christopher conceptualizes the supply chain as a network of organizations connected through upstream and downstream linkages, jointly creating value for the ultimate customer [75]. Both authors thus treat the supply chain primarily as a manageable, integrated system.

Chopra and Meindl [76] broaden the perspective by shifting focus to the full range of actors and flows involved, defining the supply chain as encompassing all actors directly or indirectly involved in fulfilling customer demand, including manufacturers, suppliers, transporters, warehouses, retailers, and end customers. They further distinguish three fundamental flows: information, products, and funds, with the objective of structuring these flows to efficiently meet customer needs while minimizing costs. More recently, Chopra [77] and Christopher [78] argue that the complexity of these relationships renders the traditional *chain* metaphor insufficient, proposing instead the notion of a *network* to better capture the intricate interdependencies among multiple actors.

For the purpose of this dissertation, a supply chain is understood as a multi-tier network of entities that are economically interdependent yet legally and operationally autonomous, such as suppliers, manufacturers, distributors, retailers, and intermediaries, that collectively enable the transformation and delivery of goods and services from upstream raw-material sources to the end customer. The nodes of this network comprise not only entities but also physical locations such as warehouses and distribution centers, as well as IT. The ties connecting these nodes represent material flows, logistic pathways, information and data exchanges, financial transactions, and relational interactions. Throughout this dissertation, the term *actor* refers to any entity within this network that operates autonomously and pursues its own interests. Clearly, no single focal company exercises full control over the entire network, particularly in the upstream or downstream tiers. Because each actor pursues its own interests, supply chains are best understood not as fully integrated systems but as partially coordinated structures shaped by a combination of market mechanisms, contracts, power asymmetries, and formal and informal governance arrangements.

2.3 Supply Chain Management

While supply chains describe the structural network of entities and flows, SCM addresses the fundamental challenge of coordinating these actors. Building on the previous Section 2.2, the following section examines how this coordination is conceptualized, what it seeks to achieve, and why it is becoming increasingly challenging in practice.

2.3.1 The Concept of Supply Chain Management

Houlihan [79] frames SCM as the coordination of goods from supplier to end customer, whereas Chopra and Meindl [76] broadens this to include the orchestration of information, product, and financial flows, with the aim to increase overall supply chain performance. Mentzer et al. [80] further extends this view by emphasizing the strategic and systematic coordination of business functions both within and across organizations, aimed at enhancing long-term performance of the supply chain. Most comprehensively, Christopher [78] conceptualizes SCM as the strategic coordination of upstream and downstream relationships to deliver superior customer value while minimizing total supply chain costs. Across these perspectives, SCM is concerned with the strategic alignment of interdependent but autonomous actors across the entire network.

2.3.2 Core Activities and Objectives

SCM coordinates several interconnected activities across the network, including sourcing, demand management, production planning, logistics, and customer service, whose integration determines overall supply chain performance [81, 82]. Yet these activities serve objectives that are often in conflict with one another: cost minimization, customer satisfaction, flexibility, responsiveness and resilience [77, 82]. Managing these competing priorities across autonomous actors is precisely what makes SCM both strategically significant and inherently complex [82].

2.3.3 Value Creation and growing Complexity

Despite this complexity, effective SCM constitutes a significant source of competitive advantage through two primary vectors: cost advantage, derived from operational efficiency, and value advantage, stemming from differentiated customer offerings [78]. This aligns with Porter's [25] value chain logic, whereby competitive advantage stems from performing strategically important activities "more cheaply or better" than competitors [25, p. 34]. Extending this view, Cox [83] contends that the competitive landscape has shifted beyond individual companies to one where entire supply chains compete against one another, rendering inter-organizational coordination not merely operational but strategically decisive.

Achieving this, however, requires transparency, trust, and seamless process integration across autonomous actors [78], conditions that are increasingly difficult to guarantee as supply chains face growing complexity on multiple fronts. Supply chains contend with demand volatility and forecasting uncertainty, which can amplify through information distortion effects across network tiers [84, 85]. As global supply chains grow more complex, they become increasingly vulnerable to disruptions such as natural disasters and geopolitical tensions [86, 87]. Beyond these operational challenges, supply chains are increasingly confronted with social and environmental pressures [88] that go beyond the traditionally cost- and efficiency-oriented scope of SCM [82]. Issues such as child labor, unsafe working conditions, and environmental degradation along supply chain tiers [4, 6] have made it evident that coordination across autonomous actors cannot be reduced to efficiency alone, it must also encompass responsibility.

Against this backdrop, synthesizing these perspectives, this dissertation conceptualizes SCM as the operational, tactical, and strategic coordination of inter-organizational functions, relationships, and flows across network boundaries to match supply with demand, to deliver customer value, to reduce cost, and to achieve competitive advantage.

2.4 Structural Characteristics of High-Risk Supply Chains

Not all supply chains are equally exposed to environmental and social risks. Certain industries, such as apparel (e.g., 89, 90), electronics (e.g., 91, 92), and agriculture (e.g., 93, 94), are repeatedly associated with severe environmental degradation and human rights abuses across their supply chains. This raises the question of what structural characteristics make some supply chains particularly prone to such adverse impacts.

In this dissertation, high-risk supply chains are understood as supply chains in which the likelihood and severity of adverse environmental and social impacts are heightened due to specific structural characteristics. This dissertation identifies two key structural characteristics: geographic-governance risk and multi-tier opacity. Together, these characteristics increase the difficulty of monitoring, controlling, and governing supply chain activities across multiple actors [95, 96].

The following sections develop each characteristic and illustrate how it manifests across apparel, electronics, and agricultural commodity supply chains. Identifying these structural patterns provides an important foundation for understanding why SSCM has become particularly relevant in high-risk industries.

2.4.1 Geographic-Governance Risk

Geographic-governance risk refers to the structural condition in which sourcing activities are concentrated in contexts where governance capacity is insufficient to ensure that environmental harm and human rights abuses generate enforceable consequences. The decisive variable is not the presence or absence of formal regulation: many major sourcing countries have enacted labor and environmental legislation, yet corruption and limited state capacity frequently undermine enforcement in practice [95, 97]. Risk is therefore structurally elevated where the conditions for effective enforcement are systematically lacking, independent of whether formal rules exist [95].

Apparel supply chains illustrate this condition clearly: manufacturing and processing are concentrated in lower-wage countries such as Bangladesh, Vietnam, and India, contexts characterized by weak labor governance and limited enforcement capacity [95, 98]. Despite formal labor legislation, systemic enforcement gaps persist, as evidenced by recurring violations of safety standards, working hours, and wage regulations [98, 99].

Electronics supply chains follow a comparable logic: raw material extraction occurs predominantly in developing countries with particularly weak institutional frameworks [95]. Cobalt mining in the Democratic Republic of the Congo [100] and tantalum extraction in the Democratic Republic of the Congo, Brazil, and Rwanda [101] take place in contexts characterized by limited state capacity, corruption [95], and in some regions armed conflict and illegal trade networks [102, 103].

A parallel dynamic characterizes agricultural supply chains: cocoa farming in Côte d'Ivoire and Ghana [5] and coffee production across Colombia, Ethiopia, and Indonesia [104] take place in contexts characterized by insufficient regulatory enforcement and limited state capacity to ensure compliance with labor and environmental standards [5, 104, 105].

2.4.2 Multi-Tier Opacity

Multi-tier opacity refers to the structural reduction of transparency and accountability as supply chains extend beyond tier-1 suppliers, driven by the depth and fragmentation of multi-tier sourcing structures and subcontracting practices that diffuse accountability [96, 106]. Transparency deteriorates with each additional tier, precisely where environmental and social risks tend to concentrate, leaving abuses difficult to detect [96, 107]. Beyond the lack of transparency, multi-tier opacity also undermines the transmission of sustainability requirements: the more tiers a supplier

is away from the focal company, the less likely that codes of conduct and compliance expectations are effectively cascaded and enforced down the chain [107, 108].

Apparel supply chains, for example, span numerous countries and production tiers, from cotton farming through fiber processing to garment assembly [109]. Lower tiers such as dyeing, bleaching, and fabric production remain largely invisible to focal companies, leaving upstream conditions unmonitored [98, 109].

In electronics, the path from raw mineral extraction through smelting, refining, component manufacturing, and final assembly involves numerous actors across multiple countries [110, 111]. The smelter and refiner tiers act as a critical opacity node: materials from multiple mines and routes are combined, making it difficult for focal companies to trace the origin and conditions of upstream materials [112].

Opacity in agricultural commodity chains arises through a distinct but equivalent mechanism: cocoa and coffee are produced by millions of small-scale farms and typically collected by local traders, aggregated by regional intermediaries, and sold to international processors, a supply chain of handoffs that progressively obscures conditions at the farm level [5, 104].

2.4.3 Synthesis

The two structural characteristics identified above do not operate in isolation but reinforce one another in systematic ways. Geographic-governance risk establishes the foundational condition: by concentrating sourcing activities in contexts with weak governance, it creates the environment in which environmental degradation and human rights violations can persist with limited consequence [95]. Multi-tier opacity compounds this dynamic: the structural invisibility of upstream tiers ensures that violations remain undetected, shielding focal companies from accountability and removing the informational preconditions for effective oversight [96, 107]. Where both characteristics converge, environmental and social burdens fall disproportionately on the most vulnerable actors in the chain, precisely at those nodes where bargaining power is weakest, transparency is most limited, and violations are least likely to be detected or remedied.

Across apparel, electronics, and agricultural supply chains, this convergence manifests in consistent patterns. In apparel supply chains, risks concentrate at dyeing and bleaching, where chemical pollution is most severe, and at garment assembly, where unsafe conditions, excessive working hours, and child labor are most prevalent [99, 109]. In electronics, risks cluster at raw material extraction, where mining causes environmental destruction and severe health impacts on local communities, and at end-of-life processing, where informal electronic waste recycling exposes workers to hazardous conditions [113–115]. Agricultural supply chains exhibit a similarly concentrated profile, with deforestation, agrochemical use, child labor, and persistently low farmer incomes converging at the farm level [5, 104]. The more such nodes are located in high-risk governance contexts and remain invisible to focal companies, the greater the overall risk profile of the supply chain. These structural conditions define the core challenge that SSCM seeks to address.

2.5 Sustainable Supply Chains

Building upon the preceding sections, this section integrates these perspectives to present sustainable supply chains.

Sustainability inherently considers the balance of the three interdependent dimensions: economic, environmental, and social (see Section 2.1). Consequently, a sustainable supply chain incorporates these dimensions across its entire scope, spanning from the extraction of raw materials through suppliers to the final delivery of products to end customers [27, 28, 116]. The realization of such sustainable supply chains requires management approaches, which are addressed in the following section.

2.6 Sustainable Supply Chain Management

The structural risk characteristics outlined in Section 2.4 underscore the importance of SSCM, which is further driven by two key forces. On one hand, market and stakeholder pressures, including consumer and employee expectations, NGO advocacy, competitive dynamics, and reputational concerns, push companies to integrate sustainability into their supply chain decisions [27, 117, 118]. On the other hand, increasing regulatory requirements are shaping how companies design and manage their supply chains (e.g., 9, 119).

Accordingly, the following section examines how SSCM is conceptualized and what it implies for focal companies managing sustainability across multiple supply chain tiers.

2.6.1 The Concept of Sustainable Supply Chain Management

SSCM represents the managerial and organizational approach through which sustainable supply chains can be realized in practice. It encompasses the configuration, coordination and control of information, material and capital flows across organizational boundaries, with the aim of integrating economic, environmental, and social objectives into supply chain decision-making to achieve overall sustainable performance [27, 120]. Central to SSCM is the notion that sustainability considerations must be explicitly acknowledged and systematically embedded within a company's objectives [28]. Carter and Rogers [28] emphasize that environmental and social aspects must be intertwined with a company's economic objectives, moving beyond a singular focus on economic gains throughout the supply chain. Their framework emphasizes the simultaneous integration of the economic, environmental, and social dimensions, supported by strategic alignment, transparency, risk management, and an enabling organizational culture. Accordingly, SSCM encompasses a range of practical initiatives, including the implementation of ethical and socially responsible business practices, the development of sustainable products, and the reduction of waste and emissions throughout the supply chain [27, 121, 122]. This reflects an understanding of SSCM as an integrative objective that includes economic, environmental, and social dimensions, consistent with the TBL perspective outlined in Section 2.1.2.

A different picture emerges from the operations research literature, however, where sustainability is typically introduced as a constraint (e.g., 3, 123, 124). In this approach, sustainability serves as a boundary condition that feasible solutions must satisfy, rather than a dimension of value to be maximized alongside economic

performance.

For the purpose of this dissertation, SSCM is understood as an integrative management approach through which focal companies pursue economic, environmental, and social objectives simultaneously across their supply chains. This encompasses the governance of upstream and downstream relationships and the management of sustainability risks beyond the tier-1 suppliers.

2.6.2 The Non-Compensability of Sustainability Violations

Unlike costs, environmental and social violations cannot always be offset against one another to achieve sustainable supply chains [125–127]. While trade-offs are inherent to SCM, prohibited violations are non-compensable: a cost advantage achieved at one supplier cannot justify human rights violations at another, nor can carbon neutrality at one production site offset deforestation caused by raw material extraction elsewhere in the supply chain. Such violations are not performance shortfalls to be balanced against achievements elsewhere, but breaches of duty that trigger independent obligations of prevention, mitigation, and remediation [125, 127].

Therefore, for the purpose of this dissertation, non-compensability is understood as a foundational principle of SSCM: true sustainability cannot be achieved through aggregation or offset, but requires identification, prevention, and remediation of prohibited environmental and social violations throughout the supply chain. This logic is reflected in due diligence legislation which mandates supplier-level due diligence to prevent and remediate such violations [9, 128].

2.6.3 Risk-Based Transparency in Supply Chains

Addressing sustainability risks, however, first requires insight into where they originate. In conventional SCM, lower-tier suppliers often remain largely invisible and tend to become salient only when disruptions threaten supply continuity [129, 130]. SSCM, by contrast, demands a more deliberate approach to supply chain transparency. Transparency refers to the disclosure of complete, accurate, and undistorted information regarding supply chain actors and activities, enabling shared understanding and informed decision-making across organizational boundaries [131–133]. Yet transparency should not be understood as a uniform requirement across all tiers and actors. While much of the literature emphasizes the need for transparency across all actors [96, 134, 135], a more nuanced view suggests that transparency efforts should be concentrated where environmental and human rights risks are most pronounced. This is consistent with risk-based due diligence approaches, which prioritize attention and resources according to the severity and likelihood of adverse impacts [112, 136]. For instance, in highly regulated contexts, such as the European Union (EU), where a dense regulatory framework already governs business conduct, structural environmental and social risks are comparatively low [95, 137]. The focus of transparency efforts should therefore lie at those actors in the supply chain where regulatory oversight is limited and sustainability risks are heightened. Targeted transparency at these actors not only enables informed decision-making, but also supports the identification and monitoring of sustainability risks across supply chains.

2.6.4 Accountability Beyond Tier-1

A focal company's sustainability performance is contingent on the actions of all actors involved in its supply chain, as environmental and social issues must be addressed not only within the focal company and its tier-1 suppliers, but also by suppliers across multiple tiers [138–140]. This multi-tier complexity raises the question of accountability: who is responsible for sustainability performance deep in the supply chain? While each actor bears direct responsibility for its own operations, focal companies, as primary orchestrators of supply chain relationships, bear particular responsibility for ensuring sustainability throughout their supply networks [27, 141]. This responsibility is increasingly reinforced by external stakeholders such as NGOs and the media, who frequently attribute environmental and social misconduct at the supplier level to the focal company. Consequently, the behavior of any single supply chain actor can significantly affect a focal company's sustainability image [142–144]. High-profile cases, including allegations of forced labor in textile supply chains, child labor in mining activities, and illegal deforestation linked to agricultural sourcing, illustrate that sustainability risks often originate beyond tier-1 suppliers [145–147]. These examples underscore the necessity of SSCM that extends oversight and responsibility across multiple supply chain tiers, as reputational, legal, and ethical exposure does not stop at tier-1 suppliers. Transforming supply chains toward sustainability therefore requires the systematic evaluation and selection of suppliers based on economic, environmental, and social criteria [29, 141, 148]. However, multi-tier opacity makes it difficult for focal companies to effectively monitor social and environmental conditions beyond their tier-1 suppliers [149, 150].

Taken together, SSCM extends conventional SCM by embedding economic, environmental, and social objectives into supply chain decision-making, with focal companies bearing particular responsibility for ensuring sustainability across multiple tiers. Yet effective SSCM requires more than strategic intent: it demands targeted transparency at those nodes where sustainability risks are most pronounced, and recognizes that certain violations cannot be traded off against performance gains elsewhere. As regulatory frameworks increasingly codify these requirements, the challenge for focal companies shifts from whether to manage sustainability in their supply chains to how.

2.7 Research Landscape of Sustainable Supply Chains

Research on sustainable supply chains has undergone two fundamental shifts. First, its primary question has moved from profitability to necessity. While early scholarship debated the financial benefits of sustainability [151, 152], the current consensus is that companies must address environmental and social challenges [122, 153]. Second, its scope has expanded from environmental to holistic. Whereas early studies focused narrowly on green supply chains (e.g., 121, 154, 155), contemporary research now integrates a comprehensive range of topics across all three dimensions of the TBL [156–158].

Consequently, this section outlines the current research landscape of sustainable supply chains, organized around four thematic directions: IT, circular economy, supplier evaluation, and regulatory frameworks, before addressing underrepresented perspectives.

2.7.1 Information Technology

A central theme dominating the research landscape is the role of IT in advancing supply chain sustainability. Scholars such as Seuring et al. [159] and Tsai et al. [160] identified IT as a critical research domain, with numerous recent studies linking digital transformation to improved sustainability outcomes [161–164]. For example, Pervez et al. [165] analyze the link between Industry 4.0 and supply chain sustainability, demonstrating how technological interventions foster operational, network, and innovation capabilities that support sustainable outcomes. Saidu et al. [166] explore how blockchain, Internet of Things (IoT), and AI create enhanced traceability systems, improving transparency for applications such as ethical sourcing and fraud prevention. However, realizing these benefits is not straightforward, as Chrifi-Alaoui et al. [167] identify barriers such as high costs and organizational resistance that hinder implementation. These studies collectively highlight both the potential and the challenges of IT in supporting sustainability objectives.

2.7.2 Circular Economy

A significant stream of research concerns the transition toward the circular economy [159, 160, 168]. Within circular economy, IT plays a crucial role in enabling data management and information flows across supply chain actors [169, 170]. Vaezinejad et al. [170] develop a framework linking digital technologies to circular economy adoption, emphasizing multi-stakeholder collaboration. Rashid et al. [171] identify key barriers to circular economy, including inadequate leadership, lack of expertise, and weak regulatory enforcement. Together, these contributions illustrate that circular economic transitions require both digital enablers and organizational capabilities.

2.7.3 Sustainable Supplier Evaluation

Another active research stream concerns supplier evaluation and development. While supplier evaluation is not a new domain [172, 173], its sustainability dimension remains dynamic and increasingly relevant [159, 174]. Recent studies show growing interest in advanced analytical methods: Gidiagba et al. [175] demonstrate that hybrid machine learning techniques enhance sustainable supplier selection; Albayrak Ünal et al. [176] highlight the value of hybrid multi-criteria decision-making (MCDM) methods combined with fuzzy logic; and Sithi et al. [174] apply TBL-based criteria to real-world textile supplier data to show how sustainability goals in supplier selection can be met. This literature emphasizes supplier selection as a strategic instrument for embedding sustainability across supply networks.

2.7.4 Supply Chain Regulations

Regulatory frameworks are another major force shaping the research agenda on sustainable supply chains. Increasingly stringent legislation, ranging from human rights due diligence (e.g., 9, 177) to circular economy (e.g., 178) and environmental regulations (e.g., 119), is driving scholarly interest in compliance, governance, and performance implications [179–181]. For instance, Buttke et al. [182] examines how the German *Act on Corporate Due Diligence Obligations in Supply Chains* (German: *Lieferkettensorgfaltspflichtengesetz*, LkSG) shapes stakeholder expectations toward SSCM, while Zainuddin et al. [183] assess limitations of Australia's *Modern Slavery*

Act, and Su et al. [184] analyze the design of global battery legislation to foster long-term sustainability. Environmental regulations have received particular attention, with studies examining the EU Deforestation Regulation (EUDR) [185] and corporate carbon emission reporting [186]. Together, these contributions illustrate how regulatory pressure translates into concrete research questions around compliance, governance, and performance.

2.7.5 Underrepresented Perspectives

A persistent gap in the literature concerns the predominant focus on the focal company, typically located in developed countries. Scholars argue that supplier perspectives, especially from developing countries, remain underrepresented [187, 188]. Developing countries often face lower income levels, limited infrastructure, and weak industries [189, 190], making sustainability challenges more acute. This research gap has been repeatedly highlighted as a future priority [191, 192]. Addressing these asymmetries is essential for understanding the global nature of sustainability challenges.

Overall, this section has outlined key developments in sustainable supply chain research, highlighting key themes across areas such as IT, circular economy, supplier evaluation, and supply chain regulations. While several research areas are relevant, this dissertation focuses specifically on the two forces IT and regulation, which will be presented in the following sections.

2.8 Information Technology as an Enabler for Sustainable Supply Chains

IT has long been recognized as a fundamental enabler of SCM [193–195]. As sustainability considerations are integrated, however, its role expands: IT must additionally support the monitoring, verification, and reporting of social and environmental conditions across multiple supply chain tiers [196–199].

This dissertation treats IT and digital technology synonymously. While the terminology varies across studies [200–202], both terms are understood here as encompassing all technologies and systems that enable the creation, acquisition, processing, storage, securing, retrieval, organization, and dissemination of data [203, 204].

This section examines the requirements SSCM places on IT, the approaches available to address them, and the challenges that remain.

2.8.1 Information Technology Requirements

SSCM requires transparency into social and environmental conditions beyond tier-1 suppliers, particularly at those nodes where sustainability risks are most pronounced [96, 205, 206]. Beyond transparency, SSCM increasingly entails the identification and monitoring of sustainability risks, as well as the reporting of compliance obligations across multiple supply chain tiers. These requirements are reinforced by due diligence legislation such as LkSG and Corporate Sustainable Due Diligence Directive (CSDDD), which mandate the documentation and traceability of related processes to ensure verification and auditability [9, 128, 207].

Meeting these demands requires IT systems capable of collecting, processing, and managing environmental and social data across complex, multi-tier supply chains at the required scale and granularity, while ensuring data integrity and reliability [208–210].

2.8.2 Relevant Information Technologies

Blockchain technology, the Internet of Things (IoT), big data analytics, and artificial intelligence (AI) have emerged as key IT approaches for SSCM, each contributing distinct capabilities to address the transparency and risk monitoring requirements outlined above [211, 212].

With regard to transparency, blockchain technology has gained particular attention for its ability to prevent fraud and promote fair supply chain practices [213–215]. IoT devices such as sensors and RFID tags complement blockchain by generating real-time data on environmental and social conditions, e.g., carbon emissions, energy use, and workplace safety indicators [211, 216]. Their integration allows these data to be securely recorded and traced, enabling monitoring across supply chain tiers [212].

For risk identification and monitoring, big data analytics enables the processing of large volumes of supply chain data to detect unsustainable practices [12], identify emission reduction opportunities [217], and facilitate a shift from reactive to proactive decision-making [211, 218, 219]. Building on this, AI further enhances risk detection by identifying anomalies in transaction data, supporting compliance with due diligence requirements, and enabling the processing of large data volumes across sustainable sourcing and regulatory adherence domains [210, 220, 221].

Collectively, these technologies offer promising capabilities to enhance transparency, risk identification, and monitoring in SSCM.

2.8.3 Limitations and Structural Challenges

While the technologies outlined above offer considerable potential, their effectiveness as enablers of sustainability ultimately depends on the quality of the underlying data [208, 210, 222]. Much of the promise attributed to blockchain, IoT, and big data analytics rests on the assumption that input data are reliable, complete, accurate, and timely [208, 209]. In practice, however, transparency in supply chains is often based on self-reported disclosures, selective audits, and incomplete documentation, constrained by persistent information asymmetries and limited observability [223–226]. Obtaining granular and timely data from numerous supply chain actors, particularly lower-tier suppliers, therefore remains an acute challenge [96, 227, 228]. Moreover, companies may strategically misreport sustainability performance when economic or reputational incentives exist [229–232], rendering even the most sophisticated analytical systems subject to the classic garbage in, garbage out problem [208, 233, 234].

Beyond data quality, successful deployment is hindered by several structural challenges. Access to the necessary infrastructure is unevenly distributed, a disparity particularly evident in many developing countries where high costs and limited educational resources further constrain adoption [13, 235, 236]. Additional impediments include system integration complexity, shortages of skilled personnel, and elevated cybersecurity risks [210, 237]. The effective implementation of IT also depends on cooperation among supply chain actors and engagement with regulatory bodies [212].

Ultimately, while IT can be an important enabler of sustainability goals in supply chains, it cannot substitute effective regulation, auditing, or genuine management commitment [238, 239]. IT can support sustainability efforts, but it does not resolve the underlying problems of data reliability, power asymmetries, or deliberate non-compliance [64, 210, 237]. Rather, it is the organizational and managerial context that ultimately determines whether IT reinforces superficial reporting or contributes to meaningful improvements in supply chain sustainability [238, 240].

2.9 Regulation as a Driver for Sustainable Supply Chains

The regulatory landscape regarding sustainable supply chains has undergone a paradigm shift over the last four decades. Historically shaped by voluntary frameworks [16, 241], the field is transitioning toward mandatory regulations that impose explicit obligations on companies [9, 119, 242]. This section traces these key developments and demonstrates how regulation has evolved into a central driver of sustainability in supply chains.

2.9.1 Early Normative Foundations

The foundation of sustainable supply chain governance emerged when international organizations began establishing normative expectations without imposing legal penalties. The Organisation for Economic and Co-operation and Development (OECD) first introduced its *Guidelines for Multinational Enterprises* in 1978, articulating early expectations for responsible corporate conduct across people, planet, and society [241]. This early period of *soft law* was further strengthened in 1987 with the publication of the WCED's *Our Common Future* report, which established the conceptual basis for sustainable development (see Section 2.1). The report called on governments and organizations to take immediate action and urged the UN General Assembly to implement a Sustainable Development Program [16].

2.9.2 The Emergence of Corporate Due Diligence Expectations

A significant step in institutionalizing corporate responsibility occurred in 2000, when then-UN Secretary-General Kofi Annan launched the UN Global Compact, encouraging companies to align with the *Ten Principles* spanning human rights, labor, environment, and anti-corruption. This development culminated in the 2011 endorsement of the UN *Guiding Principles on Business and Human Rights* (UNGPs), which articulated the *Protect, Respect, and Remedy* framework and formally established human rights due diligence expectations [127]. The UNGPs served as the foundational framework for this field, specifically calling upon governments to implement them through *National Action Plans* (NAPs). The objective of these NAPs is to establish reliable frameworks for businesses that encourage active contributions to improving human rights conditions and institutionalize due diligence processes to prevent or mitigate adverse impacts on human rights [243, 244]. By 2025, 35 countries had adopted an NAP, including not only industrialized economies such as the USA (2016), Japan (2020), and Denmark (2014), but also developing and emerging economies such as Ghana (2025), Vietnam (2023), and Kenya (2019) [245]. Germany's NAP (2016), for instance, set a target for at least 50% of German-based companies with more than 500 employees to integrate the required due diligence processes into their operations by 2020, warning that failure would trigger legislative intervention [244].

2.9.3 Disclosure-Based Approaches

During the decade following 2010, governments began moving beyond voluntary commitments toward early disclosure-based regulations. These laws assumed that transparency would mobilize consumer pressure and thereby drive improvements in corporate behavior [246]. The California *Transparency in Supply Chains Act* in 2010 was one of the first legislative initiatives to require large retailers and manufacturers to report their actions to combat slavery and human trafficking [246]. It was followed by the UK *Modern Slavery Act* (2015) and the Australian *Modern Slavery Act* (2018), which similarly mandate annual public statements disclosing their anti-slavery measures and supply chain risks [247, 248]. Sector-specific regulations also emerged, notably the USA *Dodd-Frank Act* (2010), which requires disclosure of conflict minerals (tantalum, tungsten, and gold) use under Section 1502 [249]. Despite increasing awareness, these early regulations were widely criticized for motivating *tick-box* compliance and failing to deliver substantive improvements on the ground [250–252].

2.9.4 Mandatory Due Diligence

A more transformative regulatory phase began in the late 2010s, when governments, particularly within the EU, shifted from disclosure-based approaches toward mandatory due diligence obligations accompanied by penalties for non-compliance [9, 119, 128]. France pioneered this development with the *Loi de Vigilance* in 2017, which introduced civil liability for failing to prevent human rights violations in supply chains [177]. Germany followed with the LkSG in 2021, which came into force in 2023 [9]. Notably, Germany excluded civil liability after considerable political debate [253], relying instead on sanctions and penalties [9]. Beyond due diligence requirements, the USA adopted a more restrictive approach with the *Uyghur Forced Labor Prevention Act* in 2022, prohibiting the importation of goods from Xinjiang under a rebuttable presumption of forced labor [254].

2.9.5 The European Union as a Regulatory Driver

The EU has become an influential actor shaping both the current and future regulatory environment. The *Corporate Sustainability Reporting Directive* (CSRD) mandates extensive sustainability reporting, encompassing supply chain-related disclosures such as Scope 3 emissions [255]. Following the EU's *Omnibus Package*, which entered into force in March 2026, its scope was significantly narrowed: only companies exceeding 1,000 employees and €450 million in annual net turnover (for non-EU companies, €450 million generated within the EU) remain subject to reporting obligations from 2027 onward [242]. Complementing CSRD, the CSDDD harmonizes due diligence obligations across the EU, requiring companies to conduct risk-based due diligence to identify, prevent, mitigate, and remedy adverse human rights and environmental impacts throughout their supply chains [128]. Following the Omnibus Package, however, CSDDD's scope was significantly curtailed: obligations now only apply to companies with more than 5,000 employees and €1.5 billion in net worldwide turnover (for non-EU companies, €1.5 billion generated within the EU), with implementation commencing in July 2029 [242, 256]. Crucially, unlike CSRD's focus on reporting, CSDDD mandates concrete action and establishes penalties for non-compliance.

Beyond corporate governance, the EU is also driving product- and commodity-specific sustainability legislation. The EUDR, applicable from December 2026 after

multiple postponements, prohibits the import into the EU of commodities such as cattle, cocoa, coffee, oil palm, rubber, soya, and wood unless they are proven deforestation-free [119, 257]. The *Ecodesign for Sustainable Products Regulation* (ESPR), in force since 2024, requires improved durability, reparability, recyclability, and the introduction of a Digital Product Passport (DPP) providing transparency across product lifecycles [178, 258]. The *EU Forced Labour Regulation* (EUFLR), entering application in December 2027, bans products made with forced labor from the EU market. Together, these measures signal a shift from voluntary corporate responsibility toward legally enforceable sustainability standards embedded throughout supply chains [259].

The regulatory landscape continues to evolve, as evidenced by the EU's Omnibus Package. Whether a *Brussels Effect* will materialize, whereby EU rules become de facto global standards [260], remains contingent on how multinational companies reconfigure their global operations. Taken together, the shift from voluntary initiatives to mandatory due diligence, reporting obligations, and product-specific sustainability requirements signals that regulation has emerged as a primary driver of sustainable supply chain transformation.

2.10 Summary

Sustainability has evolved from a primarily environmental concern into a multifaceted concept encompassing economic, environmental, and social dimensions [15, 21]. Supply chains constitute complex, multi-tier networks [77, 78] facing significant environmental and social challenges [4, 6], most pronounced at the origin of supply chains, particularly in high-risk contexts characterized by geographic-governance risks and multi-tier opacity.

IT is widely recognized as an enabler of sustainable supply chains [214, 215]; however, practical implementation faces substantial challenges [13, 14]. Simultaneously, the regulatory landscape has shifted decisively from voluntary approaches toward mandatory due diligence and disclosure requirements [7, 8, 128, 257]. Moreover, emerging regulations introduce new requirements that companies must integrate into their processes [9], making appropriate supplier evaluation approaches essential to achieve both regulatory compliance and enhanced sustainability performance. Yet research on IT and mandatory due diligence centers on focal company perspectives [187, 188, 261, 262], while the implications for vulnerable supply chain actors, such as smallholder farmers, remain insufficiently understood. Similarly, the integration of regulatory requirements into supplier evaluation frameworks remains an underexplored area [263].

Against this backdrop, this dissertation examines the intersection of IT and regulation in advancing sustainable supply chains. Three articles address complementary yet distinct themes of this challenge. *Article 1* (see Chapter 3) and *Article 2* (see Chapter 4) focus on agricultural supply chains in developing countries, where sustainability challenges and implementation barriers are most pronounced. *Article 1* examines blockchain technology as a transparency mechanism in agricultural supply chains, analyzing both its technological feasibility and its social implications for smallholder producers. *Article 2* analyzes LkSG from the perspective of cocoa smallholder farmers in West Africa, addressing the critical question of whether mandatory regulation drives genuine improvement for those at the origin of supply chains. *Article 3*

(see Chapter 5), in turn, shifts the perspective toward focal companies, developing a sustainability supplier evaluation framework that integrates academic literature, expert perspectives, and LkSG requirements, addressing the operational challenge of translating regulatory demands into effective supply chain governance.

2.11 Research Overview

This cumulative dissertation comprises three articles, each published as an independent, peer-reviewed manuscript with open access in recognized journals. Each article addresses distinct research question(s), contributing to a comprehensive understanding of how IT and regulatory mechanisms can advance sustainability in supply chains.

Table 2.1 provides an overview of the three articles, including their titles, research question(s), authors and contributions, publication dates, and current citation status according to Google Scholar.

The following Chapters 3, 4, and 5 present each article in detail, organized chronologically by publication date.

Table 2.1: Overview of the Three Articles in this Dissertation

	Article 1	Article 2	Article 3
Title	Can Blockchain Be a Basis to Ensure Transparency in an Agricultural Supply Chain?	Assessing the German Act on Corporate Due Diligence Obligations in Supply Chains: a perspective from the smallholder cocoa farmer	Sustainable supplier evaluation under due diligence acts
Research Question(s)	Does it make sense to implement blockchain technology to promote transparency in the cocoa supply chain?	What are the potential effects of LkSG on smallholder cocoa farmers in West Africa?	• What are the most relevant sustainability criteria for supplier evaluation according to the literature? • Which of these sustainability criteria do companies consider in evaluating suppliers with heightened human rights and environmental risks in the context of LkSG? • What additional sustainability criteria do companies consider in evaluating suppliers with heightened human rights and environmental risks in the context of LkSG?
Authors & Contribution	• Sarah K. Kraft (95%) • Florian Kellner (5%)	• Sarah K. Kraft (90%) • Matthew Quayson (5%) • Florian Kellner (5%)	• Sarah K. Kraft (90%) • Matthew Quayson (5%) • Florian Kellner (5%)
Publication Date	1 July 2022	9 May 2024	23 October 2025
DOI	https://doi.org/10.3390/su14138044	https://doi.org/10.3389/frsus.2024.1376619	https://doi.org/10.3389/frsus.2025.1677700
Citations			
(Google Scholar, as of 8 May 2026)	52	5	-

Can Blockchain be a Basis to Ensure Transparency in an Agricultural Supply Chain?

Abstract

Many supply chains within developing countries lack transparency and are fraught with fraud, corruption, and a substantial number of intermediaries. For several decades, the cocoa sector has faced multiple social, economic, and environmental challenges, some of which include the issue of child labor and very low incomes for farmers, leading to poor living conditions. Blockchain technology has a high potential to reduce — or completely eradicate — some of these hurdles. In this article, we present a blockchain-based solution based on the open-source framework Hyperledger Fabric for the cocoa supply chain to promote transparency and reduce fraud. In doing so, we explicitly describe how farmers can be directly integrated into the whole blockchain solution considering the limited infrastructure, knowledge, and technologies available to them. Since about 70% of all cocoa worldwide is produced in West Africa, this case study uses the cocoa sector in Ghana as an example.

3.1 Introduction

Chocolate, which derives its flavor from cocoa beans, is a popular luxury food worldwide and enjoyed in different varieties. Cocoa beans are among the ten most-exported commodities in the world and are imported by industrialized nations. The Netherlands is in the first place on the list of the largest importers, followed by Germany and the USA [264, 265]. In turn, Germany exports the most finished chocolate products. To meet these production needs, Germany imports 90% of its cocoa from West Africa, where over 70% of the world's cocoa beans are grown and harvested by Côte d'Ivoire and Ghana [265, 266].

The poor living and working conditions of the cocoa farmers, who form the basis of the cocoa supply chain, have been the focus of criticism in recent times [267, 268]. Voluntary international initiatives have emerged to bring an end to human rights abuses in the supply chain networks, such as child labor or unfair wages. These efforts include, for example, the Harkin–Engel Protocol, in which companies promised to eliminate severe child labor by the year 2005, or the United Nations (UN) Guiding Principles on Business and Human Rights published in 2011, as well as the published Guiding Principles of the Organisation for Economic Cooperation and

Development (OECD) [127, 269, 270]. Despite these and other voluntary actions, there has been no significant improvement in the living and working conditions of cocoa farmers and their families over the past 15 to 20 years [271].

The cocoa supply chain is complex with a lack of transparency. Thus, buying companies rarely know the origin of the cocoa beans. For instance, it is usually unknown whether the cocoa beans come from illegal plantations or whether children were engaged in the harvesting process [272]. Apart from the poor living standards of the cocoa farmers caused by low and volatile cocoa prices, the increasing demand for cocoa from Western countries also leads to environmental issues such as deforestation due to the urge to grow more cocoa [268, 272, 273].

The social and environmental impacts of the production process such as child labor, corruption, safety, and the health conditions of cocoa farmers have become increasingly important to consumers in recent years as they demand more insight into the supply chain and related processes of products. Since the agri-food supply chain is mainly burdened by intermediaries, it lacks transparency, leaving consumers with little information about the food's origin and the production process [268, 274–276].

Transparent supply chains that offer more information on the origin of products allow companies to connect well with consumers, build trust, and have an improved overview of each component of the supply chain. To achieve this, technologies need to be developed and implemented to promote transparency [276, 277]. Transparency, in this vein, means a level of common understanding and access to information about the product, such as labor circumstances, transactions, production process, or environmental impacts, which are requested from actors involved in an agri-food supply chain. The information requested needs to be complete, accurate, and without any distortion and irrelevant details. Hence, the prerequisite for a transparent agri-food supply chain is to know what information actors need [131, 278].

Existing tracking technologies such as radio frequency identification (RFID) tags, sensors, or barcodes that collect and store data along supply chains are limited, for instance, by centralized data or non-immutable data/transactions, especially in environments that are less trustworthy. A blockchain can provide a fully auditable and valid ledger of transactions, and through its encryption and control mechanism, transparency is safeguarded by storing information in such a way that it cannot be altered without recording the changes [276, 277, 279].

Many of the current challenges in the agri-food supply chain that affect the farmers could be tackled right from the origin. Nevertheless, none of the existing solutions directly involve smallholder farmers during their design and implementation, for instance, in West Africa, where almost all of the raw products are produced at a small scale. This work is original in the sense that it offers a solution to the prevailing challenges by which farmers are directly incorporated.

In this context, our paper aims to answer the following research question: Does it make sense to implement blockchain technology to promote transparency in the cocoa supply chain?

To address this question, (1) we investigated blockchain technology in agri-food supply chains and present an exemplary case study from the Ghanaian cocoa sector. Our results are based on expert interviews conducted with different Ghanaian actors along the cocoa supply chain. (2) We developed a blockchain-based solution for the cocoa supply chain based on the Hyperledger Fabric framework to promote the transparency and immutability of transactions. The uniqueness of our approach is that it

directly involves the cocoa farmers, considering their limited infrastructure, knowledge, and technologies. Our research is to establish a basis to help fight corruption and bring about fairness in the cocoa sector, especially in the country of origin.

Our paper is organized as follows: Section 3.2 presents the potential of blockchain technology in supply chains and demonstrates the implementation of blockchain applications in the agri-food sector. Section 3.3 introduces the cocoa supply chain and the situation of the cocoa farmers in Ghana. Based on this, we show our blockchain-based solution for the cocoa supply chain. In Section 3.4, we discuss the presented solution. Section 3.5 contains concluding remarks.

3.2 Literature Review

3.2.1 About the Potential of Blockchain Technology in Supply Chains

In 2008, blockchain technology became known with the emergence of the cryptocurrency Bitcoin [280, 281]. Blockchain technology does not only have a high potential in finance, but also a high ability to overcome challenges associated with supply chains such as lack of trust, risk of fraud, and counterfeiting. Moreover, the lack of transparency of all transactions across a supply chain and the authenticity of a product can be curbed using blockchain technology [282, 283].

The three most significant characteristics of blockchain technology, especially for supply chains, are immutability, decentralization, and audibility [284–286]. As of today, it is technologically impossible to change or manipulate data stored in a blockchain, such as executed transactions. If a transaction is subsequently changed, the hash value of the block concerned would also change. To conceal the manipulation, all subsequent blocks and their hash values would have to be adjusted, including the copies at all nodes/participants, for which a cryptographic puzzle would have to be solved. For this reason, the blockchain is tamper-proof or immutable. In this context, tamper-proof means that once the data, for example, a transaction, are stored in the blockchain, they cannot be deleted, altered, or falsified. This tamper-proofing of data can improve transparency in supply chains by giving participants in the blockchain network-controlled access to these data [285, 287, 288].

In a blockchain network, there is no need for a central authority to execute transactions, as the nodes decide on the documentation of transactions inside the chain. Processes can be automated using smart contracts in the blockchain network, as smart contracts apply and execute business logic. Thus, it eliminates the need for third parties, such as intermediaries, within a supply chain to execute transactions. Decentralized data storage reduces the risk of failure, unlike centralized storage with a single point of access [284, 285, 289, 290]. Each transaction in a blockchain is characterized by a timestamp and other information, such as a key. This type of record and visibility for all participants in the blockchain network allows for easy audibility and traceability of transactions. This feature is particularly beneficial in supply chains, allowing, for instance, the origin and the manufacturing process of products or food to be traced in real-time [277, 284, 286, 291].

Because of the blockchain's characteristics, it is very attractive to apply it in supply chains to gather information about each product's transaction and the different actors in real-time through the entire value chain. Since every actor in a blockchain has access to all the information stored in this network, transparency across the whole

supply chain will be promoted. This leads to less fraud and corruption. Moreover, the interaction among different actors within the supply chain can be improved [283, 292].

3.2.2 Blockchain Applications in Agri-food Supply Chains

Supply chains in the agri-food sector show high complexity as there is typically a great number of stakeholders, which leads to difficulty in approving important data such as the country of origin, safety, and quality issues across the whole supply chain [274, 293]. Transparency and trustworthiness in the supply chain of food products are an important undertaking due to food safety and contamination risks (think of, for example, the milk scandal in China in 2008 or the horse meat scandal in Europe in 2013) and rising environmental and social demands placed on palm oil and other food products, for instance [294–297]. Blockchain technology has a proven track-record to ensure the transparency, traceability, and immutability of transactions for agri-food supply chains to promote food safety or provide (transparent) information, for example, about the product's origin across the whole supply chain [275, 293].

In 2018, Walmart and Carrefour started their pilot projects to use blockchain technology to trace and track agricultural products such as mango and pork from China [298, 299]. Since 2019, Walmart has succeeded in using blockchain technology for over 25 food products, whereby all suppliers of leafy greens are obliged to use blockchain technology for tracing. Based on the blockchain, Walmart has benefited from having to trace its food and provide a transparent process all along the supply chain of its food products, making it possible to detect, for instance, the origin of a food-borne disease faster should there be an outbreak. Moreover, Walmart promotes food safety through a higher transparency process, making the food certificates more trustworthy [298, 300]. Till today, Carrefour uses blockchain technology for over seven food products and is planning to extend it to cover all food products coming from the label Auvergne Filière Qualité Carrefour by 2022. Carrefour's interest in using the blockchain is to assure their customers about the safety of their food as achieved via traceability and transparency. In doing so, it can fully inform its customers about the product's journey, starting with the food's origin [301]. Both cases show that blockchain technology can be beneficial in agri-food supply chains. Besides Walmart and Carrefour, there are many other use cases of blockchain in agri-foods, such as tuna from New Zealand or wheat from China (cf. Table 3.1).

Furthermore, the study of Bux et al. [302] investigated the opportunities and limitations of blockchain technology in the supply chain of halal food. To improve the safety and security of halal food, the authors discussed constraints like standards and opportunities such as improving trust and traceability, as well as creating standard procedures and secure hygiene. Besides this, Bux et al. [302] demonstrated how blockchain technology can also contribute to social and environmental sustainability, for example, by reducing chemical product usage in agriculture and manufacturing or increasing the level of customer trust [302].

Table 3.1: Examples of blockchain use cases in agri-food supply chains.

Agri-Food	Country of Origin	References
Coffee	Colombia, Ethiopia, Honduras	303–305
Egg	USA	306
Soybean	USA	293, 307
Tuna	New Zealand	308
Turkey	USA	309
Wheat	China	310

Blockchain technology can be implemented based on open-source frameworks such as *Ethereum* or *Hyperledger Fabric* or using dedicated software solutions such as *IBM Food Trust*, *farmer connect*, *Agriledger*, or *Grain Chain*, which are particularly designed for agri-food supply chains [304, 311–315]. Nevertheless, an outstanding barrier to applying blockchain technology to real-life solutions is the implementation in supply chain networks with low technological infrastructure [316].

Consequently, one drawback of most software solutions is that they are either designed for or used in developed countries, even though the raw materials are mostly found in developing countries. This means that most software solutions are entrenched by their inability to function in developing countries because of the unavailability of devices or infrastructures (such as internet connections that barely exist or are very slow due to poorly developed telecommunication networks) to effectively function. Another fact is that peasant farmers who directly produce the raw materials are left out or are poorly integrated because of several factors such as low education and inaccessibility. Furthermore, most software solutions are too complex and expensive for (smallholder) farmers [276, 317, 318].

3.2.3 Blockchain Applications in the Cocoa Supply Chain

Arsyad et al. [319, 320] and Chong et al. [321] showed how blockchain technology can be implemented in the cocoa supply chain. Arsyad et al. [319] suggested applying a two-factor blockchain based on digital watermarking techniques to record and validate the data of cocoa production using images. The authors showed a simulation scenario with no practical data inputs from cocoa production [319]. Chong et al. [321] developed a blockchain-based solution for cocoa export supply chains in Peru with the purpose of reducing the hurdle of obtaining real-time information from the international markets for Peruvian farmers. The authors used *Hyperledger Composer*, which has been outdated since 2019 [322]. Arsyad et al. [320] proposed via a farm simulation an *Encapsulating Block Mesh* based on blockchain technology and *the bucket principle* implemented by a Modular Block Chain sensing instrument to ensure transparent data documentation in the cocoa supply chain, especially for farm activities. Their suggestion was based on an abstract open simulator game, without inputs and consideration of the real cocoa production and its environment or supply chain [320].

In addition, neither Arsyad et al. [319, 320] nor Chong et al. [321] described how exactly the farmers can be integrated into the blockchain, even though the farmers are the basis of the whole supply chain. Moreover, the prior research projects did not point out possible challenges and recommendations for implementation. Lastly, even though the prior solutions were suggested for cocoa supply chains, they cannot

be implemented everywhere and, for example, in West Africa, where over 70% of the world's cocoa is produced, since the environmental and political situations are different [266, 319, 321].

The integration of the cocoa farmer into blockchain technology is very important because, without this, complete transparency in the supply chain cannot be achieved. Further, fraud and corruption by middlemen cannot be reduced and fair payments for the farmers cannot be guaranteed.

3.3 Blockchain-Enabled Traceability in the Cocoa Supply Chain: A Case Study of Cocoa Farmers in Ghana

In 2020, more than three million tons of cocoa beans were exported worldwide, out of which 90% originated from approximately six million small-scale farms. Farmers from two West African countries, Côte d'Ivoire and Ghana, produce over 70% of the world's cocoa beans [323]. Nevertheless, Africa consumes the least cocoa, accounting for about 4% of the global cocoa consumption. The largest consumers include Germany (45%) and the USA (27.5%) [266].

Several approaches to the application of blockchain technology to enhance transparency through data validation or access to real-time information in the cocoa sector have been reported in the literature (see Section 3.2.3) [319–321]. Nonetheless, existing approaches are not applicable to the world's largest cocoa-producing nations due to the limited infrastructure and low level of education of small-scale cocoa farmers. Moreover, the approaches pay little attention to the looming corruption and social issues that exist along the cocoa supply chain. Furthermore, the cocoa farmers, being the backbone of this sector, are mostly left out or poorly recognized in designing any solution to the issues facing the sector. This case study, however, takes into consideration all the above-mentioned issues by especially focusing on how to directly involve the farmers in any proposed solution.

3.3.1 Overview of the Cocoa Supply Chain

The cocoa supply chain is long and complex and involves different actors worldwide, such as cocoa farmers in Ghana and chocolate manufactures in Germany. Figure 3.1 gives an overview of the cocoa supply chain with its main actors, without considering certification programs such as UTZ or Fairtrade.

At the beginning of the cocoa supply chain, the farmer harvests the ripe cocoa pods and packs the cocoa beans into sacks, which are then bought by the Licensed Buying Companies (LBCs). At the LBC depot, the cocoa sacks are inspected and classified by the Quality Control Company (QCC). Subsequently, the LBC transports the sacks by truck to the Take-Over Center (TOC) of the Cocoa Marketing Company (CMC). Upon arrival at the TOC, another quality inspection takes place by the QCC, before the CMC temporarily stores the cocoa sacks at the TOC for shipment, during which period, the QCC performs a final quality check before the shipment is finally carried out. Subsequently, the cocoa sacks are exported by cargo ship (A) or transported within Ghana to processing companies (B).

In the case of option (A), the cocoa beans are exported to processing companies such as Barry Callebaut (Zurich, Switzerland) or Cargill (Wayzata, MN, USA). Major export countries are the Netherlands, Germany, and the USA, where the companies process the cocoa beans into semi-finished products such as cocoa liqueur, cocoa

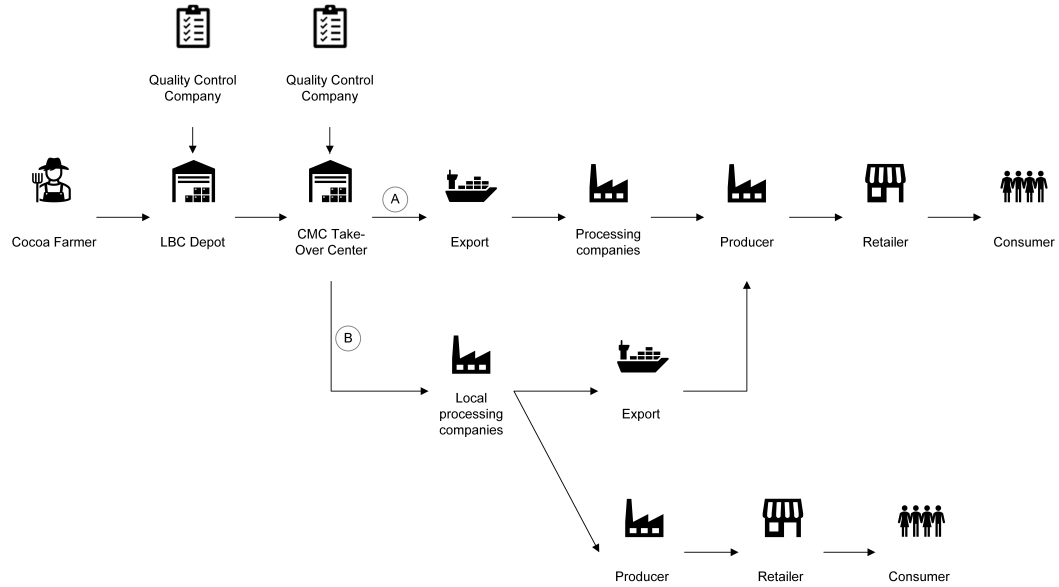


Figure 3.1: Cocoa supply chain.

butter, or cocoa powder. Afterwards, the semi-finished products are transported to chocolate manufacturers such as Mondelēz (Chicago, IL, USA), Mars (McLean, VA, USA), or Nestlé (Vevey, Switzerland), who process the semi-finished cocoa products into finished chocolate products. Then, the chocolate products are transported to retail stores worldwide, such as Aldi, Tesco, or Carrefour. After all this, the end consumer buys the finished product in a retail store [273, 324, 325].

In the case of option (B), the cocoa beans are processed into semi-finished products and partially into finished products in Ghana. After that, the semi-finished products are exported to chocolate manufacturers (like in (A)) or sold in local stores to the end consumers in Ghana.

3.3.2 The Cocoa Supply Chain Process in Ghana: from Beans to Export

The cocoa process from beans to export within Ghana involves three actors: the cocoa farmers, the LBCs, and the Ghana Cocoa Board (COCOBOD), including its subsidiaries. The COCOBOD is a government institution that regulates and controls the cocoa sector in Ghana. Beyond that, the COCOBOD grants licenses to private companies to purchase beans from individual farmers. These companies are called LBCs. However, only the subsidiary CMC of the COCOBOD is authorized to sell cocoa beans internationally [326, 327].

The process from cocoa bean to export, which we describe in the following, was reconstructed from interviews conducted with a cocoa farmer, an officer of the COCOBOD, a district manager, and a research assistant working at an LBC. Based on these interviews, we analyzed the overall process (process flow, requirements, etc.) and built the proposed blockchain-based application.

The cocoa harvest season is from October to March (main season) and from May to August (mid-season). During the harvest season, cocoa farmers harvest the ripe pods every three to four weeks [328]. The cocoa process begins at the plantation with the ripe cocoa pods cut off, collected, and carried by foot to the pod-breaking point. After every single pod is broken and the good cocoa beans are selected, the

farmer transports them to the fermentation area and, after the fermentation process, to her/his home. There, the cocoa beans will be dried on thinly stretched mats. Once the cocoa beans are dry, the farmer fills them into cocoa sacks and sells the full sacks to the LBC. Depending on whether the farmer lives in a rural or urban area, the responsible LBC employee (within an LBC, there are different positions, for which we did not differentiate due to this being complicated) is called to pick up the cocoa sacks from the farmer or the farmer transports the sacks to the LBC depot by herself/himself, usually by taxi. The LBC employee weighs the sacks with her/his scale on-site to check the weight of each sack and to adjust it if necessary. Each sack must contain 64 kg of cocoa beans. Then, the farmer receives a payment in cash or by mobile money and the LBC employee records the date, the number of sacks, and the amount paid to the farmer in both the farmers' cocoa passbook and in her/his own internal book. Afterwards, the LBC employee transports the cocoa sacks to the next LBC depot. The further process after the arrival at the LBC depot is described in Subsection 3.3.1.

3.3.3 Difficulties faced by the Cocoa Farmers

Cocoa farming in Ghana is characterized by many modest farmers with small plantations. The COCOBOD estimates that about 800,000 families are involved in cocoa farming [329]. Farmers mostly live in villages and have their farms in the nearby areas. The average harvest of one farmer is between four and six sacks of cocoa per season.

Currently, there is no standardized system used by the COCOBOD or the LBCs for all cocoa farmers, with which the traceability of the cocoa sacks up to the farmer can be guaranteed. Therefore, it sometimes happens that the LBC buys cocoa beans from Côte d'Ivoire, which are of poorer quality and cheaper, and mixes them with the Ghanaian premium cocoa beans. The customer (located, for example, in Germany or Japan) typically notices this quality defect.

Based on the expert interviews conducted, it was determined that there is a high level of fraud when the cocoa sacks are sold to the LBC by the respective farmers. This includes the manipulation of the scales with which the LBC weighs the sacks or the declaration of the wrong number of cocoa sacks. Consequently, the farmer does not receive the cocoa price per sack to which she/he is entitled [268, 330]. This is compounded by low and fluctuating cocoa prices [272]. The average annual income of cocoa farmers is between € 560 and € 800, depending on the size of the plantation or the number of cocoa sacks delivered [331].

Beyond that, the data, such as the number of cocoa sacks and their weight or the amount paid out, are entered only in handwriting in the respective notebooks and are not issued as a supplementary digital certificate. Furthermore, the QCC issues the certificates of the three quality inspections on paper and not digitally. This can not only lead to incorrect data or data shrinkage but can also be disadvantageous during evaluations.

Cocoa farmers in Ghana are generally males, over 50 years old, and have barely attended school. They live mainly in rural areas, which are characterized by poverty and poor infrastructure. This also affects their low acceptance of technical developments. There are hardly any farmers with internet-powered smart phones. Farmers typically have simple cell phones to make phone calls and send SMSs. The network coverage in the cocoa-growing areas is mainly provided by the two largest mobile phone providers, MTN and Vodafone. Nevertheless, there are places, especially in the rainforests and rural areas, where there is no stable network. A stable internet

connection exists predominantly in the cities, whereas in rural areas, if at all, a weak internet connection is available [332].

3.3.4 A Blockchain-Based Solution for the Cocoa Supply Chain in Ghana

The characteristics of blockchain technology, especially the immutability of data and the already successful implementation in other agri-food supply chains, make this technology a good solution to promote sustainable transparency along the cocoa supply chain. The beginning of the cocoa supply chain is the most challenging, packed with issues, such as illegal cocoa plantations, human rights abuses (child labor, poor living and working conditions of farmers), as well as corruption and mistrust [271, 273]. As mentioned above, the most pertinent issue is the situation where the farmers are cheated on by the LBCs in ways such as incorrect weights of cocoa sacks, leading to reduced payments made for their cocoa beans.

This paper presents a blockchain-based solution to make transactions between the cocoa farmers and the LBC more transparent and non-editable. In this context, transaction means the handover of the cocoa sacks from the farmer to the LBC, in return for payment. It is important that the cocoa farmers are integrated into the digital process using their own devices to avoid fraud. Therefore, their technical prerequisites need to be considered (no technical devices, poor internet access, etc.), as well as the complexity of handling. Since cocoa farmers rarely use any technical devices with internet access, we developed an alternative way to document the transaction via SMS into a permissioned blockchain network, through which the data are saved immutably.

In the following, we describe the implementation of our blockchain-based solution for the cocoa supply chain. Overall, we made extensive use of open-source frameworks, where everyone has free access to the program code and which can be developed further or modified individually without any financial requirements.

Among the recognized open-source blockchain platforms, especially in the areas of supply chain and logistics, are Ethereum and Hyperledger Fabric [289, 333]. For our application, we opted for Hyperledger Fabric (version 2.0) because this has unique characteristics, especially the permissioned blockchain within its private network. Thus, only authorized persons with the corresponding role profiles can access the blockchain network for the cocoa supply chain. In addition, Hyperledger Fabric is in use in the agri-food supply chains of, for example, Walmart, where it is used to map the supply chains of mangoes from the USA or pork from China [298, 333]. A further reason is the modular infrastructure of Hyperledger Fabric, which is easy to expand and modify. The implementation was performed on Ubuntu 20.04.2.0 LTS, since this is open-source and it is easier to develop Hyperledger Fabric on it than, for instance, on the Windows operating system. Sending and receiving SMSs should be free for the farmers due to their poor living conditions. For this reason, an SMS-REST-API provider who offers two-way SMS with a Ghanaian mobile phone number would be advantageous. Currently, there are only three providers who can offer this service. Regarding long configuration times and high fixed and variable costs, we chose Twilio as the preferred provider. Twilio offers for the two-way SMS an international mobile phone number, which also works in Ghana. Besides Twilio's free test version, detailed documentation for different programming languages is available [334].

Before the farmers and LBCs can operate with the blockchain-based solution, they need to be registered in a database with information such as name, phone number, region, and role. After they have been registered, they are assigned automatically to

an ID. Concerning the LBC employee, she/he additionally needs to create a password. In this case study, blockchain technology comes to its deployment when the cocoa farmer has cocoa sacks ready to sell it to the LBC. After the farmer has informed the LBC, an employee from the LBC comes to her/his home to pick up the cocoa sack. Now, the new process with the blockchain-based solution starts, as shown in Figure 3.2. First, the LBC employee has to login into the web app on her/his phone by entering her/his ID and individual password. Therefore, it is assumed that every LBC employee has a private phone, or a phone provided by her/his employer.

After logging in, the user will be directed to the main menu of the web app. From there, she/he can either create new transactions or inspect her/his previous transactions with a timestamp and statuses (pending, done, canceled, expired) in real-time. For generating a transaction, the LBC employee needs to enter the farmer's ID and select the correct number of cocoa sacks. When the LBC employee has filled in these two data, she/he can generate the transaction by pressing the *create* button. At the same time, the cocoa farmer receives an SMS with the transaction details, including the number of cocoa sacks (see Appendix A, p. xi). If the transaction details are correct, the user needs to confirm the transaction by replying to the SMS with "y". Once a transaction between the LBC employee and the cocoa farmer has been successfully confirmed, the transaction data (names of LBC employee and farmer, number of cocoa sacks, payment, timestamp) are recorded in the blockchain. Simultaneously, the transaction is visible to all authorized actors that are part of the blockchain network. In case the LBC employee entered the wrong data, the farmer has the chance to cancel the transaction by sending an SMS with the content "n". Then, the transaction will not be saved in the blockchain to eliminate storage space. Consequently, the LBC can correct her/his input and create a new transaction. In case the farmer does not reply to the received SMS about a transaction within 15 minutes of receiving, the transaction expires and will not be saved in the blockchain. If a transaction has the status "done", "canceled", or "expired", both the farmer and the LBC employee receive an SMS about the status.

Figure 3.3 gives an overview of the blockchain-based solution's IT infrastructure. The blockchain-based solution was developed with open-source frameworks, except for a free test version of Twilio, as no budget was available for this case study. The LBC employee uses the frontend, i.e., the user interface of the web app, by logging in to access the homepage so that she/he can execute transactions or view her/his history there. The frontend is written in the HTML and Bootstrap languages with the use of Pug. The cocoa farmer uses her/his own cell phone, with which she/he sends an SMS. This SMS is routed to the backend server via a configured webhook from Twilio. For the backend server, Node.js was used, which interacts with the frontend, the SQLite3 database, and the SMS rest API/webhook of Twilio, but also with the blockchain network through an interface by its software development kit (SDK). The blockchain network stores confirmed transactions in addition to the blockchain in the CouchDB database. Successfully executed transactions can be accessed directly in the blockchain or via its world state, the CouchDB database. The blockchain-based solution runs on a local server and not on a web server yet, as this was sufficient for the case study.

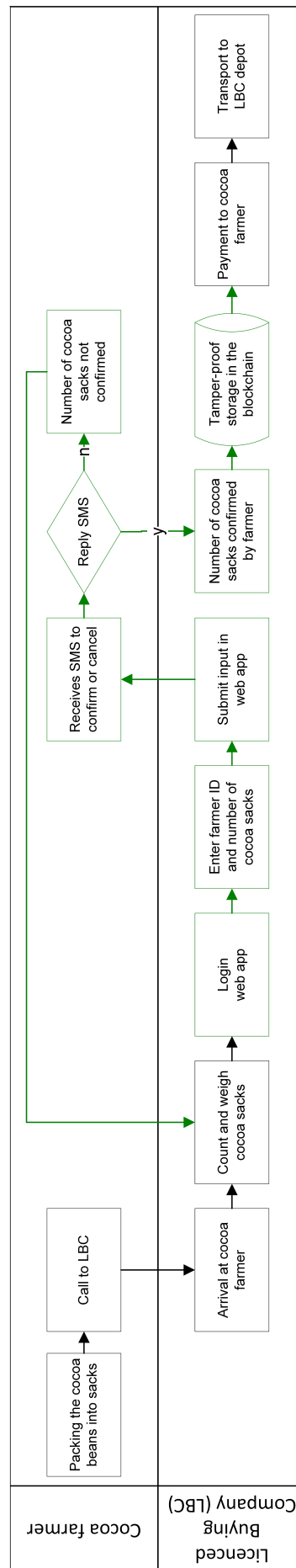


Figure 3.2: New process with the blockchain-based solution.

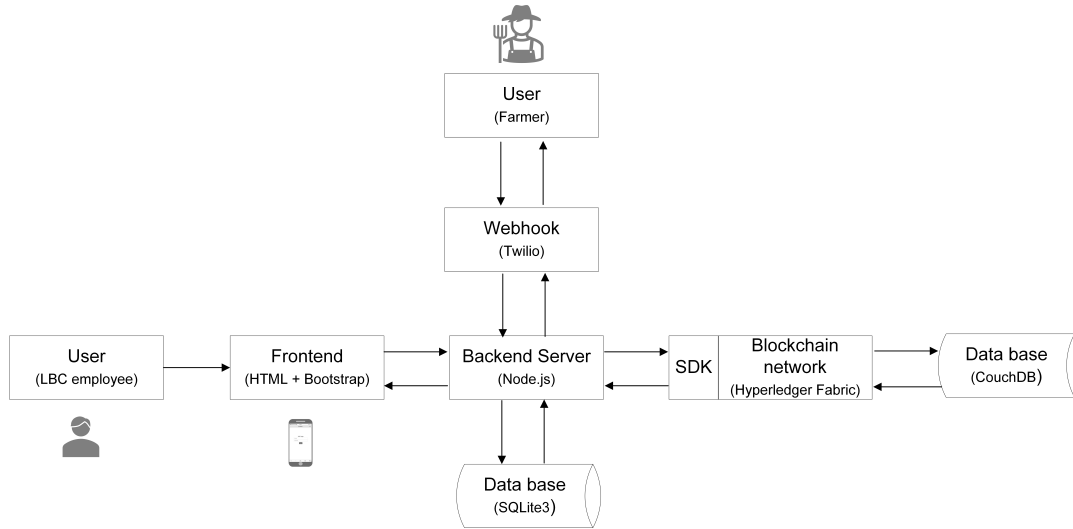


Figure 3.3: Infrastructure of the blockchain-based solution.

3.4 Discussion

In this paper, we demonstrate how blockchain technology can be used to support one step along the complex and long cocoa supply chain to establish a means by which fraud and corruption perpetrated against cocoa farmers can be tackled while promoting transparency. In addition, this paper demonstrates how high-end technologies, such as blockchain, can be implemented based on open-source frameworks without the need for significant financial investments.

Compared to the approaches in the literature, Arsyad et al. [319] used a two-factor blockchain that links legal documentation and blockchain technology within a traceability system via digital watermarking of the documentation media [319]. The downside of their approach, however, is that it relies on textual and media-based documentation (photos, videos), which are rarely available or difficult to acquire due to the expensive and limited technologies in the developing world. Arsyad et al. [320] again proposed a farm transaction simulation implemented by a Modular Block Chain sensing instrument, which is coupled with equipment such as sensors and controllers [320]. This approach, though promising, would do little in fighting corrupt practices perpetuated against farmers in Ghana, Côte d'Ivoire, and other developing cocoa-producing nations. In addition, the proposed solution would be very cost-intensive considering the fact that the cocoa farmers in the focus country are small-scale farmers and the use of the technology devices mentioned above would be a financial burden to them. This solution can be applied in developed countries such as Japan but is less likely to be adapted in under-developed nations. Both approaches aim to attain transparency in the cocoa supply chain even though the solution proposed in this paper tackles corruption right from the endpoint of the farmers, taking into consideration the limited education and technologies available to the small-scale farmers in the focus region. Again, the approaches of Arsyad et al. [319, 320] cover all aspects of cocoa farm management, whereas the case study in this paper focuses mostly on the farmer-LBC transaction after cocoa beans are harvested and bagged for sale.

Chong et al. [321] developed a blockchain system using a similar framework such as Hyperledger Fabric and programming languages such as Go and JavaScript, as

used in this case study. The authors focused on the complete traceability of the products from the farmers until the product arrives in the warehouse of the importers [321]. Moreover, their solution also requires complex and expensive infrastructure that is not available to the farmers in the focus nations.

The main purpose of the case study in this paper was to develop a blockchain-based solution that makes use of cheap and readily available devices to fight corruption in the cocoa supply chain. Information about the origin of the farmer, cocoa sacks, weight, date and time can be safely stored in the blockchain and accessed by all players along the supply chain in real-time, similar to the approach by Chong et al. [321]. The model advocated in this paper can be extended to cover all aspects of the supply chain of cocoa beans from the LBC to the warehouse of the chocolate manufactures, like that suggested in the work of Chong et al. [321].

The presented application starts directly at the beginning of the cocoa supply chain considering the technical and logistical constraints of the cocoa farmers. At the same time, the beginning of the cocoa supply chain represents a critical point, which is characterized by gross corruption and fraud. The farmers generally own and use simple mobile phones, which mainly support phone calls and SMS only. Furthermore, cocoa farmers do not have access to the internet, which poses a challenge when using technologies such as blockchain, often in conjunction with the Internet of Things (IoT) or even simple mobile applications. In this respect, the intention was to develop the application in such a way that it can be operated by farmers without prior knowledge, experience, or internet connection. This is important to ensure that the data of the transactions are stored correctly in the blockchain, as both the LBC employee and the cocoa farmer must come to an agreement before a transaction is executed. The whole blockchain-based application was tested with a cocoa farmer in one of Ghana's main cocoa regions, Suhum in the Eastern Region. The case study showed that blockchain technology can be applied to the cocoa supply chain and that it is possible to use it with a simple cell phone to include the cocoa farmer in the blockchain process.

We assumed that each cocoa farmer can send an SMS with her/his mobile phone. Accordingly, we chose SMS as a means to send and receive data from and to any simple mobile device, which can be stored into the blockchain to foster easy practicability and adaptation and to include as many farmers as possible. The usability of new IT systems is one of the main impacts that leverages the user's intention and usage [335]. The farmers use their phones mainly for phone calls, but not to send an SMS. Therefore, they are most familiar with making phone calls and less with sending an SMS. For this reason, an alternative to reply by SMS would be to communicate by voice call. This means that the farmer receives a phone call instead of an SMS, in which she/he is informed about the number of cocoa sacks. She/he could then confirm or cancel this verbally. However, it should be noted that due to the lack of school education, most cocoa farmers have little English knowledge. Therefore, this paper suggests investigating whether the existing English knowledge of cocoa farmers is enough to operate the application in a target-oriented manner, regardless of whether the communication takes place via SMS or voice call. It may also be possible to consider the adaptation of local Ghanaian languages both for voice and SMS responses instead of the English language.

Regarding fraud committed against farmers, the web app documents the number of cocoa sacks in the blockchain but does not consider the weight of the sacks. Since the weight of the sacks can be falsified by manipulated scales, it is recommended to develop a solution for this problem as well using the blockchain-based application

to eliminate the risk of fraud. It is also important to mention that the blockchain-based application only shows how the number of cocoa sacks can be stored in the blockchain, but not how the cocoa sacks can be uniquely identified afterwards. One possibility would be to give the sacks a unique identification number, for instance as a QR code sewn onto the individual sack, which would also be documented during the transaction.

As a next step, besides the number of cocoa sacks, the money transferred between the LBC and the cocoa farmer could also be digitally mapped in the blockchain network. This can transparently ensure that the cocoa farmer receives a fair price for her/his cocoa beans. In Ghana, mobile money is a widely used means of payment. Therefore, there is a good opportunity to integrate this into the process so that, for instance, the transaction confirmation of the farmer can trigger the payment automatically. In this respect, it would be clear in the blockchain how much Ghanaian cedi (local currency) the cocoa farmer has received. Likewise, this can ensure that no fraud takes place during payment. Especially with regard to premium payments from certification programs such as Fairtrade or UTZ, this step could be very beneficial. Nevertheless, this requires an investigation into whether mobile money is also widespread among cocoa farmers. The status quo is that it is uncertain how willing the cocoa farmers and LBCs are to voluntarily use the blockchain-based application. Therefore, it is recommended to conduct extensive surveys with farmers and LBC employees to ascertain their readiness. Ultimately, it is essential for the cocoa farmer to receive fair payment for her/his sacks of cocoa. What happens later to her/his cocoa beans is of less interest to her/him. At this point, it is recommended to involve the COCOBOD and gain its acceptance to implement the blockchain-based application among farmers and LBCs and decide accordingly whether its use is voluntary or mandatory. This is also an opportunity for the COCOBOD to gain a better overview of the cocoa process within Ghana.

The COCOBOD, being a state-owned organization, currently regulates the production and sale of raw cocoa beans in Ghana. In addition to setting the selling price of cocoa each year, the COCOBOD is also responsible for developing programs that ensure the sustainability of the environment [326, 327]. A widespread adaptation of the blockchain-based solution proposed in this work can only be possible through the acceptance and promotion by the COCOBOD. Nevertheless, its involvement could come with consequences, such as higher power in controlling and monopolizing the selling prices of cocoa beans, since it has already the export monopoly role with its huge political power [268].

It would also be advantageous for the COCOBOD to document quality inspections by its subsidiary QCC on the blockchain and to transfer the certificates digitally within the blockchain network. Anyway, for a large deployment of the blockchain-based solution in the cocoa sector in Ghana, it must be examined whether the open-source frameworks utilized in the case study can be implemented at a low cost on a large scale. As the complexity of the blockchain-based solution increases, due to the number of participants, more functions, as well as the development and improvement of the blockchain-based solution may increase the costs, for example, through training, further development, and maintenance [316].

Blockchain technology for the cocoa supply chain has a great potential to add further functions, which were explained in the previous sections. In addition, there is a chance that the introduction of 5G networks by Vodafone and MTN in Ghana in 2023 will boost the blockchain-based solution through the possibility of better

internet coverage, specifically in rural areas where farmers live, and in addition, a promise of unlimited and fast internet access and high data transfer speeds [336–339].

To tackle some of the challenges facing the cocoa sector, a blockchain-based solution was developed in this work, which mainly focused on the development of the process and technology for adaptability in the cocoa sector. Although a user response survey would make plain the adaptability of this solution, it is out of scope of this work and would be considered in the design of a further study.

In summary, the blockchain-based application enables the critical process steps at the beginning of the cocoa supply chain, where there is much fraud against the cocoa farmer, to be digitally documented and stored in a tamper-proof manner, thereby promoting transparency. Despite the opportunities for improvement of the blockchain-based application developed in this paper, it was shown that blockchain technology can be suitably implemented to promote transparency in the cocoa supply chain. This is because, during a transaction, relevant information, such as the number of cocoa sacks or timestamps, is made accessible to all stakeholders along the supply chain in real-time. The use of the blockchain-based application reduces fraud, as the farmer can now confirm the transaction, for example, the number of cocoa sacks, or cancel it in case of possible fraud before the payment is made. Furthermore, the developed application limits the illegal import and sale of lower-quality cocoa beans from neighboring regions, which are mixed with the farmer's cocoa beans to cover up the lack of quality. Since the blockchain-based application identifies each transaction and, thus, also the quality defect, it is possible to introduce restrictions on illegal imports and sales. Similarly, farmers working with certification programs, like UTZ or Fairtrade, can use the blockchain to document their certified sacks of cocoa. This information could also be made available to stakeholders such as chocolate manufacturers, for example, Lindt or Mondelēz, in the blockchain network.

The constraint of the results from this case study is that it focused only on one of the six cocoa regions in Ghana with a small number of farmers and LBCs, as compared to the studies published by Chong et al. [321] and Arsyad et al. [319, 320], which covered a larger geographical area. Nevertheless, this case study highlights the possibility to implement blockchain technology in the entire cocoa supply chain of Ghana, by leveraging on its uniqueness of integrating all cocoa farmer in the region into the network while aiding the fight against corruption.

However, to gain transparency along the cocoa supply chain in the long run, it is necessary for all actors in the cocoa supply chain to be fully involved, which takes much time and cost to implement. For this reason, in the long term, the number of intermediaries should be reduced. In summary, this provides an opportunity to promote high transparency, minimize fraud, and subsequently, offer fair payments to cocoa farmers. Further research will be needed if all actors in the cocoa supply chain are willing to implement this solution.

3.5 Conclusion

Researchers have presented various approaches to make (agri-)food supply chains more sustainable, for example, refs. [302, 321, 340]. Blockchain technology has already been successfully implemented in other agriculture supply chains, such as coffee. This paper shows how to implement it in the cocoa supply chain to ensure transparency. We could integrate the farmers, who are otherwise neglected when it comes to the supply chain of cocoa, even though the supply chain begins with them. Faced

with limited technology and other resources, we showed that it is possible to use simple SMSs coupled to the blockchain to promote transparency and cut down corruption at the same time.

The blockchain-based application that we presented in this paper documents all successfully executed transactions between the cocoa farmer and the LBCs, which are validated, non-manipulated, and saved into the blockchain. Due to the decentralized storage via the blockchain of transactions, as well as anti-counterfeiting, trust in the data of actors along the cocoa supply chain is improved. Authorized actors can also access the decentralized stored data in the blockchain at any time within the private blockchain network. It should be noted that this work identified critical issues relating to the blockchain-based application, for which recommendations for action were provided.

This solution constitutes a good basis to help the fight against corruption and bring about fairness in the cocoa sector. The presented solution for the farmers can be generalized and implemented in any other agriculture supply chain since it does not require internet connectivity or any extra skills from the farmers.

Finally, it should be mentioned that blockchain technology has great potential since it can be used not only for showing the number of cocoa sacks, but also in other process steps such as for money transfer or quality checks.

The unique methodology presented in this paper points out the need to pay more attention in the future to available infrastructure when designing solutions for specific geographical areas. Social issues can be better addressed by taking a more critical look at conditions on the ground and finding ways and means to develop an all-inclusive solution that integrates all actors along the supply chain in a specific food sector. This was well captured in this case study by concentrating on the incorporation of smallholder farmers into the supply chain of cocoa, without turning a blind eye to their inadequate educational background and technological infrastructure, to enhance transactional transparency between the farmers and the LBCs. In addition to this, the presented real case study enhances the field and value of blockchain technology for other agri-food industries, especially in developing countries with small-scale farmers.

Most of the challenges in agri-food supply chains, such as corruption, low payment, or child labor, especially in West Africa, affect the farmers' living and working conditions. Nonetheless, existing solutions to enhance transparency by implementing blockchain technology neither directly include smallholder farmers during their development and implementation, nor consider their limited infrastructural resources and knowledge [319–321]. Most of the raw products such as cashew or cocoa in West Africa are produced on a small scale and left out in generalized software solutions. The value of this work can be seen in its direct involvement of farmers and the simple approach to the challenges.

In the future, blockchain technology can promote transparency along the entire cocoa supply chain if all actors are included, even though it is challenging at the same time. Beyond that, for stakeholders, especially chocolate manufacturers in Europe, blockchain technology can be an interesting approach, especially considering the planned supply chain law in Germany, as well as in the European Union.

Assessing the German Act on Corporate Due Diligence Obligations in Supply Chains: A Perspective from the Smallholder Cocoa Farmer

Abstract

This research examines the potential outputs, outcomes, and impacts of the German *Act on Corporate Due Diligence Obligations in Supply Chains* (LkSG) on the smallholder cocoa farmers in West Africa. The study primarily relies on a literature review and an impact pathway to conduct a systematic analysis to identify the potential effects of the LkSG on smallholder cocoa farmers. The findings indicate that some, but not all of the risks addressed by the LkSG align with those faced by smallholder cocoa farmers and their families. Additionally, the research also reveals weaknesses, particularly in managing environmental risks, which the LkSG does not adequately cover. Our findings show that in the short- and medium-term, the LkSG has no potential effects on smallholder cocoa farmers. Furthermore, the potential positive impacts of the law on smallholder cocoa farmers will take a long time to realize, as the LkSG considers primarily tier-1 suppliers. Companies in Germany might reassess their supply chains to strive for an LkSG-risk-free supply chain, which could in the long term have sustained impacts on smallholder cocoa farmers. However, we recommend a comprehensive risk analysis of the cocoa supply chain to enhance the human rights of cocoa farmers.

4.1 Introduction

Many countries have enacted regulations regarding human rights due diligence (HRDD) or are planning to introduce them [9, 177, 247, 341, 342]. The regulations aim to improve the safeguarding of human rights and target employees in companies with a primary focus on developing countries, where there is inadequate protection and a prevalence of human rights and environmental risks and violations [9, 127]. The question then arises as to what extent these HRDD regulations impact developing countries. To answer this question, this paper aims to analyze the newly enacted *Lieferkettensorgfaltspflichtengesetz* (LkSG), in English: Act on Corporate Due Diligence Obligations in Supply Chains, for companies in Germany from the perspective of smallholder cocoa farmers in West Africa and potential effects on them.

Retailers and chocolate manufacturers in Germany are part of the global cocoa supply chain, with smallholder cocoa farmers in West Africa, saving as key upstream participants [343] by producing more than 65% of the world's cocoa beans [344]. Therefore, as part of the global cocoa supply chain, smallholder cocoa farmers may feel some spillover effects from the implementation of the LkSG. In addition, the primary aim of the LkSG is to improve fundamental human rights and environmental protection in global supply chains [345].

Therefore, the research question is:

What are the potential effects of the LkSG on smallholder cocoa farmers in West Africa?

To answer our research question, we used a methodology encompassing both a literature review and a logic model. This approach facilitated a systematic and in-depth analysis to identify the potential effects of the LkSG on smallholder cocoa farmers. Due to the rather recent enactment of the LkSG in Germany in 2023, there is a lack of available data and identifiable effects, particularly in developing countries. Furthermore, since the affected chocolate manufacturers and retailers are required by the LkSG to release their reports for 2023 by April 2024, these data are unavailable for our study. For this reason, we conducted a critical examination of the legal text of the LkSG in light of existing literature, emphasizing logical interdependencies. To capture the perspective of smallholder cocoa farmers in Ghana and Côte d'Ivoire, a comprehensive review of the cocoa supply chain with a focus on smallholder cocoa farmers was carried out. This aimed to identify the circumstances surrounding smallholder cocoa farmers and delve into their socio-cultural norms and values for the analysis of the LkSG from their perspective. Our findings were then organized through a logic model. The logic model has been proven to be an appropriate method in various studies [346–351], especially for assessing different kinds of new programs to identify potential effects [346, 347, 349, 351, 352]. Subsequently, we discussed the potential outputs, outcomes, and impacts of the LkSG on smallholder cocoa farmers in West Africa. To the best of our knowledge, this study represents the first examination of the LkSG and its effects on smallholder cocoa farmers, providing valuable insights into their perspective. Moreover, the study assesses the real-world implications of the LkSG by determining whether it can effectively enhance due diligence practices and promote supply chain sustainability in the global cocoa supply chain, with a specific focus on its first link, the smallholder cocoa farmers.

The paper is structured as follows. Section 4.2 provides the fundamentals on impact assessments and HRDD regulations as well as the current state of research regarding the effects of the LkSG on developing countries. Section 4.3 outlines the LkSG and provides an overview of insights and challenges within the cocoa supply chain. Section 4.4 analyzes the LkSG from the perspective of the smallholder cocoa farmers, examining the extent to which the LkSG addresses their identified risks. Additionally, this section explores the scope and procedural implications of the LkSG as well as the role of NGOs and the media. Furthermore, potential outputs, outcomes, and impacts of the LkSG on smallholder cocoa farmers are discussed. The final section 4.5 then outlines the research findings and points out limitations and recommendations for further research.

Our study advances the scholarly discourse on supply chain legislation. The theoretical contribution of this study lies in the extension of theoretical frameworks for impact assessments, especially in the realm of supply chain legislation using the

example of the LkSG. Our analysis of the LkSG within this theoretical context provides a deeper understanding of its implications, particularly considering the perspective of smallholder cocoa farmers in West Africa. Furthermore, the study yields practical insights relevant to policymakers, chocolate manufacturers, and retailers affected by the LkSG. Particularly, our analysis illuminates the risks pertinent to smallholder cocoa farmers' socio-cultural norms and values, and the potential effects of the LkSG on their livelihoods.

4.2 Literature Review

This study adopts a literature review to assess existing knowledge on the subject. The increased pace, fragmentation, and interdisciplinary knowledge in business research, present challenges for staying current and comprehensively evaluating cutting-edge research, underscoring the critical role of the literature review as a research method in navigating this complex landscape. This emphasizes the importance of literature review as a research method and its subsequent wide adoption for scientific investigations [353]. A literature review not only offers an overview of disparate and interdisciplinary research areas but also serves as a crucial tool for synthesizing evidence on a meta-level, revealing gaps that require further research—integral to the development of theoretical frameworks and conceptual models [353–355].

In conducting our literature review for this academic paper, we systematically employed keyword searches across electronic databases, notably Google Scholar, in both German and English languages to identify pertinent materials aligned with our research inquiry. In elucidating our analysis, particularly concerning the perspectives of smallholder cocoa farmers, their risks, and the exploration of their cultural norms and values, we confined our examination exclusively to scholarly literature from reputable journals and reports to ensure academic integrity and credibility. While our core analysis was firmly rooted in academic literature, we acknowledged the necessity of incorporating industrial literature for specific information about retailers or chocolate manufacturers. This included reports and official websites, which, although not part of our central analysis, provided valuable insights into the cocoa industry. For the LkSG, our resources included the legal text and scientific articles from recognized journals and publishers. Given the limited number of articles published on LkSG, we found it beneficial to incorporate literature from both academic and practical sources, thereby ensuring a comprehensive understanding of the subject matter. This approach allowed us to enrich our analysis by leveraging insights from diverse perspectives, enhancing our literature review's robustness and depth.

4.2.1 Fundamentals on Impact Assessments

In literature, various types of impact assessment with distinct origins and applications exist [356–360]. Impact assessment is defined as a process aimed at identify the effects of policies, projects, or programs [356, 361, 362]. It can be applied to both ex-post and ex-ante activities [356, 363]. Furthermore, some studies narrow down this applied impact assessment to what is referred to as a human rights impact assessment. However, within the literature, a uniform understanding of the definition and implementation process is lacking [356, 364, 365]. Additionally, some studies [346–351] employ a framework in the form of an impact pathway, also known as a logic model, to systematically analyze the potential effects of new programs. Thereby, the identified implications are distinguished within a temporal dimension [352, 366].

However, the term impact assessment is often inconsistently defined and used for various purposes [352, 360, 367, 368]. In this study, we distinguish between the three key concepts: output, outcome, and impact, constituting the concept of the impact pathway. Outputs in this vein mean immediate results, while outcomes are defined as medium- and long-term results of activities. Impacts are characterized as long-term effects, implying a sustained change. For instance, an output may be training farmers. Outcomes, in turn, represent sustained changes such as enhanced farming practices or increased income. Impacts, exemplified in the farmer training example, encompass broader societal benefits, such as sustained reduction of poverty and improved social well-being [352, 366, 369]. Nonetheless, outputs do not always lead to outcomes, and outcomes do not automatically result in impact [352, 366].

4.2.2 Assessments of the LkSG on Developing Countries

The LkSG is a new and highly debated law in Germany, passed in July 2022, and came into force on January 1, 2023 [9]. Few scientific publications have engaged with the LkSG since it is relatively recent [261, 262, 370, 371]. However, publications have steadily increased since the introduction of the LkSG.

The literature focuses primarily on discussing legal perspectives and examining the effects of the LkSG on companies in Germany rather than on developing countries [261, 262, 372–374]. Few scientific studies mention the potential negative implications of the LkSG on developing countries without a comprehensive assessment [375, 376]. However, some studies align partly with our research question. For example, the scientific study by Komba et al. [377] on the effects of the upcoming European Corporate Sustainability Due Diligence Directive (CSDDD) on the garment industry in Ethiopia and the coffee industry in Tanzania draw conclusions based on their findings from their literature review. Besides their methodology, their findings may be of limited relevance to this study, as they primarily suggest that companies and smallholder farmers in Ethiopia and Tanzania adapt to the CSDDD to maintain their appeal to European markets [377].

The study by Müller et al. [378] explores how public-private cooperation can strengthen supply chain laws and increase sustainability in the case of the South African mining sector. The authors did not especially analyze the effects of the LkSG but comment in their report that the LkSG would have no implications on mines in South Africa. Müller et al. [378] reason that there are no major German mining companies on-site that could exert influence on the enforcement of the LkSG. They suggest that Germany should advocate for a risk-based approach in the planned CSDDD to minimize social and environmental risks. The authors argue that such an approach would cause the private sectors to exceed the minimum legal standards and effectively address the shortcomings of the LkSG [378]. The conclusion drawn by Müller et al. [378] is in line with the main criticism of the LkSG, asserting that companies in Germany subject to the LkSG should primarily focus on their direct suppliers, rather than encompassing all suppliers along their supply chain including developing countries [379, 380]. The study by Kolev and Neligan [375] primarily focuses on the expected effects of the LkSG on affected companies in Germany. However, the authors draw conclusions for developing countries based on their survey results: Developing countries with poor governance must expect potential employment losses and negative development effects in connection with foreign investment [375]. Furthermore, risk profiles of every cocoa-producing country are available based on a Western perspective, which is provided in the context of a

guideline for cocoa-producing companies affected by the LkSG [381]. This is a starting point for a critical analysis of the addressed risks in the LkSG from the smallholder cocoa farmer's perspective.

At present, there are only a few publications about the LkSG, that consider the perspective of developing countries. In addition, broad assessments of the potential effects of the LkSG in developing countries are lacking. Hence, our study differs from the above literature by analyzing the newly implemented LkSG and its human rights due diligence implications on smallholder cocoa farmers in West Africa. To the best of our knowledge, this study represents the first comprehensive analysis and discussion of the LkSG and its effects in developing countries with a special focus on smallholder cocoa farmers.

4.3 Comprehending the LkSG and the Cocoa Supply Chain

This section provides an overview of the LkSG to enhance understanding its due diligence framework. Furthermore, we demonstrate the cocoa supply chain while exploring the issues smallholder cocoa farmers face in Ghana and Côte d'Ivoire to seek deeper insights into their situation. This contextual information proves crucial for our subsequent analysis of the LkSG in section 4.4. Figure 4.1 presents a flowchart outlining our research methodology, improving clarity, and understanding of our investigative process.

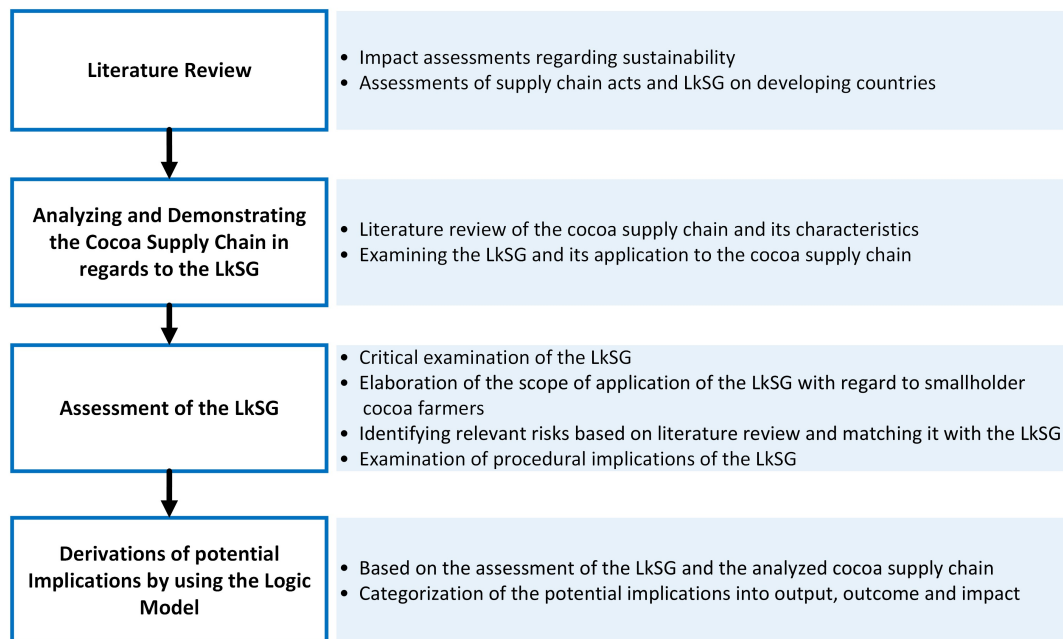


Figure 4.1: Overview of the research methodology.

4.3.1 German Act on Corporate Due Diligence Obligations in Supply Chains (LkSG)

The LkSG was passed in July 2021 and became effective in January 2023. The law applies to companies in Germany with more than 3,000 employees and, from 2024, with more than 1,000 employees within Germany, wherein employees of affiliated

companies in Germany shall also be considered and deployed employees. The LkSG aims to prevent or minimize human and environmental-related risks or to end the violation of human rights or environmental-related obligations. The appropriate cause of action by companies depends on the nature and scope of their business activities and their level of influence [9]. Furthermore, the LkSG primarily focuses on the company's own business unit and its direct (tier-1) suppliers; indirect (tier-n) suppliers only need to be considered when substantial knowledge is available. Substantial knowledge in the vein of the LkSG, means that a company has an actual indication of a human rights or environmental-related violation within its supply chain [9]. Furthermore, the actions taken by companies are also influenced by the expected severity or probability of the violation. The LkSG imposes a duty to make an effort but does not guarantee an obligation and does not entail civil liability in case of violations [9]. This means that affected companies must not guarantee that their supply chains are free of human rights and environmental-related risks. They instead need to prove that they comply with the due diligence regarding the LkSG within reason [9, 382].

In 2024, the LkSG is expected to apply directly to about 2,900 companies in Germany [383]. Among the sweet industry companies in Germany, only 18 have over 500 employees [384]. Considering the employee threshold, only a few companies in the chocolate sector might have to implement due diligence, according to LkSG. However, even small and medium enterprises, falling below the employee threshold, are indirectly impacted. Although they are not under the LkSG, they must comply with certain due diligence requirements passed on by the companies concerned with their suppliers [385].

4.3.2 The Cocoa Supply Chain in light of the LkSG

The cocoa supply chain starting in West Africa, particularly in Ghana and Côte d'Ivoire, involves numerous actors and is lengthy and complex [386]. Moreover, cocoa plays a crucial role in the region's economy and is a significant source of income for numerous smallholder families involved in cocoa farming [387, 388]. The smallholder cocoa farmers in Ghana and Côte d'Ivoire, about 1,650,000 farmers and families [389, 390] living at the subsistence level, struggle against economic, social, and environmental issues [389, 391]. Such as low income, lack of access to electricity and clean water, and inadequate road infrastructure [391].

Figure 4.2 represents the cocoa supply chain, starting with the smallholder cocoa farmers based in a high-risk country in view of the LkSG. The scope of the LkSG varies along the cocoa supply chain, determining which actors are responsible for enforcing the LkSG. Based on the LkSG, the primary focus is on the affected companies' own business units and their tier-1 suppliers. While retailers and chocolate manufacturers in Germany are directly affected by the law, the chocolate manufacturers can be considered both as their own business unit and as tier-1 suppliers to the retailers.

Retailers like Aldi, EDEKA, or REWE, who are also obliged to apply the LkSG, have their tier-1 suppliers (chocolate manufacturers) mainly in Europe. Looking at chocolate manufacturers in Germany, such as Ferrero, Mars, or Alfred Ritter¹, their tier-1 suppliers for cocoa products are usually processing companies like Barry Callebaut, headquartered in Switzerland, or Cargill, headquartered in the USA, both of

¹In terms of their employee numbers in Germany, Ferrero will be subject to the LkSG from 2023, and Mars from 2024 [392, 393]. The number of employees within Germany at Alfred Ritter is unclear, as only the worldwide number of employees is known [394].

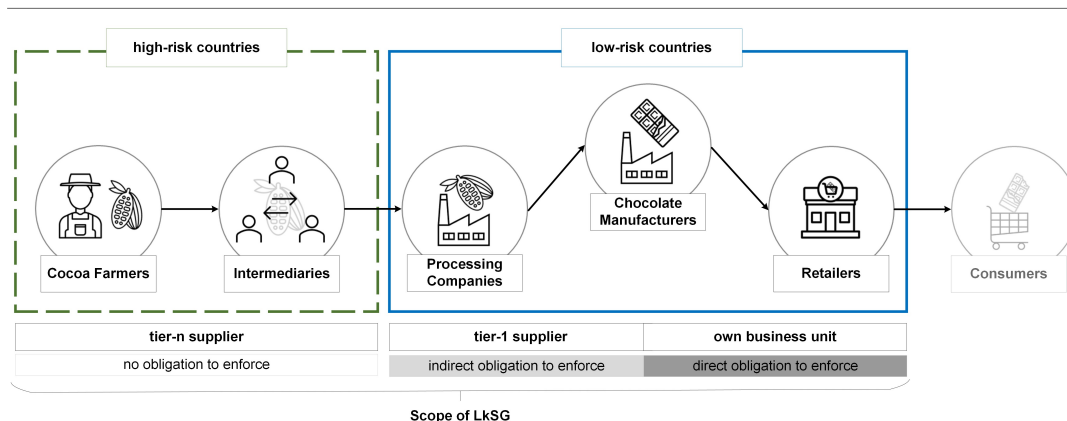


Figure 4.2: Generalized cocoa supply chain from the perspective of the LkSG. (In)directly affected entities by the LkSG are displayed by square, while those unaffected are displayed by square outlined with dashed lines.

which have sites in Germany (see Figure 4.2) [386, 395, 396]. Though 80% of the world's cocoa beans are produced in West Africa, only about one-third of them are processed there [397–399]. This indicates that the tier-1 suppliers of chocolate manufacturers in Germany, mainly processing companies, are primarily located in low-risk countries. The cocoa farmers and intermediaries operate in high-risk countries and serve as tier-n suppliers to German retailers and chocolate manufacturers that are consequently not affected by the LkSG (see Figure 4.2).

The governmental institutions, the Ghana Cocoa Board (COCOBOD) and the Conseil du Café-Cacao (CCC) in Côte d'Ivoire both regulate the cocoa market and prices in their respective countries [388, 400]. The cocoa farmers in Ghana are not mandated to sell their beans to any entity apart from the Licensed Buying Company (LBC) [400, 401], the cocoa farmers in Côte d'Ivoire can sell their beans directly to private buyers (pisteurs), cooperatives, exporters, or processing companies [388]. Despite the combined efforts by the Ivorian (CCC) and Ghanaian (COCOBOD) institutions to introduce the Living Income Differential (LID) in 2019 to raise the global cocoa market price [402], many smallholder cocoa farmers continue to receive low incomes [391, 403]. This is primarily due to the low farm gate prices for cocoa beans [391, 403].

4.4 Assessment of the LkSG from the Perspective of Smallholder Cocoa Farmers

As described in Section 4.3.1, the LkSG aims to safeguard human rights and the environment. Given that human rights abuses and environmental challenges tend to be more prevalent in developing countries, as opposed to Europe or Germany, it is important to analyze whether the LkSG has potentially positive implications for developing countries. Hence, this section examines the LkSG from the standpoint of smallholder cocoa farmers in West Africa, specifically in Ghana and Côte d'Ivoire.

4.4.1 Scope of the LkSG with regard to Smallholder Cocoa Farmers

The LkSG applies only to companies with at least 1,000 employees in Germany and encompasses its business unit and tier-1 suppliers. It is important to note that the

company's business operations may include subsidiaries in Germany and abroad, provided that the parent company exercises significant influence over them [9]. Thus, affected processing companies and chocolate manufacturers based in Germany are only obligated to consider due diligence within their business units and tier-1 suppliers. As demonstrated in Figure 4.2, smallholder cocoa farmers are not tier-1 suppliers of retailers or chocolate manufacturers in Germany, but rather tier-5 and tier-4 suppliers. Consequently, the smallholder cocoa farmers are not directly captured in the scope of the LkSG and must only be considered when the retailers or chocolate manufacturers receive an actual indication of human rights or environmental violations covered by the LkSG [9]. Such information may be received through the complaints procedure the companies have to establish under the LkSG.

In contrast to the LkSG, the planned CSDDD encompasses the entire supply chain. Consequently, smallholder cocoa farmers in Côte d'Ivoire and Ghana would need to be considered, rather than in individual cases only, as currently practised within the LkSG [9, 342]. Therefore, the LkSG might have a limited effect on smallholder cocoa farmers. However, it is also possible that the procedural implications resulting from the LkSG may already show initial improvements in the challenges of smallholder cocoa farmers.

4.4.2 Relevant Risks for the Smallholder Cocoa Farmers addressed in the LkSG

The LkSG addresses human rights risks and environmental-related risks, which are further defined within the LkSG (§ 2 para. 2 and para. 3 LkSG). The subsequent section aims to identify the relevant risks that the LkSG addresses concerning smallholder cocoa farmers in West Africa and to evaluate whether these risks can mitigate the challenges faced by these farmers and improve their well-being. According to § 2 para. 2 of the LkSG, 20 definitions are stated under human rights and environmental risks [9]. Out of the 20 definitions, we identified 5 aspects that might be relevant and partly challenging for smallholder cocoa farmers. The five relevant risks were identified based on a review of the literature on human rights and environmental risks associated with smallholder cocoa farmers in West Africa [381, 404–406]. Following that, we compared these identified risks with those addressed in the LkSG. In the following subsection, we point out and discuss these aspects.

4.4.2.1 Child Labor under 15 Years (§ 2 para. 2 no. 1 LkSG)

From the developed world's perspective, the work activities of children under the age of 15 violate human rights and are a relevant main risk for smallholder cocoa farmers addressed in the LkSG. Even though the Ivorian and Ghanaian governments have agreed to the Harkin and Engel protocol as well as to the Convention on Child Labor by the International Labour Organization (ILO), we need to understand that the concept and definition of child labor in these countries are seen as Western-centred international standards [404, 407–410]. Therefore, it is important to consider the Ghanaian and Ivorian socio-cultural norms and values, which are highly similar due to their shared history. Their norms and values make it difficult to fully align with international child rights standards [387, 404]. From the smallholder cocoa farmers' perspective, involving their children in farm work is perceived as educational, not child labor, and farming is valued more than formal education [404, 411]. This arises from the belief that farming, unlike formal education, ensures a future for their

children. The decision to involve children in farm work is based on capability, not age, to provide practical skills and experiences. This process is viewed as socialization, preparing children for independent adulthood and future family responsibility [404, 411, 412]. In line with socio-cultural norms, Ghanaian and Ivorian children bear family responsibilities from birth, supporting their parents in farming to enhance family income to meet essential needs, as hiring additional labor is often financially unfeasible for smallholder cocoa farmers. Most Ghanaians and Ivorians view child labor as culturally acceptable since it has been in practice for decades. They rather see child labor and children's rights as a foreign concept inconsistent with their social norms and values [404, 407, 411, 412]. The study by Krauss [411] indicates that the socio-cultural norms and values are sustained within farming communities and by politicians, as shown by a statement made by a Ghanaian Minister of Education during his research [411].

To summarize, child labor by smallholder cocoa farmers is perceived as a human rights violation primarily by Western countries rather than by the smallholder cocoa farmers themselves. For these farmers, their children working alongside them on the farm is seen as a form of support and education, aligning with their socio-cultural norms. However, both Ghanaian and Ivorian governments being signatories to the ILO convention to reduce child labor, view the international standard as problematic [413]. Despite, these agreements about 60% of all children in all agricultural households are still involved in cocoa farming, posing a risk for smallholder cocoa farmers [414, 415]. Smallholder cocoa farmers disagree with the Western-centered concept of child labor and have no intention to alter their way of life and farming practices, considering their socio-cultural norms and values. Nevertheless, given the objectives and risks associated with the LkSG, it can be seen as cultural imperialism as it interferes with the farmers' way of life and their socio-cultural norms and values, without asking them. The smallholder cocoa farmers are unwilling to accept this Westernization in their socio-cultural norms and values.

4.4.2.2 Worst Form of Child Labor (§ 2 para. 2 no. 2 LkSG)

§ 2 para. 2 LkSG classifies the Worst Form of Child Labor (WFCL) risk into four categories: Category (a) encompasses forced labor, (b) includes prostitution and pornography, (c) covers illicit activities such as related to drugs, while category (d) involves work that harms the health, safety, or morals of children. The first category (a) and the last category (d) are particularly relevant risks for farmers, especially for their children [9].

In a prominent case in 2005, six former child laborers filed individual lawsuits against Nestlé and Cargill under the Alien Tort Claims Act, because they were enticed from Mali and coerced to work on cocoa farms in Côte d'Ivoire under dire conditions [416, 417]. Since that case, more than two decades have passed. However, there are still instances of children being subjected to forced labor on cocoa farms, albeit on a more localized and limited scale [406, 418]. According to the study conducted by Buhr and Gordon [406], they estimated that the percentage of children in forced labor in Ghana and Côte d'Ivoire is < 0.20%.

As described in Section 4.4.2.1, the socio-cultural norms and values are crucial. Smallholder cocoa farmers prioritize their children's well-being and future, with no intention of causing harm to them [407, 419]. The study by Babo [407] indicates parents' awareness of farm activities posing risks to children, restricting their involvement in hazardous tasks like using cutlasses until the parents consider that they can

use them without hurting themselves. During this period, children observe and learn from the elders on the cocoa farm [407].

According to the Ghanaian and Ivorian governments, hazardous work for children under 18 is, e.g., spraying insecticides, breaking cocoa pods with a cutlass, or carrying heavy loads [420, 421]. Furthermore, both governments have agreed to the Harkin-Engel Protocol and the ILO Convention No. 182 to eliminate WFCL [408, 409, 413]. This indicates that the governments recognize WFCL in their countries and aim to eliminate it [420, 421]. However, according to the study by Sadhu et al. [414], about 55% and 47% of children in agricultural households in Ghana and Côte d'Ivoire, respectively, are affected by hazardous work on cocoa farms [414]. Despite parents' awareness of hazardous child labor, many children are engaged in such activities, making it a significant risk. The authors identified that injuries sustained by children involved in hazardous work on cocoa farms in both countries primarily occur in the form of wounds/cuts (35%) and skin scratches/itching (8%) [414]. Nonetheless, there is a lack of research that quantifies the actual number of children sustaining accidents or injuries due to hazardous labor.

Similar to *Child Labor under 15 Years* the LkSG acts as cultural imperialism by seeking to impose the Western perspective on WFCL among smallholder cocoa farmers. Except for the extreme case in Côte d'Ivoire, WFCL mainly involves hazardous tasks performed by physically capable children under parental supervision on cocoa farms. While farmers perceive no issues, the LkSG seeks to intervene by addressing and eliminating this risk.

4.4.2.3 Employment in Forced Labor (§ 2 para. 2 no. 3 LkSG)

In this section, we focus solely on adults in forced labor, as the issues of children in forced labor fall under the category of WFCL, as discussed in the previous section.

Forced labor is categorized as work performed involuntarily and under the threat of penalties. It includes situations where individuals are compelled to work through violence, intimidation, or coercive tactics [422]. In Côte d'Ivoire and Ghana, there are existing cases of forced labor among adults on cocoa farms [406, 423]. This issue affects not only local people but also migrants from neighboring countries. However, the risk is particularly high in Côte d'Ivoire, where migrants from neighboring countries such as Burkina Faso or Mali are coerced and forced to work on cocoa farms [381, 406]. Despite this, both countries have ratified the ILO forced labor convention [422]. According to the study by Buhr and Gordon [406], an estimated 0.33% of adult workers in Ghana and 0.42% of adult workers in Côte d'Ivoire were subjected to forced labor between 2013 and 2017 [406]. The study focused on medium- and high-production areas, excluding low-production areas and illegal farms [406]. These findings align with Lebaron's research [405], emphasizing the difficulty of isolating forced labor as workers often shift between forced labor and less severe forms of abuse within short periods [405]. With regard to the LkSG, it is crucial to acknowledge that this problem poses a human rights risk in both countries, even though measuring its extent remains challenging [406].

4.4.2.4 Occupational Safety and Health Obligations (§ 2 para. 2 no. 5 LkSG)

Cocoa farming poses health risks through the use of sharp tools, carrying heavy loads, spraying agrochemicals, or working in extreme weather conditions, as well as the possibility of being bitten by poisonous animals [424–426]. The study of Bosompem

and Mensah [425] indicates that injuries primarily from cutlasses, stump/thorn, and ant bites, are common. Furthermore, smallholder cocoa farmers suffer from back and waist pains during the harvest season or headaches from agrochemical inhalation [425]. Injuries can take up to 15 days a year when the farmer cannot work, leading to a yearly monetary loss (medical treatment and absent days) of about 17% of their annual revenue [425, 426].

Smallholder cocoa farmers, though willing to protect themselves, face challenges. Essential personal protection equipment like Wellington boots, overalls, or gloves is often unaffordable due to financial lack. Additionally, the unavailability of such equipment in local areas necessitates long-distance travel for purchase. Some farmers also encounter issues with size availability, leading to discomfort, such as wearing incorrectly sized Wellington boots or overalls for long distances in the sun [426, 427].

Occupational safety and health obligations for smallholder cocoa farmers in both countries are currently lacking. However, it is worth noting that Ghana has ratified the ILO Safety and Health in Agriculture Convention, indicating some recognition of the importance of safety and health in agricultural practices [428]. Despite the significance of safety and health for smallholder cocoa farmers, financial constraints prevent most from affording personal protection equipment that could help mitigate these risks and injuries [425–427]. This risk addressed in the LkSG benefits cocoa farmers and can significantly contribute to improving occupational safety in cocoa farmers' working lives.

4.4.2.5 Withholding an Adequate Living Wage (§ 2 para. 2 no. 8 LkSG)

This aspect of the LkSG aims to ensure that employees are paid remuneration to have a decent living for themselves and their families [9, 429]. The LkSG states that fair payment is at least the applicable minimum wage [9]. However, a minimum wage does not always lead to a decent living, so fair remuneration can also be above the minimum wage to enable an adequate living [429]. Widespread poverty persists among smallholder cocoa families, as their very low income prevents them from achieving a decent standard of living [391, 430, 431].

The majority of smallholder cocoa farmers in Côte d'Ivoire and Ghana work as self-employed individuals, implying that they do not receive any form of remuneration. The farmer's remuneration is essentially the profit from selling cocoa sacks to middlemen at government-fixed prices. Few smallholder cocoa farmers can afford occasional labor assistance, typically for specific tasks, and no formal contracts exist. Working conditions for *employed* individuals are non-transparent, relying on oral agreements without considerations like a minimum wage, making tracking of working conditions difficult [391, 432, 433]. It is crucial to highlight that Côte d'Ivoire has signed the ILO convention for a minimum wage in agriculture, whereas Ghana has not signed it [434]. In Ghana, the minimum wage is about 1.16 Euros per day per person, and that in Côte d'Ivoire is about 3.81 Euros a day per person [435, 436]. A smallholder cocoa family receives a total average annual revenue of about 600 Euros. Considering the additional expenses such as those from purchasing fertilizers and other farming equipment, the farmers in both countries earn below their local minimum wage. Thus, smallholder cocoa farmers can only meet the country's minimum wage and obtain a so-called living income or decent living, if the cocoa price is raised significantly [391, 431, 437]. Overall, this risk is a daily challenge for smallholder cocoa farmers, even though they are self-employed they can only depend on the cocoa price set by their governments.

4.4.2.6 Remarks on the relevant Risks from the Perspective of Smallholder Cocoa Farmers

About 15% of the addressed risks in the LkSG are significant issues for smallholder cocoa farmers and have a major effect on their well-being. The identified risks, which are existing issues for cocoa farmers are the following: (1) forced labor, (2) withholding adequate living wage, and (3) occupational safety and health obligations. Child labor and WFCL are omitted, as they are not perceived as issues from the perspective of the smallholder cocoa farmers due to their socio-cultural norms and values. In this regard, the LkSG would also interfere with the farmer's socio-cultural norms and values for some of the addressed risks in the LkSG, thereby enforcing cultural imperialism. Therefore, we emphasize considering the socio-cultural norms of Ghana and Côte d'Ivoire when analyzing human rights, avoiding a solely Western perspective, and refraining from imposing European standards. Smallholder cocoa farmers and their families generally do not face major or common issues related to the other specific definitions of human rights risks in the LkSG, such as forms of slavery, violation of freedom of association, and use of private or public security forces to protect enterprise projects. Although the environmental risks addressed in the LkSG have no relevance to smallholder cocoa farmers, two significant environmental risks are entirely not covered by the law. The first is deforestation. Ghana has lost about 65% of its forest area and Côte d'Ivoire about 90% in the last 30 years, where cocoa production is the primary driver [387, 438, 439]. The second risk is the high usage of agrochemicals and pesticides in cocoa production [391]. However, as a result, when considering only the identified relevant addressed risks, the LkSG can have positive impacts, especially in terms of occupational safety and health obligations, adequate living wages, and forced labor.

4.4.3 Procedural Implications of the LkSG for affected Companies in Germany

In this section, we aim to shed light on the procedural effects of the LkSG on the companies from the perspective of smallholder cocoa farmers. Therefore, we systematically assess the entire due diligence process, that the LkSG requires from the affected companies.

4.4.3.1 Risk Management and Risk Analysis

All chocolate manufacturers and retailers in Germany that are required to comply with the LkSG must primarily implement risk management for their business unit and its tier-1 suppliers to comply with the due diligence obligations (see Figure 4.3). The risk management must be effective and appropriate and needs to be monitored by a human rights officer of the company (§ 4 LkSG).

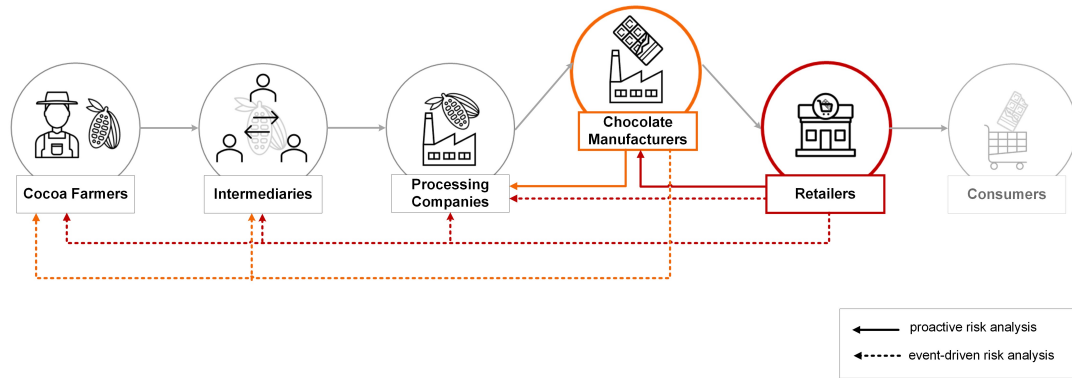


Figure 4.3: Proactive and event-driven analysis based on the own business unit of retailers and chocolate manufacturers along the generalized supply chain. Proactive risk analysis, denoted by a solid arrow, is mandatory and must be conducted at least once a year for the own business unit and tier-1 suppliers, while event-driven risk analysis of tier-n suppliers, indicated by a dashed arrow, needs to be conducted by substantiated knowledge only.

As part of risk management, it is necessary to carry out an adequate risk analysis to identify human rights and environmental-related risks within the company's business unit and its tier-1 suppliers (§ 5 LkSG). The risk analysis must be performed annually and occasionally, such as a change in the risk landscape within the supply chain [9]. However, the LkSG does not provide a specific method for conducting the risk analysis, leaving it up to the company to choose an appropriate approach [9, 372]. Initially, the annual risk analysis does not significantly affect cocoa farmers, as only the company's own business unit and tier-1 suppliers need to be considered (see Figure 4.3).

Looking at the supply chain of chocolate manufacturers in Germany (see Figure 4.3), they procure their processed cocoa, such as cocoa butter or liquor, from processing companies primarily located in Europe as pointed out in Section 4.3.2. Likewise, the chocolate manufacturers of retailers are based in Europe. Smallholder cocoa farmers, who are tier-n suppliers for companies in Germany are not covered by the LkSG because affected companies are not required to conduct a proactive risk analysis of them. A risk analysis must only be carried out for cocoa farmers if the company has substantiated knowledge [9]. Affected chocolate manufacturers in Germany can obtain substantiated knowledge about risks or violations of human rights in cocoa production through, e.g., the complaints procedure, media reports, or NGOs [9, 391, 440]. Consequently, an event-driven risk analysis must be conducted. As a result, this leads to implementing preventive measures and actions to mitigate or eliminate the identified risks in cocoa production (see Section 4.4.3.2). However, this reveals a weakness of the LkSG – the exclusion of tier-2 and beyond suppliers. Excluding tier-n suppliers from proactive risk analysis is a main criticism of the LkSG. Former UN Secretary-General John G. Ruggie, in an open letter to the German Government, highlighted this omission and expressed concerns about the timing of substantiated knowledge, as conducting a risk analysis after a violation may be too late [379]. For smallholder cocoa farmers, who are tier-n suppliers for affected companies in Germany, a risk analysis is only required if the retailer or chocolate manufacturer in Germany has substantiated knowledge of impending or existing harm [9].

4.4.3.2 Preventive and Corrective Measures

Appropriate preventive measures must be taken if a company identifies risks within its annual or event-driven risk analysis (§ 6, § 9 LkSG). If identified risks have occurred or are imminent, the company must implement corrective actions immediately to prevent, cease, or minimize violations (§ 7 LkSG). The LkSG distinguishes between ending the violation within the company's business unit and tier-1 supplier. In the business unit, the prevention measure must effectively end the violation. For tier-1 suppliers, if the violation cannot be stopped immediately, the company must develop and implement a concept with a schedule to minimize or end the violation [9]. In case of substantiated knowledge regarding tier-n suppliers, besides the event-driven risk analysis, retailers or chocolate manufacturers need to implement prevention measures (§ 9 LkSG), which can be classified as an output. Furthermore, those companies must develop and implement a concept to prevent, end, or minimize the identified risks or violations. This can significantly affect smallholder cocoa farmers' well-being since the retailers and chocolate manufacturers are legally obligated to implement the respective preventive and remedial measures and review and document them accordingly. However, it should be noted that the LkSG establishes an obligation to make an effort but does not guarantee success or assume liability. It means that companies must demonstrate that they have implemented the due diligence requirements under the LkSG. Thus, they are not obliged to ensure they are entirely free from human rights violations or environmental issues [9, 207, 382, 441]. Moreover, the LkSG states that the action taken by a company depends on its potential influence on the direct cause of the risk or violation. The LkSG provides examples such as the size of the company, order volumes, or proximity to the risk [9, 382, 441]. Falder et al. [442] argue that undefined legal terms could be problematic, as it is unclear which action should be taken. They highlight this problem by clarifying that the size of a company or the order volume should not determine the actions to be taken in case of grave human rights violations [442].

As a part of the preventive measures, retailers and chocolate manufacturers must also provide a policy statement based on their risk analysis (§ 6 LkSG). However, this policy statement does not immediately affect smallholder cocoa farmers. In the long term, it could affect smallholder cocoa farmers, as those companies need to define their human rights strategy and set expectations for their business partners along their supply chain. Whether this policy statement is more of a formal matter or has positive effects is questionable, but in any case, it may raise awareness. Therefore, it is required that companies establish agreements regarding appropriate contractual control mechanisms to ensure that the immediate supplier complies with the human rights strategy (§ 6 LkSG).

4.4.3.3 Complaints Procedure

In addition to risk analysis, companies must establish a complaints procedure (§ 8 LkSG), accessible to all individuals involved in the entire supply chain [9, 443]. In principle, this is a simple but only possibility to enable smallholder cocoa farmers to file complaints to retailers and chocolate manufacturers in Germany with regard to their issues and risks identified in section 4.4. Additionally, when a company receives an indication, it must investigate all reports and examine the reported issue. This can lead to an event-driven risk analysis of issues about smallholder cocoa farmers, eventually leading to a betterment of their situation.

However, as most farmers are uneducated and have poor technology access [386], it becomes challenging for them to learn about a German company's complaints procedure. Submitting complaints, whether through phone calls (which may incur costs for the farmers), voice messages, or websites that might be in English rather than their local language, becomes challenging. Although the complaints procedure must be implemented without any access barriers, it might still be a barrier to smallholder cocoa farmers, raising the question of whether they are even interested in utilizing it. Therefore, the smallholder cocoa farmers would also need information regarding the supply chain to contact the relevant manufacturer or retailer in Germany.

4.4.3.4 Annual Report

The affected companies must document all their actions regarding the required due diligence and publish annually a report regarding their fulfillment of the due diligence (§ 10 LkSG), which will be reviewed by the German authority (Federal Office for Economic Affairs and Export Control). In a broader sense, this due diligence will not directly affect smallholder cocoa farmers. Nevertheless, documentation and monitoring will show effects, leading companies to take seriously their due diligence obligations according to the LkSG.

4.4.3.5 Remarks on the Procedural Implications

The procedural implication of the LkSG can have a positive impact on smallholder cocoa farmers. Particularly, the complaint procedure and the event-driven analysis associated with it could have a positive effect on smallholder cocoa farmers, as companies are legally required to address the issues and initiate preventive measures (output), annually reviewed by the German authority. However, these effects may not be immediately noticeable to smallholder cocoa farmers, as the LkSG emphasizes the obligation to make an effort but not guarantee results. At the same time, they could justify their limited actions based on their influence over smallholder cocoa farmers as defined by the LkSG (§ 3 LkSG). The question then arises: suppose the big players in the chocolate industry such as Mars Wrigley, Ferrero Group, and Mondelez International, with greater influence to implement proactive and corrective measures, would fulfill their due diligence obligations, will it lead to an improvement for smallholder cocoa farmers? The answer to this question can only be provided in the future after several years of the LkSG implementation have passed. At the latest, when the CSDDD comes into force, the due diligence obligations for companies will become more extensive [342].

4.4.4 The Role of NGOs

In light of the challenges faced by smallholder cocoa farmers in lodging complaints, NGOs can play two major roles for them concerning the LkSG. Firstly, they can contribute substantial knowledge by reporting violations or risks through the complaint system of the respective chocolate manufacturer or retailer or directly to the German Federal Office for Economic Affairs and Export Control. Alternatively, they can generate reports or studies regarding human rights violations or risks faced by smallholder cocoa farmers. As explained in the previous section 4.4.3, substantiated knowledge triggers an event-driven risk analysis of the cocoa supply chain, which

in turn guides corrective measures to be taken by the respective manufacturer or retailer under the LkSG.

Secondly, according to §11 LkSG, a special litigation status is possible in that the person concerned along the supply chain, in this case, the cocoa farmer, can authorize an NGO or trade union for legal action. This special legal standing applies exclusively to NGOs and trade unions based in Germany that are not commercially active and are not only temporarily committed to human rights [9]. This implies that a German NGO, for instance, can uphold the rights of smallholder cocoa farmers, potentially resulting in significant legal expenses and harm to the reputation of the chocolate manufacturer or retailer involved. Nevertheless, the violation of an *overriding importance* of the concerned smallholder cocoa farmer's protected legal position under § 2 para. 1 of the LkSG must be asserted; the concrete requirements for such assertion remain indeterminate even according to the legislative rationale [9].

4.4.5 The Role of Media

Media is a powerful instrument and can have effects on the implications of the LkSG in two ways. Firstly, the media is crucial in creating awareness about human rights and environmental risks within supply chains for cocoa-containing products, particularly in Germany. Additionally, negative publicity regarding LkSG issues can adversely affect a company's reputation. This heightened awareness due to media can potentially influence the consumers' purchasing decisions. Consumer pressure is a main driver to push companies to more sustainable practices within their supply chains [444–446]. The consumers' awareness and pressure regarding human rights and environmental-related risks in the cocoa supply chain may shape the sourcing strategy of companies. Moreover, this might drive companies to initialize more LkSG-risk-free cocoa supply chains in the future, which will assist smallholder cocoa farmers in improving their situation in the long term.

Secondly, the media can play an important role in providing retailers and chocolate manufacturers in Germany with actual indicators of violations and risks within their cocoa supply chain, especially on cocoa farms. If this leads to a substantiated knowledge of those companies, they must conduct an event-driven risk analysis regarding smallholder cocoa farmers, as examined in Section 4.4.3 [9, 447]. In this regard, media attention could help smallholder cocoa farmers by potentially initiating a risk analysis for the retailer and chocolate manufacturers. Subsequently, preventive and corrective measures would need to be established depending on the identified risks to address existing violations and risks on cocoa farms. Therefore, the media can support smallholder cocoa farmers by generating awareness about their issues among consumers, retailers, and chocolate companies.

4.4.6 Remarks on the Effects of the LkSG on Smallholder Cocoa Farmers

The LkSG has the potential to incentivize chocolate manufacturers and retailers under the LkSG to reassess their cocoa supply chain, mitigating risks through supplier selection and development. This could instigate implications not only for German companies themselves but also for suppliers throughout the global supply chain. In addition to adjusting the sourcing strategy, worldwide suppliers may experience increased administrative requirements, as companies under the LkSG seek to ensure that their suppliers adhere to human rights compliance and pass this requirement down to their suppliers.

The LkSG's influence on awareness (outcome), driven by media attention and reputational concerns, can positively shape the entire company's cocoa supply chain in the long term. This influence can lead to increased vertical integration of chocolate manufacturers and retailers, addressing social and environmental risks, enhancing transparency, and striving for an LkSG-risk-free supply chain. Transparency, defined as a shared comprehension and accessibility to relevant information such as product information, transactions, or labor conditions, becomes crucial in achieving these goals. Achieving transparency requires providing complete, accurate, and relevant data based on the specific information needs of supply chain actors, ultimately allowing for a clear understanding of who delivered what to whom [448].

The trend towards vertical integration, already noticeable for social and environmental reasons, may intensify with the LkSG and forthcoming regulations [449–451]. However, challenges may arise due to the special cocoa market structure and governmental regulation, especially in Ghana due to COCOBOD, limiting the benefits for smallholder cocoa farmers. In Côte d'Ivoire, potential advantages through vertical integration exist, since cocoa sacks can be directly purchased from smallholder cocoa farmers. Despite this, the LkSG's efficacy might encounter limitations.

German companies, aiming for an LkSG-risk-free supply chain, may drive demand for socially and environmentally responsible cocoa, impacting sustainable farming practices. This impact may be realized through outputs such as farmer training, better resource access, and fostering social and environment-friendly farming. Simultaneously, as an output, these requirements may raise national governments' awareness of human rights and labor practices, potentially leading to long-term (national) legislative changes worldwide (impact).

Despite potential effects, emerging negative outcomes include companies contemplating withdrawing from high-risk countries or changing their purchasing strategy by prioritizing only countries with very low human rights and environmental risks [375]. The potential withdrawal of German companies from the African market as a response to LkSG, aiming to avoid serious consequences, may have adverse effects on nations characterized by elevated human rights and environmental risks. This scenario could be exacerbated by the entry of companies from countries with low human rights and environmental standards [452–454]. The LkSG, despite challenges, represents a step in the right direction. Companies in Germany, sensitized to ethical concerns, are preparing for upcoming regulations, offering potential advantages for the entire cocoa supply chain.

This study presents some limitations which provide opportunities for future research. Our literature review, though extensive, was limited to the literature that was accessible. Given that the LkSG is relatively new, forthcoming literature is anticipated to offer more pertinent insights. While our review was conducted from a desktop perspective, it provides a solid foundation for future field studies that could offer a more current representation of the situation on the ground. Based on these limitations, we recommend that future works should consider an empirical study to analyze the implications of LkSG on smallholder cocoa farmers' human rights. Additionally, future research could investigate how the LKSG influences upstream and downstream actors in the global cocoa supply chain.

4.5 Conclusion and Recommendation

A critical look at the cocoa supply chain in this study has revealed that human rights violations and environmental damages are not rampant in Europe, but rather at the beginning of the cocoa supply chain, specifically in Côte d'Ivoire and Ghana, where most of the world's cocoa is produced [381, 414].

The LkSG, a new law in Germany, has attracted considerable research attention, which tends to be argued from the perspective of Germany or Europe [261, 262, 372–374]. Given that the purpose of the LkSG is to improve the protection of human rights and the environment, it is also crucial to examine the LkSG from the perspective of individuals and countries where human rights and environmental risks persist. Few studies show the potential effects of the LkSG in developing countries, without thorough analysis [375, 376]. In addressing this gap in the literature, our contribution lies in analyzing the LkSG from the perspective of the cocoa smallholder farmers in West Africa and the potential implications the LkSG could have on them. To the best of our knowledge, this study represents the first thorough analysis and marks an initial investigation in this research area.

Due to its limitations, the LkSG may not lead to remarkable improvements for smallholder cocoa farmers and their families in the short and mid-term. This limitation arises because the LkSG primarily focuses on the affected retailers, chocolate manufacturers' business units, and tier-1 suppliers, which are mainly located in Europe. Since smallholder cocoa farmers are typically not considered tier-1 suppliers to either chocolate manufacturers or retailers in Germany due to their upstream position within a multi-echelon supply chain, they are not included in their proactive risk management, which must be conducted yearly. However, in the long term, the LkSG could positively impact smallholder cocoa farmers, as it may lead to increased awareness (outcome). This, in turn, is likely to affect the supply chain strategy of manufacturers and retailers in Germany, which might result in a positive impact on smallholder cocoa farmers. The results of this study, the effects of the LkSG on smallholder cocoa farmers may to some extent, apply to other farmers or workers in developing countries engaged in raw material production or extraction. This is because, given the complexity of supply chains, the first actors typically do not operate as tier-1 suppliers to companies in Germany and therefore are not the primary focus of the LkSG.

Overall the LkSG fails to achieve its goal of improving human rights and environmental protection by not directly including actors such as the cocoa farmers in high-risk countries, as these are usually not tier-1 suppliers to affected companies in Germany. However, the upcoming CSDDD is designed to be more stringent. For example, due diligence obligations not only apply to the company's own business unit and the tier-1 suppliers but also to the upstream and downstream value chain. Consequently, affected chocolate manufacturers and retailers in Europe would need to consider cocoa farmers, e.g., in their risk analysis which would lead to positive implications. Furthermore, affected companies could be held liable under civil law with the possibility of claims for damages being pursued, for instance [342]. All in all, we recommend German companies to develop suppliers in Africa through training and provision of necessary resources. This way, African suppliers can align with the requirements of German or European companies which are affected by the LkSG and in the future of the CSDDD.

This paper solely analyzed the perspective of smallholder cocoa farmers, neglecting other viewpoints like those of intermediaries in West Africa, chocolate manufacturers, or retailers. We recommend further research to explore these other perspectives, specifically focusing on how the LkSG influences companies' sourcing strategies and the challenges they encounter in ensuring due diligence according to the LkSG. Cocoa is one example of numerous commodities cultivated in environments plagued by human rights abuses or environmental hazards. Other commodities like Mica in India and Cobalt in the Republic of Congo, also carry substantial risks in their supply chains [455–457]. Therefore, we suggest additional surveys into the supply chains of other commodities, to gain a deeper understanding of the scope and effects of the LkSG and to determine whether its limited effect is influenced by the unique structural characteristics of the cocoa market in West Africa or if it can be generalized. Furthermore, our research does not consider the possible implications on the economy in West Africa resulting from the withdrawal of operations due to the LkSG implementation. Therefore, we recommend further analysis in this regard. Additionally, investigating any changes in companies' strategies and the extent to which vertical integration has increased to establish secure LkSG-risk-free supply chains would be valuable. Moreover, we highlight conducted studies in possible technology solutions, such as blockchain technology, where all the LkSG risks can be tracked to enhance full transparency in the cocoa supply chain.

In summary, while the LkSG is designed to enhance human rights and environmental conditions throughout supply chains, our research does not indicate any significant short- to mid-term positive implications for smallholder cocoa farmers. However, the law potentially leads to beneficial impacts for these farmers in the long run. Furthermore, our study suggests that the heightened awareness brought about by the law could ultimately shape supply chain strategies to the advantage of smallholder cocoa farmers in West Africa.

Sustainable Supplier Evaluation under Due Diligence Acts

Abstract

The enactment of due diligence legislation, such as the German Act on Corporate Due Diligence Obligations in Supply Chains, in German *Lieferkettensorgfaltspflichtengesetz* (LkSG), is reshaping global supply chain management by compelling companies to tackle heightened human rights and environmental risks in their supply chain. This study addresses the need for a comprehensive sustainability supplier evaluation framework by employing a systematic literature review with an expert survey of practitioners from German companies subject to LkSG. This methodology aligns academic findings with real-world practice and legal requirements, enriching the literature with practical insights. The results reveal that business practice prioritizes economic and social dimensions, whereas the literature focuses on economic and environmental dimensions. Although the most relevant economic and environmental criteria are consistent across both domains, the key social criteria show a notable misalignment. Managers can utilize the most relevant sustainability supplier evaluation criteria identified in this study to promote sustainable supply chains and ensure compliance with due diligence requirements. This research also highlights the high relevance of human rights as a social criterion, a dimension that has been historically under-recognized or implicitly addressed in the literature.

5.1 Introduction

In the past, companies had the option to voluntarily implement due diligence on human rights within their supply chains [458]. However, with the enactments of due diligence acts for supply chains, such as the German *Act on Corporate Due Diligence Obligations in Supply Chains*, in German *Lieferkettensorgfaltspflichtengesetz* (LkSG), the French *Loi de Vigilance*, or the US *Uyghur Forced Labor Prevention Act*, companies are compelled to adopt more sustainable practices along their supply chains [9, 177, 254].

These regulations aim to prevent and combat human rights and environmental abuse [9], particularly at the origin of supply chains, where high risks are prevalent, such as in the extraction and cultivation of raw materials [66, 459, 460]. For instance, the extraction of cobalt in the Democratic Republic of the Congo is characterized by

significant challenges, including child labor, forced eviction, and water and soil pollution [460, 461]. Concurrently, the cultivation of cashew nuts in West African countries, such as Nigeria, Ghana, and Côte d'Ivoire, is associated with child and forced labor, deforestation, and biodiversity loss [459, 462]. Consequently, companies must consider the legal requirements they fall under when evaluating existing or potential suppliers to ensure compliance [9, 463]. This is especially crucial for suppliers in regions with heightened human rights and environmental risks [463–465]. However, LkSG does not explicitly define how to evaluate the company's own business unit and suppliers. According to § 5 LkSG, a risk analysis must be performed annually or on occasion for an organization's own business unit and its tier-1 suppliers, with the objective of identifying potential human rights and environmental risks or violations as defined in § 2, para. 2 and 3 LkSG. It does not require an analysis of all tier-1 suppliers, but only those with typically heightened human rights and environmental risks [466]. Therefore, identifying the most relevant sustainability criteria for evaluating suppliers to comply with these regulations is essential; accordingly, this study examines these criteria within the context of LkSG.

Within this study, a criterion is a specific, distinguishing attribute used to evaluate a supplier's sustainability performance. Criteria capture information at various levels, from high-level indicators (e.g., environmental management system) to granular operational metrics (e.g., working hours).

Sustainability has become an increasingly prominent topic in the literature. For example, Goggin et al. [467] highlighted how the reliance of the biopharmaceutical sector on single-use plastics, despite their operational advantages, increasingly conflicts with sustainability objectives and the transition to a circular economy. The authors emphasize that prevailing life-cycle analyses often overlook post-use impacts and reveal limited industry engagement with more sustainable alternatives. In contrast, the study by Le et al. [468] proposed a model for detecting tomato plant diseases that enables real-time detection in resource-limited settings, supporting early intervention, reduced pesticide use, and more sustainable agricultural practices for tomato cultivation. Another example, Pedersen et al. [469], explored consumer perceptions of sustainability in food production and preferences for sustainability labels. The research revealed that consumers lack clear information and prioritize different sustainability indicators, such as pollution, animal welfare, and fair wages. The findings highlight the need for transparent labeling and greater responsibility from retailers and producers to support informed, sustainable food choices. This growing emphasis on sustainability across various disciplines is also evident in the realm of supply chain management [27, 470, 471]. The importance of sustainable practices in supply chains is increasing, driven by regulations, customer demand, and corporate reputation [3, 472]. Despite the growing research and practical focus on sustainability, a gap exists between theoretical frameworks and business practice in the context of sustainable supply chains [473, 474]. This gap is increasingly pronounced due to new regulations such as LkSG and the upcoming European *Corporate Sustainability Due Diligence Directive* (CSDDD), which have not yet been comprehensively addressed in the literature [179, 180, 475]. A critical issue is the lack of clarity in the literature regarding the actual application of the most relevant sustainability criteria for supplier evaluation in practice. This is especially pertinent in addressing heightened human rights and environmental risks, particularly in light of new regulatory requirements.

Literature review, which has been the most widely used methodology, presents some weaknesses. They are associated with selection bias and a lack of critical analysis [353, 476]. To address these shortcomings, this study combines a systematic

literature review (SLR) with content analysis from both literature and practical perspectives to examine the sustainability criteria for supplier evaluation in the context of due diligence acts, using LkSG. The findings will support companies in enhancing their supplier evaluation processes, promoting the selection and development of suppliers with lower human rights and environmental risks. Ultimately, this will contribute to the fostering of sustainable supply chains and ensure compliance with evolving due diligence regulations. In this context, this study aims to answer the following research questions (RQ):

- RQ 1: What are the most relevant sustainability criteria for supplier evaluation according to the literature?
- RQ 2: Which of these sustainability criteria do companies consider in evaluating suppliers with heightened human rights and environmental risks in the context of LkSG?
- RQ 3: What additional sustainability criteria do companies consider in evaluating suppliers with heightened human rights and environmental risks in the context of LkSG?

The paper is structured as follows. Section 5.2 reviews the state of research on sustainable supply chains, supplier evaluation, and sustainability criteria for supplier evaluation. Subsequently, Section 5.3 describes the research methodology and data collection. Next, the research findings will be presented and discussed in Sections 5.4 and 5.5. Finally, a conclusion in Section 5.6 will be provided.

5.2 Literature Review

5.2.1 Sustainable Supply Chains and Supplier Evaluation

The growing demand for goods and services has driven companies to undertake production activities with severe social and environmental impacts [473, 477]. The 1987 Brundtland Report [16] highlighted the need for changes in industrial practices and consumption to ensure sustainability. It popularized the concept *sustainable development*, defined as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” [16]. Building on the concept of sustainable development, ten years later, Elkington [21] introduced the Triple Bottom Line (TBL) as a framework for assessing business performance across three dimensions: economic, environmental, and social. TBL broadens the environmental agenda by integrating these aspects, encapsulated in the terms *profit, planet, and people* [21]. In the context of the supply chain, sustainability refers to embedding economic, environmental, and social considerations as raw materials are sourced, converted to products, and delivered to the customers [27, 74].

The literature has increasingly published articles on sustainability in supply chains, with the topic gaining steady importance in recent years [27, 478–480]. Particularly, supplier selection has been a prominent subject in academia over the past decades [481–483]. This is due to the fact that suppliers play a crucial role for the buying company, providing the right materials, components, and solutions at the

right time and place, all while keeping costs competitive [172]. To foster sustainability in the supply chain, the social and environmental performance of a supplier is crucial [172, 473]. Therefore, selecting the right supplier is of paramount importance [484]. Not only economic criteria but also environmental and social criteria must be considered, introducing multiple criteria into the evaluation process [482, 484, 485]. For this reason, a wide spectrum of methodologies have been developed in recent years in academia, especially various multi-criteria decision making (MCDM) methods that play an important role in supplier selection approaches [485–487]. However, a literature review by Vörösmarty and Dobos [474] concerning Data Envelopment Analysis (DEA) for supplier selection and evaluation notes a significant gap: most research focuses solely on the environmental dimension, and practice-oriented studies are scarce. Additionally, other studies [29, 473] indicate that a comprehensive focus on all three dimensions of sustainability is limited, with economic and environmental aspects dominating the research. Our study integrates all three dimensions, with an additional special focus on supplier selection criteria in the context of the due diligence acts.

5.2.2 Sustainability Criteria for Supplier Evaluation

The evaluation and selection of suppliers are pivotal for organizations, as they influence both product quality and adherence to sustainability responsibilities [29, 488]. With the recent introduction of due diligence acts in supply chains, such as LkSG or the upcoming CSDDD, organizations are legally required to comply with due diligence obligations [9, 128]. If they fall within the scope of these regulations, they must adhere to the prescribed requirements to avoid legal sanctions and reputational damage resulting from negative media coverage [9, 463]. To foster a sustainable supply chain and comply with LkSG, companies must consider human rights and environmental expectations when selecting direct suppliers [9]. This involves rigorously applying sustainability criteria to evaluate existing and potential suppliers, ensuring they meet heightened human rights and environmental protection standards. By doing so, companies can mitigate and eliminate violations and risks, promoting a more sustainable supply chain.

As sustainability considerations in supply chains have gained prominence, research on sustainable supplier evaluation has expanded accordingly [489–493]. A study by Ageron et al. [488] found that, despite the introduction of sustainability criteria for supplier evaluation over a decade ago, quality and price remained the most important criteria, while social responsibility was given the least priority. Rashidi et al. [29] presented similar findings eight years later. The study revealed that economic criteria remain the most frequently used, followed by environmental criteria, with social criteria being the least applied. They identified quality, delivery, and cost as the most frequently used economic criteria [29], representing the *traditional criteria* [484, 494]. For environmental criteria, the most applied criteria are the environmental management system, followed by recycling and pollution control. Regarding social criteria, the authors found that work safety and labor health are the most commonly used, followed by employment practices and social responsibility [29]. However, the study by Kuo et al. [495] yielded different results. Unlike Ageron et al. [488] and Rashidi et al. [29], who did not focus on a specific industry, Kuo et al. [495] concentrated on the palm oil industry. Their findings indicate that in the palm oil industry, environmental criteria receive the highest priority when evaluating sustainable suppliers, followed closely by economic criteria, while social criteria lag significantly

behind [495]. Similarly, the research by Mubarik et al. [496], which focused solely on green supplier selection in the automobile industry—specifically on economic and environmental dimensions—revealed that the most important criteria differ from traditional ones. Notably, environmental management systems, technology, and pollution take precedence, while delivery time, although traditionally considered, remains a key criterion [496].

Most researchers use the TBL framework—economic, environmental, and social—to cluster criteria for supplier evaluation [148, 497, 498]. Some scholars have expanded this framework, for instance, Ghamari et al. [499] introduced a resilience dimension, while Khalili Nasr et al. [500] incorporated a circular dimension. Conversely, other researchers have opted not to use any classification of the criteria [501, 502]. Notably, some researchers categorize the criteria into main and sub-criteria [490, 497, 503], while others adopt a more holistic approach without such distinctions [491, 504]. The variation in classification, ranging from broad to granular, was highlighted in a comprehensive literature review by Rashidi et al. [29], emphasizing the absence of a standard framework in the field.

This section synthesized key findings from the existing literature on sustainability criteria for supplier evaluation, establishing a foundational basis for our study. It is not an exhaustive systematic review but rather a focused selection of relevant findings. A comprehensive, ungrouped list of all criteria identified by the authors cited in this review is available in Appendix B, p. xiii, which illustrates their full variety and total count. In contrast, the most relevant sustainability criteria, as determined by our SLR, can be found in Table 5.3.

5.2.3 Gaps in the Literature

Although extensive research exists on sustainable supplier evaluation [69, 493, 505], Rashidi et al. [29] highlight a persistent gap between business practice and academia that needs to be bridged to gain deeper insights into sustainable supplier evaluation. Additionally, Rajeev et al. [473] and Vörösmarty and Dobos [474] emphasize that studies rarely focus on all three dimensions of sustainability, with the social dimension being particularly underrepresented. They underscore the need for more practice-focused studies to address this gap. Furthermore, various scholars have identified numerous criteria essential for sustainable supplier evaluation [488, 495, 501, 503]. However, there is no universally accepted classification framework for these criteria [29, 499].

Also, historically, due diligence was largely voluntary for organizations [458, 506] but given the recent legal developments that require companies to comply with sustainability-related regulations, there are limited studies that examine which criteria companies apply. While due diligence acts in supply chains emphasize human rights and environmental risks, academic research has yet to thoroughly examine the sustainability criteria by which suppliers with heightened human rights and environmental risks should be evaluated.

5.3 Research Methodology and Data Collection

The first objective of this study is to develop a comprehensive, structured list of the most relevant sustainability criteria for supplier evaluation, derived from an SLR (see Section 5.3.1). The second and third objectives are to assess which of the identified

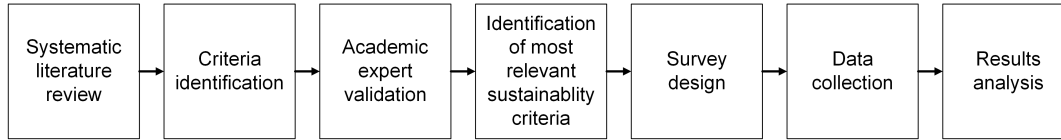


Figure 5.1: Research process.

criteria from the literature are also relevant in practice and to identify additional criteria for evaluating suppliers with heightened human rights and environmental risks in the context of LkSG. To achieve this, we conducted a survey with experts (see Section 5.3.2). Figure 5.1 presents a concise overview of our research process, which will be detailed in the following sections.

We apply the TBL framework, which advocates for a balanced consideration of economic, environmental, and social dimensions [21]. Although LkSG primarily focuses on human rights and, to a lesser extent, specific environmental protections, it does not explicitly address economic criteria. Despite this, the TBL remains the appropriate theoretical framework for our study due to the inherent interconnectedness of these dimensions, where, e.g., social and environmental risk have an impact on economic performance [507]. For instance, a supplier’s commitment to fair labor practices and safe working conditions often leads to a more skilled and motivated workforce. This directly contributes to higher product quality, which presents an economic criterion [508, 509]. Therefore, applying the TBL framework allows us to develop a holistic sustainability framework for evaluating suppliers, recognizing that addressing human rights and environmental risks is not merely a matter of compliance but a critical component of strategic economic management. This approach strengthens the theoretical foundation of our study, demonstrating that due diligence is an indispensable part of a company’s comprehensive sustainability and risk management strategy.

5.3.1 Systematic Literature Review

A SLR is employed as a method for structured and transparent data gathering and assessment from existing literature [510]. While SLRs are typically used for synthesizing knowledge in established fields [353, 511], our study utilizes it to establish a foundational understanding of sustainability criteria for supplier evaluation from the existing literature. This provides a comprehensive academic baseline, crucial for addressing the nascent research that links these criteria with the business practice and LkSG, bridging the current gap in their practical application for suppliers with heightened human rights and environmental risks. This systematic identification and assessment of the available literature lay the theoretical groundwork for our subsequent empirical investigation into business practice. Consequently, this section examines the sustainability criteria in the literature for supplier evaluation through a systematic review and structured content analysis.

Following a framework ensures that the review is conducted rigorously, enhancing both the transparency and applicability of the research [353, 510]. Therefore, a four-phase literature review process is conducted, following the framework of Seuring and Gold [510] with the following phases: 1) collection of materials, 2) descriptive analysis, 3) definition of categories, and 4) evaluation of the materials. For a more comprehensive result, we used the two major databases of peer-reviewed articles: Elsevier’s Scopus (Scopus) and Clarivate Analytics’ Web of Science (WoS) for the SLR.

Both databases are currently recognized as the primary sources for bibliographic data searches in academia [512, 513]. The screening factors of the reviewed literature were determined (see Table 5.1), the sample was collected, and the articles were selected and analyzed following the first research question. Relevant data were identified using the search string topic (“supplier evaluation” OR “supplier selection” OR “supplier assessment” OR “supplier performance”) AND (sustainab* OR “ESG” OR “environmental” OR “social”) AND (criter* OR factor*). By combining keywords with the Boolean operator AND, we identified articles that discuss supplier evaluation and sustainability criteria. The OR operator was used to include synonym terms for supplier evaluation, sustainability, and criteria. A broad word stem was used to avoid bias and ensure a comprehensive sample. All articles included in this study were peer-reviewed, written in English, and published between 2017 and 2024. The year 2017 was selected to capture the latest advancements and trends in the field. According to the studies by Tasdemir and Gazo [514] and Rashidi et al. [29], publications in the field of sustainability in supply chains fundamentally increased in 2017, making it a suitable starting point for our analysis. Articles that focused solely on MCDM methods without addressing sustainable supplier evaluation criteria, as well as those limited to literature reviews, were excluded from our analysis (see Table 5.1). This exclusion aligns with the objective of our study, which is to provide a comprehensive examination of sustainability criteria in supplier evaluation. To ensure the relevance of the identified criteria, we included only those studies that explicitly addressed sustainability criteria in the context of supplier evaluation.

Table 5.1: Overview of sample selection.

Screening factors	Description	Number of remaining Articles
Search string	(“supplier evaluation” OR “supplier selection” OR “supplier assessment” OR “supplier performance”) AND (sustainab* OR “ESG” OR “environmental” OR “social”) AND (criter* OR factor*)	418
Inclusion criteria	Peer-Reviewed articles, English, year 2017–2024	
Exclusion criteria	Multi-criteria decision-making methods, literature review only	
Removing duplicates		354
Manual screening	Titles and abstracts	62
Manual screening	Full articles	36

This approach was necessary because MCDM studies (e.g., 515, 516) often adopt criteria from a single source or use criteria without transparency regarding their selection method, which can introduce bias and compromise the robustness of our findings. However, some MCDM studies (e.g., 490, 517) focus on sustainability criteria.

Therefore, we designed our search string to also capture articles that address both MCDM approaches and sustainability criteria to avoid overlooking relevant studies that contribute valuable findings for our study. Using the search string, we identified 252 articles on Scopus and 166 articles on WoS, in total 418 articles in September 2024. After removing duplicates, 354 articles remained. These remaining articles were manually screened based on their titles and abstracts to ensure they addressed sustainability criteria for supplier evaluation. In the last step, the final sample ($n=36$) was fully manually analyzed to retrieve the identified sustainability criteria.

5.3.1.1 Descriptive Analysis

This section presents the descriptive characteristics of the reviewed literature, with publication dates ranging between 2017 and 2024 (see Figure 5.2). The articles were published in 24 different journals, spanning various disciplines and geographical contexts. 19% of the articles were published in the *Journal of Cleaner Production*, followed by the journal *Sustainability* with 11%, and 6% each in the *Environment, Development and Sustainability* and *Journal of Financial Management and Property and Construction*. Most journals published only one article, collectively accounting for over half of the total publications (see Table 5.2). Figure 5.2 illustrates that the peak of the publications occurred in 2021.

Table 5.2: Journal distribution.

Journal	Number of articles
Journal of Cleaner Production	7
Sustainability	4
Environment, Development and Sustainability	2
Journal of Financial Management of Property and Construction	2
Mathematics	2
Others	19

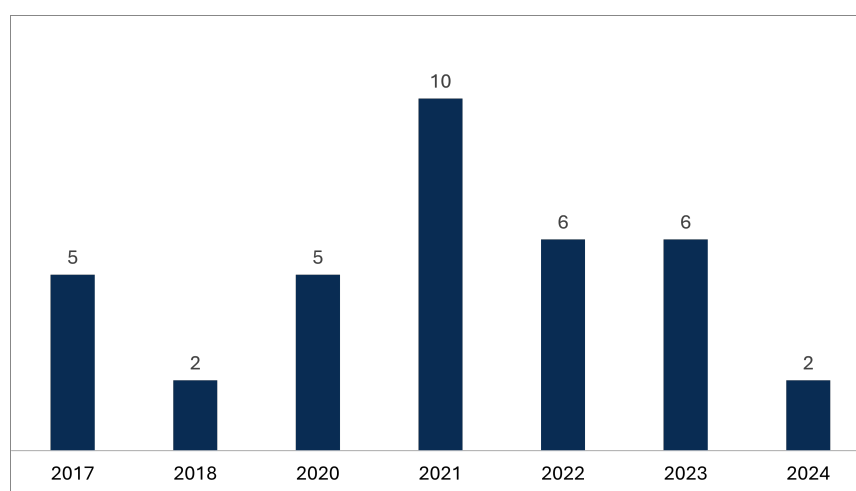


Figure 5.2: Articles published per year.

5.3.1.2 Categorization and Validation of the identified Sustainability Criteria

We identified the sustainability criteria from the final sample of the SLR without distinguishing between main criteria and sub-criteria, as no uniform standard in literature exists (see Section 5.2.2). We then grouped all the identified criteria derived from logical relationships and coherence and then developed a main criterion for each group. Afterwards, we categorized the main criteria with their sub-criteria within the three dimensions of the TBL (see Section 5.4.1). Subsequently, we sought approval from five academic experts in sustainable supply chain management for both the categorization within the dimensions of the TBL and the alignment of sub-criteria with the main criteria, aiming to mitigate any potential bias. To enhance meaning and clarity, we designed a leading question for each sub-criterion. The allocation to the three dimensions was not predetermined and had to be assigned by the experts. While we initially assigned the sub-criteria to the main criteria, the experts had the option to modify these assignments as well.

In the next step, the criteria were selected in accordance with the number of articles that identified each criterion. Thereby, equal significance is attributed to all criteria, regardless of whether they are main or sub-criteria categorized by us. Subsequently, we calculated a total count for each main criterion by summing the number of its associated sub-criteria with the number of times the main criterion itself was mentioned. This total count was then used to determine a percentage weighting for each main criterion within its respective sustainability dimension. Finally, for each dimension, we selected the five main criteria with the highest percentage weighting (see Section 5.4.1).

5.3.2 Expert Survey

This study aims to align the most relevant sustainability criteria from the literature with practical applications through an anonymous online survey conducted with selected company experts. In addition, we investigate whether companies apply further sustainability criteria that were not considered in the literature. Therefore, we exclusively involved experts who work in companies across various industries in Germany that are subject to LkSG and are engaged in supplier evaluation.

Involving experts from diverse industries allows us to identify the main sustainability criteria used across different sectors. While the specific risks and their surface-level manifestations may vary, the structural challenges, particularly those at the origin of the supply chain, are fundamentally consistent [518, 519]. This approach ensures that our study develops a comprehensive and adaptable framework for sustainable supplier evaluation in the context of LkSG that is not limited to a specific industry.

We used LinkedIn to identify experts who have professional experience in evaluating suppliers, based on their position and company. For the position, we selected experts in procurement, supply chain management, and sustainability. Regarding the company, we did research if the company falls under LkSG by identifying the number of employees, since all companies with more than 1,000 employees fall under it (see § 1, para 1 LkSG). If the company was obliged under LkSG and the expert's profile fit, we contacted the expert by a personal message, where we first described the background and goal of the survey and then asked if they are willing to take part in it. When they replied positively, we sent them a link to our online survey. Before

engaging with the experts, we conducted a pretest of the online survey with both expert and non-expert participants to ensure clarity and functionality.

The survey is structured into six parts. The first part introduces the study to the experts. The second part collects general information and includes a screening question to ensure the suitability of the respondents. This question was designed to confirm that the expert works in procurement, supply chain management, or sustainability and is actively involved in supplier evaluation. Experts who answered *yes* could proceed with the survey and were then asked for general information, including their company's industry, their role, and their years of experience.

In the third part, we asked experts to identify the product groups and countries where their company faces heightened human rights and environmental risks. The purpose of this section was twofold: first, to obtain an overview of these heightened risk areas across the participants, and second, to make the experts aware of their company's specific risks, which they were asked to keep in mind when assessing the criteria in the subsequent sections.

The fourth and fifth parts constitute the main body of the survey. In these sections, experts were asked to assess 15 main sustainability criteria and two corresponding sub-criteria, which were identified from our SLR (see 5.4.1). To facilitate this assessment, leading questions were included to place experts in specific scenarios and to enhance their understanding of each criterion. Using a five-point Likert scale (no relevance, very low relevance, low relevance, high relevance, and very high relevance), the experts had the option to evaluate each main criterion. This categorization aligns with the Content Validity Index, which is a crucial metric used in research and measurement development to assess the relevance and clarity of items in an instrument like a survey [520, 521]. The distinction between the fourth and fifth parts is that in the fourth part, experts assessed the criteria based on product groups with heightened human rights and environmental risks, while in the fifth part, they assessed the criteria based on countries. This separation was implemented to account for companies that may differentiate their criteria based on either the product category or the country. If a company did not make this distinction, experts were asked to assess the criteria only once for both parts. For each assessment, a note was included to remind the expert to consider the heightened-risk product groups and/or countries they had identified in the third part.

After assessing the criteria in the fourth and/or fifth part, experts were also given the opportunity to identify additional criteria not mentioned in the literature. Furthermore, experts were asked if certifications and/or scores play a role in their supplier evaluation and, if so, which specific ones.

Upon the completion of the expert survey, the results were analyzed based on the responses. For each criterion, we calculated the percentage weights for each of the five Likert scale points. To validate these findings, the median was also calculated for each criterion's Likert scale evaluations. The findings are presented in Section 5.4.2.

5.4 Analysis and Results

This section presents the analysis and findings of the SLR and the expert survey. Section 5.4.1 identifies the most relevant sustainability main-criteria from the literature. Subsequently, Section 5.4.2 presents the results of the expert survey, which aims to link these theoretical insights with practical applications. These findings will be discussed in Section 5.5.

5.4.1 Systematic Literature Review

In the course of the SLR, we identified a total of 137 sustainability criteria. As explained in Section 5.3.1.2, we did not distinguish between main and sub-criteria when identifying the criteria. These criteria were clustered, resulting in the formation of 41 main criteria. These main criteria were subsequently categorized within the dimensions of the TBL. Notably, nearly half of the main criteria fall under the economic dimension, followed by the environmental dimension, which constitutes approximately 30%, and the social dimension, which has the smallest share at around 20%. Table 5.3 represents the most relevant main sustainability criteria for supplier evaluation, as identified in the existing literature. For each main criterion, we have identified and listed the two most significant sub-criteria according to the literature. In addition, for each main criterion, we formulated a leading question to enhance clarity and understanding (see Table 5.3).¹ According to our analysis of the SLR, the most relevant sustainability criteria for evaluating sustainable suppliers are as follows. For the economic dimension, the most relevant main criteria identified are cost, delivery, quality, flexibility, and management and reporting. Together, these criteria account for over 60% of all identified main economic criteria, determined by their weighted proportional values. For the environmental dimension, the relevant main criteria are green material and resources, green management and reporting, pollution, and waste, which together constitute over two-thirds of all main criteria in the environmental category. In the social dimension, the criteria include working conditions, health and safety, service, stakeholder, and community, which represent over 84% of the total main social criteria. Interestingly, human rights, including issues such as child and forced labor, rank sixth with a weighting of less than 8% of the total main social criteria.

In this study, we adhere to the concept of main and sub-criteria and focus on the most relevant main criteria in the analysis. By prioritizing these main criteria, we aim to provide a clearer understanding. Nevertheless, it is also interesting to look at all the criteria without our categorization into main criteria and sub-criteria. The five highest-weighted criteria are quality, closely followed by green design, emission, environmental management system, and delivery time. Cost ranks sixth. It is noteworthy that among the top five highest-weighted criteria, no social criteria appear. The highest-weighted social criterion, health and safety, ranks seventh. This further highlights that social aspects are currently given less importance in the literature compared to economic and environmental aspects.

¹During the validation of the main and sub-criteria by academic experts, we deliberately formulated a leading question for each sub-criterion in order to better validate the assignment to the main criterion. As this assignment has already been determined and we are primarily concerned with the main criteria in this study, we developed a leading question only for each main criterion.

Table 5.3: Most relevant sustainability criteria according to literature.

Dimension	Main criteria	Sub-criteria	Leading question	References (examples)
Economic	Cost	• Product/material price • Transportation cost	Are reasonable product/material prices and transportation costs considered?	148, 496, 504, 522
	Delivery	• Lead time • Delivery time	Can the supplier meet reliable delivery times?	491, 496, 498, 523
	Flexibility	• Flexibility in ordering • Delivery flexibility	Is the supplier flexible with changes to orders?	148, 498, 503, 524
	Quality	• Material/product quality	Can a reliable and consistently high quality of materials/products be ensured?	148, 490, 504, 525
	Management & reporting	• Corporate social responsibility • Information disclosure	Are social and environmental responsibilities integrated into business practices and information disclosed, e.g., about the materials used and emissions generated?	148, 490, 491, 498
Environment	Green material & resource	• Green design • Resource consumption	Are environmentally friendly materials and resource-saving processes used for production?	148, 491, 497, 498
	Green management & reporting	• Environmental management system • Green image	Is an environmental management system used, and are "green" contents reported?	490, 491, 500, 522
	Pollution	• Emission • Pollution	Is the amount of pollution generated during the production and transportation of materials minimized and handled responsibly?	491, 503, 504, 526

Continued on next page

Table 5.3 – continued

Dimension	Main criteria	Sub-criteria	Leading question	References (examples)
Environment (continued)	Waste	• Waste management • Hazardous waste	Is the amount of (hazardous) waste generated minimized and handled responsibly?	148, 503, 523, 527
	Recycling	• Recycle • Re-use	Are materials used that can be environmentally friendly recycled, or reused at the end of their life cycle?	[493, 503, 523, 524]
Social	Working conditions	• Employment practice • Employee rights	Are legal labor regulations complied with, and fair working conditions for employees ensured?	490, 497, 500, 503
	Health & safety	• Training & safety programs • Health insurance	Is attention paid to the health and safety of employees?	493, 503, 517, 527
	Service	• Warranties and claims • After-sales service	How are warranties and claims handled, and is after-sales service offered?	491, 498, 499, 503
	Stakeholder	• Rights of stakeholders • Customer satisfaction	Are the rights of stakeholders respected and customer satisfaction ensured?	148, 490, 493, 517
	Community	• Community welfare • Community development	Are initiatives taken to have a positive impact on the local community through social engagement and volunteer work?	491, 493, 522, 526

5.4.2 Expert Survey

The survey was conducted from February 2025 to March 2025. A total of 170 experts were personally approached, with a response rate of 20.6% (n=35). We received expert responses from 11 different industries, with nearly 80% coming from the four sectors: plant and mechanical engineering, automotive, electronics and electrical engineering, and chemicals and pharmaceuticals (see Figure 5.3). Out of the surveyed experts, 25% are sustainability specialists, 14% are purchasing managers, and 11% each are strategic buyers and project buyers. More than 69% of the experts have over 6 years of professional experience in the fields of supply chain management, sustainability, and/or procurement (see Table 5.4).

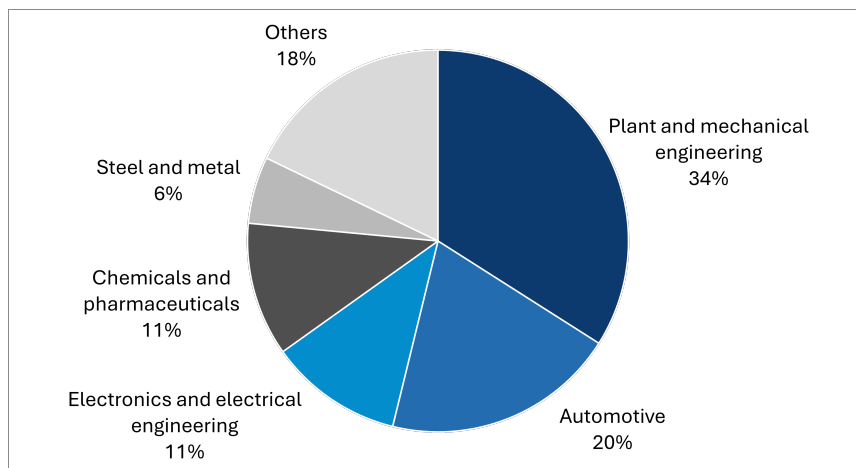


Figure 5.3: Branch distribution of survey experts.

We asked the experts about their own product groups and supplier countries that pose heightened human rights and environmental risks. This was intended to create a scenario for the respondents to consider when evaluating the criteria. A total of 87 different product groups were specified, ranging from aluminum, electronic components, circuit boards, and palm oil to various cables. For better clarity, since companies often define product groups very specifically, we grouped the specified product groups according to the *CSR Risk Check* [528], which is provided free of charge. This resulted in 17 categories to enhance the overall overview. While this classification is quite broad, it is sufficient for this study as it is intended to provide a general snapshot. Two-thirds of the highest human rights and environmental risk categories of the surveyed companies involve metal goods (48%), manufactured goods (13%), and rubber goods (6%). For supplier countries with heightened human rights and environmental risk, a total of 37 different countries were specified, with a few experts indicating entire continents such as Africa and Asia. More than one-third of the most frequently mentioned supplier countries with heightened risk are China (about 15%), followed by India (approximately 13%) and Brazil (around 6%). Among the continents, Asia is the most risk-prone, accounting for half of the mentions, followed by Africa and South America.

The five most relevant used criteria for evaluating suppliers with heightened risk due to product group and country can be clearly identified. While 43% of the surveyed companies distinguish between product group and country when applying these criteria, the set of the five most relevant criteria remains unchanged; only the weighting differs. While the ranking of the top five criteria rated as *very high relevant*

varies depending on the weighting, the overall analysis (see Table 5.5) indicates that *quality* is assigned the highest relevance, followed by *delivery*, *working conditions*, *cost*, and *health and safety*. Notably, three of these five main criteria pertain to the economic dimension, while the remaining two fall within the social dimension. Interestingly, none of the top five main criteria in practice are from the environmental dimension. In the overall analysis, based on the expert's assessment of the product group and country, Table 5.6 presents the five main criteria by dimension, including the weighting provided by experts. The main criteria *community* and *service* were rated as having low relevance in the overall assessment. However, among companies that differentiate between product groups and countries in their evaluation, *community* remained of low relevance when evaluating based on the supplier country, whereas *service* was considered as relevant. All other main criteria were generally rated as having high relevance.

Table 5.4: Distribution of experts by years of experience.

Years of experience	Number of experts
0–5	11
6–10	9
11–15	4
16–20	7
21+	4

Table 5.5: Main criteria identified by experts as most relevant.

Main criteria	Overall weight
Quality	88%
Delivery	75%
Working conditions	70%
Cost	67%
Health & safety	59%

Beyond assessing the predefined criteria, experts were asked whether any additional criteria, not identified in literature, are used in practice. In response, experts mentioned a total of 39 distinct items, which primarily consisted of evaluation instruments rather than additional criteria. 30% of the most frequently mentioned instruments include the *supplier code of conduct*, *EcoVadis Score*, and *certifications*. For companies that differentiate between product groups and country, there was no distinction in this regard.

As observed with the additional criteria, certifications, and scores also play a significant role in the evaluation of suppliers facing heightened human rights and environmental risks. Nearly 95% of the companies surveyed indicated that certifications or scores are considered in their assessment process. In total, 30 different certifications and scores were mentioned, with ISO 14001 (environmental management systems) being the most frequently cited (approximately 21%), followed by the EcoVadis Score (around 14%) and the IntegrityNext Score (about 9%).

Table 5.6: Relevance of sustainability criteria for supplier evaluation, based on surveyed experts.

Environment	Economic	Social
Green material & resource	(58%) Quality	(88%) Working conditions (70%)
Green management & reporting	(56%) Delivery	(75%) Health & safety (59%)
Waste	(54%) Cost	(67%) Stakeholder (54%)
Pollution	(46%) Flexibility	(56%) Community (44%)
Recycling	(46%) Management & reporting	(50%) Service (33%)

5.5 Discussion

In this section, we discuss the results of our SLR and expert survey by synthesizing them with each of the three dimensions of sustainability. We align these findings with LkSG and provide recommendations for the main sustainability criteria for evaluating suppliers with heightened human rights and environmental risks.

5.5.1 Findings from Systematic Literature Review and Expert Survey

Economic Dimension

Our SLR revealed that the economic dimension remains the most prevalent in academic discourse on sustainable supplier selection, accounting for nearly half of all identified criteria. This finding is consistent with prior research by Ageron et al. [488] and Rashidi et al. [29], which also highlight the dominance of economic factors.

Interestingly, our expert survey corroborates this academic emphasis, showing that economic criteria continue to hold significant weight in practice. The survey data reveals that quality (88%) and delivery (75%) were ranked as the top two most relevant criteria for supplier evaluation, with cost (67%) also cited among the top five (see Table 5.6). This finding highlights a potential gap between the growing discourse on sustainability and the enduring prioritization of traditional economic metrics within the industry. It suggests that economic performance may still be prioritized over environmental and social considerations in supply chain management, which points to an imbalance among the three dimensions of sustainability.

Environmental Dimension

In the academic literature, the environmental dimension accounts for approximately 30% of the sustainability criteria identified in our SLR, which is similar to the findings of Ageron et al. [488] and Rashidi et al. [29].

In contrast, our expert survey revealed a notable imbalance: none of the top five criteria cited by practitioners stemmed from the environmental dimension. This is a critical finding, as it highlights a significant disconnect between academic emphasis and practical application. This could be due to the early academic research centered on concepts like green supply chain management [446, 529] before the scope broadened to fully include social dimensions [482, 530]. The prevalent focus on the environment can be attributed to its dimensions being more tangible and readily quantifiable compared to those in the social dimension [531, 532]. The specific regulatory context of LkSG likely influences this imbalance. Although LkSG addresses both human rights and environmental protection, its legal requirements for the latter are less comprehensive. Consequently, companies subject to this act might have become more sensitive to social criteria, which could currently shift their prioritization away from environmental factors.

Social Dimension

Based on our SLR, we find that the social dimension is the least represented in the academic literature, accounting for only about 20% of the criteria. This is consistent with previous studies that often rank social factors last [474, 495].

However, our expert survey presents a compelling counter-narrative. Within LkSG context, social criteria like working conditions (70%) and health and safety (59%) were ranked among the top five most relevant in practice. This finding

indicates a significant shift, where the legal obligation to protect human rights under LkSG directly elevates the importance of social criteria, making them a priority for companies. It is important to emphasize that we exclusively surveyed experts from companies subject to LkSG. This means that these companies have been required to implement LkSG for at least one or two years, making them more attuned to sustainable supplier evaluation.

Tools in Practice

Besides the sustainability criteria, practitioners highlighted the use of instruments not frequently mentioned in the literature, such as sustainability ratings (e.g., EcoVadis), supplier codes of conduct, and certificates. These tools are crucial for conveying expectations and monitoring compliance, directly supporting the due diligence requirements under LkSG. This shows that the legal framework is not only shifting priorities but also influencing the practical tools and methods used for supplier selection. While these tools serve to verify compliance and build stakeholder trust, their effectiveness is a subject of ongoing debate in the academic literature, particularly concerning the potential for a *checkbox* mentality and the risk of green-washing [533, 534]. Therefore, these ratings and certifications should be used critically, serving as a support for, rather than a replacement for, comprehensive supplier evaluation.

5.5.2 Alignment with LkSG: Recommendation for Sustainability Criteria

Building upon the sustainability criteria for supplier evaluation identified in the preceding SLR and through the expert survey, this section critically examines their alignment with LkSG. This legal review is paramount to ensure that the identified sustainability criteria comprehensively address all mandated human rights and environmental protection areas. Given that LkSG is a relatively recent legislative development and the extent of its practical implementation and understanding across companies is still evolving, this validation is essential. Therefore, to foster a sustainable supply chain and ensure compliance with LkSG, companies must integrate human rights and environmental expectations into their criteria when evaluating and selecting their direct suppliers [9].

As highlighted earlier, the primary focus of LkSG is the protection of human rights. The legal text specifically addresses the following human rights issues: child labor, forced labor, slavery, occupational safety and health obligations, freedom of association, unequal treatment in employment, withholding adequate living wage, cause of harmful soil change, water and air pollution, harmful noise emissions, or excessive water consumption, unlawful eviction, deployment of security forces to protect business project with violation [9]. It is noteworthy that neither the five most relevant criteria through the SLR nor those applied in practice consider human rights criteria, such as child labor, forced labor, slavery, and freedom of association, as highly relevant. Our SLR ranks human rights sixth within the social dimension, with a weighting of under 8%. Across all dimensions, its weighting is less than 2%. However, these are critical criteria for evaluating suppliers with heightened risk, particularly in the context of LkSG requirements. Therefore, we recommend establishing a main criterion of *human rights* with sub-criteria, including child labor, forced labor, slavery, freedom of association, the use of security forces to protect business projects, and excessive water consumption. Even though human rights were not explicitly mentioned in practice, this main criterion is covered within the framework of sustainability ratings. The two sustainability rating providers [535, 536] mentioned by the

surveyed experts focus not only on human rights but also on the broader spectrum of environmental, social, and governance factors. Ultimately, companies using these scores gain a comprehensive overview, not only of human rights but also of all aspects of the environmental, social, and governance performance of the suppliers being evaluated. Therefore, it cannot be assumed that the issue is entirely overlooked in practice, even if it is not explicitly listed as a criterion. Nonetheless, we recommend incorporating human rights as one of the most relevant criteria by establishing it as a distinct main criterion. For the other human rights issues addressed in LkSG, we do not propose additional main criteria, as they can be assigned to the existing main criteria outlined in Table 5.3. In this study, we assign occupational safety and non-discrimination in employment, as referenced in LkSG, to the main criteria *health and safety* and *working conditions*, respectively. Similarly, harmful noise emissions are categorized under *health and safety*, while unlawful evictions fall under *community*. With regard to environmental protection, the aspects mentioned in LkSG correspond to the main criteria *green materials and resources*, *pollution*, and *waste* and are thus already among the relevant criteria in the literature and practice.

In summary, based on our SLR, we identified the five most relevant sustainability criteria for each dimension. This selection was based on the frequency with which each criterion was identified in the literature, which we then used to perform a percentage weighting to establish an initial set of main criteria (see Table 5.3). Next, we validated these criteria with an expert survey. As described in Section 5.3.2, experts assessed the 15 criteria using a five-point Likert scale, and we analyzed their responses (see Table 5.6). Finally, we aligned the results with the requirements of the LkSG. To ensure alignment with the LkSG's emphasis on human rights, we integrated this crucial social main criterion into our final framework and consequently removed the service criterion, which was identified as the least relevant (33%) based on our expert survey. This comprehensive process, combining insights from the SLR, expert validation, and legal alignment, allowed us to propose the most relevant sustainability criteria for evaluating suppliers with heightened human rights and environmental risks, as presented in Table 5.7.

Table 5.7: Most relevant main sustainability criteria and instruments for supplier evaluation.

Environment	Economic	Social
Green material & resource	Quality	Working conditions
Green management & reporting	Delivery	Health & safety
Waste	Cost	Stakeholder
Pollution	Flexibility	Community
Recycling	Management & reporting	Human rights
Further recommended instruments:		
Supplier code of conduct		
Sustainability rating scores		
Certificates		

This proposed framework offers implications for practitioners. The holistic supplier evaluation framework, which balances the economic, environmental, and social dimensions of sustainability, serves as a guide for companies. By adopting these criteria, companies can not only ensure compliance with LkSG, but also proactively mitigate supply chain risks and enhance their corporate social responsibility. To move

beyond a checkbox mentality, top management must be actively involved and view sustainability not as a compliance task but as a source of long-term value. This requires integrating it into the company's core strategy and business processes [537, 538]. Furthermore, building stronger supplier partnerships and investing in supplier development are essential for establishing authentic sustainability practices throughout the supply chain and enhancing the organization's overall sustainability performance [539, 540].

At first glance, a narrow focus on LkSG might suggest an unbalanced assessment of supply chain risks, with human rights taking precedence over environmental concerns. However, this view is incomplete for two reasons. First, the due diligence obligations within LkSG itself demonstrate that human rights and environmental risks are highly interlinked. For example, the law protects against harmful soil degradation or water pollution that denies communities access to safe food and drinking water [9], framing an environmental problem as a human rights violation. Second, organizations in Germany operate within a broader and evolving European regulatory landscape that extends beyond LkSG. For instance, the EU Deforestation Regulation, which takes effect in December 2025, mandates strict due diligence for commodities linked to deforestation [119]. Similarly, the European Corporate Sustainability Reporting Directive obliges companies to report holistically on both environmental and social impacts across their value chains, e.g., including upstream and downstream emissions [255]. When viewed in this wider context, LkSG is one piece of a larger regulatory puzzle that pushes for a more comprehensive risk assessment. Nevertheless, looking at LkSG in isolation, we argue that its framing could be enhanced. Policymakers should consider evolving legislation to give environmental due diligence the same explicit legal weight as human rights mandates, thereby clarifying and strengthening their interconnection.

5.6 Conclusion

This study examined the most relevant sustainability criteria and instruments for supplier evaluation within the framework of LkSG. To achieve this, we conducted an SLR to identify the most relevant sustainability criteria from the literature, which were then evaluated by experts to determine their relevance in practice and to assess whether additional criteria or instruments are being utilized. Despite the increasing focus on sustainability in the literature, two significant gaps remain unaddressed: (1) a comparison between the criteria discussed in the literature and those applied in practice, and (2) the identification of the most relevant sustainability criteria and instruments that should be applied when evaluating suppliers with heightened human rights and environmental risks in the context of due diligence acts.

Derived from our SLR, the study categorizes 41 main criteria within the TBL dimensions, with nearly half classified under the economic dimension, followed by environmental (30%) and social (20%). Expert survey results indicate that the most relevant criteria in practice are quality, delivery, working conditions, cost, and health and safety. Notably, among the five highest-rated main sustainability criteria, only economic and social dimensions are represented, while environmental aspects are absent. This suggests a shift in focus compared to the literature, where environmental considerations are more prominent.

Overall, the main criteria identified in the SLR align with practical applications in the environmental and economic dimensions. Furthermore, the environmental

requirements of LkSG are implicitly covered within the five main environmental criteria we created through the results of the SLR. Regarding the social dimension, we recommend emphasizing human rights, working conditions, health and safety, stakeholders, and community as the most relevant main criteria. Interestingly, human rights did not emerge among the top five social criteria in either the SLR or the expert survey. Moreover, instruments like supplier code of conduct, sustainability ratings, and certifications are frequently applied in practice, reinforcing the recommendation to incorporate them into supplier evaluations. These insights provide a foundation for companies to refine their supplier evaluation frameworks, ensuring compliance with due diligence regulations while fostering a more sustainable supply chain.

Theoretically, this study reinforces the TBL framework in high-risk contexts. Specifically, the study empirically shows that balancing people, planet, and profit is non-optional in supply chains facing heightened human rights and environmental risks. Legal mandates force companies to prioritize *people* and *planet*, shifting the traditional dominance of profit-first decision-making. The study implies a need for greater transparency in corporate governance regarding the trade-offs inherent in profit maximization and more effective regulatory approaches that acknowledge the reality of profit prioritization. This research contributes to ongoing debates on the role of business in society, highlighting the tensions between profit-seeking behavior and societal objectives. This deepens balancing the TBL prioritization of sustainability criteria for supplier evaluation in the context of due diligence acts, using LkSG as an example from academic and practitioners' perspectives.

Additionally, this study makes two key contributions to the existing literature. (1) Unlike previous research that primarily focused on general sustainability criteria for supplier evaluations, this study specifically examines suppliers with heightened human rights and environmental risks in the context of due diligence regulations, particularly through the lens of LkSG. (2) This study also offers a valuable business practice perspective of the applied sustainability criteria and instruments for supplier evaluation in the context of due diligence acts, bridging the gap between academia and practice, thereby enriching the literature with insights from real-world application.

This study exclusively surveyed experts from companies subject to LkSG, with a sample of 35 companies. This represents only a fraction of the companies affected by LkSG, highlighting the need for future quantitative research to provide deeper insights. It also focused on selected literature that fell into the inclusion and exclusion criteria, ignoring other potential articles related to the subject. Given that LkSG is relatively new and does not explicitly prescribe supplier evaluation criteria, companies may need time to reassess their most relevant criteria, suggesting that a follow-up study over time would be valuable. Additionally, while this study focused on LkSG's due diligence requirements, future research should explore similar acts in other countries. Our study also did not differentiate between industries, and further investigation into industry-specific criteria would be insightful. The study only briefly addressed sustainability ratings and certifications; therefore, future research should critically examine their impact. This is crucial for both practice and academia to determine if those tools drive sustainable performance improvements or simply contribute certification fatigue and checkbox mentality. To bridge the gap between scholarly and practical perspectives, future research could focus on understanding and linking both. For example, using case studies to test theoretical frameworks in real-world situations would help to identify discrepancies [541]. Furthermore, industry interviews could be used to understand the perspectives of professionals and connect them to theoretical constructs [542]. Lastly, we emphasize that future

research on sustainable supplier evaluation must move beyond static assessments to design studies that can quantitatively and qualitatively measure its enduring effects on supply chain environmental and social performance, without overlooking intangible measures of the social dimension. This is crucial because a significant gap exists in understanding the social dimension of sustainability, especially in developing economies where issues are contextual and dynamic [543, 544].

Overall, despite these limitations, this study offers valuable insights into the most relevant sustainability criteria for evaluating suppliers with heightened human rights and environmental risks in the context of due diligence acts in supply chains. It bridges the gap between real-world applications and existing literature, providing a solid foundation for future research in this rapidly evolving field.

Final Conclusion

This cumulative dissertation examined sustainable supply chains at the intersection of IT and regulation through three published articles. This research provided integrated insights into how blockchain technology and due diligence regulations, particularly LkSG, affect sustainability in supply chains. Findings demonstrate that neither technology nor regulation alone provides complete solutions; their effectiveness depends in particular on implementation context and stakeholder inclusion. The dissertation advances theoretical understanding while offering practical guidance for companies, policymakers, and technology developers.

Article 1 demonstrates that blockchain technology has the technical potential to enable transparency in agricultural supply chains, thereby preventing fraud against smallholder farmers. The open-source framework Hyperledger Fabric with an SMS-based approach in Ghana's cocoa sector shows that inclusive design requires understanding users' constraints, not merely scaling down existing solutions. Technology's value depends on addressing inclusion challenges; without deliberate support for smallholder farmers, digital solutions risk creating new forms of exclusion rather than empowerment. Technology adoption in supply chains must be analyzed through the lens of digital inclusion, not just technical feasibility.

Article 2 reveals a critical limitation of the LkSG design: the tier-1 supplier focus creates an enforcement gap for upstream supply chain actors, and not all risks addressed by the LkSG are relevant for cocoa smallholder farmers, given their distinct socio-cultural norms and values. Furthermore, LkSG is unlikely to produce meaningful effects on smallholder farmers in the short- to medium-term due to its design. Positive impacts are more likely in the long-term through voluntary company efforts beyond the legal minimum and through NGO intervention triggering substantiated knowledge requirements.

Article 3 suggests a framework of the most relevant sustainable criteria to evaluate suppliers with heightened human rights and environmental risks, integrating academic knowledge, practitioner experience, and regulatory mandates. By combining an SLR with an expert survey of practitioners subject to the LkSG, the article reveals a misalignment between academic research and business practice: while literature emphasizes economic and environmental dimensions, practice prioritizes economic and social dimensions, with human rights criteria historically underrepresented in both.

The three articles collectively demonstrate that sustainability mechanisms face what might be termed an *inclusion deficit*, a systematic gap between those for whom

these mechanisms are designed and those they effectively reach in practice. A pattern that, while manifesting differently across domains, remains consistent. In IT, the deficit emerges from infrastructure and capability barriers that prevent meaningful participation by those with limited resources. In regulation, this disconnect stems from the structural scope of due diligence laws such as the LkSG, which often place the most vulnerable actors outside their direct reach. In supplier evaluation, it reflects historical research priorities and organizational pressures that marginalize certain dimensions despite their legal and ethical centrality. What unites these patterns is that inclusion deficits are not random implementation failures, but structural features reflecting how power, resources, and voice are distributed in supply chains. The dissertation thus argues that addressing sustainability in supply chains requires not only better IT or stronger regulations, but also ensuring that the actors affected are included and able to benefit.

6.1 Theoretical and Practical Contribution

Each article in this cumulative dissertation presents detailed contributions within its respective section. This section synthesizes these contributions at a higher level of abstraction to demonstrate how the three articles advance knowledge and practice within sustainable supply chains.

In Articles 1 and 2, the dissertation employs a consistent analytical stance that centers the perspective of vulnerable actors at the origin of supply chains rather than that of focal companies. This origin-centric perspective challenges a pervasive assumption in sustainability research: that mechanisms designed from a focal company's or developed country's perspective will automatically benefit upstream actors. By centering the analysis on the realities of smallholder farmers, the dissertation reveals blind spots that remain invisible under focal company-centric views. In a complementary analysis, Article 3 addresses suppliers with heightened risks, who are typically the vulnerable actors at the lower-tiers of supply chains. Rather than centering their perspective as in Articles 1 and 2, however, it examines how focal companies in developed countries can evaluate these suppliers in ways that ensure compliance with legislative requirements.

This dissertation highlights how sustainability interventions often fail due to structural misalignment: IT may be feasible yet inaccessible in practice; regulations may be legally sound yet practically unreachable for vulnerable supply chain actors; and evaluation criteria may be academically validated yet disconnected from the specific economic and social dimensions required for legal due diligence. Moreover, it provides researchers with transferable methodological approaches. While grounded in specific empirical contexts, these approaches remain adaptable to diverse commodities, regulatory environments, and supply chains.

Beyond methodology insights, the dissertation offers directly applicable frameworks for companies and policymakers. For IT developers and companies implementing supply chain solutions, the research demonstrates how to design for inclusion by treating user constraints as the foundational starting point rather than as implementation obstacles. For policymakers, the dissertation clarifies the limits of regulatory obligations while identifying the pathways through which positive upstream effects might be achieved. Specifically, for procurement professionals, the work provides a validated set of sustainability criteria that integrates academic rigor with practical relevance and regulatory alignment.

Collectively, these contributions suggest that advancing sustainable supply chains requires simultaneous attention to technology, regulation, and supplier evaluation. Each must be designed with explicit consideration of who is included in its reach and who is excluded from it.

6.2 Limitations and Further Research

Although Section 6.1 synthesized contributions of all three articles at a high level, this section addresses limitations and future research directions with greater specificity to the scope of each article. The identified limitations serve to delineate the scope of the research's validity while indicating promising directions for future inquiry.

In Article 1, the focus on the Ghanaian cocoa sector limits the direct transferability of the findings to other commodities, industries, or geographic regions with different infrastructural conditions. Because the technological analysis focused specifically on a blockchain solution using Hyperledger Fabric, the results may not transfer to other digital technologies or different blockchain frameworks. Furthermore, the proposed solution was not tested through a longitudinal evaluation, which means that the research demonstrates technical feasibility and initial implementation, but it cannot yet consider long-term or scaled adoption of the technology. Future research should therefore focus on monitoring adoption rates over several years to assess the actual impacts on smallholder livelihoods over time.

Similarly, the examination of a single regulation in Article 2 cannot capture the full range of due diligence approaches. Different regulatory scopes or enforcement mechanisms, such as the CSDDD or EUDR, may yield different outcomes for actors at the origin of supply chains. Additionally, because the perspectives of cocoa smallholders were accessed primarily through secondary sources, the depth of understanding regarding their socio-cultural norms and values remains limited. Future research should involve primary data collection through direct engagement with smallholders to gather firsthand data. This would allow for assessing whether long-term impacts truly materialize, or whether structural limitations continue to prevent benefits from reaching upstream supply chain actors.

The research on sustainability criteria in Article 3 reflects literature published between 2017 and 2024, meaning earlier studies and more recent developments may not be fully captured. While the expert survey conducted in 2025 provides a valuable overview of current priorities, these criteria are likely to evolve as LkSG implementation matures and companies gain more experience. Furthermore, the survey sample represents only a fraction of the companies covered by LkSG, indicating patterns rather than a universal corporate stance. Future research should employ larger and more diverse survey samples to capture a broader range of industry responses. It would also be valuable to study how sustainability criteria shift as regulations mature and as the regulatory landscape continues to change.

Ultimately, while these limitations highlight the inherent complexity of the field, they provide starting points for future research.

Closing Remarks on the Topic of Sustainable Supply Chains

The findings of this dissertation point to a broader tension at the heart of sustainable supply chains: globalization that has enabled unprecedented economic growth has also created supply chains so long, fragmented and opaque that ensuring human rights and environmental protection at lower tiers becomes challenging [1, 96]. The inclusion deficit identified in this dissertation is not merely a blind spot within specific IT solutions or regulatory frameworks. Rather, it reflects a structural challenge in governing economic relationships that span continents, cultures, and regulatory jurisdictions, one in which the most vulnerable actors tend to be underrepresented.

The protection of human rights and environmental standards across supply chains has become an increasingly regulated endeavor, one that requires companies to act. Due diligence legislation such as the LkSG, CSDDD, and EUDR, alongside non-financial reporting requirements like the CSRD, mark a shift from voluntary commitments to binding legal obligations [7–9, 119, 242]. Yet even this regulatory momentum comes with uncertainty: the European Commission’s Omnibus has demonstrated that significant amendments may emerge before regulations are fully applied [256, 545], creating considerable uncertainty for companies preparing to comply with requirements that may change before or shortly after implementation. Nonetheless, legal compliance, while necessary, does not guarantee that conditions in supply chains actually improve; it sets a minimum threshold.

Beyond meeting regulatory requirements, the implementation of sustainable supply chains requires infrastructure investments. While IT is not the primary barrier at an aggregate level, the reality looks different at the origin of supply chains: in many producing countries, the technological and organizational preconditions for meaningful data collection are still lacking, and local circumstances are rarely reflected in the systems designed to capture them. At the same time, the infrastructure is evolving: as sustainability demands information across all tiers, new data providers and digital tools are emerging to fill the gaps that existing systems were not designed to address [546–548]. Yet beyond infrastructure, the quality, completeness, and reliability of sustainable supply chain data remains a fundamental challenge [96, 227, 228], particularly for upstream tiers where information is most scarce yet most critical [96]. Improving this data landscape is one of the defining tasks for the years ahead, as sustainable supply chain governance can only be as robust as the information on

which it is built. Decisions based on incomplete or unreliable data risk misidentifying risks, overlooking violations, or creating a false sense of compliance.

At the strategic level, companies face decisions regarding the structure of sustainable supply chains. One response to the challenge of opacity and non-compliance can be vertical integration into upstream tiers of the supply chain, enabling greater transparency and control. Vertical integration is not without trade-offs, but it offers a structural solution to the information asymmetries that undermine due diligence efforts [549]. A related question concerns the length of supply chains themselves. Reshoring and nearshoring trends, accelerated by pandemic-related disruptions and geopolitical uncertainties, are gaining momentum [550, 551], and shorter supply chains can indeed reduce complexity and improve accountability. However, for commodities such as cocoa, coffee, or cobalt, whose extraction or cultivation is geographically bound, reshoring of primary production is not a viable option. What remains possible, however, is a structural shortening of supply chains through more direct sourcing relationships, which can reduce intermediaries and improve transparency and accountability. The challenge, therefore, is not to retreat from global trade but to enhance the governance structures of global supply chains in ways that improve transparency, accountability, and the distribution of responsibility across multiple tiers.

Finally, no single company, however committed, can transform sustainable supply chains alone. Multi-stakeholder initiatives, bringing together companies, governments, and NGOs, are essential for addressing challenges that exceed the reach of individual actors [552, 553]. Yet such initiatives must directly address the inclusion deficit identified in this dissertation: whether those most affected by supply chain conditions have a genuine voice in shaping the standards that govern them, and whether the benefits generated reach the vulnerable actors of supply chains or remain concentrated among those with the power to design and administer the systems.

Achieving truly sustainable supply chains remains a long-term endeavor, but progress in legislation, corporate practice, IT, and multi-stakeholder governance shows that the direction is set.

Appendix A: Detailed SMS Process

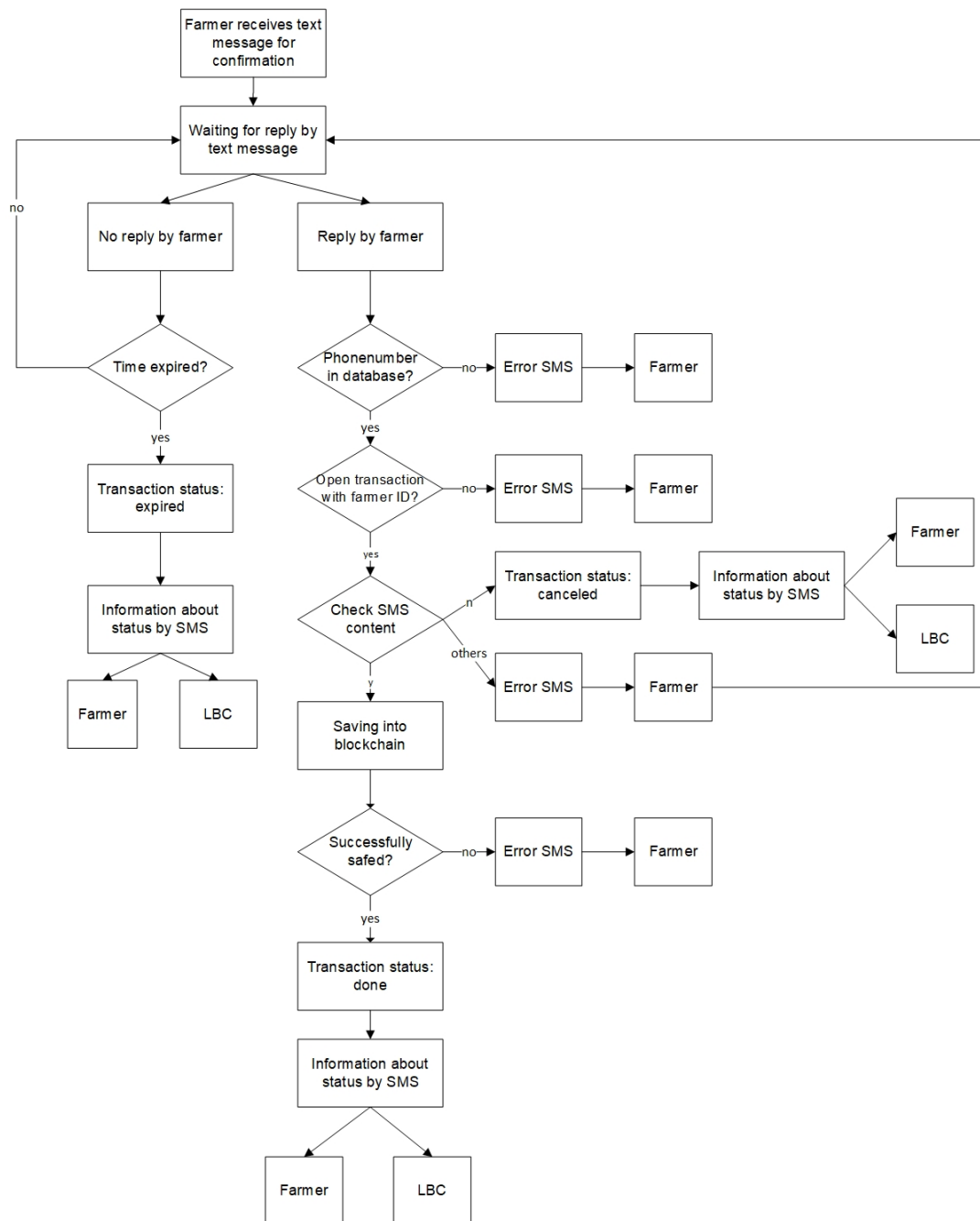


Figure 7.1: Detailed SMS process.

Appendix B: List of Sustainability Criteria

This table presents a comprehensive list of sustainability supplier evaluation criteria identified by the authors cited in Section 5.2.2. The list is unfiltered and ungrouped to showcase the full variety and total number of criteria from the literature, providing a foundational overview for our study. The criteria are listed in alphabetical order for ease of reference.

Table 7.1: List of Sustainability Criteria (Alphabetical Order)

Criteria	Sources
Air emissions	29, 503
Air/Water/Land Emission	491
Alternative transportation	501
Availability of supplier support	499
Capacity	148, 495
Carbon footprint	493, 498
Certification	488
Child and forced labor	495
Cleaner technology availability	491
Communication and information systems	502
Community involvement	498
Comprehensive strength	493
Confidence	488
Corporate social responsibility	493, 498
Cost	29, 484, 489, 491, 492, 494, 496, 498, 504
Culture	489
Customer satisfaction	498
Delivery	29, 148, 484, 488–492, 494–496, 498, 499, 502
Development Commitment	504
Dust emission	499
Eco-design	29, 490, 492, 496, 498, 503, 504
Economic	500
Economic dependency	488
Employee welfare	498
Employee's compensation	498

Continued on next page

Table 7.1 – continued

Criteria	Sources
Employment practice	29, 489–491, 497, 504
Energy consumption	29, 504
Energy management system	490
Environmental and social responsibilities	502
Environmental certifications	492, 498, 504
Environmental competencies	148
Environmental cost	148, 495
Environmental issues	488
Environmental management system	29, 148, 489–491, 495, 496, 498, 500, 503
Environmental performance	497
Environmentally friendly materials	491, 498, 500, 503
Experience	502
Financial capability and position	491, 498
Financial position	504
Financial stability	499, 502
Flexibility	29, 148, 484, 488, 489, 491, 493, 494, 498, 503, 504
Geography proximity	488
Green competencies	497
Green design and purchasing	148, 493
Green image	497, 498, 504
Green innovation	498
Green management	148
Green manufacturing	148
Green monitoring and follow up	498
Green packing and labeling	148
Green products	503
Green R&D and Innovation	148
Green technology	490, 503
Green transportation	503
Green warehousing	503
Hazardous substance management	498

Continued on next page

Table 7.1 – continued

Criteria	Sources
Health and safety	29, 148, 488–491, 493, 495, 497, 498, 500, 503, 504
Human rights	490, 498
Information disclosure	148, 491, 495, 498
Information technology and information system	488
Innovative technologies	501
Innovation level	484, 489
Interests and rights of employees	148, 491, 493, 495
Lead time	148, 504
Local community influence	489, 504
Management commitment	496
Market share	498
Market structure	498
Payment conditions	502
Personal relationships	488
Philanthropy	498
Pollution control	29, 148, 489, 490, 495–499, 504
Pollution production	489, 492
Price	29, 148, 488, 490, 493, 502
Production capability & facilities	504
Production facilities	148, 490, 495
Profit on product	148
Quality	29, 148, 484, 488–496, 498–502, 504
Recyclable raw materials	500
Recycled material	491
Recycling	29, 493, 498
Reduce toxic emissions	501
Regional supplier	501
Rejection rate	494
Relationships	488, 489
Reliability	488, 491
Repair Service	490
Reputation	498
Reputation and position	499, 502, 504

Continued on next page

Table 7.1 – continued

Criteria	Sources
Resource consumption	489, 491–493, 498
Resource's life cycle	501
Responsiveness	498
Rights of stakeholders	148, 490, 492, 493
Safety culture	492
Sensitivity to political situation	499
Service	488, 491, 493, 498, 499
Service of product	148
Size	488
Social commitment	491
Social influence	492
Social responsibility	29, 488, 490, 499
Staff training	498
Stakeholder empowerment	498, 499
Stakeholder influence	489, 490
Strategic stock	499
Supportive activities	503, 504
Technical capability	490
Technology	489, 492, 493, 496, 498, 499
Technology capability	29
Technology & financial capability	148
Transportation cost	148
Waste disposal	493
Waste management	148, 501
Warranties and claim policies	502
Water consumption	499
Workers' rights	503

References

- [1] Kareem, Sunny; Fehrer, Julia A.; Shalpegin, Timofey; Stringer, Christina. Navigating tensions of sustainable supply chains in times of multiple crises: A systematic literature review. In: *Business Strategy and the Environment* 34 (1), 2025, 316–337. DOI: 10.1002/bse.3990.
- [2] Mohsin, A. K. M.; Schmidt, Valentin; Aschauer, Franz; Plasch, Michael; Gerschberger, Markus. Examining the Evolution of Sustainable Supply Chain Management: A Systematic Review and Bibliometric Analysis. In: *Sustainable Development* 33 (6), 2025, 8213–8238. DOI: 10.1002/sd.70093.
- [3] Truant, Elisa; Borlatto, Edoardo; Crocco, Edoardo; Sahore, Nidhi. Environmental, social and governance issues in supply chains. A systematic review for strategic performance. In: *Journal of Cleaner Production* 434, 2024, 140024. DOI: 10.1016/j.jclepro.2023.140024.
- [4] International Labour Organization and United Nations Children’s Fund. Methodology of the 2024 ILO-UNICEF Global Estimates of Child Labour. Geneva and New York: ILO and UNICEF, 2025. DOI: 10.54394/PADV1388.
- [5] Fountain, Antonie C.; Huetz-Adams, Friedel. Cocoa Barometer 2025. Executive Summary. 2025. <https://www.suedwind-institut.de/fileadmin/Suedwind/Publikationen/2025/2025-Cocoa-Barometer-Executive-Summary.pdf> (accessed 27 Dec. 2025).
- [6] United Nations Environment Programme. Global Resources Outlook 2024. Bend the Trend – Pathways to a liveable planet as resource use spikes. Nairobi, 2024. <https://www.unep.org/resources/Global-Resource-Outlook-2024> (accessed 1 Dec. 2025).
- [7] Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung. Hintergrundinformationen. Lieferketten und Lieferkettensorgfaltspflichten-gesetz. 2023. <https://www.bmz.de/de/themen/lieferketten/hintergrund-lieferketten-lieferkettengesetz> (accessed 27 Dec. 2025).
- [8] Anit Slavery. A call for a UK Business, Human Rights and Environment Act. Executive Summary. 2024. https://www.antislavery.org/wp-content/uploads/2022/01/ASI_Report_UKBHREA_FULL.pdf (accessed 27 Dec. 2025).
- [9] Bundesrepublik Deutschland. Gesetz über die unternehmerischen Sorgfaltspflichten in Lieferketten: LkSG. Berlin, July 16, 2021. https://www.bgbl.de/xaver/bgbl/start.xav?start=//*%5b@attr_id=%27bgbl121

- s2959.pdf%27%5d#_bgb1_%2F%2F*%5B%40attr_id%3D%27bgb1121s2959.pdf%27%5D__1671030168057 (accessed 14 Dec. 2022).
- [10] Khan, Syed Abdul Rehman; Godil, Danish Iqbal; Jabbour, Charbel Jose Chiappetta; Shujaat, Sobia; Razzaq, Asif; Yu, Zhang. Green data analytics, blockchain technology for sustainable development, and sustainable supply chain practices: evidence from small and medium enterprises. In: *Annals of Operations Research* 350 (2), 2025, 603–627. DOI: 10.1007/s10479-021-04275-x.
 - [11] Malakar, Prerna; Khan, Sharfuddin Ahmed; Gunasekaran, Angappa; Mubarik, Muhammad Shujaat. Digital Technologies for Social Supply Chain Sustainability: An Empirical Analysis Through the Lens of Dynamic Capabilities and Complexity Theory. In: *IEEE Transactions on Engineering Management* 72, 2025, 664–675. DOI: 10.1109/TEM.2024.3524896.
 - [12] Mageto, Joash. Big Data Analytics in Sustainable Supply Chain Management: A Focus on Manufacturing Supply Chains. In: *Sustainability* 13 (13), 2021, 7101. DOI: 10.3390/su13137101.
 - [13] Akinbamini, Ebenezer; Vargas, Alix; Traill, Angela; Boza, Andrés; Cuenca, Llanos. Critical Analysis of Technologies Enhancing Supply Chain Collaboration in the Food Industry: A Nigerian Survey. In: *Logistics* 9 (1), 2025, 8. DOI: 10.3390/logistics9010008.
 - [14] Mubarik, Muhammad Shujaat. Overcoming barriers to digital transformation: Challenges of implementing innovative digital technologies in supply chains. In: *Technological Innovations and Industry 5.0. A Supply Chain Perspective*. Ed. by Vilko D. Sc., Jyri. 1st ed. Developments and Advances in the Supply Chain Industry Series. Chantilly: Elsevier, 2025, 19–36. DOI: 10.1016/B978-0-443-33813-7.00002-6.
 - [15] Bundesministerium für Landwirtschaft, Ernährung und Heimat. Über 300 Jahre forstliche Nachhaltigkeit. 2023. <https://www.bmel.de/DE/themen/wald/wald-in-deutschland/carlowitz-jahr.html> (accessed 11 May 2025).
 - [16] World Commission on Environment and Development. Our Common Future. New York, 1987. <https://digitallibrary.un.org/record/139811?v=pdf> (accessed 5 Jan. 2026).
 - [17] Hueting, Roefie. The Brundtland report. In: *Ecological Economics* 2 (2), 1990, 109–117. DOI: 10.1016/0921-8009(90)90002-C.
 - [18] Keeble, Brian R. The Brundtland report: ‘Our common future’. In: *Medicine and War* 4 (1), 1988, 17–25. DOI: 10.1080/07488008808408783.
 - [19] Haland, Wenche. On Needs - a Central Concept in the Brundtland Report. In: *Towards Sustainable Development. On the Goals of Development - and the Conditions of Sustainability*. Ed. by Lafferty, W.; Langhelle, William. London: Palgrave Macmillan UK, 1999, 48–69.
 - [20] Sneddon, Chris; Howarth, Richard B.; Norgaard, Richard B. Sustainable development in a post-Brundtland world. In: *Ecological Economics* 57 (2), 2006, 253–268. DOI: 10.1016/j.ecolecon.2005.04.013.
 - [21] Elkington, John. Cannibals with Forks: The Triple Bottom Line of 21st Century Business. Oxford: Capstone, 1997.
 - [22] United Nations. The 17 Goals. History. 2025. <https://sdgs.un.org/goals> (accessed 3 Apr. 2026).

-
- [23] Hart, Stuart L. Beyond Greening: Strategies for a Sustainable World. In: *Harvard Business Review* (January - February 1997), 1997, 67–76.
 - [24] Barney, Jay. Firm Resources and Sustained Competitive Advantage. In: *Journal of Management* 17 (1), 1991, 99–120. DOI: 10.1177/014920639101700108.
 - [25] Porter, Michael E. Competitive advantage. Creating and sustaining superior performance. New York: Free Press, 1998.
 - [26] Teece, David J.; Pisano, Gary; Shuen, Amy. Dynamic capabilities and strategic management. In: *Strategic Management Journal* 18 (7), 1997, 509–533. DOI: 10.1002/(SICI)1097-0266(199708)18:7<509::AID-SMJ882>3.0.CO;2-Z.
 - [27] Seuring, Stefan; Müller, Martin. From a literature review to a conceptual framework for sustainable supply chain management. In: *Journal of Cleaner Production* 16 (15), 2008, 1699–1710. DOI: 10.1016/j.jclepro.2008.04.020.
 - [28] Carter, Craig R.; Rogers, Dale S. A framework of sustainable supply chain management: moving toward new theory. In: *International Journal of Physical Distribution & Logistics Management* 38 (5), 2008, 360–387. DOI: 10.1108/09600030810882816.
 - [29] Rashidi, Kamran; Noorizadeh, Abdollah; Kannan, Devika; Cullinane, Kevin. Applying the triple bottom line in sustainable supplier selection: A meta-review of the state-of-the-art. In: *Journal of Cleaner Production* 269, 2020, 122001. DOI: 10.1016/j.jclepro.2020.122001.
 - [30] Milne, Markus J.; Gray, Rob. W(h)ither Ecology? The Triple Bottom Line, the Global Reporting Initiative, and Corporate Sustainability Reporting. In: *Journal of Business Ethics* 118 (1), 2013, 13–29. DOI: 10.1007/s10551-012-1543-8.
 - [31] Nursimloo, Sandira; Ramdhony, Dinesh; Mooneeapen, Oren. Influence of board characteristics on TBL reporting. In: *Corporate Governance: The International Journal of Business in Society* 20 (5), 2020, 765–780. DOI: 10.1108/CG-06-2019-0187.
 - [32] Norman, Wayne; MacDonald, Chris. Getting to the Bottom of “Triple Bottom Line”. In: *Business Ethics Quarterly* 14 (2), 2004, 243–262. DOI: 10.5840/beq200414211.
 - [33] Elkington, John. 25 Years Ago I Coined the Phrase “Triple Bottom Line.” Here’s Why It’s Time to Rethink It. 2018. <https://hbr.org/2018/06/25-years-ago-i-coined-the-phrase-triple-bottom-line-heres-why-im-giving-up-on-it> (accessed 3 Feb. 2025).
 - [34] United Nations. Transforming our world: the 2030 Agenda for Sustainable Development. 2015. <https://docs.un.org/en/A/RES/70/1> (accessed 11 June 2025).
 - [35] Bundesministerium für Umwelt, Klimaschutz, Naturschutz und nukleare Sicherheit. Deutsche Nachhaltigkeitsstrategie. 2025. <https://www.bundesregierung.de/breg-de/aktuelles/deutsche-nachhaltigkeitsstrategie-2025-2332540> (accessed 11 Jan. 2026).
 - [36] United Nations Department of Economic and Social Affairs. The Sustainable Development Goals Report 2025. New York, 2025. <https://unstats.un.org/sdgs/report/2025/> (accessed 11 May 2026).
 - [37] Ellili, Nejla Ould Daoud. Bibliometric analysis of sustainability papers: Evidence from Environment, Development and sustainability. In: *Environment, Development and Sustainability* 26 (4), 2023, 1–27. DOI: 10.1007/s10668-023-03067-6.

-
- [38] Yamaguchi, Natália Ueda; Bernardino, Eduarda Gameleira; Ferreira, Maria Eliana Camargo; Lima, Bruna Pietroski de; Pascotini, Mauro Renato; Yamaguchi, Mirian Ueda. Sustainable development goals: a bibliometric analysis of literature reviews. In: *Environmental Science and Pollution Research* 30 (3), 2023, 5502–5515.
- [39] Schoolman, Ethan D.; Guest, Jeremy S.; Bush, Kathleen F.; Bell, Andrew R. How interdisciplinary is sustainability research? Analyzing the structure of an emerging scientific field. In: *Sustainability Science* 7 (1), 2012, 67–80. DOI: 10.1007/s11625-011-0139-z.
- [40] Olawumi, Timothy O.; Chan, Daniel W.M. A scientometric review of global research on sustainability and sustainable development. In: *Journal of Cleaner Production* 183, 2018, 231–250. DOI: 10.1016/j.jclepro.2018.02.162.
- [41] Feng, Jianghong; Liu, Wenjing; Chen, Feng. Moving towards a circular economy: A systematic review of barriers to electric vehicle battery recycling. In: *Sustainable Production and Consumption* 54, 2025, 241–260. DOI: 10.1016/j.spc.2025.01.006.
- [42] Zimmermann, Wolfgang. Polyester-degrading enzymes in a circular economy of plastics. In: *Nature Reviews Bioengineering*, 2025, 1–16. DOI: 10.1038/s44222-025-00308-3.
- [43] Kumar, Satish; Sharma, Dipasha; Rao, Sandeep; Lim, Weng Marc; Mangla, Sachin Kumar. Past, present, and future of sustainable finance: insights from big data analytics through machine learning of scholarly research. In: *Annals of Operations Research* 345 (2), 2022, 1–44. DOI: 10.1007/s10479-021-04410-8.
- [44] Rau, P. Raghavendra; Yu, Ting. A survey on ESG: investors, institutions and firms. In: *China Finance Review International* 14 (1), 2024, 3–33. DOI: 10.1108/CFRI-12-2022-0260.
- [45] Fatima, Tahniyath; Elbanna, Said. Corporate Social Responsibility (CSR) Implementation: A Review and a Research Agenda Towards an Integrative Framework. In: *Journal of Business Ethics* 183 (1), 2023, 105–121. DOI: 10.1007/s10551-022-05047-8.
- [46] Kuhzady, Salar; Olya, Hesam; Han, Heesup. Corporate social responsibility (CSR): a contemporary review of practices, impacts, and future directions. In: *International Journal of Contemporary Hospitality Management* 37 (7), 2025, 2556–2579. DOI: 10.1108/IJCHM-08-2024-1150.
- [47] Cao, Yinyin; Lawson, Benn; Pil, Frits K. Social sustainability and human rights in global supply chains. In: *International Journal of Operations & Production Management* 44 (1), 2024, 370–390. DOI: 10.1108/IJOPM-10-2022-0670.
- [48] Dhingra, Gourav; Kumar, Anil. Carbon Capture and Sequestration: Cutting-Edge Technologies to Combat Climate Change. In: *Sustainable Energy Technologies and Assessments* 75, 2025, 104226. DOI: 10.1016/j.seta.2025.104226.
- [49] Moore, Jonathan W.; Schindler, Daniel E. Getting ahead of climate change for ecological adaptation and resilience. In: *Science (New York, N.Y.)* 376 (6600), 2022, 1421–1426. DOI: 10.1126/science.abo3608.

- [50] Nicholson, Emily; Watermeyer, Kate E.; Rowland, Jessica A.; Sato, Chloe F.; Stevenson, Simone L.; Andrade, Angela; Brooks, Thomas M.; Burgess, Neil D.; Cheng, Su-Ting; Grantham, Hedley S.; Hill, Samantha L.; Keith, David A.; Maron, Martine; Metzke, Daniel; Murray, Nicholas J.; Nelson, Cara R.; Obura, David; Plumptre, Andy; Skowno, Andrew L.; Watson, James E. M. Scientific foundations for an ecosystem goal, milestones and indicators for the post-2020 global biodiversity framework. In: *Nature Ecology & Evolution* 5 (10), 2021, 1338–1349. DOI: 10.1038/s41559-021-01538-5.
- [51] Seddon, Nathalie; Smith, Alison; Smith, Pete; Key, Isabel; Chausson, Alexandre; Girardin, Cécile; House, Jo; Srivastava, Shilpi; Turner, Beth. Getting the message right on nature-based solutions to climate change. In: *Global change biology* 27 (8), 2021, 1518–1546. DOI: 10.1111/gcb.15513.
- [52] Huang, Chaoqun; Liu, Weibai; Iqbal, Wasim; Shah, Syed Ale Raza. Does digital governance matter for environmental sustainability? The key challenges and opportunities under the prism of natural resource management. In: *Resources Policy* 91, 2024, 104812. DOI: 10.1016/j.resourpol.2024.104812.
- [53] Zhang, Cheng-Yao; Oki, Taikan. Water pricing reform for sustainable water resources management in China's agricultural sector. In: *Agricultural Water Management* 275, 2023, 108045. DOI: 10.1016/j.agwat.2022.108045.
- [54] Dissanayake, Kavishka; Kularatna-Abeywardana, Dulsha. A review of supercapacitors: Materials, technology, challenges, and renewable energy applications. In: *Journal of Energy Storage* 96, 2024, 112563. DOI: 10.1016/j.est.2024.112563.
- [55] Khalid, Muhammad. Smart grids and renewable energy systems: Perspectives and grid integration challenges. In: *Energy Strategy Reviews* 51, 2024, 101299. DOI: 10.1016/j.esr.2024.101299.
- [56] Mensah, Kristina; Wieck, Christine; Rudloff, Bettina. Sustainable food consumption and Sustainable Development Goal 12: Conceptual challenges for monitoring and implementation. In: *Sustainable Development* 32 (1), 2024, 1109–1119. DOI: 10.1002/sd.2718.
- [57] Rahaman, Md. Tareque; Pranta, Arnob Dhar; Repon, Md. Reazuddin; Ahmed, Md. Samin; Islam, Tarekul. Green production and consumption of textiles and apparel: Importance, fabrication, challenges and future prospects. In: *Journal of Open Innovation: Technology, Market, and Complexity* 10 (2), 2024, 100280. DOI: 10.1016/j.joitmc.2024.100280.
- [58] Costa, Ana Carolina Ferreira; Brito Silva, Andresa Monique de; Espuny, Maximilian; Rocha, Aglaé Baptista Torres; Oliveira, Otávio José de. Toward quality education: Contributions of EdTech to the achievement of the fourth United Nations sustainable development goal. In: *Sustainable Development* 32 (3), 2024, 1634–1651. DOI: 10.1002/sd.2742.
- [59] Zickafoose, Alexis; Ilesanmi, Olawunmi; Diaz-Manrique, Miguel; Adeyemi, Anjorin E.; Walumbe, Benard; Strong, Robert; Wingenbach, Gary; Rodriguez, Mary T.; Dooley, Kim. Barriers and Challenges Affecting Quality Education (Sustainable Development Goal #4) in Sub-Saharan Africa by 2030. In: *Sustainability* 16 (7), 2024, 2657. DOI: 10.3390/su16072657.

-
- [60] Rahat, Nazish; Sahni, Shalini; Nasim, Saboohi. Mapping sustainability practices in the healthcare sector: A systematic literature review and future research agenda. In: *International Journal of Consumer Studies* 48 (1), 2024. DOI: 10.1111/ijcs.12997.
- [61] Vishwakarma, Laxmi Pandit; Singh, Rajesh Kr; Mishra, Ruchi; Kumari, Archana. Application of artificial intelligence for resilient and sustainable healthcare system: systematic literature review and future research directions. In: *International Journal of Production Research* 63 (2), 2025, 822–844. DOI: 10.1080/00207543.2023.2188101.
- [62] Sahoo, Debashish Kumar; Lenka, Usha. Affirmative action and government initiatives to improve gender equality in India: a retrospective view. In: *Equality, Diversity and Inclusion: An International Journal* (ahead-of-print), 2024. DOI: 10.1108/EDI-03-2021-0086.
- [63] Yang, Biao; Subramanian, Nachiappan; Al Harthy, Shaima. Are gender diversity issues a hidden problem in logistics and supply chain management? Building research themes through a systematic literature review. In: *Journal of Purchasing and Supply Management* 30 (5), 2024, 100937. DOI: 10.1016/j.pursup.2024.100937.
- [64] Lima, Felipe Alexandre de; Vanpoucke, Evelyne; Gold, Stefan; Seuring, Stefan. From Power to Sustainability? Unpacking the Role of Justice in Agricultural Commodity Supply Networks. In: *Journal of Operations Management*, 2025. DOI: 10.1002/joom.1372.
- [65] Meemken, Eva-Marie; Barrett, Christopher B.; Michelson, Hope C.; Qaim, Matin; Reardon, Thomas; Sellare, Jorge. Sustainability standards in global agrifood supply chains. In: *Nature Food* 2 (10), 2021, 758–765. DOI: 10.1038/s43016-021-00360-3.
- [66] Dou, Shiquan; Xu, Deyi; Zhu, Yongguang; Keenan, Rodney. Critical mineral sustainable supply: Challenges and governance. In: *Futures* 146, 2023, 103101. DOI: 10.1016/j.futures.2023.103101.
- [67] Xames, Md Doulotuzzaman; Topcu, Taylan G. How Can Digital Twins Support the Economic, Environmental, and Social Sustainability of Healthcare Systems: A Systematic Review Focused on the Triple Bottom Line. In: *IEEE Access* 13, 2025, 64390–64411. DOI: 10.1109/ACCESS.2025.3559502.
- [68] Wuni, Ibrahim Yahaya. Burden of proof beyond the triple bottom line: Mapping the benefits of circular construction. In: *Sustainable Production and Consumption* 34, 2022, 528–540. DOI: 10.1016/j.spc.2022.10.006.
- [69] Govindan, Kannan; Khodaverdi, Roohollah; Jafarian, Ahmad. A fuzzy multi criteria approach for measuring sustainability performance of a supplier based on triple bottom line approach. In: *Journal of Cleaner Production* 47, 2013, 345–354. DOI: 10.1016/j.jclepro.2012.04.014.
- [70] Strange, Tracey; Bayley, Anne. Sustainable Development. Linking Economy, Society, Environment. OECD Insights. Paris: Organisation for Economic Co-operation and Development, 2008. DOI: 10.1787/9789264055742-en.
- [71] Cooper, Jasmin; Stamford, Laurence; Azapagic, Adisa. Shale Gas: A Review of the Economic, Environmental, and Social Sustainability. In: *Energy Technology* 4 (7), 2016, 772–792. DOI: 10.1002/ente.201500464.

-
- [72] Maynard, Dayanne; Vidigal, Mayara; Farage, Priscila; Zandonadi, Renata; Nakano, Eduardo; Botelho, Raquel. Environmental, Social and Economic Sustainability Indicators Applied to Food Services: A Systematic Review. In: *Sustainability* 12 (5), 2020, 1804. DOI: 10.3390/su12051804.
- [73] Forrester, Jay W. Industrial Dynamics. A Major Breakthrough for Decision Makers. In: *Harvard Business Review* 36 (4), 1958, 37–66.
- [74] Stevens, Graham C. Integrating the Supply Chain. In: *International Journal of Physical Distribution & Materials Management* 19 (8), 1989, 3–8. DOI: 10.1108/EUM00000000000329.
- [75] Christopher, Martin. Logistics and supply chain management. Strategies for Reducing Costs and Improving Services. London: Pitman Publ, 1992.
- [76] Chopra, Sunil; Meindl, Peter. Supply Chain Management. Strategy, Planning, and Operation. 3rd ed. New Jersey: Prentice Hall, 2007.
- [77] Chopra, Sunil. Supply Chain Management. Strategy, Planning, and Operation. Seventh edition. New York, NY: Pearson, 2019.
- [78] Christopher, Martin. Logistics & supply chain management. Sixth edition. Harlow, England: Pearson, 2023.
- [79] Houlihan, John B. International Supply Chain Management. In: *International Journal of Physical Distribution & Materials Management* 15 (1), 1985, 22–38. DOI: 10.1108/eb014601.
- [80] Mentzer, John T.; DeWitt, William; Keebler, James S.; Min, Soonhong; Nix, Nancy W.; Smith, Carlo D.; Zacharia, Zach G. DEFINING SUPPLY CHAIN MANAGEMENT. In: *Journal of Business Logistics* 22 (2), 2001, 1–25. DOI: 10.1002/j.2158-1592.2001.tb00001.x.
- [81] Lambert, Douglas M.; Cooper, Martha C. Issues in Supply Chain Management. In: *Industrial Marketing Management* 29 (1), 2000, 65–83. DOI: 10.1016/S0019-8501(99)00113-3.
- [82] Stevens, Graham C. Successful Supply–Chain Management. In: *Management Decision* 28 (8), 1990. DOI: 10.1108/00251749010140790.
- [83] Cox, Andrew. Power, value and supply chain management. In: *Supply Chain Management: An International Journal* 4 (4), 1999, 167–175. DOI: 10.1108/13598549910284480.
- [84] Lee, Hau L., Padmanabhan, V., Whang, Seungjin. The Bullwhip Effect in Supply Chains. In: *Sloan Management Review* (Spring 1997), 1997, 93–102.
- [85] Saoud, Patrick; Kourentzes, Nikolaos; Boylan, John E. The importance of forecast uncertainty in understanding the Bullwhip effect. In: *International Journal of Production Research*, 2025, 1–22. DOI: 10.1080/00207543.2025.2527957.
- [86] Sunil Chopra; ManMohan S. Sodhi. Managing Risk to Avoid Supply-Chain Breakdown. In: *MIT Sloan Management Review* 46 (1), 2004, 53–61.
- [87] Bednarski, Lukasz; Roscoe, Samuel; Blome, Constantin; Schleper, Martin C. Geopolitical disruptions in global supply chains: a state-of-the-art literature review. In: *Production Planning & Control*, 2023, 1–27. DOI: 10.1080/09537287.2023.2286283.

- [88] Marculetiu, Alina; Ataseven, Cigdem; Mackelprang, Alan W. A review of how pressures and their sources drive sustainable supply chain management practices. In: *Journal of Business Logistics* 44 (2), 2023, 257–288. DOI: 10.1111/jbl.12332.
- [89] Al Aghbari, Sarah; Mohammed, Ahmed; Zubairu, Nasiru; Abdul Rahman, Noorul Shaiful Fitri. Exploring the social and environmental performance in fast-fashion supply chains: a comparative analysis between MNCs and SMEs. In: *International Journal of Productivity and Performance Management* 74 (8), 2025, 2932–2958. DOI: 10.1108/IJPPM-05-2024-0342.
- [90] Shaw, Mahesh; Majumdar, Abhijit; Govindan, Kannan. How are the barriers of social sustainability perceived in a multi-tier supply chain? A case of textile and clothing industry. In: *Operations Management Research* 17 (1), 2024, 91–113. DOI: 10.1007/s12063-023-00406-8.
- [91] Dhar, Amit; Nandi, Debapriya. Exploring the Effects of Electronic Waste: A Comprehensive Study of Production, Management, and Health Risks in India. In: *International Journal of Environmental Research* 20 (1), 2026, 51. DOI: 10.1007/s41742-025-00984-4.
- [92] Menon, Rakesh R.; Ravi, V. Analysis of barriers of sustainable supply chain management in electronics industry: An interpretive structural modelling approach. In: *Cleaner and Responsible Consumption* 3, 2021, 100026. DOI: 10.1016/j.clrc.2021.100026.
- [93] Grabs, Janina; Carodenuto, Sophia; Jespersen, Kristjan; Adams, Marshall A.; Camacho, Manuel Antonio; Celi, Giacomo; Chandra, Adelina; Dufour, Jeremy; Ermgassen, Erasmus K. H. J. zu; Garrett, Rachael D.; Lyons-White, Joss; McLeish, Moray; Niehues, Ina; Silverman, Sofia; Stone, Emily. The role of midstream actors in advancing the sustainability of agri-food supply chains. In: *Nature Sustainability* 7 (5), 2024, 527–535. DOI: 10.1038/s41893-024-01296-9.
- [94] Li, Tania Murray. Securing oil palm smallholder livelihoods without more deforestation in Indonesia. In: *Nature Sustainability* 7 (4), 2024, 387–393. DOI: 10.1038/s41893-024-01279-w.
- [95] Transparency International. Corruption Perceptions Index 2025. 2026. <https://www.transparency.org/en/cpi/2025> (accessed 3 May 2026).
- [96] Schaëfer, Kati; Kähkönen, Anni-Kaisa; Luzzini, Davide. Traceability in multi-tier supply chains: insights from five case studies. In: *Supply Chain Management: An International Journal* 30 (7), 2025, 77–99. DOI: 10.1108/SCM-07-2024-0428.
- [97] Organisation for Economic Co-operation and Development; European Union Intellectual Property Office. From Fakes to Forced Labour. Evidence of Correlation Between Illicit Trade in Counterfeits and Labour Exploitation. Paris, 2026. DOI: 10.1787/540dc43e-en.
- [98] Alamgir, Fahreen; Banerjee, Subhabrata Bobby. Contested compliance regimes in global production networks: Insights from the Bangladesh garment industry. In: *Human Relations* 72 (2), 2019, 272–297. DOI: 10.1177/0018726718760150.
- [99] International Labour Organization. Advancing Decent Work in Supply Chains. Decent Work Challenges and Opportunities in the Textiles and Clothing Sector. ILO Brief. Geneva, 2025. DOI: 10.54394/PKJM3600.

-
- [100] European Commission. RMIS - Raw Materials Information Systems. Raw Material Profiles - Cobalt. 2026. <https://rmis.jrc.ec.europa.eu/rmp/Cobalt> (accessed 5 Mar. 2026).
- [101] European Commission. RMIS – Raw Materials Information System. Raw Materials Profiles - Tantalum. 2026. <https://rmis.jrc.ec.europa.eu/rmp/Tantalum> (accessed 5 Mar. 2026).
- [102] Drive Sustainability, The Responsible Minerals Initiative, The Dragonfly Initiative. Material Change. A Study of Risks and Opportunities for collective Action in the Materials Supply Chains of the Automotive and Electronics Industries. 2018. <https://eiccoalition.sharefile.com/share/view/s1787b0a407047d29> (accessed 5 Mar. 2026).
- [103] European Commission. Conflict Minerals Regulation: The regulation explained. 2021. https://policy.trade.ec.europa.eu/development-and-sustainability/conflict-minerals-regulation/regulation-explained_en (accessed 10 May 2026).
- [104] Panhuysen, Sjoerd; Pierrot, Joost. Coffee Barometer. 2020. In: 2020. <https://hivos.org/assets/2021/01/Coffee-Barometer-2020.pdf> (accessed 6 Mar. 2026).
- [105] International Labour Organization. Challenges and opportunities to advance decent work in five countries and supply chains. A synthesis report. 2023. <https://www.ilo.org/publications/challenges-and-opportunities-advance-decent-work-five-countries-and-supply> (accessed 3 May 2026).
- [106] Organisation for Economic Co-operation and Development. Due diligence essentials for responsible garment and footwear. 2026. https://www.oecd.org/en/publications/responsible-business-conduct-spotlights_03a75bf9-en/due-diligence-essentials-for-responsible-garment-and-footwear_c7ae4e4a-en.html (accessed 8 May 2026).
- [107] Villena, Verónica H.; Gioia, Dennis A. On the riskiness of lower-tier suppliers: Managing sustainability in supply networks. In: *Journal of Operations Management* 64 (1), 2018, 65–87. DOI: 10.1016/j.jom.2018.09.004.
- [108] Marttinen, Kati; Kähkönen, Anni-Kaisa. Fostering firms' ability to cascade sustainability through multi-tier supply chains: an investigation of power sources. In: *International Journal of Operations & Production Management* 42 (8), 2022, 1146–1172. DOI: 10.1108/IJOPM-11-2021-0739.
- [109] Niinimäki, Kirsi; Peters, Greg; Dahlbo, Helena; Perry, Patsy; Rissanen, Timo; Gwilt, Alison. The environmental price of fast fashion. In: *Nature Reviews Earth & Environment* 1 (4), 2020, 189–200. DOI: 10.1038/s43017-020-0039-9.
- [110] PwC. Climate change threatens the world's most critical technology. Briefing for business leaders. 2025. <https://www.pwc.com/gx/en/issues/esg/pwc-semi-con-report.pdf> (accessed 5 Mar. 2026).
- [111] Yeung, Henry Wai-chung. Explaining Geographic Shifts of Chip Making toward East Asia and Market Dynamics in Semiconductor Global Production Networks. In: *Economic Geography* 98 (3), 2022, 272–298. DOI: 10.1080/00130095.2021.2019010.

- [112] Organisation for Economic Co-operation and Development. OECD Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas. Version 3. Paris, 2016. https://www.oecd.org/en/publications/oecd-due-diligence-guidance-for-responsible-supply-chains-of-minerals-from-conflict-affected-and-high-risk-areas_9789264252479-en.html (accessed 10 May 2026).
- [113] Sovacool, Benjamin K.; Ali, Saleem H.; Bazilian, Morgan; Radley, Ben; Nemery, Benoit; Okatz, Julia; Mulvaney, Dustin. Sustainable minerals and metals for a low-carbon future. In: *Science (New York, N.Y.)* 367 (6473), 2020, 30–33. DOI: 10.1126/science.aaz6003.
- [114] Finn, Brandon Marc; Cobbinah, Patrick Brandful; Gounaridis, Dimitrios. The informal paradox: electronic waste and the toxic circular economy in Ghana. In: *npj Urban Sustainability* 5 (1), 2025, 101. DOI: 10.1038/s42949-025-00299-5.
- [115] United Nations Environment Programme. Minerals and metals extraction. Sector profile. 2026. <https://www.unepfi.org/humanrightstoolkit/minerals-and-metals-extraction/> (accessed 5 Mar. 2026).
- [116] Pagell, Mark; Wu Zhaohui. Building a more complete Theory of Sustainable Supply Chain Management using Case Studies of 10 Exemplars. In: *Journal of Supply Chain Management* 45 (2), 2009, 37–56. DOI: 10.1111/j.1745-493X.2009.03162.x.
- [117] Dai, Jun; Xie, Li; Chu, Zhaofang. Developing sustainable supply chain management: The interplay of institutional pressures and sustainability capabilities. In: *Sustainable Production and Consumption* 28, 2021, 254–268. DOI: 10.1016/j.spc.2021.04.017.
- [118] Alharbi, Khalid Mujahid; Elshamly, Amina; Mahgoub, Ibrahim G. Do Regulatory Pressures and Stakeholder Expectations Drive CSR Adherence in the Chemical Industry? In: *Sustainability* 17 (5), 2025, 2128. DOI: 10.3390/su17052128.
- [119] European Parliament; Council of the European Union. Regulation (EU) 2023/1115 of the European Parliament and of the Council of 31 May 2023 on the making available on the Union market and the export from the Union of certain commodities and products associated with deforestation and forest degradation and repealing Regulation (EU) No 995/2010. Brussels, May 31, 2023. <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32023R1115&qid=1687867231461> (accessed 30 Aug. 2025).
- [120] Pagell, Mark; Shevchenko, Anton. Why Research in Sustainable Supply Chain Management Should Have no Future. In: *Journal of Supply Chain Management* 50 (1), 2014, 44–55. DOI: 10.1111/jscm.12037.
- [121] Srivastava, Samir K. Green supply-chain management: A state-of-the-art literature review. In: *International Journal of Management Reviews* 9 (1), 2007, 53–80. DOI: 10.1111/j.1468-2370.2007.00202.x.
- [122] Beske, Philip; Seuring, Stefan. Putting sustainability into supply chain management. In: *Supply Chain Management: An International Journal* 19 (3), 2014, 322–331. DOI: 10.1108/SCM-12-2013-0432.

- [123] Barbosa-Póvoa, Ana Paula; Da Silva, Cátia; Carvalho, Ana. Opportunities and challenges in sustainable supply chain: An operations research perspective. In: *European Journal of Operational Research* 268 (2), 2018, 399–431. DOI: 10.1016/j.ejor.2017.10.036.
- [124] Homayouni, Zahra; Pishvae, Mir Saman; Jahani, Hamed; Ivanov, Dmitry. A robust-heuristic optimization approach to a green supply chain design with consideration of assorted vehicle types and carbon policies under uncertainty. In: *Annals of Operations Research* 324 (1-2), 2023, 395–435. DOI: 10.1007/s10479-021-03985-6.
- [125] UN Global Compact. The Ten Principles of the UN Global Compact. 2011. <https://www.unglobalcompact.org/what-is-gc/mission/principles> (accessed 14 Dec. 2025).
- [126] Montabon, Frank; Pagell, Mark; Wu, Zhaohui. Making Sustainability Sustainable. In: *Journal of Supply Chain Management* 52 (2), 2016, 11–27. DOI: 10.1111/jscm.12103.
- [127] United Nations. Guiding Principles on Business and Human Rights. Implementing the United Nations “Protect, Respect and Remedy” Framework. 2011. https://www.ohchr.org/sites/default/files/documents/publications/guidingprinciplesbusinesshr_en.pdf (accessed 3 Jan. 2026).
- [128] European Union. Directive (EU) 2024/1760 of the European Parliament and of the Council of 13 June 2024 on corporate sustainability due diligence and amending Directive (EU) 2019/1937 and Regulation (EU) 2023/2859. Brussels, 13.06.2024. <https://eur-lex.europa.eu/eli/dir/2024/1760/oj> (accessed 2 Apr. 2025).
- [129] Bowen, Francis; Siegler, Janaina. The role of visibility in supply chain resiliency: Applying the Nexus supplier index to unveil hidden critical suppliers in deep supply networks. In: *Decision Support Systems* 176, 2024, 114063. DOI: 10.1016/j.dss.2023.114063.
- [130] Taghizadeh, Elham; Venkatachalam, Saravanan; Chinnam, Ratna Babu. Impact of deep-tier visibility on effective resilience assessment of supply networks. In: *International Journal of Production Economics* 241, 2021, 108254. DOI: 10.1016/j.ijpe.2021.108254.
- [131] Hofstede, Gerd Jan. Trust and Transparency in Netchains: A Contradiction? In: *Supply Chain Management. Issues in the New Era of Collaboration and Competition*. Ed. by Chung Wang, William Yu; Heng, Michael S. H.; Chau, Patrick Y. K. Hershey PA, London: Idea Group Inc (IGI), 2007, 105–126. DOI: 10.4018/978-1-59904-231-2.ch005.
- [132] Sodhi, ManMohan S.; Tang, Christopher S. Research Opportunities in Supply Chain Transparency. In: *Production and Operations Management* 28 (12), 2019, 2946–2959. DOI: 10.1111/poms.13115.
- [133] Gardner, T. A.; Benzie, M.; Börner, J.; Dawkins, E.; Fick, S.; Garrett, R.; Godar, J.; Grimard, A.; Lake, S.; Larsen, R. K.; Mardas, N.; McDermott, C. L.; Meyfroidt, P.; Osbeck, M.; Persson, M.; Sembres, T.; Suavet, C.; Strassburg, B.; Trevisan, A.; West, C.; Wolvekamp, P. Transparency and sustainability in global commodity supply chains. In: *World Development* 121, 2019, 163–177. DOI: 10.1016/j.worlddev.2018.05.025.

-
- [134] García-Torres, Sofia; Rey-García, Marta; Sáenz, Josune. Enhancing sustainable supply chains through traceability, transparency and stakeholder collaboration: A quantitative analysis. In: *Business Strategy and the Environment* 33 (7), 2024, 7607–7629. DOI: 10.1002/bse.3884.
- [135] McGrath, Paul; McCarthy, Lucy; Marshall, Donna; Rehme, Jakob. Tools and Technologies of Transparency in Sustainable Global Supply Chains. In: *California Management Review* 64 (1), 2021, 67–89. DOI: 10.1177/00081256211045993.
- [136] Bundesamt für Wirtschaft und Ausfuhrkontrolle. FAQ zum risikobasierten Vorgehen. 2025. https://www.bafa.de/SharedDocs/Downloads/DE/Lieferketten/faq_risikobasierte_vorgehen.html (accessed 10 May 2026).
- [137] World Justice Project. WJP Rule of Law Index. 2025. <https://worldjusticeproject.org/rule-of-law-index/global> (accessed 10 May 2026).
- [138] Høgevoid, Nils M.; Svensson, Göran. A business sustainability model: a European case study. In: *Journal of Business & Industrial Marketing* 27 (2), 2012, 142–151. DOI: 10.1108/08858621211197001.
- [139] Yawar, Sadaat Ali; Seuring, Stefan. Management of Social Issues in Supply Chains: A Literature Review Exploring Social Issues, Actions and Performance Outcomes. In: *Journal of Business Ethics* 141 (3), 2017, 621–643. DOI: 10.1007/s10551-015-2719-9.
- [140] Marty, Justine; Tosi, Laetitia. Enhancing sustainable supply chain through downstream actor integration: a comprehensive framework. In: *Supply Chain Forum: An International Journal* 25 (3), 2024, 321–336. DOI: 10.1080/16258312.2023.2288854.
- [141] Seuring, Stefan. Supply chain management for sustainable products - insights from research applying mixed methodologies. In: *Business Strategy and the Environment* 20 (7), 2011, 471–484. DOI: 10.1002/bse.702.
- [142] Foerstl, Kai; Reuter, Carsten; Hartmann, Evi; Blome, Constantin. Managing supplier sustainability risks in a dynamically changing environment—Sustainable supplier management in the chemical industry. In: *Journal of Purchasing and Supply Management* 16 (2), 2010, 118–130. DOI: 10.1016/j.pursup.2010.03.011.
- [143] Liu, Junjun; Zhu, Qinghua; Feng, Yunting. The circular economy and green supply chain management. In: *Handbook on the sustainable supply chain*. Ed. by Sarkis, Joseph. Edward Elgar E-Book Archive. Cheltenham, UK and Northampton, MA, USA: Edward Elgar Publishing, 2019. DOI: 10.4337/9781786434272.00007.
- [144] Kim, Seongtae; Foerstl, Kai; Schmidt, Christoph G.; Wagner, Stephan M. Adoption of green supply chain management practices in multi-tier supply chains: examining the differences between higher and lower tier firms. In: *International Journal of Production Research* 60 (21), 2022, 6451–6468. DOI: 10.1080/00207543.2021.1992032.
- [145] Böge, Friederike; Schubert, Christian; Welter, Patrick. Konzerne sollen an Zwangsarbeit durch Uiguren profitiert haben. In: *Frankfurter Allgemeine*, 2021. <https://www.faz.net/aktuell/wirtschaft/unternehmen/ob-firmen-vonder-ausbeutung-der-uiguren-profitieren-17419555.html> (accessed 5 July 2025).

- [146] Stempel, Jonathan. US court sides with Apple, Tesla, other tech companies over child labor in Africa. Mar. 6, 2024. <https://www.reuters.com/legal/us-appels-court-dismisses-child-labor-case-against-tech-companies-2024-03-05/> (accessed 10 Aug. 2025).
- [147] Mathias, Peer. Nestlé: Neue Vorwürfe gegen Palmöl-Zulieferer. Sept. 19, 2018. <https://www.handelsblatt.com/unternehmen/handel-konsumgueter/konsumgueterriese-debatte-um-illegale-regenwald-rodung-neue-vorwuere-gegen-palmoelzulieferer-von-nestle/23080522.html> (accessed 5 July 2025).
- [148] Luthra, Sunil; Govindan, Kannan; Kannan, Devika; Mangla, Sachin Kumar; Garg, Chandra Prakash. An integrated framework for sustainable supplier selection and evaluation in supply chains. In: *Journal of Cleaner Production* 140, 2017, 1686–1698. DOI: 10.1016/j.jclepro.2016.09.078.
- [149] M. Tachizawa, Elcio; Yew Wong, Chee. Towards a theory of multi-tier sustainable supply chains: a systematic literature review. In: *Supply Chain Management: An International Journal* 19 (5/6), 2014, 643–663. DOI: 10.1108/SCM-02-2014-0070.
- [150] Diego, Jesus; Montes-Sancho, Maria J. Nexus supplier transparency and supply network accessibility: effects on buyer ESG risk exposure. In: *International Journal of Operations & Production Management* 45 (4), 2025, 895–924. DOI: 10.1108/IJOPM-12-2023-0972.
- [151] King, Andrew A.; Lenox, Michael J. Does It Really Pay to Be Green? An Empirical Study of Firm Environmental and Financial Performance: An Empirical Study of Firm Environmental and Financial Performance. In: *Journal of Industrial Ecology* 5 (1), 2001, 105–116. DOI: 10.1162/108819801753358526.
- [152] Russo, Michael V.; Fouts, Paul A. A Resource-Based Perspective On Corporate Environmental Performance And Profitability. In: *Academy of Management Journal* 40 (3), 1997, 534–559. DOI: 10.5465/257052.
- [153] Seuring, Stefan; Sarkis, Joseph; Müller, Martin; Rao, Purba. Sustainability and supply chain management – An introduction to the special issue. In: *Journal of Cleaner Production* 16 (15), 2008, 1545–1551. DOI: 10.1016/j.jclepro.2008.02.002.
- [154] Jaggernath, Runala; Khan, Zaffar. Green supply chain management. In: *World Journal of Entrepreneurship, Management and Sustainable Development* 11 (1), 2015, 37–47. DOI: 10.1108/WJEMSD-06-2014-0018.
- [155] Sarkis, Joseph. A boundaries and flows perspective of green supply chain management. In: *Supply Chain Management: An International Journal* 17 (2), 2012, 202–216. DOI: 10.1108/13598541211212924.
- [156] Han, Hui; Li, Jingyue. Leveraging industry 4.0 technologies for sustainable supply chain management: A systematic review. In: *Cleaner Logistics and Supply Chain* 16, 2025, 100246. DOI: 10.1016/j.clscn.2025.100246.
- [157] Jia, Fu; Aboagye, Samuel; Shahzadi, Gulnaz; Chen, Lujie. Sustainable practices in healthcare supply chains: a review of strategies, challenges, and impacts. In: *International Journal of Logistics Research and Applications*, 2025, 1–25. DOI: 10.1080/13675567.2025.2461102.

- [158] Khan, Iqra Sadaf; Ahmad, Muhammad Ovais; Majava, Jukka. Industry 4.0 and sustainable development: A systematic mapping of triple bottom line, Circular Economy and Sustainable Business Models perspectives. In: *Journal of Cleaner Production* 297, 2021, 126655. DOI: 10.1016/j.jclepro.2021.126655.
- [159] Seuring, Stefan; Aman, Sadaf; Hettiarachchi, Biman Darshana; Lima, Felipe Alexandre de; Schilling, Lara; Sudusinghe, Jayani Ishara. Reflecting on theory development in sustainable supply chain management. In: *Cleaner Logistics and Supply Chain* 3, 2022, 100016. DOI: 10.1016/j.clscn.2021.100016.
- [160] Tsai, Feng Ming; Bui, Tat-Dat; Tseng, Ming-Lang; Ali, Mohd Helmi; Lim, Ming K.; Chiu, Anthony S. F. Sustainable supply chain management trends in world regions: A data-driven analysis. In: *Resources, Conservation and Recycling* 167, 2021, 105421. DOI: 10.1016/j.resconrec.2021.105421.
- [161] Gomez-Trujillo, Ana Maria; Gonzalez-Perez, Maria Alejandra. Digital transformation as a strategy to reach sustainability. In: *Smart and Sustainable Built Environment* 11 (4), 2022, 1137–1162. DOI: 10.1108/SASBE-01-2021-0011.
- [162] Li, Lixu; Zhu, Wenwen; Chen, Lujie; Liu, Yaoqi. Generative AI usage and sustainable supply chain performance: A practice-based view. In: *Transportation Research Part E: Logistics and Transportation Review* 192, 2024, 103761. DOI: 10.1016/j.tre.2024.103761.
- [163] Seyyedi, Seyed Reza; Kowsari, Elaheh; Gheibi, Mohammad; Chinnappan, Amutha; Ramakrishna, Seeram. A comprehensive review integration of digitalization and circular economy in waste management by adopting artificial intelligence approaches: Towards a simulation model. In: *Journal of Cleaner Production* 460, 2024, 142584. DOI: 10.1016/j.jclepro.2024.142584.
- [164] Stroumpoulis, Asterios; Kopanaki, Evangelia. Theoretical Perspectives on Sustainable Supply Chain Management and Digital Transformation: A Literature Review and a Conceptual Framework. In: *Sustainability* 14 (8), 2022, 4862. DOI: 10.3390/su14084862.
- [165] Pervez, Hamza; Saunila, Minna; Rantala, Tero; Ukko, Juhani. Navigating the sustainable Industry 4.0 transformation in supply chains: a systematic review and future research agenda. In: *International Journal of Production Research*, 2025, 1–36. DOI: 10.1080/00207543.2025.2550458.
- [166] Saidu, Yahaya; Shuhidan, Shuhaida Mohamed; Aliyu, Dahiru Adamu; Abdul Aziz, Izzatdin; Adamu, Shamsuddeen. Convergence of Blockchain, IoT, and AI for Enhanced Traceability Systems: A Comprehensive Review. In: *IEEE Access* 13, 2025, 16838–16865. DOI: 10.1109/ACCESS.2025.3528035.
- [167] Chrifi-Alaoui, Chaimae; Bouhaddou, Imane; Benabdellah, Abba Chaouni; Zekhnini, Kamar. Industry 5.0 for Sustainable Supply Chains: A Fuzzy AHP Approach for Evaluating the adoption Barriers. In: *Procedia Computer Science* 253, 2025, 2645–2654. DOI: 10.1016/j.procs.2025.01.324.
- [168] Sudusinghe, Jayani Ishara; Seuring, Stefan. The practitioner perspective is more complete: analysing supply chain collaboration for the circular economy. In: *Production Planning & Control*, 2025, 1–24. DOI: 10.1080/09537287.2025.2484556.

- [169] Liu, Lingdi; Song, Wenyan; Liu, Yang. Leveraging digital capabilities toward a circular economy: Reinforcing sustainable supply chain management with Industry 4.0 technologies. In: *Computers & Industrial Engineering* 178, 2023, 109113. DOI: 10.1016/j.cie.2023.109113.
- [170] Vaezinejad, Soode; Kouhizadeh, Mahtab; Schniederjans, Dara; Sarkis, Joseph. Digital technology and the circular economy: A theoretical perspective. In: *Computers & Industrial Engineering* 206, 2025, 111225. DOI: 10.1016/j.cie.2025.111225.
- [171] Rashid, Kh. Harun Or; Aziz, Ridwan Al; Karmaker, Chitra Lekha; Bari, A.B.M. Mainul; Raihan, Asif. Evaluating the challenges to circular economy implementation in the apparel accessories industry: Implications for sustainable development. In: *Green Technologies and Sustainability* 3 (2), 2025, 100140. DOI: 10.1016/j.grets.2024.100140.
- [172] Igarashi, Mieko; Boer, Luitzen de; Fet, Annik Magerholm. What is required for greener supplier selection? A literature review and conceptual model development. In: *Journal of Purchasing and Supply Management* 19 (4), 2013, 247–263. DOI: 10.1016/j.pursup.2013.06.001.
- [173] Ho, William; Xu, Xiaowei; Dey, Prasanta K. Multi-criteria decision making approaches for supplier evaluation and selection: A literature review. In: *European Journal of Operational Research* 202 (1), 2010, 16–24. DOI: 10.1016/j.ejor.2009.05.009.
- [174] Sithi, Sanjucta Saha; Ara, Mst. Anjuman; Dhrubo, Ahnaf Tahmid; Rony, Abid Hasan; Shabur, Md. Abdus. Sustainable supplier selection in the textile industry using triple bottom line and SWARA-TOPSIS approaches. In: *Discover Sustainability* 6 (1), 2025, 1–23. DOI: 10.1007/s43621-025-01206-9.
- [175] Gidiagba, Joachim O.; Tartibu, Lagouge K.; Okwu, Modestus O. A systematic review of machine learning applications in sustainable supplier selection. In: *Decision Analytics Journal* 14, 2025, 100547. DOI: 10.1016/j.dajour.2025.100547.
- [176] Albayrak Ünal, Özge; Kiliç Sarigül, Raziye; ErKayman, Burak. Supplier Selection with Multi-Criteria Decision-Making Methods: Trends in the Literature, Bibliometric Analysis, Future Recommendations. In: *Intelligent and Fuzzy Systems. Artificial Intelligence in Human-Centric, Resilient & Sustainable Industries, Proceedings of the INFUS 2025 Conference, Volume 1*. International Conference on Intelligent and Fuzzy Systems. Ed. by Kahraman, Cengiz; Cebi, Selcuk; Oztaysi, Basar; Cevik Onar, Sezi; Tolga, Cagri.; Ucal Sari, Irem; Otay, Irem. Lecture Notes in Networks and Systems 1528. Cham: Springer Nature Switzerland and Imprint Springer, 2025, 772–780. DOI: 10.1007/978-3-031-97985-9_85.
- [177] République Française. LOI no 2017-399 du 27 mars 2017 relative au devoir de vigilance des sociétés mères et des entreprises donneuses d’ordre (1). Law. Paris, 2017. <https://www.legifrance.gouv.fr/jorf/id/JORFTEXT000034290626/> (accessed 27 Dec. 2025).
- [178] European Commission. Ecodesign for Sustainable Products and Energy Labelling Working Plan 2025-2030. SWD(2025) 112 final. In: 2025. https://environment.ec.europa.eu/document/download/5f7ff5e2-ebe9-4bd4-a139-db881bd6398f_en?filename=FAQ-UPDATE-4th-Iteration_clean.pdf (accessed 22 Dec. 2025).

- [179] Brandenburg, Marcus; Warasthe, Ronakeh; Seuring, Stefan. Impact pathways: improving supply chain sustainability by due diligence acts? Insights from a German case. In: *International Journal of Operations & Production Management* 44 (4), 2024, 859–874. DOI: 10.1108/IJOPM-03-2023-0200.
- [180] Dupont, Vincent; Pietrzak, Diana; Verbrugge, Boris. A step in the right direction, or more of the same? A systematic review of the impact of human rights due diligence legislation. In: *Human Rights Review* 25 (2), 2024, 131–154. DOI: 10.1007/s12142-024-00724-9.
- [181] Volpato, Giada. Mandatory Human Rights Due Diligence Legislation in Europe and the Identification of Rural Victims of Modern Slavery and Forced Labour within the Agri-horticultural Supply Chain. In: *International Journal of Rural Criminology* 9 (1), 2025, 47–76. DOI: 10.18061/ijrc.v9i1.10010.
- [182] Buttke, Livia; Schötteler, Sebastian; Seuring, Stefan; Ebinger, Frank. The German Supply Chain Due Diligence Act: impacts on sustainable supply chain management from a stakeholder perspective. In: *Supply Chain Management: An International Journal*, 2024. DOI: 10.1108/SCM-01-2024-0058.
- [183] Zainuddin, Zairul Nurshazana; Dumay, John; Bui, Binh. A critical review of modern slavery disclosure legislation: an academic response to Australia's Modern Slavery Act 2018. In: *Meditari Accountancy Research* 33 (3), 2025, 1052–1077. DOI: 10.1108/MEDAR-03-2025-2931.
- [184] Su, Dan; Mei, Yu; Liu, Tongchao; Amine, Khalil. Global Regulations for Sustainable Battery Recycling: Challenges and Opportunities. In: *Sustainability* 17 (7), 2025, 3045. DOI: 10.3390/su17073045.
- [185] Pham, Thu Thuy; Tang, Thi Kim Hong; Lowe, Andrew. Policy forum: Opportunities and challenges for Vietnamese companies to source sustainable timber from Africa, and implications for future implementation of the EU deforestation regulation. In: *Forest Policy and Economics* 170, 2025, 103387. DOI: 10.1016/j.forpol.2024.103387.
- [186] Hettler, Maximilian; Graf-Vlachy, Lorenz. Corporate scope 3 carbon emission reporting as an enabler of supply chain decarbonization: A systematic review and comprehensive research agenda. In: *Business Strategy and the Environment* 33 (2), 2024, 263–282. DOI: 10.1002/bse.3486.
- [187] Jia, Fu; Zuluaga-Cardona, Laura; Bailey, Adrian; Rueda, Ximena. Sustainable supply chain management in developing countries: An analysis of the literature. In: *Journal of Cleaner Production* 189, 2018, 263–278. DOI: 10.1016/j.jclepro.2018.03.248.
- [188] Sánchez-Flores, Rebeca B.; Cruz-Sotelo, Samantha E.; Ojeda-Benitez, Sara; Ramírez-Barreto, Ma. Elizabeth. Sustainable Supply Chain Management—A Literature Review on Emerging Economies. In: *Sustainability* 12 (17), 2020, 6972. DOI: 10.3390/su12176972.
- [189] Aguilar, A. G.; Campuzano, E. P. Informal Sector. In: *International encyclopedia of human geography*. Ed. by Thrift, N. J.; Kitchin, Rob. Gale eBooks. Amsterdam, London, and Oxford: Elsevier, 2009, 446–453. DOI: 10.1016/B978-008044910-4.00102-4.

-
- [190] Roztocki, Narcyz; Weistroffer, H. Roland. Information technology success factors and models in developing and emerging economies. In: *Information Technology for Development* 17 (3), 2011, 163–167. DOI: 10.1080/02681102.2011.568220.
- [191] Centobelli, Piera; Cerchione, Roberto; Cricelli, Livio; Esposito, Emilio; Strazzullo, Serena. The future of sustainable supply chains: a novel tertiary-systematic methodology. In: *Supply Chain Management: An International Journal* 27 (6), 2022, 762–784. DOI: 10.1108/SCM-08-2020-0383.
- [192] Amofa, Birago; Oke, Adekunle; Morrison, Zoe. Mapping the trends of sustainable supply chain management research: a bibliometric analysis of peer-reviewed articles. In: *Frontiers in Sustainability* 4, 2023, 1129046. DOI: 10.3389/frsus.2023.1129046.
- [193] Gunasekaran, A.; Ngai, E.W.T. Information systems in supply chain integration and management. In: *European Journal of Operational Research* 159 (2), 2004, 269–295. DOI: 10.1016/j.ejor.2003.08.016.
- [194] Cachon, Gérard P.; Fisher, Marshall. Supply Chain Inventory Management and the Value of Shared Information. In: *Management Science* 46 (8), 2000, 1032–1048. DOI: 10.1287/mnsc.46.8.1032.12029.
- [195] Olhager, Jan. Evolution of operations planning and control: from production to supply chains. In: *International Journal of Production Research* 51 (23-24), 2013, 6836–6843. DOI: 10.1080/00207543.2012.761363.
- [196] Cromwell, Jonas; Turkson, Charles; Dora, Manoj; Yamoah, Fred Amofa. Digital technologies for traceability and transparency in the global fish supply chains: A systematic review and future directions. In: *Marine Policy* 178, 2025, 106700. DOI: 10.1016/j.marpol.2025.106700.
- [197] Ebinger, Frank; Omondi, Bramwel. Leveraging Digital Approaches for Transparency in Sustainable Supply Chains: A Conceptual Paper. In: *Sustainability* 12 (15), 2020, 6129. DOI: 10.3390/su12156129.
- [198] Stroumpoulis, Asterios; Kopanaki, Evangelia; Chountalas, Panos T. Enhancing Sustainable Supply Chain Management through Digital Transformation: A Comparative Case Study Analysis. In: *Sustainability* 16 (16), 2024, 6778. DOI: 10.3390/su16166778.
- [199] Chen, Yuan; Feng, Yunting; Lai, Kee-hung; Zhu, Qinghua. Value of blockchain for scope 3 carbon disclosure: The moderating role of data processing technologies. In: *International Journal of Production Economics* 279, 2025, 109445. DOI: 10.1016/j.ijpe.2024.109445.
- [200] Al-Talib, Moayad; Al-Saad, Walid; Alzoubi, Anan; Anosike, Anthony I. A systematic review of the literature on the use of information technologies in supply chain management. In: *International Journal of Industrial Engineering and Operations Management* 7 (3), 2025, 247–268. DOI: 10.1108/IJIEOM-09-2023-0073.
- [201] Zhang, Haibo; Nakamura, Toru; Sakurai, Kouichi. Security and Trust Issues on Digital Supply Chain. In: *IEEE 17th International Conference on Dependable, Autonomic and Secure Computing/IEEE 17th International Conference on Pervasive Intelligence and Computing/IEEE 5th International Conference on Cloud and*

- Big Data Computing/IEEE 4th Cyber Science and Technology Congress. DASC-PiCom-CBDCom-CyberSciTech 2019 : 5-8 August 2019, Fukuoka, Japan : proceedings.* 2019 IEEE Intl Conf on Dependable, Autonomic and Secure Computing, Intl Conf on Pervasive Intelligence and Computing, Intl Conf on Cloud and Big Data Computing, Intl Conf on Cyber Science and Technology Congress (DASC/PiCom/CBDCom/CyberSciTech) (Fukuoka, Japan). Institute of Electrical and Electronics Engineers et al. Piscataway, NJ: IEEE, 2019, 338–343. DOI: 10.1109/DASC/PiCom/CBDCom/CyberSciTech.2019.00069.
- [202] Ghobakhloo, Morteza. Determinants of information and digital technology implementation for smart manufacturing. In: *International Journal of Production Research* 58 (8), 2020, 2384–2405. DOI: 10.1080/00207543.2019.1630775.
- [203] Boaden, R.; Lockett, G. Information technology, information systems and information management: definition and development. In: *European Journal of Information Systems* 1 (1), 1991, 23–32. DOI: 10.1057/ejis.1991.4.
- [204] Rossiter, David G. Past, present & future of information technology in pedometrics. In: *Geoderma* 324, 2018, 131–137. DOI: 10.1016/j.geoderma.2018.03.009.
- [205] Wilhelm, Miriam M.; Blome, Constantin; Bhakoo, Vikram; Paulraj, Antony. Sustainability in multi-tier supply chains: Understanding the double agency role of the first-tier supplier. In: *Journal of Operations Management* 41 (1), 2016, 42–60. DOI: 10.1016/j.jom.2015.11.001.
- [206] Govindan, Kannan; Shaw, Mahesh; Majumdar, Abhijit. Social sustainability tensions in multi-tier supply chain: A systematic literature review towards conceptual framework development. In: *Journal of Cleaner Production* 279, 2021, 123075. DOI: 10.1016/j.jclepro.2020.123075.
- [207] Bundesamt für Wirtschaft und Ausfuhrkontrolle. Angemessenheit: Handreichung zum Prinzip der Angemessenheit nach den Vorgaben des Lieferkettensorgfaltspflichtengesetzes. 2022. https://www.bafa.de/SharedDocs/Downloads/DE/Lieferketten/handreichung_angemessenheit.html?sessionid=0104B23287701BBD2BA0A0594601347E.internet281?nn=1469820 (accessed 5 June 2023).
- [208] Ng, Stephen Chi Hung; Ho, Georg To Sum; Wu, Jack Chun Ho. Blockchain-IIoT-big data aided process control and quality analytics. In: *International Journal of Production Economics* 261, 2023, 108871. DOI: 10.1016/j.ijpe.2023.108871.
- [209] Tavana, Madjid; Sohrabi, Mahsa; Rezaei, Homa; Sorooshian, Shahryar; Mina, Hassan. A sustainable circular supply chain network design model for electric vehicle battery production using internet of things and big data. In: *Expert Systems* 41 (7), 2024. DOI: 10.1111/exsy.13395.
- [210] Yadav, Alok; Garg, Rajiv Kumar; Sachdeva, Anish. Artificial intelligence applications for information management in sustainable supply chain management: A systematic review and future research agenda. In: *International Journal of Information Management Data Insights* 4 (2), 2024, 100292. DOI: 10.1016/j.jjime.2024.100292.
- [211] Agrawal, Rohit; Islam, Nazrul; Samadhiya, Ashutosh; Shukla, Vinaya; Kumar, Anil; Upadhyay, Arvind. Paving the way to environmental sustainability: A systematic review to integrate big data analytics into high-stake decision forecasting. In: *Technological Forecasting and Social Change* 214, 2025, 124060. DOI: 10.1016/j.techfore.2025.124060.

-
- [212] Soori, Mohsen; Jough, Fooad Karimi Ghaleh; Dastres, Roza; Arezoo, Behrooz. Blockchains for industrial Internet of Things in sustainable supply chain management of industry 4.0, a review. In: *Sustainable Manufacturing and Service Economics* 3, 2024, 100026. DOI: 10.1016/j.smse.2024.100026.
 - [213] Kshetri, Nir. Blockchain systems and ethical sourcing in the mineral and metal industry: a multiple case study. In: *The International Journal of Logistics Management* 33 (1), 2022, 1–27. DOI: 10.1108/IJLM-02-2021-0108.
 - [214] Thanasi-Boçe, Marsela; Hoxha, Julian. Blockchain for Sustainable Development: A Systematic Review. In: *Sustainability* 17 (11), 2025, 4848. DOI: 10.3390/su17114848.
 - [215] Zhang, Tianyu; Jia, Fu; Chen, Lujie. Blockchain adoption in supply chains: implications for sustainability. In: *Production Planning & Control* 36 (5), 2025, 699–722. DOI: 10.1080/09537287.2023.2296669.
 - [216] Russom, Philip. Big Data Analytics. TDWI Best Practices Report. Version Fourth Quarter. Renton, WA, 2011.
 - [217] Zhao, Rui; Liu, Yiyun; Zhang, Ning; Huang, Tao. An optimization model for green supply chain management by using a big data analytic approach. In: *Journal of Cleaner Production* 142, 2017, 1085–1097. DOI: 10.1016/j.jclepro.2016.03.006.
 - [218] Aljohani, Abeer. Predictive Analytics and Machine Learning for Real-Time Supply Chain Risk Mitigation and Agility. In: *Sustainability* 15 (20), 2023, 15088. DOI: 10.3390/su152015088.
 - [219] Amoah, John; Jibril, Abdul Bashiru; Odei, Michael Amponsah; Bankuoru Egala, Sulemana; Dziwornu, Raymond; Kwarteng, Kofi. Deficit of digital orientation among service-based firms in an emerging economy: a resource-based view. In: *Cogent Business & Management* 10 (1), 2023, 119001–119015. DOI: 10.1080/23311975.2022.2152891.
 - [220] Yang, Yadong; Du, Yating; Gupta, Vijai Kumar; Ahmad, Fisal; Amiri, Hamid; Pan, Junting; Aghbashlo, Mortaza; Tabatabaei, Meisam; Rajaei, Ahmad. Exploring blockchain and artificial intelligence in intelligent packaging to combat food fraud: A comprehensive review. In: *Food Packaging and Shelf Life* 43, 2024, 101287. DOI: 10.1016/j.fpsl.2024.101287.
 - [221] Zebari, Gheyath Mustafa; Al Musalhi, Nasser. A Comprehensive Review of Integrating AI and Blockchain Security: Innovations, Challenges, and Future Directions. In: *Security and Privacy* 8 (5), 2025, e70094. DOI: 10.1002/spy2.70094.
 - [222] Mansouri, Taha; Sadeghi Moghadam, Mohammad Reza; Monshizadeh, Fatemeh; Zareravasan, Ahad. IoT Data Quality Issues and Potential Solutions: A Literature Review. In: *The Computer Journal* 66 (3), 2023, 615–625. DOI: 10.1093/comjnl/bxab183.
 - [223] Santos, Célia; Coelho, Arnaldo; Cancela, Beatriz Lopes. The impact of greenwashing on sustainability through green supply chain integration: the moderating role of information sharing. In: *Environment, Development and Sustainability* 27 (9), 2025, 21709–21736. DOI: 10.1007/s10668-024-05009-2.
 - [224] Vandenbroucke, Sarah; Pluut, Helen; Erkens, Yvonne; Kantorowicz, Jaroslaw. Do companies walk the talk? Commitments and actions in global supply chain labor standards. In: *International Journal of Corporate Social Responsibility* 9 (1), 2024, 17. DOI: 10.1186/s40991-024-00103-0.

- [225] Lublóy, Ágnes; Keresztúri, Judit Lilla; Berlinger, Edina. Quantifying firm-level greenwashing: A systematic literature review. In: *Journal of Environmental Management* 373, 2025, 123399. DOI: 10.1016/j.jenvman.2024.123399.
- [226] Schäfer, Naemi; Petersen, Lars; Hörisch, Jacob. The Interplay Between Supply Chain Transparency and NGO Pressure: A Quantitative Analysis in the Fashion Industry Context. In: *Journal of Business Ethics* 192 (4), 2024, 713–727. DOI: 10.1007/s10551-023-05480-3.
- [227] Fraser, Iain J.; Müller, Martin; Schwarzkopf, Julia. Transparency for Multi-Tier Sustainable Supply Chain Management: A Case Study of a Multi-tier Transparency Approach for SSCM in the Automotive Industry. In: *Sustainability* 12 (5), 2020, 1814. DOI: 10.3390/su12051814.
- [228] Sayogo, Djoko Sigit; Zhang, Jing; Luna-Reyes, Luis; Jarman, Holly; Tayi, Giri; Andersen, Deborah Lines; Pardo, Theresa A.; Andersen, David F. Challenges and requirements for developing data architecture supporting integration of sustainable supply chains. In: *Information Technology and Management* 16 (1), 2015, 5–18. DOI: 10.1007/s10799-014-0203-3.
- [229] Shi, Yilin; Wu, Jing; Zhang, Yu; Zhou, Yuqing. Supply chain washing: Strategic disclosure of corporate suppliers. In: *Journal of Accounting and Economics*, 2026, 101883. DOI: 10.1016/j.jacceco.2026.101883.
- [230] Fatemi, Ali; Fooladi, Iraj; Hebb, Greg. Greenwashing: Motivations, causes and consequences. In: *International Review of Economics & Finance* 105, 2026, 104887. DOI: 10.1016/j.iref.2025.104887.
- [231] Li, Menghan; Chen, Qi. Executive pay gap and corporate ESG greenwashing: Evidence from China. In: *International Review of Financial Analysis* 95, 2024, 103375. DOI: 10.1016/j.irfa.2024.103375.
- [232] Zong, Shengliang; Shen, Chunyang; Su, Siping. Decision Making in Green Supply Chain with Manufacturers' Misreporting Behavior. In: *Sustainability* 14 (9), 2022, 4957. DOI: 10.3390/su14094957.
- [233] Powell, Warwick; Foth, Marcus; Cao, Shoufeng; Natanelov, Valéri. Garbage in garbage out: The precarious link between IoT and blockchain in food supply chains. In: *Journal of Industrial Information Integration* 25, 2022, 100261. DOI: 10.1016/j.jii.2021.100261.
- [234] Hazen, Benjamin T.; Boone, Christopher A.; Ezell, Jeremy D.; Jones-Farmer, L. Allison. Data quality for data science, predictive analytics, and big data in supply chain management: An introduction to the problem and suggestions for research and applications. In: *International Journal of Production Economics* 154, 2014, 72–80. DOI: 10.1016/j.ijpe.2014.04.018.
- [235] Ajebo, Wasyhun Abdela; Solomon, Dahlak Daniel; Sonia. Challenges of IoT Adoption in Developing Countries: A Case Study of Ethiopia. In: *Proceedings of the 2024 3rd edition of IEEE Delhi Section Flagship Conference (DELCON). 21st-23rd November 2024. 2024 3rd Edition of IEEE Delhi Section Flagship Conference (DELCON) (New Delhi, India). Institute of Electrical and Electronics Engineers and Bharati Vidyapeeth's Institute of Computers Applications and Management. Piscataway, NJ: IEEE, 2024, 1–8. DOI: 10.1109/DELCON64804.2024.10867084.*

-
- [236] Samuel-Okon, Amaka Debie; Abejide, Oluwatotan. Bridging the Digital Divide: Exploring the Role of Artificial Intelligence and Automation in Enhancing Connectivity in Developing Nations. In: *SSRN Electronic Journal* 26 (6), 2024, 165–177. DOI: 10.2139/ssrn.4839447.
- [237] Samuels, Alexander. Examining the integration of artificial intelligence in supply chain management from Industry 4.0 to 6.0: a systematic literature review. In: *Frontiers in artificial intelligence* 7, 2024, 1477044. DOI: 10.3389/frai.2024.1477044.
- [238] Butt, Atif Saleem; Alghababsheh, Mohammad. Exploring the barriers and enablers of technology adoption for managing social sustainability in supply chains. In: *Industrial Management & Data Systems*, 2025, 1–30. DOI: 10.1108/IMDS-01-2025-0014.
- [239] Dwivedi, Ashish; Ganguly, Anirban; Paul, Sanjoy Kumar. Critical success factors for linking digital technologies and circular supply chains. In: *Business Strategy and the Environment* 33 (8), 2024, 8332–8360. DOI: 10.1002/bse.3907.
- [240] Haldorai, Kavitha; Kim, Woo Gon; Phetvaroon, Kullada. Top management commitment, institutional pressures and green supply chain practices: pathways to sustainable performance. In: *Journal of Hospitality and Tourism Insights* 8 (8), 2025, 2860–2879. DOI: 10.1108/JHTI-07-2024-0773.
- [241] OECD. OECD Guidelines for Multinational Enterprises on Responsible Business Conduct. Paris: OECD Publishing, 2023. DOI: 10.1787/81f92357-en.
- [242] European Parliament; Council of the European Union. Directive (EU) 2026/470 of the European Parliament and of the Council of 24 February 2026 amending Directives 2006/43/EC, 2013/34/EU, (EU) 2022/2464 and (EU) 2024/1760 as regards certain corporate sustainability reporting requirements and certain corporate sustainability due diligence requirements. Feb. 24, 2026. <https://eur-lex.europa.eu/eli/dir/2026/470/oj/eng> (accessed 30 Mar. 2026).
- [243] United Nations Working Group on Business and Human Rights. Guidance on National Action Plans on Business and Human Rights. Version 1.0. 2014. https://www.ohchr.org/sites/default/files/Documents/Issues/Business/UNWG_NAPGuidance.pdf (accessed 20 Dec. 2025).
- [244] Auswärtiges Amt, ed. Nationaler Aktionsplan. Umsetzung der VN-Leitprinzipien für Wirtschaft und Menschenrechte. 2016-2020. 2017. <https://www.auswaertiges-amt.de/resource/blob/297434/8d6ab29982767d5a31d2e85464461565/nap-wirtschaft-menschenrechte-data.pdf> (accessed 20 Dec. 2025).
- [245] United Nations Office of the High Commissioner for Human Rights. National action plans on business and human rights. 2025. <https://www.ohchr.org/en/special-procedures/wg-business/national-action-plans-business-and-human-rights> (accessed 20 Dec. 2025).
- [246] State of California. The California Transparency in Supply Chains Act. 2015. <https://oag.ca.gov/SB657> (accessed 20 Dec. 2025).
- [247] United Kingdom Government. Modern Slavery Act 2015. London. <https://www.legislation.gov.uk/ukpga/2015/30/contents/enacted> (accessed 19 Sept. 2023).

- [248] Australian Government. Modern Slavery Act 2018. No. 153, 2018. Dec. 20, 2025. <https://www.legislation.gov.au/C2018A00153/latest/text> (accessed 20 Dec. 2025).
- [249] U.S. Government. H.R.4173 - Dodd-Frank Wall Street Reform and Consumer Protection Act. July 21, 2010. <https://www.congress.gov/bill/111th-congress/house-bill/4173/text> (accessed 21 Dec. 2025).
- [250] Mares, Radu. Corporate transparency laws. In: *Netherlands Quarterly of Human Rights* 36 (3), 2018, 189–213. DOI: 10.1177/0924051918786623.
- [251] Nolan, Justine. Hardening Soft Law: Are the emerging corporate social disclosure and due diligence laws capable of generating substantive compliance with human rights norms? In: *Revista de Direito Internacional* 15 (2), 2018. DOI: 10.5102/rdi.v15i2.5355.
- [252] Schaper, Stefan; Pollach, Irene. Modern slavery statements: From regulation to substantive supply chain reporting. In: *Journal of Cleaner Production* 313, 2021, 127872. DOI: 10.1016/j.jclepro.2021.127872.
- [253] Dohmen, Caspar. Lieferkettengesetz. Die Haftungsfrage. In: *Süddeutsche Zeitung*, 2020. <https://www.sueddeutsche.de/wirtschaft/lieferkettengesetz-hubertus-heil-gerd-mueller-entwurf-1.5104713> (accessed 21 Dec. 2025).
- [254] U.S. Congress House. H.R.1155 - 117th Congress (2021-2022): Uyghur Forced Labor Prevention Act. Dec. 22, 2022. <https://www.congress.gov/bill/117th-congress/house-bill/1155/text> (accessed 14 Mar. 2025).
- [255] European Parliament; Council of the European Union. Directive (EU) 2022/2464 of the European Parliament and of the Council of 14 December 2022 amending Regulation (EU) No 537/2014, Directive 2004/109/EC, Directive 2006/43/EC and Directive 2013/34/EU, as regards corporate sustainability reporting. Brussels, Dec. 16, 2022. <https://eur-lex.europa.eu/eli/dir/2024/1760/oj> (accessed 2 Apr. 2025).
- [256] European Parliament. Simplified sustainability reporting and due diligence rules for businesses. 2025. <https://www.europarl.europa.eu/news/en/press-room/20251211IPR32164/simplified-sustainability-reporting-and-due-diligence-rules-for-businesses> (accessed 22 Dec. 2025).
- [257] European Parliament. Deforestation law: Parliament adopts changes to postpone and simplify measures. 2025. <https://www.europarl.europa.eu/news/en/press-room/20251211IPR32168/deforestation-law-parliament-adopts-changes-to-postpone-and-simplify-measures> (accessed 22 Dec. 2025).
- [258] European Union. Regulation (EU) 2024/1781 of the European Parliament and of the Council of 13 June 2024 establishing a framework for the setting of eco-design requirements for sustainable products, amending Directive (EU) 2020/1828 and Regulation (EU) 2023/1542 and repealing Directive 2009/125/EC. June 13, 2024. <https://eur-lex.europa.eu/eli/reg/2024/1781/oj> (accessed 22 Dec. 2025).
- [259] European Union. Regulation (EU) 2024/3015 of the European Parliament and of the Council of 27 November 2024 on prohibiting products made with forced labour on the Union market and amending Directive (EU) 2019/1937. Nov. 27, 2024. <https://www.eur-lex.europa.eu/eli/reg/2024/3015/oj/eng> (accessed 22 Dec. 2025).

- [260] Bradford, Anu. The Brussels effect. How the European Union rules the world. New York, NY: Oxford University Press, 2020. DOI: 10.1093/oso/9780190088583.001.0001.
- [261] Gehling, Christian; Ott, Nicolas; Lüneborg, Cäcilie. Das neue Lieferketten-sorgfaltspflichtengesetz – Umsetzung in der Unternehmenspraxis. In: *Corporate Complicance Zeitschrift* 14 (5), 2021, 230–240.
- [262] Koos, Stefan. The German Supply Chain Due Diligence Act 2021 and Its Impact on Globally Operating German Companies. In: *Proceedings of the 2nd Riau Annual Meeting on Law and Social Sciences (RAMLAS 2021) Advances in Social Science, Education and Humanities Research*, 2022, 111–115. DOI: 10.2991/assehr.k.220406.027.
- [263] Lou, Shuqi; You, Xiaoyue; Xu, Tao. Sustainable Supplier Evaluation: From Current Criteria to Reconstruction Based on ESG Requirements. In: *Sustainability* 16 (2), 2024, 757. DOI: 10.3390/su16020757.
- [264] United Nations. 2019 International Trade Statistics Yearbook, Volume 1. 2020. <https://comtrade.un.org/pb/downloads/2019/VolI2019.pdf> (accessed 2 Dec. 2020).
- [265] International Cocoa Organization. Table 19 - Imports of cocoa beans by country. Internal data, provided by ICCO upon request via email. 2021.
- [266] International Cocoa Organization. Table 2 - Cocoa Consumption. Internal data, provided by ICCO upon request via email. 2021.
- [267] UmweltDialog. Neue SÜDWIND-Studie: „Vom Kakaobaum bis zum Konsumenten“. 2012. https://umweltdialog.de/de/wirtschaft/produktion/archiv/2012-05-21_Neue_SUEDWIND-Studie_Vom_Kakaobaum_bis_zum_Konsumenten.php (accessed 29 Oct. 2020).
- [268] Amankwaah, Barima Akwasi; Asomaning, Glen; Atuguba, Raymond A.; Ayifah, Emmanuel; Brudney, Allie; Citro, Brian; Ryerson, Charity; Sarkwah, Sandra Kwabea; Tarzikhan, Alexandra. COCOBOD’s Unrealised Potential. Promoting Human Rights, Welfare, and the Environment in Ghana’s Cocoa-Growing Communities. Ghana: Northwestern Pritzker School of Law Center for International Human Rights, University of Ghana School of Law, Corporate Accountability Lab & SEND Ghana, 2021.
- [269] International Labour Organization. Africa: Child Labor in Cocoa Fields/Harkin-Engel Protocol. 2011. https://www.ilo.org/africa/technical-cooperation/accel-africa/WCMS_159486 (accessed 4 May 2021).
- [270] Organisation for Economic Co-operation and Development. OECD Guidelines for Multinational Enterprises. Paris, 2011. DOI: <https://doi.org/10.1787/9789264115415-en>.
- [271] Hahn, Norbert. Noch viel Kinderarbeit in der Schokolade. In: *Tagesschau*. <https://www.tagesschau.de/ausland/kinderarbeit-kakao-101.html> (accessed 29 Apr. 2021).
- [272] International Cocoa Organization. Statistics. 2021. <https://www.icco.org/statistics/> (accessed 2 May 2021).
- [273] Fountain, Antonie C.; Huetz-Adams, Friedel. Cocoabarometer 2020. 2020. <https://www.voicenetwork.eu/wp-content/uploads/2021/03/2020-Cocoa-Barometer-EN.pdf> (accessed 4 May 2021).

- [274] Shahid, Affaf; Almogren, Ahmad; Javaid, Nadeem; Al-Zahrani, Fahad Ahmad; Zuair, Mansour; Alam, Masoom. Blockchain-Based Agri-Food Supply Chain: A Complete Solution. In: *IEEE Access* 8, 2020, 69230–69243. DOI: 10.1109/ACCESS.2020.2986257.
- [275] Tripoli, Mischa; Schmidhuber, Josef. Emerging opportunities for the application of blockchain in the agri-food industry. Genf, 2018.
- [276] Astill, Jake; Dara, Rozita A.; Campbell, Malcolm; Farber, Jeffrey M.; Fraser, Evan D.G.; Sharif, Shayan; Yada, Rickey Y. Transparency in food supply chains: A review of enabling technology solutions. In: *Trends in Food Science & Technology* 91, 2019, 240–247. DOI: 10.1016/j.tifs.2019.07.024.
- [277] Kouhizadeh, Mahtab; Sarkis, Joseph. Blockchain Practices, Potentials, and Perspectives in Greening Supply Chains. In: *Sustainability* 10 (10), 2018.
- [278] Hofstede, Gerd Jan; Beulens, Adrie; Spaans, Lisa. Transparency: practices, perceptions and promises. In: *The Emerging World of Chains and Networks: Bridging Theory and Practice*. Ed. by Camps, Theo; Diederer, Paul; Hofstede, Gerd Jan; Vos, Bart. The Hague: Reed Business Information, 2004, 285–310.
- [279] Francisco, Kristoffer; Swanson, David. The Supply Chain Has No Clothes: Technology Adoption of Blockchain for Supply Chain Transparency. In: *Logistics* 2 (1), 2018, 2. DOI: <https://doi.org/10.3390/logistics2010002>.
- [280] Nakamoto, Satoshi. Bitcoin: A Peer-to-Peer Electronic Cash System. 2008. <https://bitcoin.org/bitcoin.pdf> (accessed 12 Jan. 2021).
- [281] Fill, Hans-Georg; Meier, Andreas. Blockchain. Wiesbaden: Springer Fachmedien Wiesbaden, 2020.
- [282] Laroiya, Chetna; Saxena, Deepika; Komalavalli C. Applications of Blockchain Technology. In: *Handbook of Research on Blockchain Technology*. Ed. by Krishnan, Harish; Balas, Valentina E.; Julie, Golden; Robinson, Harold; Kumar Raghvendra. Academic Press, 2020, 213–244.
- [283] Gaur, Vishal; Gaiha, Abhinav. Building a Transparent Supply Chain: Blockchain can enhance trust, efficiency, and speed. In: *Harvard Business Review* May-June (May-June), 2020, 94–103.
- [284] Wang, Yingli; Han, Jeong Hugh; Beynon-Davies, Paul. Understanding blockchain technology for future supply chains: a systematic literature review and research agenda. In: *Supply Chain Management: An International Journal* 24 (1), 2019, 62–84.
- [285] Fridgen, Gilbert; Guggenberger, Nikolas; Hoeren, Thomas; Prinz, Wolfgang; Urbach, Nils. Chancen und Herausforderungen von DLT (Blockchain) in Mobilität und Logistik. Berlin: Bundesministerium für Verkehr und digitale Infrastruktur, 2019.
- [286] Kamble, Sachin S.; Gunasekaran, Angappa; Sharma, Rohit. Modeling the blockchain enabled traceability in agriculture supply chain. In: *International Journal of Information Management* 52, 2020, 101967. DOI: 10.1016/j.ijinfomgt.2019.05.023.
- [287] Weber, Ingo; Xu, Xiwei; Riveret, Régis; Governatori, Guido; Ponomarev, Alexander; Mendling, Jan. Untrusted Business Process Monitoring and Execution Using Blockchain. In: *Business process management*. Ed. by La Rosa, Marcello. Lecture Notes in Computer Science. Cham: Springer, 2016, 329–347.

- [288] Kshetri, Nir. *Blockchain and Supply Chain Management*. Amsterdam: Elsevier, 2021.
- [289] Shalaby, Salma; Abdellatif, Alaa Awad; Al-Ali, Abdulla; Mohamed, Amr; Erbad, Aiman; Guizani, Mohsen. Performance Evaluation of Hyperledger Fabric. In: *2020 IEEE International Conference on Informatics, IoT, and Enabling Technologies (ICIoT)*, 2020, 608–613. DOI: 10.1109/ICIoT48696.2020.9089614.
- [290] Zheng, Zibin; Xie, Shaoan; Dai, Hongning; Chen, Xiangping; Wang, Huaimin. An Overview of Blockchain Technology: Architecture, Consensus, and Future Trends. In: *2017 IEEE International Congress on Big Data (BigData Congress)*, 2017, 557–564. DOI: 10.1109/BigDataCongress.2017.85.
- [291] Viriyasitavat, Wattana; Hoonsoopon, Danupol. Blockchain characteristics and consensus in modern business processes. In: *Journal of Industrial Information Integration* 13, 2019, 32–39. DOI: <https://doi.org/10.1016/j.jii.2018.07.004>.
- [292] Jardim, Leonor; Pranto, Samuel; Ruivo, Pedro; Oliveira, Tiago. What are the main drivers of Blockchain Adoption within Supply Chain? – an exploratory research. In: *Procedia Computer Science* 181, 495–502. DOI: 10.1016/j.procs.2021.01.195.
- [293] Salah, Khaled; Nizamuddin, Nishara; Jayaraman, Raja; Omar, Mohammed. Blockchain-based Soybean Traceability in Agricultural Supply chain. In: *IEEE Access* 7, 2019, 73295–73305. DOI: 10.1109/ACCESS.2019.2918000.
- [294] Agnoli, Lara; Capitello, Roberta; Salvo, Maria de; Longo, Alberto; Boeri, Marco. Food fraud and consumers’ choices in the wake of the horsemeat scandal. In: *British Food Journal* 118 (8), 2016, 1898–1913. DOI: 10.1108/BFJ-04-2016-0176.
- [295] Oosterveer, Peter. Promoting sustainable palm oil: viewed from a global networks and flows perspective. In: *Journal of Cleaner Production* 107, 2015, 146–153. DOI: 10.1016/j.jclepro.2014.01.019.
- [296] Xiu, Changbai; Klein, Kurt. Melamine in milk products in China: Examining the factors that led to deliberate use of the contaminant. In: *Food Policy* 35 (5), 2010, 463–470. DOI: 10.1016/j.foodpol.2010.05.001.
- [297] Yamoah, Fred; Yawson, David Eshun. Assessing Supermarket Food Shopper Reaction to Horsemeat Scandal in the UK. In: *International Review of Management and Marketing* 4 (2), 2014, 98–107.
- [298] Hyperledger. Case Study: How Walmart brought unprecedented transparency to the food supply chain with Hyperledger Fabric. 2019. <https://www.hyperledger.org/learn/publications/walmart-case-study> (accessed 12 May 2021).
- [299] Carrefour. Carrefour launches Europe’s first Food Blockchain. 2018. <https://www.carrefour.com/en/newsroom/carrefour-launches-europes-first-food-blockchain> (accessed 27 Mar. 2024).
- [300] Walmart. In Wake of Romaine E. coli Scare, Walmart Deploys Blockchain to Track Leafy Greens. 2018. <https://corporate.walmart.com/newsroom/2018/09/24/in-wake-of-romaine-e-coli-scare-walmart-deploys-blockchain-to-track-leafy-greens> (accessed 21 Mar. 2022).
- [301] Carrefour. The Food Blockchain. 2021. <https://www.carrefour.com/en/group/food-transition/food-blockchain> (accessed 21 Mar. 2022).

- [302] Bux, Christian; Varese, Erica; Amicarelli, Vera; Lombardi, Mariarosaria. Halal Food Sustainability between Certification and Blockchain: A Review. In: *Sustainability* 14 (4), 2022, 2152. DOI: 10.3390/su14042152.
- [303] Blockchain Coffee Beans. Blockchain Coffee Beans. 2021. <https://www.blockchaincoffeebeans.com/about> (accessed 1 Oct. 2021).
- [304] IBM. IBM Food Trust - Blockchain for the world's food supply. 2021. <https://www.ibm.com/blockchain/solutions/food-trust> (accessed 16 Mar. 2022).
- [305] Moyee Coffee. Blockchain and Coffee. 2021. <https://moyeecoffee.ie/pages/building-a-digital-supply-chain> (accessed 11 Aug. 2021).
- [306] Bumblauskas, Daniel; Mann, Arti; Dugan, Brett; Rittmer, Jacy. A blockchain use case in food distribution: Do you know where your food has been? In: *International Journal of Information Management* 52, 2020, 102008. DOI: 10.1016/j.ijinfomgt.2019.09.004.
- [307] Hoffman, Andy; Munsterman, Ruben. Dreyfus Teams With Banks for First Agriculture Blockchain Trade. In: *Bloomberg*, 22.01.2018. <https://www.bloomberg.com/news/articles/2018-01-22/dreyfus-teams-with-banks-for-first-agriculture-blockchain-trade> (accessed 16 Mar. 2022).
- [308] WWF. New Blockchain Project has potential to revolutionise seafood industry. 2021. https://www.wwf.org.nz/what_we_do/marine/blockchain_tuna_project/ (accessed 16 Mar. 2021).
- [309] Cargill Inc. Honeysuckle White® expands Thanksgiving traceable turkey program, continuing its commitment to food transparency | Cargill. 2018. <https://www.cargill.com/2018/honeysuckle-white-expands-thanksgiving-traceable-turkey-program> (accessed 15 Mar. 2022).
- [310] Mao, Dianhui; Hao, Zhihao; Wang, Fan; Li, Haisheng. Innovative Blockchain-Based Approach for Sustainable and Credible Environment in Food Trade: A Case Study in Shandong Province, China. 2018. DOI: <https://doi.org/10.3390/su10093149>.
- [311] Ethereum. Ethereum development documentation. 2021. <https://ethereum.org/en/developers/docs/> (accessed 11 May 2021).
- [312] Hyperledger. About Hyperledger. 2020. <https://www.hyperledger.org/about> (accessed 11 May 2021).
- [313] Agriledger. AgriLedger. 2019. <http://agriledger.io/> (accessed 16 Mar. 2022).
- [314] farmer connect. Never lose track of a single bean. 2022. <https://farmerconnect.com/?hsLang=en> (accessed 16 Mar. 2022).
- [315] GrainChain. GrainChain. 2022. <https://grainchain.io/> (accessed 16 Mar. 2022).
- [316] Dasaklis, Thomas K.; Voutsinas, Theodore G.; Tsoulfas, Giannis T.; Casino, Fran. A Systematic Literature Review of Blockchain-Enabled Supply Chain Traceability Implementations. In: *Sustainability* 14 (4), 2022, 2439. DOI: 10.3390/su14042439.
- [317] Gakwaya, Olivier; Meier-Hahn, Uta; Mbouna, Oyini; Wannemacher, Lars. Blockchain in Africa: Opportunities and challenges for the next decade. Ed. by Deutsche Gesellschaft für internationale Zusammenarbeit. 2020. <https://smartafrica.org/knowledge/data-scientist/> (accessed 3 Dec. 2021).

- [318] Kshetri, Nir. Blockchain and sustainable supply chain management in developing countries. In: *International Journal of Information Management* 60, 2021, 102376. DOI: 10.1016/j.ijinfomgt.2021.102376.
- [319] Arsyad, Andi Arniaty; Dadkhah, Sajjad; Köppen, Mario. Two-Factor Blockchain for Traceability Cacao Supply Chain. In: *Advances in Intelligent Networking and Collaborative Systems*. Ed. by Xhafa, Fatos. Vol. 23. Lecture Notes on Data Engineering and Communications Technologies Ser. Cham: Springer International Publishing AG, 2019, 332–339. DOI: <https://doi.org/10.1007/978-3-319-98557-230>.
- [320] Arsyad, Andi Arniaty; Widayat, Irawan Widi; Köppen, Mario. Supporting farming smart documentation system by modular blockchain solutions. In: *Decision Making: Applications in Management and Engineering* 5 (1), 2022, 1–26. DOI: 10.31181/dmame0326022022a.
- [321] Chong, Mario; Perez, Eduardo; Castilla, Jet; Rosario; Herman. Blockchain Technology Applied to the Cocoa Export Supply Chain: A Latin America Case. In: *Handbook of research on emerging technologies for effective project management*. Ed. by Jamil, George Leal; Ribeiro, Fernanda; Da Silva, Armando Malheiro; Lopes Sèrgio Maravilhas. Advances in logistics, operations, and management science (ALOMS) book series. Hershey PA: IGI Global, 2020, 323–339. DOI: <https://doi.org/10.4018/978-1-5225-9993-7.ch019>.
- [322] Hyperledger Composer. Hyperledger Composer. 2019. <https://github.com/hyperledger/composer/blob/main/README.md> (accessed 21 Mar. 2022).
- [323] International Cocoa Organization. Table 13 - Exports of cocoa beans by country. Internal data, provided by ICCO upon request via email. 2021.
- [324] Sutton, John; Kpentey, Bennet. An enterprise map of Ghana. London: International Growth Centre, 2012.
- [325] Friedel, Hütz-Adams. Studie Menschenrechtsverletzungen im Kakaoanbau. Warum wir ein Lieferkettengesetz brauchen. 2019. <https://www.suedwind-institut.de/informieren/publikationen/beitrag/menschenrechtsverletzungen-im-kakaoanbau-warum-wir-ein-lieferkettengesetz-brauchen> (accessed 29 Oct. 2021).
- [326] Ghana Cocoa Board. About COCOBOD. 2021. <https://cocobod.gh/about-us> (accessed 22 Apr. 2021).
- [327] Cocoa Marketing Company. About Us. 2021. <https://www.cocoamarketing.com.gh/cmgh/about/aboutus> (accessed 23 Apr. 2021).
- [328] Ghana Cocoa Board. Manual for cocoa extension in Ghana. Accra, 2018.
- [329] Ghana Cocoa Board. Cocoa. 2021. <https://cocobod.gh/pages/cocoa> (accessed 22 Apr. 2021).
- [330] Nartey, Kwetey. Missing Kilos: How state-owned Produce Buying Companies fleece cocoa buyers. 2020. <https://www.myjoyonline.com/missing-kilos-how-state-owned-produce-buying-companies-fleece-cocoa-buyers/> (accessed 27 June 2021).
- [331] Ghana Cocoa Board. Cocoa Producer Price goes up 28% from GH¢515 to GH¢660 PER BAG. 2020. <https://cocobod.gh/news/cocoa-producer-price-goes-up-28-from-gh515-to-gh660-per-bag> (accessed 27 Apr. 2021).
- [332] GSM Association. Mobile Network Coverage Maps. 2021. <https://www.gsma.com/coverage/#415> (accessed 23 Apr. 2021).

-
- [333] Hinckeldeyn, Johannes. Blockchain-Technologie in der Supply Chain. Wiesbaden: Springer Fachmedien Wiesbaden, 2019. DOI: 10.1007/978-3-658-26440-6.
- [334] Twilio. Programmable SMS Quickstart for Node.js. 2021. <https://www.twilio.com/docs/sms/quickstart/node> (accessed 15 May 2021).
- [335] Akram, Umair; Fülöp, Melinda Timea; Tiron-Tudor, Adriana; Topor, Dan Ioan; Căpușneanu, Sorinel. Impact of Digitalization on Customers' Well-Being in the Pandemic Period: Challenges and Opportunities for the Retail Industry. In: *International journal of environmental research and public health* 18 (14), 2021, 7533. DOI: 10.3390/ijerph18147533.
- [336] Appiah-duku, Joseph. MTN and Vodafone are bringing Africa's third 5G network to Ghana. In: *MyTechHubGh*, 27.06.2021. <https://mytechhubgh.com/mtn-and-vodafone-are-bringing-africas-third-5g-network-to-ghana/> (accessed 22 June 2022).
- [337] Kuebler, Martin. 5G in Africa set to bring green benefits — but not everywhere. 2022. <https://www.dw.com/en/5g-mobile-technology-africa-fiber-optic-3g-wi-fi/a-55011882> (accessed 22 June 2022).
- [338] Ionescu, Constantin Aurelian; Fülöp, Melinda Timea; Topor, Dan Ioan; Căpușneanu, Sorinel; Breaz, Teodora Odett; Stănescu, Sorina Geanina; Coman, Mihaela Denisa. The New Era of Business Digitization through the Implementation of 5G Technology in Romania. In: *Sustainability* 13 (23), 2021, 13401. DOI: 10.3390/su132313401.
- [339] Hewa, Tharaka Mawanane; Kalla, Anshuman; Nag, Avishek; Ylianttila, Mika E.; Liyanage, Madhusanka. Blockchain for 5G and IoT: Opportunities and Challenges. In: *2020 IEEE Eighth International Conference on Communications and Networking (ComNet)*, 2020, 1–8. DOI: 10.1109/ComNet47917.2020.9306082.
- [340] Johannes Igl; Florian Kellner. Exploring greenhouse gas reduction opportunities for retailers in Fast Moving Consumer Goods distribution networks. In: *Transportation Research Part D: Transport and Environment* 50, 2017, 55–69. DOI: 10.1016/j.trd.2016.10.008.
- [341] Ministerie van Buitenlandse Zaken. Wet van 24 oktober 2019 houdende de invoering van een zorgplicht ter voorkoming van de levering van goederen en diensten die met behulp van kinderarbeid tot stand zijn gekomen (Wet zorgplicht kinderarbeid). The Hague, 24.10.2019. <https://www.zoek.officielebekendmakingen.nl/stb-2019-401.html> (accessed 19 Sept. 2023).
- [342] European Commission. Proposal for a Directive of the European Parliament and of the Council on Corporate Sustainability Due Diligence and amending Directive (EU) 2019/1937. 2022. <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52022PC0071> (accessed 2 May 2023).
- [343] Fountain, Antonie C.; Huetz-Adams, Friedel. Kakao-Barometer 2015. 2015. https://suedwind-institut.de/files/Suedwind/Publikationen/2015/2015-16%20Kakaobarometer%202015_Deutsch.pdf (accessed 24 Mar. 2023).
- [344] International Cocoa Organization. Exports of cocoa beans by country: Table 13_XLVII-2. In: 2020.
- [345] Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung. Das Lieferkettengesetz. 2021. <https://www.bmz.de/de/themen/lieferkettengesetz> (accessed 4 May 2021).

- [346] Barnett, Michael L.; Henriques, Irene; Husted, Bryan W. Beyond Good Intentions: Designing CSR Initiatives for Greater Social Impact. In: *Journal of Management* 46 (6), 2020, 937–964. DOI: 10.1177/0149206319900539.
- [347] Stewart, D.; Law, M.; Russell, D.; Hanna, S. Evaluating children’s rehabilitation services: an application of a programme logic model. In: *Child: care, health and development* 30 (5), 2004, 453–462. DOI: 10.1111/j.1365-2214.2004.00441.x.
- [348] Springer-Heinze, Andreas; Hartwich, Frank; Henderson, J.Simon; Horton, Douglas; Minde, Isaac. Impact pathway analysis: an approach to strengthening the impact orientation of agricultural research. In: *Agricultural Systems* 78 (2), 2003, 267–285. DOI: 10.1016/S0308-521X(03)00129-X.
- [349] Lovell, Belinda; Brown, Angela; Steen, Mary; Esterman, Adrian. Process Evaluation of a Prison Parenting Education Program for Women. In: *Social Sciences* 12 (7), 2023, 370. DOI: 10.3390/socsci12070370.
- [350] Wagner, Marcus; Schaltegger, Stefan; Hansen, Erik G.; Fichter, Klaus. University-linked programmes for sustainable entrepreneurship and regional development: how and with what impact? In: *Small Business Economics* 56, 2019, 1141–1158. DOI: 10.1007/s11187-019-00280-4.
- [351] Truong, V. Dao; Dong, X. Dam; Saunders, Stephen Graham; Pham, Quynh; Nguyen, Hanh; Tran, Ngoc Anh. Measuring, evaluating, and documenting social marketing impact. In: *Journal of Social Marketing* 11 (3), 2021, 259–277. DOI: 10.1108/JSOCM-11-2020-0224.
- [352] Ebrahim, Alnoor; Rangan, V. Kasturi. What Impact? A Framework for Measuring the Scale and Scope of Social Performance. In: *California Management Review* 56 (3), 2014, 118–141. DOI: 10.1525/cmr.2014.56.3.118.
- [353] Snyder, Hannah. Literature review as a research methodology: An overview and guidelines. In: *Journal of Business Research* 104, 2019, 333–339. DOI: 10.1016/j.jbusres.2019.07.039.
- [354] Bai, Chunguang; Quayson, Matthew; Sarkis, Joseph. COVID-19 pandemic digitization lessons for sustainable development of micro-and small- enterprises. In: *Sustainable Production and Consumption* 27, 2021. DOI: 10.1016/j.spc.2021.04.035.
- [355] Lage, Jonas. Sufficiency and transformation—A semi-systematic literature review of notions of social change in different concepts of sufficiency. In: *Frontiers in Sustainability* 3, 2022. DOI: 10.3389/frsus.2022.954660.
- [356] Harrison, J. Human Rights Measurement: Reflections on the Current Practice and Future Potential of Human Rights Impact Assessment. In: *Journal of Human Rights Practice* 3 (2), 2011, 162–187. DOI: 10.1093/jhuman/hur011.
- [357] Ngan, Sue Lin; Er, Ah Choy; Yatim, Puan; How, Bing Shen; Lim, Chun Hsion; Ng, Wendy Pei Qin; Chan, Yi Herng; Lam, Hon Loong. Social Sustainability of Palm Oil Industry: A Review. In: *Frontiers in Sustainability* 3, 2022. DOI: 10.3389/frsus.2022.855551.
- [358] Islam, Muhammad Azizul; van Staden, Chris J. Modern Slavery Disclosure Regulation and Global Supply Chains: Insights from Stakeholder Narratives on the UK Modern Slavery Act. In: *Journal of Business Ethics* 180 (2), 2022, 455–479. DOI: 10.1007/s10551-021-04878-1.

- [359] Annandale, David. Developing and evaluating environmental impact assessment systems for small developing countries. In: *Impact Assessment and Project Appraisal* 19 (3), 2001, 187–193. DOI: 10.3152/147154601781766998.
- [360] Adebayo, Ogunniyi; Olagunju, Kehinde Oluseyi; Ogundipe, Adeyemi Adefioye. Impact of Agricultural Innovation on Improved Livelihood and Productivity Outcomes Among Smallholder Farmers in Rural Nigeria. In: *SSRN Electronic Journal*, 2016. DOI: 10.2139/ssrn.2847537.
- [361] Sadler, Barry. Environmental Assessment in a Changing World. Evaluating Practice to Improve Performance. Ottawa: Canadian Environmental Assessment Agency, 1996.
- [362] European Commission. Better Regulation: Toolbox. 2023. <https://commission.europa.eu/law/law-making-process/planning-and-proposing-law/better-regulation/better-regulation-guidelines-and-toolbox> (accessed 4 Oct. 2023).
- [363] Carini, Cristian; Rocca, Laura; Veneziani, Monica; Teodori, Claudio. Ex-Ante Impact Assessment of Sustainability Information–The Directive 2014/95. In: *Sustainability* 10 (2), 2018, 560. DOI: 10.3390/su10020560.
- [364] European Commission. Guidelines on the analysis of human rights impacts in impact assessments for trade-related policy initiatives. 2022. <https://circabc.europa.eu/ui/group/7fc51410-46a1-4871-8979-20cce8df0896/library/991d8e1d-dbaa-49d6-8582-bb3aab2cab48/details> (accessed 22 Sept. 2023).
- [365] Schwarz, Katharina; Celiksoy, Ergul; Smetek, Johanna; Wolosik, Ewelina; Lubianiec, Katarzyna; Makulec, Agnieszka; Landmann, Todd. External policy tools to address modern slavery and forced labour. 2022. [https://www.europarl.europa.eu/RegData/etudes/STUD/2022/653664/EXPO_STU\(2022\)653664_EN.pdf](https://www.europarl.europa.eu/RegData/etudes/STUD/2022/653664/EXPO_STU(2022)653664_EN.pdf) (accessed 21 Sept. 2023).
- [366] Nelson, Valerie; Opoku, Kwasi; Martin, Adrienne; Bugri, John; Posthumus, Helena. Assessing the poverty impact of sustainability standards: Fairtrade in Ghanaian cocoa. London: Natural Resources Institute, University of Greenwich, 2014. DOI: 10.13140/2.1.1454.2407.
- [367] Wongrak, Garnchanok; Hur, Nany; Pyo, Insoo; Kim, Jungsuk. The Impact of the EU IUU Regulation on the Sustainability of the Thai Fishing Industry. In: *Sustainability* 13 (12), 2021, 6814. DOI: 10.3390/su13126814.
- [368] European Commission. Handbook for trade sustainability impact assessment: 2nd edition. 2016. <https://op.europa.eu/en/publication-detail/-/publication/8b3a2b37-1028-11e6-ba9a-01aa75ed71a1> (accessed 2 Sept. 2023).
- [369] Stannard-Stockton, Sean. Getting Results: Outputs, Outcomes and. In: *Stanford Social Innovation Review*, 2010. DOI: 10.48558/6jgx-jk11.
- [370] Bäumlér, Jelena. Germany’s Supply Chain Due Diligence Act: Is It Compatible with WTO Obligations? In: *Zeitschrift für europarechtliche Studien* 25 (2), 2022, 265–286. DOI: 10.5771/1435-439X-2022-2-265.
- [371] Dovbischuk, Irina. Investigating the Interplays between Supplier Relationship Management and the German Supply Chain Act for better Sustainability in Global Value Chains. In: *International Journal of Management and Applied Science* 7 (10), 2021, 28–32.

-
- [372] Lorenz, Fabian; Krülls, Sebastian. Die Lieferketten-Risikoanalyse nach dem LkSG – Ein taugliches Konzept, aber unklare Maßstäbe. In: *Corporate Compliance Zeitschrift* 16, 2023, 100–108.
- [373] Berger, Lucina. Lieferkettenverantwortung aus Unternehmens- und Berater-sicht: Notwendigkeit oder Überforderung? In: *Zeitschrift für Unternehmens- und Gesellschaftsrecht* 51 (4-5), 2022, 607–622. DOI: 10.1515/zgr-2022-0026.
- [374] Johann, Christian; Sangi, Roya; Gabriel, Moritz, eds. LkSG: Lieferketten-sorgfaltspflichtengesetz: Handkommentar. 1st ed. Beck-online Bücher. Baden-Baden: Nomos, 2023.
- [375] Kolev, Galina V.; Neligan, Adriana. Effects of a supply chain regulation: Survey-based results on the expected effects of the German Supply Chains Act. In: *Institut der deutschen Wirtschaft (IW)* (IW-Report, No. 8/2022), 2022. <https://www.econstor.eu/bitstream/10419/251050/1/1793802963.pdf> (accessed 3 Nov. 2022).
- [376] Felbermayr, Gabriel; Herrmann, Christoph; Langhammer, Rolf J.; Sandkamp, Alexander-Nikolai; Trapp, Patricia. Ökonomische Bewertung eines Lieferkettengesetzes. Kiel, 2022. https://ifw-kiel.de/fileadmin/Dateiverwaltung/IfW-Publications/-ifw/Kieler_Beitraege_zur_Wirtschaftspolitik/2022/wipo_42.pdf (accessed 5 Oct. 2022).
- [377] Komba, Neema; Annala Tesfaye, Linda; Nilsson, Eva; Solitander, Nikodemus; Trommer, Silke; Verbrugge, Boris; Andersson, Greta. Towards inclusive European CSR legislation : Analysing the impacts of the EU corporate sustainability directive on LDC trade. Helsinki, 2023. <https://julkaisut.valtioneuvosto.fi/handle/10024/164759> (accessed 3 Oct. 2022).
- [378] Müller, Melanie; Saulich, Christina; Schulze, Meike. Public-private alliances for sustainable commodity supply chains. In: *Stiftung Wissenschaft und Politik*, 2022. DOI: 10.18449/2022C05.
- [379] Ruggie, John G. Letter from John Ruggie to German Ministers. 2021. https://shiftproject.org/wp-content/uploads/2021/03/Shift_John-Ruggie_Letter_German-DD.pdf (accessed 10 May 2023).
- [380] Initiative Lieferkettengesetz. Was das neue Lieferkettengesetz liefert - und was nicht: Eine Analyse der Initiative Lieferkettengesetz. 2021. https://www.lieferkettengesetz.de/wp-content/uploads/2021/06/Initiative-Lieferkettengesetz_Analyse_Was-das-neue-Gesetz-liefert.pdf (accessed 26 Oct. 2023).
- [381] Hütz-Adams, Friedel. Guide to conducting risk analyses for cocoa producing countries: Guidelines and analyses for Côte d'Ivoire, Ghana, Cameroon, Nigeria, Ecuador, Peru, the Dominican Republic, Nicaragua, Liberia, Togo, Sierra Leone and Bolivia. Bonn: SÜDWIND e.V. - Institut für Ökonomie und Ökumene, 2021. <https://www.suedwind-institut.de/informieren/publikationen/beitrag/guide-to-conducting-risk-analyses-for-cocoa-producing-countries> (accessed 10 June 2023).
- [382] Deutscher Bundestag. Gesetzentwurf der Bundesregierung. Entwurf eines Gesetzes über die unternehmerischen Sorgfaltspflichten in Lieferketten. BT-Drs. 19/28649. 19.04.2021.

- [383] Federal Ministry for Economic Cooperation and Development. More fairness in global supply chains – Germany leads the way. 2021. <https://www.bmz.de/en/issues/supply-chains> (accessed 15 June 2023).
- [384] Bundesverband der Deutschen Süßwarenindustrie e.V. Wie wichtig ist Ihnen beim Kauf von Süßwaren Nachhaltigkeit? 2021. https://www.bdsi.de/fileadmin/redaktion/Grafik___Statistik/BDSI_Nachhaltigkeit_300dpi.jpg (accessed 29 May 2023).
- [385] Konrads, Sebastian; Walter, Stine. Das neue Lieferkettensorgfaltspflichtengesetz – Herausforderungen, Chancen und Ausblick. In: *Zeitschrift für Außen- und Sicherheitspolitik* 15 (4), 2022, 373–385. DOI: 10.1007/s12399-022-00925-5.
- [386] Kraft, Sarah Katharina; Kellner, Florian. Can Blockchain Be a Basis to Ensure Transparency in an Agricultural Supply Chain? In: *Sustainability* 14 (13), 2022, 8044. DOI: 10.3390/su14138044.
- [387] European Commission. Ending Child Labour and Promoting Sustainable Cocoa Production in Cote d’Ivoire and Ghana: Final Report. 2021. https://www.kakaoforum.de/fileadmin/Redaktion/Studien/Ending_child_labour_and_promoting_sustainable_cocoa_production_in_Co__te_dIvoire_and_Ghana_Report_FINAL.pdf (accessed 5 Jan. 2023).
- [388] Mujica Mota, Miguel; El Makhoulfi, Abdel; Scala, Paolo. On the logistics of cocoa supply chain in Côte d’Ivoire: Simulation-based analysis. In: *Computers & Industrial Engineering* 137, 2019, 106034. DOI: 10.1016/j.cie.2019.106034.
- [389] International Labour Organization. Financing responsibility the cocoa supply chain in Côte d’Ivoire: the “leverage” role of the financial sector in eliminating child labour. 2021. https://www.ilo.org/wcmsp5/groups/public/---africa/---ro-abidjan/documents/vacancynotice/wcms_811440.pdf (accessed 10 May 2023).
- [390] Ghana Cocoa Board. Cocoa. 2023. <https://cocobod.gh/pages/cocoa> (accessed 11 July 2023).
- [391] Fountain, Antonie C.; Huetz-Adams, Friedel. Cocoa Barometer 2022. 2022. <https://cocoabarometer.org/wp-content/uploads/2022/12/Cocoa-Barometer-2022.pdf> (accessed 29 Dec. 2022).
- [392] Ferrero Deutschland GmbH. Menschen bei Ferrero: Verantwortung gegenüber Mitarbeitern und Partnern. 18.07.2023. <https://www.ferrero.de/mitarbeiter> (accessed 23 Sept. 2023).
- [393] Mars Incorporated. Mars in Deutschland. 2023. <https://careers.mars.com/de/de/why-join-mars> (accessed 18 July 2023).
- [394] Alfred Ritter GmbH & Co. KG. Ritter Sport auf einen Blick: Die wichtigsten Daten des Familienunternehmens. 2021. <https://www.ritter-sport.com/auf-einen-blick> (accessed 18 July 2023).
- [395] Bary Callebaut AG. Barry Callebaut auf einen Blick. 2023. <https://www.barry-callebaut.com/en/group/about-us/barry-callebaut-glance-german> (accessed 8 June 2023).
- [396] Cargill, Incorporated. What matters most: 2022 Annual Report. 2022. <https://www.cargill.com/doc/1432215917376/2022-cargill-annual-report.pdf> (accessed 8 June 2023).

-
- [397] International Cocoa Organization. Exports of cocoa butter by country: Table 15_XLVII-2. Internal data, provided by ICCO upon request via email. Abidjan, 2020.
- [398] International Cocoa Organization. Exports of cocoa powder and cake by country: Table 16_XLVII-2. Internal data, provided by ICCO upon request via email. Abidjan, 2020.
- [399] International Cocoa Organization. Exports of cocoa paste/liquor by country: Table 17_XLVII-2. Internal data, provided by ICCO upon request via email. Abidjan, 2020.
- [400] Board, Ghana Cocoa. Cocoa Marketing Company. 29.12.2022. <https://cocobod.gh/subsidiaries-and-divisions/cocoa-marketing-company> (accessed 29 Dec. 2022).
- [401] Cocoa Marketing Company (GH) LTD. Core Operations. 29.12.2022. https://www.cocoamarketing.com.gh/cmcgh/about/core_operations (accessed 29 Dec. 2022).
- [402] Cote D'Ivoire-Ghana Cocoa Initiative. Who We are. 2021. <https://www.cighci.org/about-us/> (accessed 29 Dec. 2022).
- [403] Boysen, Ole; Ferrari, Emanuele; Nechifor, Victor; Tillie, Pascal. Earn a living? What the Côte d'Ivoire–Ghana cocoa living income differential might deliver on its promise. In: *Food Policy* 114, 2023, 102389. DOI: 10.1016/j.foodpol.2022.102389.
- [404] Babo, Alfred. Child Labor in Cocoa-Growing Communities in Cote d'Ivoire: Ways to Implement International Standards in Local Communities. In: *UC Davis Journal of International Law & Policy* 21 (1), 2014, 23–41.
- [405] LeBaron, Genevieve. The Role of Supply Chains in the Global Business of Forced Labour. In: *Journal of Supply Chain Management* 57 (2), 2021, 29–42. DOI: 10.1111/jscm.12258.
- [406] Buhr, Elke; Gordon, Elise. BITTER SWEETS: Prevalence of forced labour & child labour in the cocoa sectors of Côte d'Ivoire & Ghana. Ed. by Tulane University & Walk Free Foundation. 2018. https://www.cocoainitiative.org/sites/default/files/resources/Cocoa-Report_181004_V15-FNL_digital_0.pdf (accessed 13 July 2023).
- [407] Babo, Alfred. Eliminating Child Labour in Rural Areas: Limits of Community-Based Approaches in South-Western Côte d'Ivoire. In: *Child Exploitation in the Global South*. Ed. by Ballet, Jérôme; Bhukuth, Augendra. Cham: Springer International Publishing, 2019, 65–90. DOI: 10.1007/978-3-319-91177-9_5.
- [408] International Labour Organization. Africa: Child Labor in Cocoa Fields/Harkin-Engel Protocol. 2011. https://www.ilo.org/africa/technical-cooperation/accel-africa/WCMS_159486 (accessed 21 Mar. 2023).
- [409] International Labour Organization. ILO Conventions on child labour (IPEC). 2023. <https://www.ilo.org/ipec/facts/ILOconventionsonchildlabour/lang-en/index.htm> (accessed 21 Mar. 2023).
- [410] Abdullah, Alhassan; Huynh, Inès; Emery, Clifton R.; Jordan, Lucy P. Social Norms and Family Child Labor: A Systematic Literature Review. In: *International journal of environmental research and public health* 19 (7), 2022, 4082. DOI: 10.3390/ijerph19074082.

-
- [411] Krauss, Alexander. Understanding child labour beyond the standard economic assumption of monetary poverty. In: *Cambridge Journal of Economics*, 2016, 545–574. DOI: 10.1093/cje/bew019.
- [412] Adonteng-Kissi, Obed. Child Labour Versus Realising Children’s Right to Provision, Protection, and Participation in Ghana. In: *Australian Social Work* 74 (4), 2021, 464–479. DOI: 10.1080/0312407X.2020.1742363.
- [413] International Labour Organization. Ratifications of ILO conventions: Ratifications for Côte d’Ivoire. 2023. https://www.ilo.org/dyn/normlex/en/f?p=1000:11200:0::NO:11200:P11200_COUNTRY_ID:103023 (accessed 21 Mar. 2023).
- [414] Sadhu, Santadarshan; Kysia, Kareem; Onyango, Letitia; Zinnes, Clifford; Lord, Sarah; Monnard, Alexandre; Arellano, Ingrid Rojas. NORC Final Report: Assessing Progress in Reducing Child Labor in Cocoa Production in Cocoa Growing Areas of Côte d’Ivoire and Ghana Initiative. 2020. https://www.cocoainitiative.org/sites/default/files/resources/NORC%202020%20Cocoa%20Report_English.pdf (accessed 15 Mar. 2023).
- [415] International Cocoa Initiative. Child labour in Africa’s cocoa sector: Why it’s so hard to combat and what Olam Cocoa is doing about it. 2019. <https://www.cocoainitiative.org/news/news-partners/child-labour-africas-cocoa-sector-why-its-so-hard-combat-and-what-olam-cocoa> (accessed 1 June 2023).
- [416] Collingsworth, Terry. Nestlé & Cargill v. Doe Series: Meet the “John Does” – the Children Enslaved in Nestlé & Cargill’s Supply Chain - Just Security. 2020. <https://www.justsecurity.org/73959/nestle-cargill-v-doe-series-meet-the-john-does-the-children-enslaved-in-nestle-cargills-supply-chain/> (accessed 14 July 2023).
- [417] BBC. US Supreme Court blocks child slavery lawsuit against chocolate firms. 18.06.2021. <https://www.bbc.com/news/world-us-canada-57522186> (accessed 14 July 2023).
- [418] Perkiss, Stephanie; Bernardi, Cristiana; Dumay, John; Haslam, Jim. A sticky chocolate problem: Impression management and counter accounts in the shaping of corporate image. In: *Critical Perspectives on Accounting* 81, 2021, 102229. DOI: 10.1016/j.cpa.2020.102229.
- [419] Adonteng-Kissi, Obed. Causes of child labour: Perceptions of rural and urban parents in Ghana. In: *Children and Youth Services Review* 91, 2018, 55–65. DOI: 10.1016/j.childyouth.2018.05.034.
- [420] Republic of Ghana Ministry of Manpower, Youth and Employment. Hazardous Child Labour Activity Framework: For the Cocoa Sector in Ghana. 2018. https://www.cocoainitiative.org/sites/default/files/resources/hazardous_ghana_framework_2008.pdf (accessed 21 Mar. 2023).
- [421] Ministère de la Fonction publique et de l’Emploi, Côte d’Ivoire. Arrêté n° 2250 portant détermination de la liste des travaux dangereux interdits aux enfants de moins de dix huit (18) ans. Abidjan, 2005.
- [422] International Labour Organization. Ratifications of C029 - Forced Labour Convention, 1930 (No. 29). 2024. https://www.ilo.org/dyn/normlex/en/f?p=NORMLEXPUB:11300:0::NO::P11300_INSTRUMENT_ID:312174 (accessed 13 July 2023).

- [423] Feasley, Ashley. Eliminating Corporate Exploitation: Examining Accountability Regimes as Means to Eradicate Forced Labor from Supply Chains. In: *Journal of Human Trafficking* 2 (1), 2016, 15–31. DOI: 10.1080/23322705.2016.1137194.
- [424] Olaleye, Abayomi Samuel. Non-Compliance with Agrochemical Safety Guides and Associated Health Risks among Cocoa Farmers in the Ashanti Region of Ghana. In: *African Journal of Biomedical Research* 20 (1), 2017, 9–15.
- [425] Bosompem, Martin; Mensah, Emmanuel. Occupational hazards among cocoa farmers in the Birim south district in the Eastern region of Ghana. In: *ARP Journal of Agricultural and Biological Science* 7 (12), 2012, 1055–1061.
- [426] Muilerman, Sander. Occupational Safety and Health on Ghanaian cocoa farms: Baseline report. Sustainable tree Crops Program. 2013. <https://www.cocoainitiative.org/sites/default/files/resources/Occupational-safety-and-health-on-Ghanaian-cocoa-farms.pdf> (accessed 30 Mar. 2023).
- [427] Osei-Owusu, Yaw; Owusu-Achiaw, Raymond. Assessment on the Gender Dynamics of Highly Hazardous Pesticides (HHPs) within Cocoa Production Landscape in Ghana. 2020. <https://webshop.inkota.de/node/1653> (accessed 3 Sept. 2023).
- [428] International Labour Organization. Ratifications of C184 - Safety and Health in Agriculture Convention, 2001 (No. 184): Date of entry into force: 20 Sep 2003. 15.07.2023. https://www.ilo.org/dyn/normlex/en/f?p=NORMLEXPUB:11300:0::NO:11300:P11300_INSTRUMENT_ID:312329:NO (accessed 15 July 2023).
- [429] Johann, Christian; Gabriel, Moritz. Menschenrechtliches Risiko (Abs. 2). In: *LkSG*. Ed. by Johann, Christian; Sangi, Roya; Gabriel, Moritz. Beck-online Bücher. Baden-Baden: Nomos, 2023, 82–123.
- [430] Busquet, Milande; Bosma, Niels; Hummels, Harry. A multidimensional perspective on child labor in the value chain: The case of the cocoa value chain in West Africa. In: *World Development* 146, 2021, 105601. DOI: 10.1016/j.worlddev.2021.105601.
- [431] van Vliet, Jiska A.; Slingerland, Maja A.; Waarts, Yuca R.; Giller, Ken E. A Living Income for Cocoa Producers in Côte d’Ivoire and Ghana? In: *Frontiers in Sustainable Food Systems* 5, 2021. DOI: 10.3389/fsufs.2021.732831.
- [432] Meemken, Eva-Marie; Sellare, Jorge; Kouame, Christophe N.; Qaim, Martin. Effects of Fairtrade on the livelihoods of poor rural workers. In: *Nature Sustainability* 2 (7), 2019, 635–642. DOI: 10.1038/s41893-019-0311-5.
- [433] Amfo, Bismark; Aidoo, Robert; Osei Mensah, James. Food coping strategies among migrant labourers on cocoa farms in southern Ghana. In: *Food Security* 13 (4), 2021, 875–894. DOI: 10.1007/s12571-021-01186-4.
- [434] International Labour Organization. Ratifications of C099 - Minimum Wage Fixing Machinery (Agriculture) Convention, 1951 (No. 99): Date of entry into force: 23 Aug 1953. 2023. https://www.ilo.org/dyn/normlex/en/f?p=NORMLEXPUB:11300:0::NO:11300:P11300_INSTRUMENT_ID:312244:NO (accessed 12 July 2023).
- [435] WageIndicator Foundation. Minimum Wage - Cote d’Ivoire. 2023. <https://wageindicator.org/salary/minimum-wage/ivory-coast> (accessed 29 Mar. 2023).

- [436] WageIndicator Foundation. Minimum Wage Updated in Ghana from 01 January 2023. 2023. <https://wageindicator.org/salary/minimum-wage/minimum-wages-news/2023/minimum-wage-updated-in-ghana-from-01-january-2023-january-18-2023> (accessed 29 Mar. 2023).
- [437] Fountain, Antonie C.; Huetz-Adams, Friedel. Necessary Farm Gate Prices for a Living Income. 2019. <https://voicenetwork.cc/wp-content/uploads/2020/01/200113-Necessary-Farm-Gate-Prices-for-a-Living-Income-Definitive.pdf> (accessed 30 Mar. 2023).
- [438] The World Bank. Forest area (% of land area) - Cote d'Ivoire, Ghana. 2020. https://data.worldbank.org/indicator/AG.LND.FRST.ZS?end=2020&locations=CI-GH&name_desc=true&start=1990&view=chart (accessed 29 Dec. 2022).
- [439] Ashiagbor, George; Asante, Winston Adams; Forkuo, Eric Kwabena; Acheampong, Emmanuel; Foli, Ernest. Monitoring cocoa-driven deforestation: The contexts of encroachment and land use policy implications for deforestation free cocoa supply chains in Ghana. In: *Applied Geography* 147, 2022, 102788. DOI: 10.1016/j.apgeog.2022.102788.
- [440] Andersen, Lykke E.; Medinaceli, Agnes; Gonzales, Alejandro; Anker, Richard; Anker, Martha. Living Wage Update Report Peri-urban Lower Volta Region, Ghana 2022. In: 2022. https://www.globallivingwage.org/wp-content/uploads/2022/04/Updatereport_Ghana_2022_June-FINAL.pdf (accessed 3 Mar. 2023).
- [441] Walden, Daniel. Überblick/Regelungsgegenstand und Zweck. In: *LkSG*. Ed. by Depping, André; Walden, Daniel. München: C.H. Beck, 2022, 198–221.
- [442] Falder, Roland; Frank-Fahle, Constantin; Poleacov, Peter, eds. Lieferkettensorgfaltspflichtengesetz. Wiesbaden: Springer Fachmedien Wiesbaden, 2022. DOI: 10.1007/978-3-658-36837-1.
- [443] Kämpf, Andrea. Zugang zum Beschwerdeverfahren. In: *LkSG*. Ed. by Johann, Christian; Sangi, Roya; Gabriel, Moritz. Beck-online Bücher. Baden-Baden: Nomos, 2023, 306–308.
- [444] Hartmann, Julia. Toward a more complete theory of sustainable supply chain management: the role of media attention. In: *Supply Chain Management: An International Journal* 26 (4), 2021, 532–547. DOI: 10.1108/SCM-01-2020-0043.
- [445] Sajjad, Aymen; Eweje, Gabriel; Tappin, David. Managerial perspectives on drivers for and barriers to sustainable supply chain management implementation: Evidence from New Zealand. In: *Business Strategy and the Environment* 29 (2), 2020, 592–604. DOI: 10.1002/bse.2389.
- [446] Zhu, Qinghua; Sarkis, Joseph. The moderating effects of institutional pressures on emergent green supply chain practices and performance. In: *International Journal of Production Research* 45 (18-19), 2007, 4333–4355. DOI: 10.1080/00207540701440345.
- [447] Bundesministerium für Arbeit und Soziales. Fragen und Antworten zum Lieferkettengesetz. 2023. <https://www.csr-in-deutschland.de/DE/Wirtschaft-Menschenrechte/Gesetz-ueber-die-unternehmerischen-Sorgfaltspflichten-in-Lieferketten/FAQ/faq.html> (accessed 16 Sept. 2023).
- [448] Hofstede, Gerd Jan. Transparency in Netchains. In: *EFITA Conference*, 2003, 17–29.

- [449] Orsdemir, Adem; Hu, Bin; Deshpande, Vinayak. Ensuring Corporate Social and Environmental Responsibility Through Vertical Integration and Horizontal Sourcing. In: *Manufacturing & Service Operations Management* 21 (2), 2019, 417–434. DOI: 10.1287/msom.2018.0744.
- [450] Murcia, Maria Jose; Panwar, Rajat; Tarzijan, Jorge. Socially Responsible Firms Outsource Less. In: *Business & Society* 60 (6), 2021, 1507–1545. DOI: 10.1177/0007650319898490.
- [451] Ritter Sport. Mit Kakao aus eigenem Anbau. 2020. <https://www.ritter-sport.com/mit-kakao-aus-eigenem-anbau> (accessed 15 May 2023).
- [452] Schaefer, Manfred. Wir beenden das klassische Baugeschäft in Afrika: In einem Monat tritt das Lieferkettengesetz in Kraft. Die EU plant eigene Regeln, die noch schärfer sind. Wie wirken diese Vorgaben? Ein Baukonzern zieht schon jetzt Konsequenzen. In: *Frankfurter Allgemeine Zeitung* (Nr. 278), 29.11.2022, 19.
- [453] Creutzburg, Dietrich; Schäfers, Manfred. Millionenbußen drohen. In: *Frankfurter Allgemeine Zeitung*, 03.03.2021, 16.
- [454] Vinke, Kira; Campbell, Loyale; Schirwon, Dana; Seyuba, Katongo; Krampe. Climate and Environmental Security in the Democratic Republic of Congo: Competing over Abundant Resources - Adapting to Change. DGAP Report. 3. Berlin: Forschungsinstitut der Deutschen Gesellschaft für Auswärtige Politik e.V., 2023. <https://www.ssoar.info/ssoar/handle/document/86649> (accessed 9 June 2023).
- [455] Mayer, Oliver. Illegales Glitzer-Geschäft: Mica-Abbau durch Kinderarbeit. 2.01.2022. <https://www.tagesschau.de/wirtschaft/weltwirtschaft/kinderarbeit-micaminen-indien-101.html> (accessed 1 June 2023).
- [456] Hynes, Mike. Virtual consumption: A review of digitalization’s “green” credentials. In: *Frontiers in Sustainability* 3, 2022, 969329. DOI: 10.3389/frsus.2022.969329.
- [457] Franke, Martin. Kobalt aus Kongo: Die dunkle Seite der Verkehrswende. In: *Frankfurter Allgemeine Zeitung*, 14.01.2022. <https://www.faz.net/aktuell/wirtschaft/schneller-schlau/kobalt-aus-kongo-der-dunkle-preis-der-verkehrswende-17731386.html> (accessed 1 June 2023).
- [458] Bundesministerium für Arbeit und Soziales. NAP International. 2025. <https://www.csr-in-deutschland.de/DE/Wirtschaft-Menschenrechte/NAP/Ueber-den-NAP/NAP-International/nap-international.html> (accessed 4 Mar. 2025).
- [459] Agyemang, Martin; Kusi-Sarpong, Simonov; Agyemang, John; Jia, Fu; Adzanyo, Mary. Determining and evaluating socially sustainable supply chain criteria in agri-sector of developing countries: insights from West Africa cashew industry. In: *Production Planning & Control* 33 (11), 2022, 1115–1133. DOI: 10.1080/09537287.2020.1852479.
- [460] Umpula, Emmanuel; Dummett, Mark. The Blood Cobalt Narrative: Addressing Human Rights Concerns or Scaremongering? In: *Business and Human Rights Journal* 9 (2), 2024, 308–314. DOI: 10.1017/bhj.2024.4.
- [461] MVO Nederland. CSR Risk Check. Risk Analysis. Cobalt ores and concentrates. 2025. <https://mvorisicochecker.nl/en/check-your-risks/start-check/result?uuid=9f7a3e45-387b-485e-9c0e-ac6c2a3518f0> (accessed 25 July 2025).

- [462] MVO Nederland. CSR Risk Check. Risk Analysis. Cashew nuts. 2025. <https://mvorisicochecker.nl/en/check-your-risks/start-check/result?uuid=9f7a3d62-69cc-4ebe-b790-c0418b25213e> (accessed 25 July 2025).
- [463] Kraft, Sarah Katharina; Quayson, Matthew; Kellner, Florian. Assessing the German Act on Corporate Due Diligence Obligations in Supply Chains: a perspective from the smallholder cocoa farmer. In: *Frontiers in Sustainability* 5, 2024, 1376619. DOI: 10.3389/frsus.2024.1376619.
- [464] Berthet, Etienne; Lavalley, Julien; Anquetil-Deck, Candy; Ballesteros, Fernanda; Stadler, Konstantin; Soytaş, Ugur; Hauschild, Michael; Laurent, Alexis. Assessing the social and environmental impacts of critical mineral supply chains for the energy transition in Europe. In: *Global Environmental Change* 86, 2024, 102841. DOI: 10.1016/j.gloenvcha.2024.102841.
- [465] Han, Chen; Jia, Fu; Jiang, Mengqi; Chen, Lujie. Modern slavery in supply chains: a systematic literature review. In: *International Journal of Logistics Research and Applications* 27 (7), 2024, 1206–1227. DOI: 10.1080/13675567.2022.2118696.
- [466] Bundesamt für Wirtschaft und Ausfuhrkontrolle. FAQ zum risikobasierten Vorgehen. Eschborn, 2025. https://www.bafa.de/SharedDocs/Downloads/DE/Lieferketten/faq_risikobasierte_vorgehen.pdf?__blob=publicationFile&v=2 (accessed 31 Aug. 2025).
- [467] Goggin, Malcolm; Fleming, Adrienne; MacMahon, Cormac; Owende, Philip. Exploring the sustainability of single use plastics in the biopharmaceuticals sector: a scoping review of challenges, opportunities, and impacts. In: *Frontiers in Sustainability* 6, 2025, 1536382. DOI: 10.3389/frsus.2025.1536382.
- [468] Le, An Thanh; Shakiba, Masoud; Ardekani, Iman. Tomato disease detection with lightweight recurrent and convolutional deep learning models for sustainable and smart agriculture. In: *Frontiers in Sustainability* 5, 2024, 1383182. DOI: 10.3389/frsus.2024.1383182.
- [469] Pedersen, Susanne; Benson, Tony; Tsalis, George; Futtrup, Rebecca; Dean, Moira; Aschemann-Witzel, Jessica. What consumers want in a sustainability food label: Results from online co-creation workshops in the United Kingdom, Ireland and Denmark. In: *Frontiers in Sustainability* 4, 2024, 1342215. DOI: 10.3389/frsus.2023.1342215.
- [470] Kuruneru, Joseph. Exploring the Challenges of Sustainable Procurement Implementation: Insights from Botswana’s Public Sector. In: *Frontiers in Sustainability* 6, 2025, 1645902. DOI: 10.3389/frsus.2025.1645902.
- [471] Putsche, Victoria L.; Pattany, Jasmine; Ghosh, Tapajyoti; Atnoorkar, Swaroop; Zuboy, Jarett; Carpenter, Alberta; Takeuchi, Esther S.; Marschilok, Amy C.; Takeuchi, Kenneth J.; Burrell, Anthony; Mann, Margaret K. A framework for integrating supply chain, environmental, and social justice factors during early stationary battery research. In: *Frontiers in Sustainability* 4, 2023, 1287423. DOI: 10.3389/frsus.2023.1287423.
- [472] Quintana-García, Cristina; Benavides-Chicón, Carlos G.; Marchante-Lara, Macarena. Does a green supply chain improve corporate reputation? Empirical evidence from European manufacturing sectors. In: *Industrial Marketing Management* 92, 2021, 344–353. DOI: 10.1016/j.indmarman.2019.12.011.

- [473] Rajeev, A.; Pati, Rupesh K.; Padhi, Sidhartha S.; Govindan, Kannan. Evolution of sustainability in supply chain management: A literature review. In: *Journal of Cleaner Production* 162, 2017, 299–314. DOI: 10.1016/j.jclepro.2017.05.026.
- [474] Vörösmarty, Gyöngyi; Dobos, Imre. A literature review of sustainable supplier evaluation with Data Envelopment Analysis. In: *Journal of Cleaner Production* 264, 2020, 121672. DOI: 10.1016/j.jclepro.2020.121672.
- [475] Trindade, Maria A.M.; Bellieni, Francesco; Stabilini, Giuseppe; Silvio, Manlio de. Design principles for corporate sustainability due Diligence: An investigation with expert interviews. In: *Journal of Purchasing and Supply Management*, 2025, 101032. DOI: 10.1016/j.pursup.2025.101032.
- [476] Haddaway, Neal R.; Bethel, Alison; Dicks, Lynn V.; Koricheva, Julia; Macura, Biljana; Petrokofsky, Gillian; Pullin, Andrew S.; Savilaakso, Sini; Stewart, Gavin B. Eight problems with literature reviews and how to fix them. In: *Nature Ecology & Evolution* 4 (12), 2020, 1582–1589. DOI: 10.1038/s41559-020-01295-x.
- [477] Quayson, Matthew; Bai, Chunguang; Mahmoudi, Amin; Hu, Weihao; Chen, Wei; Omoruyi, Osayuwamen. Designing a decision support tool for integrating ESG into the natural resource extraction industry for sustainable development using the ordinal priority approach. In: *Resources Policy* 85, 2023, 103988. DOI: 10.1016/j.resourpol.2023.103988.
- [478] Eisen, Charis; Schenten, Julian; Theis, Anna; Rehn-Groenendijk, Jonas; Helferich, Marvin; Müller, Helena; Hanss, Daniel. Toward system innovation for more sustainable chemistry: insights into consumers’ perceptions, knowledge, and behavior related to traceability and product design strategies along leather supply chains. In: *Frontiers in Sustainability* 5, 2024, 1351638. DOI: 10.3389/frsus.2024.1351638.
- [479] Kellner, Florian. Generating greenhouse gas cutting incentives when allocating carbon dioxide emissions to shipments in road freight transportation. In: *OR Spectrum* 44 (3), 2022, 833–874. DOI: 10.1007/s00291-022-00675-y.
- [480] Linton, Jonathan D.; Klassen, Robert; Jayaraman, Vaidyanathan. Sustainable supply chains: An introduction. In: *Journal of Operations Management* 25 (6), 2007, 1075–1082. DOI: 10.1016/j.jom.2007.01.012.
- [481] Sarkis, Joseph. A strategic decision framework for green supply chain management. In: *Journal of Cleaner Production* 11 (4), 2003, 397–409. DOI: 10.1016/S0959-6526(02)00062-8.
- [482] Schramm, Vanessa Batista; Cabral, Luciana Priscila Barros; Schramm, Fernando. Approaches for supporting sustainable supplier selection - A literature review. In: *Journal of Cleaner Production* 273, 2020, 123089. DOI: 10.1016/j.jclepro.2020.123089.
- [483] Wetzstein, Anton; Feisel, Edda; Hartmann, Evi; Benton, W. C. Uncovering the supplier selection knowledge structure: A systematic citation network analysis from 1991 to 2017. In: *Journal of Purchasing and Supply Management* 25 (4), 2019, 100519. DOI: 10.1016/j.pursup.2018.10.002.
- [484] Genovese, Andrea; Lenny Koh, S. C.; Bruno, Giuseppe; Esposito, Emilio. Greener supplier selection: state of the art and some empirical evidence. In: *International Journal of Production Research* 51 (10), 2013, 2868–2886. DOI: 10.1080/00207543.2012.748224.

- [485] Karakoç, Ömer; Memiş, Samet; Sennaroglu, Bahar. A Review of Sustainable Supplier Selection with Decision-Making Methods from 2018 to 2022. In: *Sustainability* 16 (1), 2024, 125. DOI: 10.3390/su16010125.
- [486] Štreimikienė, Dalia; Bathaei, Ahmad; Streimikis, Justas. MCDM Approaches for Supplier Selection in Sustainable Supply Chain Management. In: *Sustainability* 16 (23), 2024, 10446. DOI: 10.3390/su162310446.
- [487] Tronnebati, Imane; El Yadari, Manal; Jawab, Fouad. A Review of Green Supplier Evaluation and Selection Issues Using MCDM, MP and AI Models. In: *Sustainability* 14 (24), 2022, 16714. DOI: 10.3390/su142416714.
- [488] Ageron, Blandine; Gunasekaran, Angappa; Spalanzani, Alain. Sustainable supply management: An empirical study. In: *International Journal of Production Economics* 140 (1), 2012, 168–182. DOI: 10.1016/j.ijpe.2011.04.007.
- [489] Bai, Chunguang; Sarkis, Joseph. Integrating sustainability into supplier selection with grey system and rough set methodologies. In: *International Journal of Production Economics* 124 (1), 2010, 252–264. DOI: 10.1016/j.ijpe.2009.11.023.
- [490] Jain, Naveen; Singh, A. R. Sustainable supplier selection under must-be criteria through Fuzzy inference system. In: *Journal of Cleaner Production* 248, 2020, 119275. DOI: 10.1016/j.jclepro.2019.119275.
- [491] Khan, Sharfuddin Ahmed; Kusi-Sarpong, Simonov; Arhin, Francis Kow; Kusi-Sarpong, Horsten. Supplier sustainability performance evaluation and selection: A framework and methodology. In: *Journal of Cleaner Production* 205, 2018, 964–979. DOI: 10.1016/j.jclepro.2018.09.144.
- [492] Singh, Arpit; Kumar, Vimal; Verma, Pratima. Sustainable supplier selection in a construction company: a new MCDM method based on dominance-based rough set analysis. In: *Construction Innovation* 25 (2), 2025, 328–362. DOI: 10.1108/CI-12-2022-0324.
- [493] You, Xiaoyue; Song, Yuan. Research on Sustainable Supplier Evaluation Index System in Architectural Design Industry. In: *Sustainability* 16 (11), 2024, 4466. DOI: 10.3390/su16114466.
- [494] Liao, Zhiying; Rittscher, Jens. A multi-objective supplier selection model under stochastic demand conditions. In: *International Journal of Production Economics* 105 (1), 2007, 150–159. DOI: 10.1016/j.ijpe.2006.03.001.
- [495] Kuo, Tsai-Chi; Muniroh, Muniroh; Fau, Kristin Halisa. An Integrated Kano Model, Fuzzy Analytical Hierarchy Process, and Decision Matrix for Sustainable Supplier Selection in Palm Oil Industries Indonesia, a Case Study. In: *Processes* 9 (6), 2021, 1078. DOI: 10.3390/pr9061078.
- [496] Mubarik, Muhammad Shujaat; Kazmi, Syed Hasnain Alam; Zaman, Syed Imran. Application of gray DEMATEL-ANP in green-strategic sourcing. In: *Technology in Society* 64, 2021, 101524. DOI: 10.1016/j.techsoc.2020.101524.
- [497] Ghadimi, Pezhman; Dargi, Ahmad; Heavey, Cathal. Making sustainable sourcing decisions: practical evidence from the automotive industry. In: *International Journal of Logistics Research and Applications* 20 (4), 2017, 297–321. DOI: 10.1080/13675567.2016.1227310.
- [498] Tong, Li Zhong; Wang, Jindan; Pu, Zhongmin. Sustainable supplier selection for SMEs based on an extended PROMETHEE II approach. In: *Journal of Cleaner Production* 330, 2022, 129830. DOI: 10.1016/j.jclepro.2021.129830.

- [499] Ghamari, Roya; Mahdavi-Mazdeh, Mohammad; Ghannadpour, Seyed Farid. Resilient and sustainable supplier selection via a new framework: a case study from the steel industry. In: *Environment, Development and Sustainability* 24 (8), 2022, 10403–10441. DOI: 10.1007/s10668-021-01872-5.
- [500] Khalili Nasr, Arash; Tavana, Madjid; Alavi, Behrouz; Mina, Hassan. A novel fuzzy multi-objective circular supplier selection and order allocation model for sustainable closed-loop supply chains. In: *Journal of Cleaner Production* 287, 2021, 124994. DOI: 10.1016/j.jclepro.2020.124994.
- [501] Castro e Silva, Andreia; Seleme, Robson; Assis Silva, Wiliam de; Zattar, Izabel Cristina; Nara, Elpidio Oscar Benitez; Júnior, Osiris Canciglieri; Benitez, Lisianne Brittes. Evaluation and Choice Criteria of Sustainable Suppliers in the Construction Industry: A Comparative Study in Brazilian Companies. In: *Sustainability* 14 (23), 2022, 15711. DOI: 10.3390/su142315711.
- [502] Garcia, Blanca; León, Víctor; Hidalgo Gallardo, Amada. Supplier selection for Mexican manufacturing MSMEs: A study-based on multi-criteria approach. In: *Journal of the International Council for Small Business* 2 (4), 2021, 347–354. DOI: 10.1080/26437015.2021.1939199.
- [503] Fallahpour, Alireza; Udency Oluogu, Ezutah; Nurmaya Musa, Siti; Yew Wong, Kuan; Noori, Samira. A decision support model for sustainable supplier selection in sustainable supply chain management. In: *Computers & Industrial Engineering* 105, 2017, 391–410. DOI: 10.1016/j.cie.2017.01.005.
- [504] Aslani, Babak; Rabiee, Meysam; Tavana, Madjid. An integrated information fusion and grey multi-criteria decision-making framework for sustainable supplier selection. In: *International Journal of Systems Science: Operations & Logistics* 8 (4), 2021, 348–370. DOI: 10.1080/23302674.2020.1776414.
- [505] Bai, Chunguang; Kusi-Sarpong, Simonov; Badri Ahmadi, Hadi; Sarkis, Joseph. Social sustainable supplier evaluation and selection: a group decision-support approach. In: *International Journal of Production Research* 57 (22), 2019, 7046–7067. DOI: 10.1080/00207543.2019.1574042.
- [506] United Nations. Guiding Principles for Business and Human Rights: Implementing the United Nations “Protect, Respect and Remedy” Framework. 2011. <https://unglobalcompact.org/library/2> (accessed 3 Jan. 2026).
- [507] Nogueira, Elisabete; Gomes, Sofia; Lopes, João M. Unveiling triple bottom line’s influence on business performance. In: *Discover Sustainability* 6 (1), 2025, 1–18. DOI: 10.1007/s43621-025-00804-x.
- [508] Gazi, Md. Abu Issa; Yusof, Mohd Faizal; Islam, Md. Aminul; Amin, Mohammad Bin; Senathirajah, Abdul Rahman bin S. Analyzing the impact of employee job satisfaction on their job behavior in the industrial setting: An analysis from the perspective of job performance. In: *Journal of Open Innovation: Technology, Market, and Complexity* 10 (4), 2024, 100427. DOI: 10.1016/j.joitmc.2024.100427.
- [509] Yuen, Kum Fai; Loh, Hui Shan; Zhou, Qingji; Wong, Yiik Diew. Determinants of job satisfaction and performance of seafarers. In: *Transportation Research Part A: Policy and Practice* 110, 2018, 1–12. DOI: 10.1016/j.tra.2018.02.006.
- [510] Seuring, Stefan; Gold, Stefan. Conducting content-analysis based literature reviews in supply chain management. In: *Supply Chain Management: An International Journal* 17 (5), 2012, 544–555. DOI: 10.1108/13598541211258609.

- [511] Durach, Christian F.; Kembro, Joakim Hans; Wieland, Andreas. How to advance theory through literature reviews in logistics and supply chain management. In: *International Journal of Physical Distribution & Logistics Management* 51 (10), 2021, 1090–1107. DOI: 10.1108/IJPDLM-11-2020-0381.
- [512] Kumpulainen, Miika; Seppänen, Marko. Combining Web of Science and Scopus datasets in citation-based literature study. In: *Scientometrics* 127 (10), 2022, 5613–5631. DOI: 10.1007/s11192-022-04475-7.
- [513] Pranckutė, Raminta. Web of Science (WoS) and Scopus: The Titans of Bibliographic Information in Today's Academic World. In: *Publications* 9 (1), 2021, 12. DOI: 10.3390/publications9010012.
- [514] Tasdemir, Cagatay; Gazo, Rado. A Systematic Literature Review for Better Understanding of Lean Driven Sustainability. In: *Sustainability* 10 (7), 2018, 2544. DOI: 10.3390/su10072544.
- [515] Guo, Sen; Zhao, Haoran. Fuzzy best-worst multi-criteria decision-making method and its applications. In: *Knowledge-Based Systems* 121, 2017, 23–31. DOI: 10.1016/j.knosys.2017.01.010.
- [516] Ulutaş, Alptekin; Topal, Ayşe; Pamučar, Dragan; Stević, Željko; Karabašević, Darjan; Popović, Gabrijela. A New Integrated Multi-Criteria Decision-Making Model for Sustainable Supplier Selection Based on a Novel Grey WISP and Grey BWM Methods. In: *Sustainability* 14 (24), 2022, 16921. DOI: 10.3390/su142416921.
- [517] Althaqafi, Torky. Environmental and Social Factors in Supplier Assessment: Fuzzy-Based Green Supplier Selection. In: *Sustainability*, 2023, 15643. DOI: 10.3390/su152115643.
- [518] International Labour Organization. Child labour: Global estimates 2020, trends and the road forward. New York, NY, USA, 2021. https://www.ilo.org/wcmsp5/groups/public/---ed_norm/---ipec/documents/publication/wcms_797515.pdf (accessed 20 Mar. 2023).
- [519] International Labour Organization. Profits and poverty: The economics of forced labour. Version Second edition. Geneva, Switzerland, 2024. <https://www.ilo.org/publications/major-publications/profits-and-poverty-economics-forced-labour> (accessed 4 Sept. 2025).
- [520] Ebnehoseini, Z.; Jangi, M.; Tara, M.; Tabesh, H. Investigation the success rate of hospital information system (HIS): Development of a questionnaire and case study. In: *Journal of healthcare quality research* 36 (2), 2021, 103–112. DOI: 10.1016/j.jhqr.2020.03.010.
- [521] Lynn, Mary R. Determination and Quantification Of Content Validity. In: *Nursing Research* 35 (6), 1986. DOI: 10.1097/00006199-198611000-00017.
- [522] Zhang, Jing; Yang, Dong; Li, Qiang; Lev, Benjamin; Ma, Yanfang. Research on Sustainable Supplier Selection Based on the Rough DEMATEL and FVIKOR Methods. In: *Sustainability* 13 (1), 2021, 88. DOI: 10.3390/su13010088.
- [523] Singh, Gaurvendra; Pandey, Ashutosh. Environmental sustainability integrated supplier selection in electric vehicle supply chains: a grey relational analysis approach. In: *Environment, Development and Sustainability*, 2024, 1–29. DOI: 10.1007/s10668-024-05294-x.

- [524] Sonar, Harshad; Gunasekaran, Angappa; Agrawal, Swati; Roy, Matthew. Role of lean, agile, resilient, green, and sustainable paradigm in supplier selection. In: *Cleaner Logistics and Supply Chain* 4, 2022, 100059. DOI: 10.1016/j.clscn.2022.100059.
- [525] Kumar, Divesh; Rahman, Zillur; Chan, Felix T. S. A fuzzy AHP and fuzzy multi-objective linear programming model for order allocation in a sustainable supply chain: A case study. In: *International Journal of Computer Integrated Manufacturing* 30 (6), 2017, 535–551. DOI: 10.1080/0951192X.2016.1145813.
- [526] Vahidi, F.; Torabi, S. Ali; Ramezankhani, M. J. Sustainable supplier selection and order allocation under operational and disruption risks. In: *Journal of Cleaner Production* 174, 2018, 1351–1365. DOI: 10.1016/j.jclepro.2017.11.012.
- [527] Oliveira, Daniel Felipe; Souza, Ricardo Gabbay. Life cycle sustainability impact categories for sustainable procurement. In: *Journal of Cleaner Production* 383, 2023, 135448. DOI: 10.1016/j.jclepro.2022.135448.
- [528] MVO Nederland. CSR Risk Check. 2025. <https://www.mvorisicochecker.nl/en> (accessed 27 Mar. 2025).
- [529] Hsu, C. W.; Hu, A. H. Green supply chain management in the electronic industry. In: *International Journal of Environmental Science & Technology* 5 (2), 2008, 205–216. DOI: 10.1007/BF03326014.
- [530] Santos, Davidson de Almeida; Quelhas, Osvaldo Luiz Gonçalves; Gomes, Carlos Francisco Simões; Filho, José Rodrigues de Farias. Theoretical Proposal for an Integrated Sustainability Performance Measurement System in the Supply Chain. In: *Frontiers in Sustainability* 2, 2021, 720763. DOI: 10.3389/frsus.2021.720763.
- [531] Ashby, Alison; Leat, Mike; Hudson-Smith, Melanie. Making connections: a review of supply chain management and sustainability literature. In: *Supply Chain Management: An International Journal* 17 (5), 2012, 497–516. DOI: 10.1108/13598541211258573.
- [532] Ahi, Payman; Searcy, Cory. Measuring social issues in sustainable supply chains. In: *Measuring Business Excellence* 19 (1), 2015, 33–45. DOI: 10.1108/MBE-11-2014-0041.
- [533] Amundsen, Vilde Steiro. From checking boxes to actual improvement: A new take on sustainability certification. In: *Aquaculture* 548, 2022, 737672. DOI: 10.1016/j.aquaculture.2021.737672.
- [534] Nygaard, Arne. Is sustainable certification’s ability to combat greenwashing trustworthy? In: *Frontiers in Sustainability* 4, 2023, 1188069. DOI: 10.3389/frsus.2023.1188069.
- [535] EcoVadis. Nachhaltigkeitsratings für globale Lieferketten. 2025. <https://ecovadis.com/de/solutions/ratings/> (accessed 27 Mar. 2025).
- [536] IntegrityNext. Umfassende Abdeckung von ESG-Themen. 2025. <https://www.integritynext.com/de/plattform> (accessed 27 Mar. 2025).
- [537] Abdul Basit, Shoaib; Gharlegghi, Behrooz; Batool, Khadija; Hassan, Sohaib S.; Jahanshahi, Asghar Afshar; Kliem, Mujde Erdinc. Review of enablers and barriers of sustainable business practices in SMEs. In: *Journal of Economy and Technology* 2, 2024, 79–94. DOI: 10.1016/j.ject.2024.03.005.

- [538] Bourini, Islam; Khassawneh, Osama; Mohammad, Tamara. Towards sustainability in the services industry: Does green top management support stimulate an organization's green operational performance? A moderated mediation model. In: *Business Strategy and the Environment* 33 (8), 2024, 7788–7799. DOI: 10.1002/bse.3897.
- [539] Kumar, Divesh; Rahman, Zillur. Buyer supplier relationship and supply chain sustainability: empirical study of Indian automobile industry. In: *Journal of Cleaner Production* 131, 2016, 836–848. DOI: 10.1016/j.jclepro.2016.04.007.
- [540] Zhang, Min; Pawar, Kulwant S.; Bhardwaj, Saurabh. Improving supply chain social responsibility through supplier development. In: *Production Planning & Control* 28 (6-8), 2017, 500–511. DOI: 10.1080/09537287.2017.1309717.
- [541] Chen, Yue. How blockchain adoption affects supply chain sustainability in the fashion industry: a systematic review and case studies. In: *International Transactions in Operational Research* 31 (6), 2024, 3592–3620. DOI: 10.1111/itor.13273.
- [542] Ortiz, Alberto; Carrillo, Natalia; Elghannam, Ahmed; Escribano, Miguel; Gaspar, Paula. Views of Farmers and Industrial Entrepreneurs on The Iberian Pig Quality Standard: An In-Depth Interview Research Study. In: *Animals* 10 (10), 2020, 1772. DOI: 10.3390/ani10101772.
- [543] Mani, Venkatesh; Gunasekaran, Angappa; Delgado, Catarina. Enhancing supply chain performance through supplier social sustainability: An emerging economy perspective. In: *International Journal of Production Economics* 195, 2018, 259–272. DOI: 10.1016/j.ijpe.2017.10.025.
- [544] Marra, Mita. Bridging the gaps in sustainability assessment: A systematic literature review, 2014-2023. In: *Evaluation and program planning* 110, 2025, 102557. DOI: 10.1016/j.evalprogplan.2025.102557.
- [545] European Parliament. Deforestation law: Parliament adopts changes to postpone and simplify measures. 2025. <https://www.europarl.europa.eu/news/en/press-room/20251211IPR32168/deforestation-law-parliament-adopts-changes-to-postpone-and-simplify-measures> (accessed 22 Dec. 2025).
- [546] Prewave. Due Diligence. Solution. 2026. <https://www.prewave.com/solutions/due-diligence> (accessed 8 May 2026).
- [547] EcoVadis. Risk Management. 2026. <https://ecovadis.com/solutions/risk-management/> (accessed 8 May 2026).
- [548] Integrity Next. Supply Chain Due Diligence. 2026. <https://www.integritynext.com/supply-chain-due-diligence> (accessed 8 May 2026).
- [549] Li, Yifei; Wang, Anni; Wu, Qun; Zhou, Zejiang. Vertical integration, supply chain disruptions, and corporate yield spreads. In: *The British Accounting Review*, 2025, 101639. DOI: 10.1016/j.bar.2025.101639.
- [550] D'Angelo, Stefano; Di Bernardino, Claudio; Pernagallo, Giuseppe. Do reshoring and nearshoring drive reindustrialization? The case of Germany. In: *Economic Systems Research* 37 (4), 2025, 572–600. DOI: 10.1080/09535314.2025.2555257.
- [551] Wu, Jing. The Trend of Deglobalization: Reshoring, Friend-Shoring, and Regionalization. In: *Global Trends in Manufacturing Supply Chains*. Vol. 26. Springer Series in Supply Chain Management 26. Singapore: Springer Singapore, 2025, 93–111. DOI: 10.1007/978-981-96-3228-2_4.

- [552] Forum Nachhaltiger Kakao e.V. Monitoring Report 2024. Bonn, 2024. https://kakaoforum.de/wp-content/uploads/251126_MonitoringBericht2024_web.pdf (accessed 28 Dec. 2025).
- [553] Forum Nachhaltiges Palmöl. Fortschrittsbericht 2024. Bonn, 2025. <https://forumpalmoel.org/download/fortschrittsbericht-2024/> (accessed 28 Dec. 2025).