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UNSTITCHED: Rethinking How Environmental Impact Is Measured in Early-Stage Fashion Ventures

Nikka Gerona

Supervisor

Dr. Andrius Plepys

andrius.plepys@iiiee.lu.se

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Tel: +46 – 46 222 02 00, Fax: +46 – 46 222 02 10, e-mail: iiiee@iiiee.lu.se.

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Abstract

Early-stage sustainable fashion enterprises face a structural paradox: they are increasingly expected by funders, investors, and programme partners to demonstrate measurable environmental performance, yet the ISO-compliant Life Cycle Assessment (LCA) that rigorous measurement demands is largely inaccessible to ventures operating with small teams, limited data infrastructure, and constrained budgets. This gap is especially consequential in development finance contexts, where environmental data quality is a direct prerequisite for capital access, yet the conditions for full LCA implementation are least likely to exist.

This thesis designs and validates a set of life-cycle-informed environmental impact indicators that are credible, feasible, and legible to both environmental and financial audiences, specifically for early-stage sustainable fashion enterprises in Global South contexts. The study asks how indicators can be designed to credibly measure sustainability performance while remaining operationally feasible under real-world data and capacity constraints, and through what mechanism structured environmental data reduces information asymmetry and improves enterprise bankability.

A sequential four-stage methodology was employed: structured literature review and indicator longlisting, a modified Delphi validation with ten purposively selected experts across sustainability, impact investment, development finance, and enterprise founding, and embedded comparative case studies of two UNDP Youth4Climate-supported enterprises: Manifiesta (Colombia) and Inkaya - Community Studio (Zambia).

Three of five proposed indicators, namely Water Risk Tier, Renewable Energy Share, and Fabric Utilisation Rate, reached full expert consensus (mean Relevance and Feasibility ≥4.0), while Material Carbon Intensity and Chemistry Compliance Level were retained as aspirational indicators with clear upgrade pathways. The central empirical finding is that feasibility, not relevance, is the binding constraint; and that feasibility divides sharply along a supplier-dependency axis: indicators enterprises can measure themselves achieve consensus, while those requiring voluntary upstream disclosure do not. Both case enterprises demonstrate strong environmental practice with inadequate documentation, precisely the information asymmetry the framework targets.

The validated five-indicator framework, paired with a Bronze-Silver-Gold Data Quality Score mechanism, offers a transparent, actionable, and institutionally legible tool for early-stage founders, impact investors, and development programme monitors alike.

Keywords: Life Cycle Assessment; sustainable fashion; environmental indicators; early-stage enterprise or venture; information asymmetry; impact investing

Executive Summary

Problem

Early-stage sustainable fashion enterprises face a structural paradox at the intersection of environmental accountability and operational capacity. Partners, funders, and impact investors increasingly require credible evidence of environmental performance, yet the internationally recognized standard for environmental measurement, ISO-compliant Life Cycle Assessment (LCA), is largely inaccessible to ventures in their early years. The four-phase ISO LCA process demands specialized technical expertise, extensive primary supply chain data, and significant financial investment. For enterprises operating with small teams, informal supply chains, and constrained budgets, these requirements are structurally prohibitive.

This gap carries practical consequences. Without structured, verifiable environmental data, early-stage sustainable fashion enterprises cannot track performance credibly, substantiate sustainability claims in markets where greenwashing scrutiny is intensifying, or meet the evidence requirements of development finance instruments and impact investors. The European Banking Authority (2021) has formalized environmental risk assessment as part of credit underwriting, while the Global Impact Investing Network (GIIN, 2020) documents that 68% of impact investors use structured impact measurement frameworks to screen investments. The absence of environmental documentation is therefore not only an environmental management deficit, it functions as a direct financial inclusion barrier for early-stage founders.

This problem is particularly acute in the context of UNDP Youth4Climate, a programme supporting early-stage climate innovation across 59 countries through seed funding and capacity development. Two supported enterprises, Manifiesta in Colombia and Inkaya - Community Studio in Zambia, provide the empirical field context for this study. They both operates under real pressures to demonstrate environmental results credibly and feasibly, in contrasting production systems and data infrastructure contexts.

Aim and Research Questions

The study aims to design and validate a set of life-cycle-informed environmental impact indicators that are feasible for early-stage sustainable fashion enterprises operating under real-world data and capacity constraints. It further examines the mechanism through which structured environmental data improves enterprise bankability and access to impact capital.

The central research question asks: How can environmental impact indicators be designed to credibly measure sustainability performance of early-stage sustainable fashion enterprises while remaining feasible under data and capacity constraints? Four sub-questions address:

- Which environmental impact categories are most relevant when ISO-compliant LCA is not feasible;
- Which candidate indicators experts judge as both relevant and feasible;
- How the framework performs across two contrasting cases in terms of feasibility, credibility, and transferability;
- Through what mechanism structured environmental data reduces information asymmetry and improves bankability.

Theoretical Framework

Five interlocking theoretical perspectives form the analytical architecture. Life-cycle epistemology anchors the framework in ISO boundary logic without requiring full computational modelling. Sustainability indicator theory provides normative principles for translating life-cycle logic into accessible, purposive metrics. Double materiality guides indicator selection by prioritising environmental categories that are simultaneously significant as environmental hotspots and financially material as risk or opportunity drivers. Information asymmetry theory, drawing on Akerlof (1970) and Spence (1973), explains why structured, verifiable indicators function as credibility signals that reduce the verification gap between enterprises and investors. Replication logic (Yin, 2018) provides the methodological rationale for the two-case comparative design.

Research Design and Methods

The study follows a sequential four-stage design. First, a structured literature review across fashion LCA studies, SME sustainability indicator frameworks, and industry tools generated a long list of candidate indicators screened against four criteria: environmental relevance, financial materiality, feasibility, and boundary clarity. This produced five proposed core indicators: Material Carbon Intensity, Water Risk Tier, Chemistry Compliance Level, Renewable Energy Share, and Fabric Utilisation Rate.

Second, a modified Delphi validation engaged ten purposively selected experts across five complementary domains: sustainability practice and fashion supply chains, impact investment and venture capital, development finance, programme design and monitoring, and enterprise founding in Global South contexts. Participants scored each indicator on relevance and feasibility (1-5 scale) across two rounds, with qualitative consultation between rounds which enabled refinement of the definitions. The consensus threshold was set at a mean score of 4.0 on both dimensions.

Third, embedded comparative case studies applied the validated framework to Manifiesta (Colombia) and Inkaya - Community Studio (Zambia), selected as theoretically contrasting cases differing in production system, regulatory context, material base, and data infrastructure. Data was collected through semi-structured interviews with enterprise founders and review of organizational documentation, with each indicator assigned a Data Quality Score (Bronze: Estimated; Silver: Documented; Gold: Verified). Fourth, a cross-case synthesis and translation layer development mapped the validated indicators onto IRIS+, SDG targets, and UNDP reporting language.

Main Findings

The Delphi validation produced four principal findings:

- All five environmental impact categories, namely climate, water, chemical safety, resource efficiency, and manufacturing energy, were validated as relevant by the expert panel, confirming the double materiality selection approach. Mean Relevance scores ranged from 4.3 to 4.8 across both rounds.
- Feasibility, not relevance, is the binding constraint. Four of five indicators fell below the Round 1 feasibility threshold of 3.5. The primary barrier is not data complexity or enterprise size, it is supplier-dependency: indicators enterprises can measure themselves reached consensus, while those requiring voluntary upstream disclosure did not.
- Three indicators achieved full consensus in Round 2: Water Risk Tier (R=4.5, F=4.0), Renewable Energy Share (R=4.3, F=4.0), and Fabric Utilization Rate (R=4.8, F=4.2).

Two indicators, Material Carbon Intensity (F=3.9) and Chemistry Compliance Level (F=3.2), are retained as aspirational indicators with clear upgrade pathways.

- Fabric Utilization Rate achieved consensus without modification and is the framework's most robust anchor indicator, which uniquely combining environmental and financial performance rationale in a single, internally measurable metric.
- The Chemistry Compliance Level indicator revealed a certification bias against Global South artisanal producers: Inkaya's plant-based natural dye system, inherently low-risk, was misclassified as undocumented (Level 1) under European certification frameworks. A Level 2 expansion recognizing documented botanical dye processes corrects this systematically.

Both case enterprises demonstrate strong environmental practice, Manifiesta's near-circular deadstock model, Inkaya's off-grid solar commitment and natural dye system, with inadequate documentation. This documentation-practice gap is the information asymmetry problem the framework directly targets.

Conclusions and Recommendations

The validated five-indicator framework, paired with a Bronze-Silver-Gold Data Quality Score mechanism, is feasible at the Bronze tier for both case enterprises and offers clear, low-to-medium effort upgrade pathways for all indicators. The framework is positioned as decision-grade environmental data, appropriate for internal design decisions and programmatic monitoring, rather than label-grade data for legal sustainability claims.

Key recommendations by audience:

For enterprise founders:

- Start at Bronze and build progressively: measurement intent and trajectory matter as much as precision.
- Prioritize Fabric Utilization Rate first; it is the only indicator most enterprises can reach at Silver with minimal additional effort.
- Use Renewable Energy Share as the most immediately communicable environmental claim where applicable.

For impact investors and development finance institutions:

- Treat Bronze/Estimated data as a productive conversation starter, not a disqualifying condition.
- Use Data Quality Score progression across reporting periods as a maturation tracking tool.
- Weight documented off-grid solar adoption positively as both an environmental and operational resilience signal.

For UNDP Youth4Climate staff:

- Integrate the five-indicator framework as a programme-level environmental monitoring tool across the supported portfolio.
- Apply the expanded Chemistry Compliance Level definition to avoid misclassifying artisanal or botanical production practices as high-risk.
- Frame the framework as a practice improvement tool that walks alongside enterprises rather than evaluating them from the outside.

Four directions for future research are recommended:

- testing the framework across a larger and geographically diverse enterprise sample, particularly in South and Southeast Asia;

- longitudinal study of whether improved Data Quality Score tiers translate into measurable improvements in capital access;
- extension of the framework to incorporate social sustainability dimensions;
- and investigation of potential connections between the Data Quality Score mechanism and emerging environmental credit market infrastructure.

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Abbreviations

ADP	Abiotic Depletion Potential
DQS	Data Quality Score
ESG	Environmental, Social, Governance
GHG	Greenhouse Gas
GIIN	Global Impact Investing Network
GOTS	Global Organic Textile Standards
GWP	Global Warming Potential
IFC	International Finance Corporation
IMM	Impact Measurement and Management
IRIS+	Impact Reporting and Investment Standards
ISO	International Organization for Standardization
KPI	Key Performance Indicator
LCA	Life Cycle Assessment
LCI	life-cycle inventory
LCIA	life-cycle impact assessment
PISTA	Platform for Investment Support and Technical Assistance
PPA	Power Purchase Agreement
REACH	Registration, Evaluation, Authorization and Restriction of Chemicals
SES	Social and Environmental Standards
SME	Small, Medium Enterprise
TC	Thermal Coal
TCFD	Task Force on Climate-related Financial Disclosures
UN	United Nations
UNDP	United Nations Development Programme
UN SDGs	United Nations Sustainable Development Goals
VC	Venture Capital
WRI	World Resources Institute

1 Introduction

Environmental sustainability challenges increasingly require decision-makers in both public and private spheres to understand not only what environmental impacts occur, but where they occur across complex supply chains and how they can be reduced through well-targeted interventions. In many sectors, environmental burdens are distributed across multiple lifecycle stages, meaning that partial or facility-only assessments risk shifting impacts upstream or downstream rather than reducing them overall. These realities have contributed to the growing prominence of life cycle thinking in environmental management, including analytical methods such as Life Cycle Assessment (LCA), to systematically evaluate the environmental impacts along the entire lifecycle of goods or services (Hellweg & Canals, 2014).

Within this broader environmental context, the global fashion and textile system is widely recognised as one of the most environmentally intensive production sectors. Niinimäki et al. (2020) document that the fashion industry's value chain is responsible for approximately 4-5 billion tonnes of CO_2 equivalent annually, roughly 10% of global greenhouse gas emissions, while Sahimaa et al. (2023) estimate that the sector consumes approximately 79 trillion litres of freshwater, generates 92 million tonnes of textile waste, and uses over thousands chemicals across its value chain. These environmental pressures are compounded by the industry's structural characteristics: high material throughput, geographically dispersed production networks, fast product cycles, and purchasing dynamics that accelerate resource consumption and waste generation (Niinimäki et al., 2020; Fletcher, 2014).

At the same time, the fashion sector is also an arena of rapidly expanding innovation and experimentation. In response to growing environmental concerns, sustainable fashion initiatives have proliferated, including among youth-led and mission-driven enterprises that position themselves as alternatives to fast fashion by prioritizing strategies such as sustainable materials, circular practices, and reduced environmental footprints (D'Itria & Vacca, 2024). The rise of youth-led climate and environmental solutions is also reflected in global initiatives such as United Nations Development Programme (UNDP) Youth4Climate, which supports early-stage solutions through financial support and capacity development to foster more innovative and inclusive impact (UNDP, 2025). Through its annual Call for Solutions, the programme awarded a total of USD 4 million in direct seed funding to 150 youth-led projects across 59 countries, selecting initiatives based on innovative design, measurable community impact, and demonstrated capacity to scale (UNDP Rome Centre, 2025). Beyond funding, awardees receive tailored capacity building including one-on-one mentorship from a global network of mentors, masterclasses that provides foundational learning across topics of interest to all awardees, and access to a growing knowledge and engagement platform of more than 30,000 members. Through this initiative UNDP has created an ecosystem of financial, technical, and peer support that is particularly significant for early-stage ventures operating without established institutional infrastructure.

In this setting, the ability of early-stage sustainable fashion enterprises to measure and credibly communicate environmental performance has become increasingly important, and increasingly contested. Credible environmental measurement serves two distinct but interconnected purposes: internal decision support (identifying hotspots, comparing material options, prioritising interventions) and external accountability (meeting partner monitoring requirements, demonstrating progress to investors and supporters, and substantiating sustainability claims in markets where greenwashing scrutiny is intensifying) (Ahmed et al., 2025;

Textile Exchange, 2025). The integrity of such measurement is particularly critical in fashion, where the use and misuse of lifecycle and footprint data has attracted sustained public and regulatory attention, and where guidance from organisations such as the Textile Exchange (2025) emphasises careful interpretation, boundary transparency, and honest communication of scope limitations.

Despite this growing emphasis on credible environmental evidence, a persistent structural gap remains between what rigorous environmental measurement requires and what early-stage fashion ventures can realistically deliver. ISO 14040 and ISO 14044, the international standards governing LCA, prescribe a demanding four-phase process requiring specialised technical expertise, extensive primary inventory data across geographically dispersed supply chains, and significant time and financial investment (ISO, 2006a; ISO, 2006b). For enterprises operating in their early years, often with small teams, limited data infrastructure, and constrained budgets, these requirements are frequently prohibitive. Ahmed et al. (2025) confirm that these barriers are structural rather than incidental, systematically preventing LCA adoption across fashion SMEs even when environmental intent is strong.

This gap is particularly consequential in the context of international development and climate-innovation support programmes. UNDP's Youth4Climate supports youth solutions for environmental and climate challenges, explicitly combining financial support with capacity development, meaning that its monitoring approaches must simultaneously ensure environmental accountability and remain operationally feasible for young innovators working in diverse global contexts (UNDP Rome Centre, 2025). Two Youth4Climate-supported initiatives, Manifiesta in Colombia and Inkaya – Community Studio in Zambia, provide the practical field context for this study. These enterprises combine environmental aims with enterprise and community development objectives, face real pressures to demonstrate environmental results credibly and feasibly, and operate in contrasting production systems, regulatory environments, and data infrastructure contexts that allow the study to test the robustness and transferability of a simplified measurement framework.

1.1 Problem Definition

Environmental assessment tools that adhere to the full four-phase ISO LCA process are often challenging to implement for early-stage enterprises. ISO 14040 and ISO 14044 explicitly frame LCA as a structured process involving goal and scope definition, life-cycle inventory (LCI) analysis, life-cycle impact assessment (LCIA), and interpretation, accompanied by reporting and, where relevant, critical review (ISO, 2006a; ISO, 2006b). Klüppel (2005) notes that these requirements were specifically tightened during the revision process to enhance methodological credibility and comparability, a deliberate design choice that increases implementation demands as a consequence. The requirements help ensure rigour, but they also create substantial barriers for enterprises that lack the technical, human, and financial resources to comply with.

This creates a practical dilemma for early-stage sustainable fashion ventures: they may be expected by partners, funders, and ecosystem actors to demonstrate environmental performance, yet they frequently lack the capability to conduct ISO-compliant LCA across their supply chains. This dilemma is consistent with findings across the small, medium enterprise (SME) sustainability measurement literature. Feil et al. (2015) demonstrate that micro and small enterprises require explicitly 'right-sized' measurement frameworks, indicator sets that are limited in number, rely on accessible or proxy-based data, and support managerial decision-making rather than external compliance alone. Clarke-Sather et al. (2011) similarly find that SME-oriented sustainability frameworks must exhibit adaptability and contextual sensitivity, as technical capacity varies enormously across small enterprise settings.

The practical consequences of this measurement gap are significant. Without a credible, feasible indicator framework, early-stage sustainable fashion enterprises may struggle to: track internal environmental performance consistently across product lines and lifecycle stages; make evidence-based design decisions about material selection, chemistry, energy, and waste management; communicate results with sufficient credibility to meet the expectations of partner monitoring frameworks and impact investors; and avoid the reputational and legal risks associated with ambiguous or poorly supported environmental claims in an era of intensifying greenwashing scrutiny (Textile Exchange, 2025; Mezzanotte, 2023).

This challenge is compounded by developments in the finance and impact investment ecosystem. The European Banking Authority (2021) has formalised the expectation that lending institutions assess environmental risk profiles as part of credit underwriting, creating a direct pathway through which environmental data quality affects enterprise access to capital. The Global Impact Investing Network (GIIN, 2020) documents that 68% of surveyed impact investors use structured Impact Measurement and Management (IMM) frameworks specifically to navigate information asymmetry in sustainable investment screening. For early-stage fashion ventures, the absence of structured, verifiable environmental data is therefore not only an environmental management deficit but a financial inclusion barrier.

Three knowledge gaps are especially relevant:

First, while ISO LCA standards clearly define what constitutes rigorous life-cycle assessment, they do not directly specify how to develop minimum-viable indicator sets for contexts where ISO-compliant LCA is not feasible for enterprises with limited data infrastructure and technical capacity. This leaves a space for research on structured simplification that retains the boundary discipline and transparency of life-cycle thinking without requiring full procedural compliance with ISO 14040 and ISO 14044 (Laurin et al., 2016)

Second, while the fashion industry has developed simplified sustainability scoring tools drawing on LCA logic (e.g., the Higg Materials Sustainability Index), ongoing debate about their transparency, methodological integrity, and appropriate use underscores the need for frameworks that embed explicit integrity safeguards, data quality documentation, and scope clarity (Watson & Wiedemann, 2019).

Third, while SME sustainability indicator literature demonstrates approaches for selecting feasible indicator sets (including Delphi validation), there is limited work that (a) integrates ISO-disciplined life-cycle logic, (b) is tailored to early-stage sustainable fashion enterprises in diverse Global South contexts, and (c) explicitly tests real-world feasibility through embedded comparative case studies designed with replication logic (Feil et al., 2015; Ahmed et al., 2025) The measurement gap addressed in this study is not unique to Global South contexts, early-stage enterprises face similar LCA accessibility barriers regardless of geography. However, the conditions under which a simplified framework must remain feasible, including limited supply chain documentation, lower availability of third-party certifications along regional value chains, and the specific accountability requirements of development finance instruments such as UNDP Youth4Climate, tend to be more pronounced in the enterprise settings examined here. The framework's underlying logic is therefore intended to be broadly transferable, but its design and validation are anchored in the operational realities of two Global South enterprises supported by UNDP Youth4Climate.

1.2 Aim and Research Questions

1.2.1 Research Aim

The aim of this study is to design and validate a set of life-cycle-informed environmental impact indicators that are feasible for early-stage sustainable fashion enterprises operating under real-world data and capacity constraints. The study further develops practical implementation guidance specifying how each indicator is measured, what data sources are required, and how data quality is documented and communicated. The applicability of the resulting indicator set is assessed across two contrasting operational contexts through embedded comparative case studies of Youth4Climate-supported enterprises, and the mechanism through which structured environmental data improves enterprise bankability and access to impact capital is examined

1.2.2 Research Questions

How can environmental impact indicators be designed to credibly measure the sustainability performance of early-stage sustainable fashion enterprises while remaining feasible under data and capacity constraints?

Sub-questions:

1. Which environmental impact categories and indicator types are most relevant for early-stage sustainable fashion enterprises when ISO-compliant LCA is not feasible due to data and resource constraints?
2. Which candidate indicators are judged by experts to be both relevant (environmentally meaningful, decision-useful) and feasible (implementable with realistic data and effort) for early-stage ventures?
3. How does the resulting indicator framework perform in practice across two contrasting cases (Manifiesta; Inkaya – Community Studio), in terms of feasibility, credibility, and transferability?
4. Through what mechanism does structured, simplified environmental data reduce information asymmetry and improve the bankability of early-stage fashion ventures in impact investing and development finance contexts?

1.3 Scope and Delimitations

This study is environment-focused. It develops environmental indicators grounded in life-cycle thinking but does not conduct ISO-compliant LCA, which requires formal inventory analysis, impact characterisation modelling, and the full four-phase process prescribed by ISO 14040 and ISO 14044. The framework is intentionally "LCA-lite", which preserves the intellectual discipline and boundary logic of life-cycle epistemology while reducing data and technical requirements to levels achievable by early-stage enterprises.

The system boundary for most indicators follows a cradle-to-gate perspective, covering raw material extraction, fibre and fabric processing, manufacturing, and upstream logistics to the point of finished product. Inclusion of use-phase or end-of-life stages is considered only where case evidence clearly supports their significance and where indicators can be credibly operationalised without speculative consumer behaviour assumptions. This boundary choice is empirically justified by the finding that upstream material and production stages account for the dominant share of lifecycle environmental burdens in apparel systems (Niinimäki et al., 2020; Watson & Wiedemann, 2019).

Moreover, social, peacebuilding, and cultural co-benefits associated with Manifiesta and Inkaya are treated as contextual characteristics rather than formally measured outcomes, in order to maintain the transferability of the environmental indicator framework. The study does not attempt to operationalise social LCA or integrated sustainability assessment across all dimensions of the SDGs.

The research focuses specifically on early-stage sustainable fashion enterprises, which is defined here as mission-driven organisations combining commercial activity with explicit environmental objectives, operating for fewer than five years with limited data infrastructure and technical capacity. The term “venture” appears in investor-facing and bankability contexts, where it reflects standard usage in impact finance literature. The framework is validated against two enterprises operating in Global South contexts. As noted in the Problem Definition, the core measurement gap addressed here is not unique to the Global South; early-stage enterprises face similar LCA accessibility barriers regardless of geography. The focus on Global South settings reflects the practical context of this study: both case enterprises are supported by UNDP Youth4Climate, which operates specifically in these contexts, and the framework is calibrated against the data realities, supply chain conditions, and development finance accountability requirements characteristic of those settings. While the framework is designed for broader transferability, claims of universal applicability are not made, and its validation is anchored in two specific cases. The framework is positioned as “decision-grade” environmental data, appropriate for internal design decisions and programmatic monitoring, rather than “label-grade” data suitable for legal sustainability claims on product labelling without additional verification.

Finally, the measurement gap addressed in this study, the inaccessibility of full ISO LCA for early-stage enterprises, is not unique to Global South contexts. However, the conditions under which a simplified framework must remain feasible including limited supply chain documentation, lower availability of third-party certifications along regional value chains, and the specific accountability requirements of development finance instruments such as UNDP Youth4Climate, tend to be more pronounced in the enterprise contexts examined here. The framework's underlying logic is transferable beyond these contexts, but its validation is anchored in the operational realities of two Global South enterprises.

1.4 Ethical Considerations

This research involves human participants in individual structured consultations conducted through interviews. Participation is voluntary and based on informed consent. Prior to each consultation, participants are provided with a clear briefing covering the study's purpose, how collected data will be used, confidentiality arrangements, and their right to withdraw at any time without consequence. All participant contributions are anonymised in reporting, with direct quotes attributed only to role descriptions (e.g., “Venture Capital Investor, Round 1”) unless participants explicitly consent to attribution by name. For live interviews, audio recording is used only where participants provide explicit consent; where consent is not given, data is captured through researcher notes alone.

Inkaya – Community Studio's activities are rooted in indigenous knowledge systems, particularly those of the BaTonga people of Zambia. This study does not document, extract, evaluate, or appropriate indigenous knowledge itself. The research acknowledges indigenous knowledge as part of the enterprise's operational context, as reported in publicly available UNDP documentation (UNDP Rome Centre, 2025), and focuses solely on environmental indicators related to production processes and resource use. The study avoids any framing that would instrumentalise, commodify, or reduce the BaTonga community's cultural practices to environmental metrics.

Data collected from the case enterprises regarding production processes, material inputs, and resource use is treated as commercially sensitive. Such data is used exclusively for the purposes of this study and is not shared with third parties without explicit enterprise consent. The study does not make comparative performance judgments that could harm the enterprises' commercial or reputational interests.

The researcher acknowledges potential positionality tensions as an external academic observer studying enterprise contexts in the Global South from a Northern institutional affiliation. Efforts to mitigate this positionality include involving enterprise founders as active co-validators in the Delphi process; framing findings in terms of framework design rather than enterprise performance evaluation; and prioritising the practical utility of findings for the enterprises themselves alongside academic contribution.

1.5 Audience

This thesis is directed at four principal audiences, each of whom may engage with its findings differently. Early-stage sustainable fashion enterprise founders are the primary intended beneficiaries of the indicator framework itself: the practical outputs of this study, which is the validated indicator set, the Data Quality Score (DQS) mechanism, and the implementation guidance, are designed to be directly usable by founders without LCA expertise. Impact investors, development finance institutions, and procurement professionals working in sustainable fashion constitute the secondary audience: the bankability analysis and information asymmetry framing provide these actors with a theoretical and empirical basis for integrating simplified environmental indicators into portfolio screening and monitoring processes. UNDP Youth4Climate programme staff and monitoring specialists represent a third audience for whom the indicator framework offers a feasible, credible mechanism for programme-level environmental accountability. Finally, academic researchers working in simplified LCA methodology, SME sustainability measurement, and sustainable fashion governance will find in this study a validated methodological contribution and a set of conceptual tools for further development.

1.6 Disposition (outline)

This thesis is structured across six substantive chapters.

- Chapter 1 (this chapter) establishes the research problem, aim, and questions, and defines the scope, ethical considerations, and intended audience.

- Chapter 2 presents the Literature Review, organised around four analytical pillars: the methodological gap between full and simplified LCA; environmental hotspots and indicator longlisting in the fashion sector; the relationship between environmental data and enterprise bankability; and methodological precedents for Delphi validation and replication-logic case design.
- Chapter 3 articulates the Theoretical Framework, integrating five interlocking theoretical perspectives, life-cycle epistemology, sustainability indicator theory, double materiality, information asymmetry theory, and replication logic, into a unified analytical architecture.
- Chapter 4 presents the Research Design and Methods, detailing the sequential design, data requirements, Delphi process, and case study application.
- Chapter 5 (Findings and Analysis) will present the results of the Delphi validation and case study implementation.
- Chapter 6 (Discussion) will interpret findings against the theoretical framework and prior literature
- Chapter 7 (Conclusions) will present empirical, methodological, and practical conclusions, recommendations for each audience, and directions for future research.
- Supporting methodological materials are provided in the Annex.

2 Literature Review

This chapter provides a systematic review of four interrelated bodies of scholarship that together underpin the conceptual and empirical design of the simplified environmental indicator framework.

2.1 Pillar I: The Methodological Gap (From ISO-Compliant LCA to Indicator-Based Assessment)

2.1.1 Architecture and Requirements of ISO LCA

Life Cycle Assessment is internationally codified through ISO 14040 (2006) and ISO 14044 (2006), which define the principles, framework, requirements, and guidelines for a rigorous product system assessment. The ISO framework prescribes four iterative and interdependent phases: (1) goal and scope definition, establishing purpose, functional unit, system boundary, and intended audience; (2) life cycle inventory (LCI) analysis, quantifying material and energy inputs and emissions across all lifecycle stages; (3) life cycle impact assessment (LCIA), translating inventory flows into environmental impact categories such as global warming potential, water scarcity, and eutrophication; and (4) interpretation, synthesising results, identifying hotspots, and evaluating completeness and consistency (ISO, 2006a; ISO, 2006b). Importantly, ISO LCA does not prescribe a minimum number of impact categories. A study covering a single impact category such as GWP can be fully ISO-compliant provided the four phases are rigorously executed. The barriers for early-stage enterprises therefore lie not in the scope of impact categories assessed but in the data intensity of the inventory phase, the technical requirements of impact characterisation, and the resource demands of formal compliance. Klüppel (2005) notes that these requirements were deliberately tightened during the ISO 14040 revision process to enhance methodological transparency and international comparability. The result is a robust but demanding analytical protocol that Hellweg and Canals (2014) describe as representing "the most comprehensive method available for environmental assessment" of a product system.

2.1.2 Barriers for SMEs and Early-Stage Ventures

Despite its methodological rigour, ISO-compliant LCA, which requires formal inventory analysis, impact characterisation, and systematic data collection across supply chains, presents significant implementation barriers for small enterprises. Ahmed et al. (2025) identify three structural obstacles encountered by fashion-sector SMEs: (1) the requirement for specialised technical expertise in impact characterisation and modelling; (2) the need for extensive, high-quality primary inventory data across geographically dispersed supply chains; and (3) substantial time and financial costs. These barriers are systemic. Feil et al. (2015) demonstrate in the context of micro and small furniture manufacturers that enterprise sustainability measurement systems must be "right-sized" because resource constraints and data limitations will otherwise prevent adoption entirely. Clarke-Sather et al. (2011) reach a parallel conclusion, arguing that frameworks must exhibit adaptability and contextual sensitivity, as technical capacity varies enormously across small enterprise settings.

For early-stage fashion ventures, the paradox is particularly acute: they may lack the primary data on which ISO-compliant LCA relies, meaning that a nominally rigorous assessment may in practice produce results with large unquantified uncertainties, potentially less reliable than a well-designed indicator-based approach using established secondary emission factors. Laurin et al. (2016) observe that LCA's practical utility depends critically on the availability of relevant, context-specific data, and that when primary data is absent, rigorous methodology does not guarantee reliable results.

2.1.3 Screening LCA and Simplified Approaches

A substantial body of methodology literature has developed around "screening LCA" and "simplified LCA" approaches that apply life-cycle logic within reduced scope and with reduced data demands. Finnveden et al. (2009) document the evolution of these approaches, noting that streamlining methods have become increasingly prevalent as practitioners seek to balance methodological integrity with operational feasibility. Hauschild et al. (2018) distinguish between screening LCA (a qualitative or semi-quantitative exercise designed to identify dominant impact categories before investing in full assessment) and simplified LCA (a quantitative assessment that deliberately limits scope to hotspot categories using generic or secondary inventory data). Both are consistent with ISO provisions for iterative, goal-appropriate assessment when the goal and scope are clearly stated.

The decision-value of simplified approaches depends fundamentally on understanding where the majority of environmental impact is concentrated. Rebitzer et al. (2004) demonstrate through meta-analysis of apparel LCAs that material production, textile processing, and finishing stages consistently account for the dominant share of lifecycle burdens across multiple impact categories. This finding means that a simplified assessment focused on upstream material and production stages (cradle-to-gate boundary) can capture the majority of environmentally significant decisions while remaining feasible for enterprises without specialised LCA capacity.

2.1.4 Design-Phase Lock-In

A particularly compelling rationale for early-stage environmental measurement emerges from the eco-design literature's concept of "design-phase lock-in." Finkbeiner (2014) notes that LCA studies across multiple product categories consistently find that upstream material and design decisions determine the trajectory of a product's total environmental footprint before manufacturing begins. In fashion, Niinimäki et al. (2020) confirm that fibre type, fabric weight, dyeing chemistry, and processing technology, all decisions made during design and sourcing, collectively lock in the majority of a garment's lifecycle impact. Fletcher (2014) similarly argues that sustainable fashion transformation depends on shifting environmental intelligence to the earliest stages of the design process.

This evidence supports a normative conclusion central to this study: for an early-stage fashion venture, the goal of environmental measurement is not retrospective accounting but prospective decision support. Approximate environmental data at the design and sourcing phase has high decision value, enabling a founder to choose between Fabric A and Fabric B before production commitments are made. even when it does not meet the precision standards required for lifecycle-graded public claims. This distinction between "decision-grade" and "label-grade" data frames the design requirements for the indicator framework.

2.2 Pillar II: Environmental Hotspots and Indicator Longlisting

2.2.1 Fashion Industry as an Environmentally Intensive System

The global fashion and textile system is characterised by high material throughput, geographically dispersed supply chains, and purchasing dynamics that accelerate resource consumption and waste (Niinimäki et al., 2020). Sahimaa et al. (2023) synthesise sector-level evidence estimating that the industry generates approximately 4-5 billion tonnes of CO_2 annually, consumes approximately 79 trillion litres of freshwater, produces 92 million tonnes of textile waste, and uses over 15,000 chemicals, of which approximately 10% carry high health risks. These impacts are not uniformly distributed across the lifecycle but are concentrated in upstream stages, fibre production, yarn spinning, dyeing, and finishing, which collectively account for the majority of environmental burdens (Niinimäki et al., 2020; Fletcher, 2014). This upstream concentration provides the empirical basis for the cradle-to-gate boundary adopted in this study.

2.2.2 Global Warming Potential

GWP, expressed as kilograms of CO_2 equivalent, is the most consistently tracked environmental indicator in fashion LCA literature and the primary bridging metric between environmental performance and financial risk frameworks such as the Task Force on Climate-related Financial Disclosures (TCFD, 2017). Watson and Wiedemann (2019) review GWP intensities across major fibre types, documenting that conventional cotton production generates approximately 1.8-5.9 kg CO_2e per kilogram of fibre, while organic cotton produces 0.9-2.0 kg CO_2e/kg. Virgin polyester generates approximately 5.5-6.0 kg CO_2e/kg, whereas recycled polyester achieves a 30-70% reduction relative to virgin production depending on production method. These differential benchmarks provide the empirical foundation for a "Material Multiplier" indicator, comparing a venture's material choice against an established industry baseline, which is more accessible to non-specialist founders and more directly decision-relevant than raw GWP figures.

2.2.3 Water Scarcity

Water indicators in fashion LCA must distinguish between volumetric consumption (total litres withdrawn) and scarcity-weighted consumption (litres weighted by basin-level water stress), as the same volume of water carries substantially different ecological significance depending on its geographic source (Hellweg & Canals, 2014). Cotton cultivation in water-stressed regions such as Central Asia, Pakistan, and parts of India generates scarcity-weighted water consumption orders of magnitude higher than cotton grown in water-abundant regions, creating supply chain risk that is both environmentally and financially material (Niinimäki et al., 2020; TCFD, 2017). For early-stage enterprises that cannot conduct primary water accounting, proxy indicators based on fibre origin and published water intensity benchmarks offer a feasible first-order approximation.

2.2.4 Eutrophication and Abiotic Depletion

Eutrophication potential captures the contribution of nitrogen and phosphorus emissions to aquatic and terrestrial ecosystem degradation, arising primarily from agricultural fertiliser runoff in natural fibre cultivation, dyehouse effluent, and wastewater from wet processing operations (Gonçalves & Silva, 2021). Gonçalves and Silva (2021) identify eutrophication as one of the most methodologically contested categories in apparel LCA due to high variability in effluent treatment assumptions across production geographies. Abiotic depletion potential (ADP) is most significant for synthetic fibre production and energy-intensive wet processing; for early-stage enterprises, renewable energy share at the assembly stage serves as a practical proxy for the fossil resource intensity of manufacturing.

2.2.5 Chemical Pollution and Certification-Based Proxies

The fashion sector's use of over 15,000 chemicals creates significant ecotoxicity and human health risks that full LCA frameworks measure through characterisation factors requiring detailed chemical speciation and receiving environment data (Sahimaa et al., 2023). These requirements are entirely infeasible for early-stage enterprises. Watson and Wiedemann (2019) identify chemical management as a priority area for simplified proxy indicators, noting that third-party certification systems such as OEKO-TEX® STANDARD 100 and Bluesign® independently verify chemical compliance against established restricted substance lists and production standards, providing a documented, credible signal of chemical management quality without laboratory-grade measurement.

Feil et al. (2015) demonstrate that proxy-based indicators can be simultaneously valid and feasible, provided their proxy nature is explicitly disclosed and the underlying correlation is empirically grounded. Certification-based proxies for chemical management represent a well-developed application of this principle. Registration, Evaluation, Authorization and Restriction of Chemicals (REACH) compliance establishes a minimum legal threshold; Bluesign® certification verifies comprehensive production facility standards; OEKO-TEX® STANDARD 100 certifies finished product safety. Together these create a graduated scale from regulatory compliance to comprehensive certification that this study operationalises as a tiered "Chemistry Compliance Level" indicator.

2.2.6 Functional Units and System Boundaries in Fashion LCA

The choice of functional unit profoundly affects both impact magnitude and interpretability of results (Hauschild et al., 2018). Watson and Wiedemann (2019) review three primary functional units in apparel LCA: impact per kilogram of fibre (most common in materials databases; limited intuitive meaning for enterprise decision-making); impact per garment (aligned with the product unit most meaningful to designers and investors); and impact per wear (most comprehensive but most assumption-dependent). For early-stage enterprises, impact per garment provides the most accessible and feasible functional unit for internal decision-making.

The cradle-to-gate boundary choice in this study is grounded in two considerations: first, upstream stages dominate total lifecycle impact for most apparel categories (Niinimäki et al., 2020; Watson & Wiedemann, 2019); and second, use-phase and end-of-life impacts are substantially determined by consumer behaviour outside the enterprise's direct control, involving assumptions that are inherently speculative for ventures without consumer data (Hellweg & Canals, 2014). Limiting scope to cradle-to-gate concentrates measurement on the portion of the value chain where physical data, fabric weights, processing records, supplier certifications, actually exists.

2.3 Pillar III: Environmental Data, Bankability, and the Investment Nexus

2.3.1 ESG Data Maturity and Access to Capital

The relationship between environmental data quality and access to capital has evolved from theoretical proposition to documented market mechanism. The European Banking Authority (2021) formalised the expectation that lending institutions systematically assess borrowers' environmental risk profiles as part of standard credit underwriting, creating a regulatory mechanism through which environmental data quality directly affects credit conditions. The present study provides empirical evidence that higher ESG disclosure completeness, particularly climate-change, energy-efficiency, emissions and anti-corruption information, is positively associated with greater access to conventional credit, as reflected in increases in leverage, long-term debt and short-term debt for European listed firms (Gallucci et al., 2025). This relationship is more pronounced for SMEs, where information asymmetries between firms and financial intermediaries are inherently greater than for large corporations that typically have dedicated sustainability reporting systems.

For early-stage fashion ventures, the absence of structured environmental performance data creates a credibility gap functioning as a barrier to impact-oriented capital. D'Itria and Vacca (2024) document the growing prominence of impact measurement as a prerequisite for engagement with sustainability-oriented investors and procurement partners in the fashion sector. The indicator framework proposed in this study is therefore positioned not only as an environmental management tool but as a financial inclusion mechanism for young founders who lack resources to commission full LCA reports but can demonstrate environmental intentionality through accessible, documented metrics.

2.3.2 Transition Finance and Verified Impact Data

The emergence of transition finance, instruments offering preferential pricing or terms to enterprises demonstrating credible environmental improvement trajectories, has created direct financial incentives for investment in environmental data quality. The International Finance Corporation (2012) Performance Standards require clients accessing IFC financing to implement environmental and social management systems capable of generating verifiable performance data, establishing a precedent for verified environmental data as a condition of development finance access. The Climate Bonds Initiative has similarly developed sector-specific certification criteria requiring documented environmental performance benchmarks as a condition for climate bond issuance.

A critical principle across transition finance frameworks is the distinction between 'stated' and 'verified' environmental impact: institutions providing transition finance systematically discount self-reported environmental claims lacking documentary evidence of data provenance. This market dynamic directly motivates the ESG(DQS) mechanism in this study. This differentiates “Estimated” (industry average factors), “Documented” (supplier specifications or transaction certificates), and “Verified” (third-party LCA reports or certified supply chain data), which makes the origin of the data transparent and auditable in a way that financial intermediaries can easily understand and assess.

2.3.3 Climate Risk as a Proxy for Financial Resilience

The TCFD (2017) framework has established supply chain climate risk as a material financial risk category for fashion enterprises, distinguishing physical risks (water stress, extreme weather affecting agricultural supply chains) from transition risks (carbon pricing, regulatory tightening, consumer preference shifts). For brands with concentrated sourcing from climate-vulnerable regions, both risk categories are material. Watson and Wiedemann (2019) note that fashion supply chains relying on water-intensive conventional cotton in water-stressed geographies face compounding physical and regulatory risks translating into input cost volatility and potential supply disruption.

Simplified environmental indicators capturing material choice, chemical management, and production energy source therefore serve a dual purpose in impact investing contexts: they communicate environmental performance to sustainability-oriented stakeholders and simultaneously signal the enterprise's exposure to climate-related financial risks. An enterprise documenting its transition toward certified materials, renewable energy in manufacturing, and reduced chemical hazard exposure demonstrates not only environmental intentionality but also supply chain risk management — a dimension of operational resilience that impact investors increasingly integrate into portfolio risk assessment (GIIN, 2020).

2.3.4 Operational Co-Benefits and Waste Efficiency

Evidence from De-La-Flor et al. (2024) suggests that waste-reduction metrics are quickly embraced by small- and medium-sized enterprises because they map directly onto cost-management incentives: cutting fabric waste lowers material expenses while simultaneously easing environmental pressure. In the case-study textile dyeing plant, the Lean-Green intervention achieved an 18 % drop in water use and a 43 % cut in electricity consumption, delivering a monthly saving of S/ 2 350 (≈ US $647). This is a clear illustration of how resource-waste reductions translate into tangible cost benefits. The Fabric Utilisation Rate (finished-garment weight ÷ purchased-fabric weight) captures this dual payoff in a single, easily calculated figure, which mirrors the study's use of per-kilogram water and energy metrics to benchmark performance. This convergence of environmental and financial incentives makes waste efficiency particularly valuable as a foundation indicator for ventures where the business case for environmental measurement must be demonstrated through operational efficiency as well as regulatory compliance or premium pricing.

2.3.5 Information Asymmetry and Credibility Signalling

Akerlof's (1970) theory of information asymmetry demonstrates that markets systematically undervalue quality goods when buyers cannot verify quality claims, potentially causing market failure through adverse selection. In sustainable fashion markets, buyers of environmental claims, investors, procurement professionals, retail partners, face a fundamental verification problem: they cannot directly observe production processes, material origins, or chemical management practices, and must rely on producer representations. When verification is costly, firms can selectively disclose or misreport Environmental, Social, Governance (ESG) performance, distorting investment decisions and advantaging those making unverifiable claims over genuinely sustainable enterprises (Wang and Nishihara 2025).

Simplified, verifiable environmental indicators function as credibility signals reducing this asymmetry by providing observable, documentable proxies for underlying environmental performance. The GIIN (2020) Annual Impact Investor Survey documents that 68% of surveyed impact investors use structured Impact Measurement and Management (IMM) frameworks specifically to reduce information asymmetry in deal screening. This is consistent with Stachelscheid & Dutzi's (2025) research which highlights that structured and standardized environmental data, particularly when translated into investor-oriented indicators, enhances the comparability and evaluation of corporate environmental performance, thereby supporting more informed decision-making.

Spence's (1973) shows that a signal reduces information asymmetry only when it is an observable, agent-chosen attribute and its acquisition cost is lower for high-quality types than for low-quality types, which makes the signal harder for low-quality providers to fake, and when employers' beliefs about the signal-quality link are verified by observed outcomes. In this study, I extend this logic by treating 'credibility' as requiring that signals be grounded in verifiable evidence; the Data Quality Score mechanism addresses this by making evidential provenance explicit.

2.3.6 Double Materiality as a Selection Lens

Double materiality, which requires assessment of both outward impacts on the environment (impact materiality) and inward financial implications of sustainability risks and opportunities (financial materiality), provides a principled framework for prioritising environmental indicators (Mezzanotte, 2023). Embedded in the European Union's Corporate Sustainability Reporting Directive and operationalised through the European Sustainability Reporting Standards, double materiality requires enterprises to identify and disclose sustainability impacts significant both environmentally and financially. For an early-stage fashion venture, the highest-priority indicators are those simultaneously capturing significant environmental hotspots and exposing the enterprise to financially material risks: GWP from material choice sits at the intersection of environmental significance and transition risk; water scarcity is both an environmental hotspot and a physical climate risk with direct input cost implications; chemical management quality is both an environmental priority and a regulatory compliance risk affecting market access. This double materiality framing directly informed the indicator selection logic applied in Delphi validation.

2.4 Pillar IV: Methodological Precedents

2.4.1 Modified Delphi Method for Indicator Validation

The Delphi method is a structured, iterative expert elicitation technique designed to achieve informed consensus on complex questions involving normative judgment and uncertainty. Originally developed for technological forecasting, it has been extensively applied in sustainability research as a mechanism for validating indicator sets where value judgments about relevance, feasibility, and boundary conditions are inherent (Hasson et al., 2000). Hasson et al. (2000) identify the Delphi method's particular suitability for contexts in which a definitive empirical answer is unavailable and where the opinions of expert panels with complementary knowledge bases are required for informed consensus.

Feil et al. (2015) provide a directly relevant precedent: their development of an indicator set for micro and small furniture enterprises employs a modified Delphi with structured scoring rounds to iteratively narrow a long list to a validated short list based on expert judgments of relevance and feasibility. Their modification, replacing anonymous postal rounds with structured facilitated sessions among practitioners with direct SME experience, is particularly applicable when participant time is limited and the objective is convergence on implementable indicators rather than individual opinion generation. In this study, structured expert consultation with sustainability practitioners, UNDP Youth4Climate staff, and enterprise founders serve as the primary validation mechanism, aligning expert validation with operational feasibility assessment and monitoring accountability requirements.

2.4.2 Replication Logic in Multiple-Case Design

Yin (2018) provides the authoritative foundation for multiple-case study designs using replication logic rather than sampling logic. Cases are not chosen to represent a population but to test boundary conditions of a theoretical proposition under varied circumstances. Yin (2018) distinguishes literal replication (cases expected to produce similar results, confirming generality) from theoretical replication (cases expected to produce contrasting results for identifiable theoretical reasons, refining boundary conditions). This study employs theoretical replication through the selection of Manifiesta (Colombia) and Inkaya - Community Studio (Zambia): cases contrasting in production system, material base, regulatory context, and data infrastructure. The cross-case synthesis tests not whether the framework works in all contexts, but under what conditions it is more or less feasible and what adaptations are required, precisely the analytical output that replication logic is designed to generate.

2.4.3 Data Quality Scoring as an Integrity Safeguard

The Textile Exchange (2025) directly addresses greenwashing risk in its guidance on ensuring integrity in the use of LCA data, noting that the absence of explicit data quality documentation is a key weakness in existing fashion sustainability scoring tools. Watson and Wiedemann (2019) identify opacity in data quality as undermining comparability, limiting verification, and creating legal risks for enterprises and tools alike. ISO 14044 (2006) includes provisions for data quality characterisation; Weidema and Wesnaes (1996) operationalise these into a practical data quality indicator framework assigning ratings based on temporal, geographical, technical, completeness, and reliability dimensions. The Data Quality Score mechanism in this study draws on these precedents to operationalise quality transparency in a form accessible to early-stage enterprises, distinguishing 'Estimated' (industry average factors), 'Documented' (supplier specifications or transaction records), and 'Verified' (third-party certificates or accredited reports) tiers.

2.4.4 Synthesis: Knowledge Gaps and Research Positioning

The preceding four-pillar review reveals a coherent pattern of interconnected knowledge gaps. ISO-compliant LCA is structurally inaccessible for early-stage fashion enterprises. Simplified LCA frameworks offer a pragmatic path forward but have not been systematically developed, validated, and tested for youth-led fashion ventures operating in diverse Global South contexts under dual accountability to environmental and financial audiences. The fashion sector's environmental hotspots are comprehensively documented but have not been assembled into a validated, feasible indicator framework with explicit data quality differentiation and direct translation into forms legible to impact investors and development programme monitors. The relationship between structured environmental data and financial access is increasingly empirically demonstrated, but the specific mechanisms through which simplified proxy-based indicators function as credibility signals for early-stage ventures remain underexplored.

The Delphi method and theoretical replication case design provide validated methodological precedents. However, their combination with ISO-disciplined life cycle thinking in the specific context of youth-led Global South fashion enterprises, with explicit attention to dual environmental and financial audiences, represents a methodological and empirical contribution not previously synthesised in the literature. These gaps collectively define the research space this study occupies.

3 Theoretical Frameworks

This chapter articulates five theoretical perspectives that together inform the design, validation, and interpretation of the environmental indicator framework. Rather than isolated lenses, these perspectives form a mutually reinforcing analytical architecture, each addressing a different dimension of the core challenge: how to design environmental impact measurement that is simultaneously credible, feasible, decision-useful, and legible to financial and programmatic audiences. The chapter concludes with an integrated conceptual model mapping relationships among the components.

3.1 Life-Cycle Epistemology: ISO-Anchored Thinking Without Full Modelling

Life-cycle epistemology, as operationalised in this study, does not require the full computational modelling prescribed by ISO 14044. It requires a principled commitment to accounting for environmental burdens across the relevant stages of a product's value chain rather than gate-to-gate facility performance alone. Finkbeiner (2014) describes the ISO LCA standards as "the constitution of life cycle assessment", not a prescriptive algorithm but a set of principles for disciplined, transparent, and reproducible environmental reasoning. These principles include explicit definition of system boundaries and functional units; transparent treatment of data quality and uncertainty; consistency in allocation and boundary choices; and honest communication of scope limitations.

Adopting life-cycle epistemology means that even where full LCIA modelling is not performed, the indicator framework is designed to reflect the life-cycle structure of environmental burdens, distinguishing upstream material impacts from processing and manufacturing impacts, and to prevent the boundary truncation errors that characterise gate-to-gate assessments (Hellweg & Canals, 2014). This epistemological commitment distinguishes an "LCA-lite" framework from an ad hoc collection of arbitrary metrics: it is grounded in the same intellectual architecture as full LCA while being appropriately simplified for the operational context of early-stage enterprises. Rebitzer et al. (2004) confirm that this approach preserves decision-relevant information provided system boundaries are explicitly stated and scope limitations are honestly communicated.

3.2 Sustainability Indicator Theory and the Politics of Simplification

Sustainability indicator theory provides the conceptual foundation for understanding indicators as purpose-driven simplifications of complex environmental systems rather than exhaustive measurements of reality. Olsthoorn et al. (2001, p. 454) define environmental indicators as 'parameters, or a value derived from parameters, which point to, provide information about, describe the state of a phenomenon/environment/area.' Critically, this definition foregrounds the selective and constructed nature of indicators: they are not discovered but designed, and their design reflects normative judgments about which aspects of environmental performance are most relevant to the decision context.

Azapagic (2004) and Veleva and Ellenbecker (2001) both emphasise that sustainability indicators must balance scientific rigour with operational feasibility, a tension particularly acute for early-stage enterprises. Decisions about which impact categories to include, which proxy metrics to accept as valid surrogates, and what data quality thresholds to require all reflect judgments about whose environmental concerns matter, what degree of precision is necessary for credible communication, and what operational burden is reasonable for enterprises at different development stages. This study explicitly acknowledges the constructedness of its indicator framework: the indicators selected are argued to be relevant to the most significant environmental hotspots, feasible under realistic early-stage data constraints, transparent in their proxy status, and sufficiently robust to support directional decision-making. The Modified Delphi validation process is the primary mechanism through which normative judgments embedded in indicator selection are subjected to structured expert scrutiny.

3.3 Double Materiality and Decision Usefulness

The double materiality framework requires organisations to assess both their outward impacts on environmental and social systems (impact materiality) and the inward financial implications of sustainability risks and opportunities (financial materiality) (Mezzanotte, 2023). As operationalised in this study, double materiality functions as an indicator selection filter. Candidate indicators are retained if they capture environmental phenomena that are significant on both dimensions: environmentally meaningful (addressing a documented hotspot in the fashion value chain) and financially material (reflecting a risk or opportunity relevant to enterprise performance, access to capital, or regulatory exposure).

Double materiality is analytically powerful in this context because it explicitly connects environmental measurement to financial access, the bankability dimension that differentiates this framework from purely academic environmental assessment tools. GWP from material choice is doubly material: it represents a significant environmental hotspot and exposes the enterprise to financially significant transition risks (carbon pricing trajectories and low-carbon procurement requirements). Water scarcity indicators are doubly material for similar reasons. Chemical management quality is doubly material as both an environmental priority and a regulatory compliance risk affecting market access. This dual-purpose framing justifies investment in simplified environmental measurement for founders who must prioritise resource allocation across multiple competing demands.

3.4 Information Asymmetry and Credibility Signalling

Akerlof's (1970) theory of information asymmetry, developed through the principal-agent and market signalling literatures, provides the microeconomic foundation for understanding why structured environmental indicators function as value-generating instruments in impact markets. When buyers (investors, procurement professionals, programme monitors) cannot directly verify sellers' environmental performance claims, adverse selection risk arises: capital, contracts, or programme support may be awarded to enterprises making superior claims rather than those with superior environmental performance. This creates perverse incentives against genuine environmental performance improvement and in favour of sophisticated environmental communication.

Simplified, documentable environmental indicators reduce this asymmetry by providing observable, verifiable proxies for underlying environmental performance that buyers can assess without conducting full independent audits. Spence (1973) formalises the conditions under which signals effectively reduce information asymmetry: signals must be observable, differentially costly (harder for lower-quality providers to fake), and credible (grounded in verifiable evidence). The Data Quality Score mechanism in this study directly addresses the credibility condition: by distinguishing "Estimated," "Documented," and "Verified" data quality tiers, the framework makes evidentiary basis explicit and auditable, increasing the differential cost of maintaining high-tier data quality claims without genuine supply chain documentation.

This theoretical framing has a direct practical implication: the indicator framework is not only an environmental management tool but a market infrastructure intervention, reducing information asymmetry in sustainable fashion finance markets in a way that financially disadvantaged early-stage ventures can access without commissioning ISO-compliant LCA studies.

3.5 Replication Logic in Multiple-Case Research

Yin's (2018) replication logic provides the methodological-theoretical foundation for the embedded comparative case design. Replication logic distinguishes case study research from survey research: where survey research generalises from a sample to a statistical population, case study research generalises from a case to a theoretical proposition through analytic reasoning. The goal is not to claim that findings hold for all early-stage fashion enterprises but to develop and test a theoretical understanding of the conditions under which the indicator framework is feasible, credible, and transferable.

Theoretical replication, selecting cases expected to produce contrasting results for identifiable theoretical reasons, is particularly appropriate for a framework development study because contrasting contexts reveal boundary conditions: where it works well, where adaptation is required, and what operational preconditions are necessary. Manifiesta and Inkaya are selected as theoretically contrasting cases, differing in production system, material base, regulatory context, and data infrastructure, in a way that generates insight into robustness and adaptation requirements that could not be obtained from a single case or from a survey.

3.6 The Conceptual Model

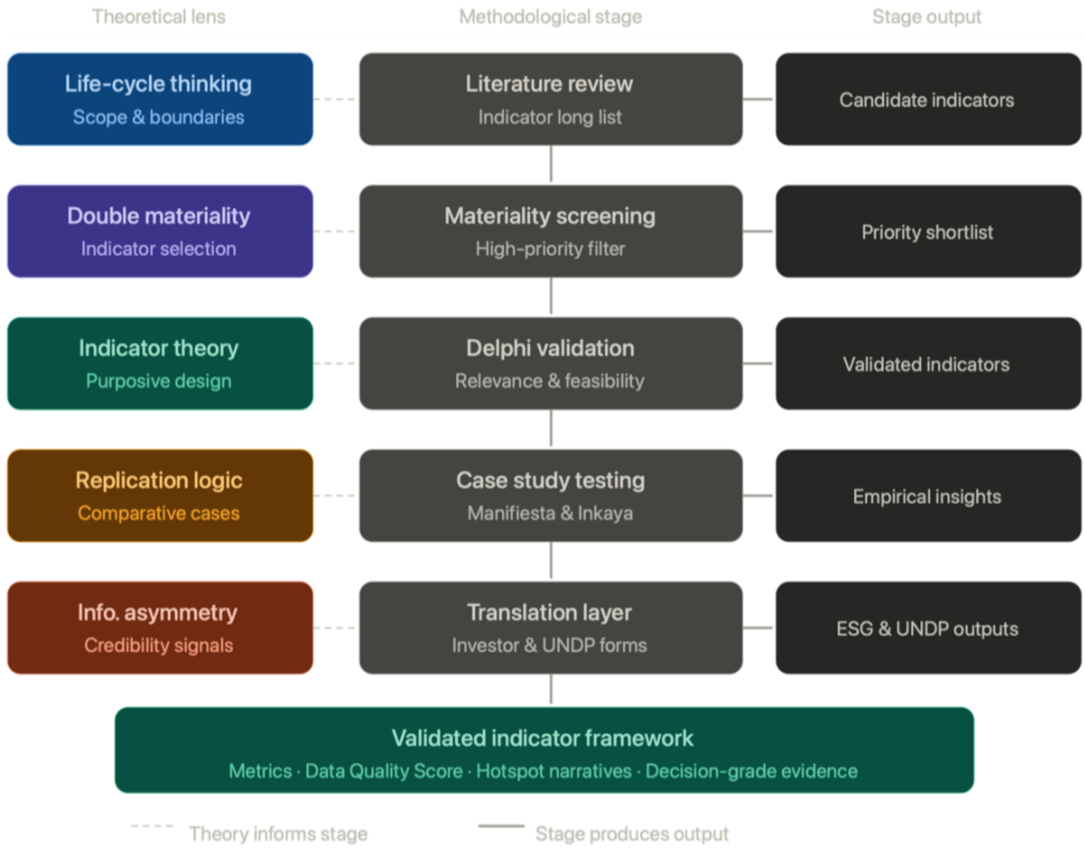

Figure 1 *Maps the five theoretical perspectives onto the study's sequential methodological stages and their corresponding outputs.*

The five theoretical perspectives form an integrated analytical architecture. Life-cycle epistemology defines the intellectual discipline and scope boundaries of the indicator framework. Sustainability indicator theory provides normative and methodological principles for translating life-cycle logic into accessible, purposive metrics. Double materiality provides the selection criterion prioritising indicators at the intersection of environmental significance and financial relevance. Information asymmetry theory explains the market mechanism through which structured environmental indicators generate financial value for early-stage enterprises. Replication logic provides the methodological rationale for the cross-case comparative design through which robustness and transferability are empirically tested.

The integrated conceptual model maps these components onto the study's methodological stages: structured literature review informed by life-cycle epistemology generates the candidate indicator long list; double materiality screening filters the long list to high-priority candidates; Modified Delphi validation, which is grounded in sustainability indicator theory, establishes expert consensus on relevance and feasibility; embedded comparative case studies, designed through replication logic, test the validated framework against real-world data constraints; and the resulting output, metrics, data quality tags, and hotspot narratives, are translated through an information asymmetry lens into forms legible to impact investors and development programme monitors.

4 Research Design & Methods for Data Collection

This chapter presents the methodological design of the study. The research combines qualitative and quantitative elements across four sequential stages: a literature-based indicator longlisting phase, a modified Delphi validation, embedded comparative case studies, and a cross-case synthesis. Qualitative methods dominate the case study and validation stages, where expert judgment and organisational context are central. Structured scoring during the Delphi process introduces a quantitative dimension that supports transparent, comparable decision-making across indicators. This combination is appropriate for a framework development study in which the goals include producing a theoretically justified indicator set and testing its practical feasibility across contrasting real-world contexts (Yin, 2018).

4.1 Overview of the Sequential Research Design

The study follows a sequential, four-stage design: (1) structured literature review and indicator longlisting; (2) indicator screening and modified Delphi validation; (3) embedded comparative case study implementation; and (4) cross-case synthesis and framework refinement. Each stage builds on the preceding stage, with the outputs of each informing the design of the next.

Table 1 *Sequential Research Design: Stages, Methods, Data Sources, and Research Sub-Questions Addressed*

Stage	Method	Data Sources	Sub-Questions Addressed	Output
1. Longlisting	Structured literature review	Peer-reviewed LCA literature; fashion sustainability tools; SME indicator frameworks	Sub-question 1	Long list of candidate indicators with impact category, proxy type, and boundary specification
2. Screening & Delphi	Modified Delphi (interview + scoring)	Sustainability practitioners; UNDP Youth4Climate staff; enterprise founders	Sub-question 1 & 2	Validated short list of indicators with relevance and feasibility ratings; qualitative refinement notes
3. Case Implementation	Embedded comparative case studies (theoretical replication)	Manifiesta (Colombia); Inkaya (Zambia); enterprise documentation;	Sub-question 3	Applied indicator results; data quality tags; feasibility and credibility

		primary data collection		assessments per case
4. Synthesis	Cross-case analysis; translation layer development	Aggregated case evidence; investor IMM literature; UNDP monitoring frameworks	Sub-question 3 & 4	Refined final framework; Data Quality Score mechanism; ESG/IMM translation outputs

4.2 Stage 1: Structured Literature Review and Indicator Longlisting

4.2.1 Search Strategy and Source Selection

The initial pool of candidate environmental indicators is drawn from three bodies of literature: (1) peer-reviewed fashion and textile LCA studies identifying consistent environmental hotspots across the value chain; (2) sustainability indicator theory and SME measurement literature providing criteria for indicator selection in resource-constrained contexts; and (3) existing industry tools and guidance documents (including the Higg Materials Sustainability Index, OEKO-TEX standards, and Textile Exchange publications) that have operationalised LCA-derived knowledge into accessible metrics. Sources were identified through Google Scholar searches and targeted retrieval of grey literature from ISO, GIIN, TCFD, and UNDP, supplemented by reference list review of key papers. Sources were selected based on their relevance to the fashion value chain, their applicability to environmental measurement in SME or early-stage contexts, and their coverage of the four indicator categories prioritised in this study.

4.2.2 Screening Rubric for the Long List

Each candidate indicator identified through the literature review is evaluated against a four-criterion screening rubric prior to the Delphi process. The rubric operationalises the double materiality principle and the feasibility requirements established in the SME indicator literature (Feil et al., 2015).

Table 2 *Indicator Screening Rubric*

Criterion	Definition	Assessment Question	Basis of Literature
Environmental Relevance	Indicator addresses a documented environmental hotspot in the fashion value chain	Is this impact category supported by at least two independent fashion LCA studies?	Niinimäki et al. (2020); Watson & Wiedemann (2019)

Financial Materiality	Indicator reflects a risk or opportunity with potential financial implications for the enterprise	Is this indicator connected to transition risk, physical risk, or regulatory compliance risk?	TCFD (2017); Mezzanotte (2023)
Feasibility	Indicator can be operationalised using data available to an early-stage enterprise with limited technical capacity	Can this indicator be populated using supplier specs, certifications, or publicly available benchmarks?	Feil et al. (2015); Clarke-Sather et al. (2011)
Boundary Clarity	Indicator maps clearly onto the cradle-to-gate system boundary without requiring use-phase or end-of-life assumptions	Can the scope of this indicator be defined without speculative consumer behaviour assumptions?	ISO (2006a); Hellweg & Canals (2014)

4.3 Stage 2: Modified Delphi Validation

4.3.1 Rationale for the Modified Delphi

The Delphi method is employed to validate the relevance and feasibility of the screened indicators through structured expert consensus. As Hasson et al. (2000) demonstrate, the Delphi method is particularly appropriate for sustainability indicator validation contexts where definitive empirical answers are unavailable and where normative judgments about relevance and practicality must be made explicit and deliberate. Feil et al. (2015) provide a directly applicable precedent in the SME sustainability indicator context.

The modification from classic Delphi protocol involves replacing anonymous multi-round postal surveys with individual structured consultations conducted through live interviews (in-person or via video or zoom call). This modification is justified by three considerations: (1) individual consultations allow each participant to reflect independently on indicator feasibility without being influenced by the views of others before scoring, preserving the epistemic independence that the Delphi method is designed to protect; (2) the qualitative discussion embedded within each consultation enables deeper exploration of indicator-specific constraints and modification pathways than anonymous surveys alone would permit; and (3) individual consultations are more practically feasible given the diverse time zones, schedules, and availability of busy practitioners and enterprise founders across multiple countries. To preserve rigour, all consultations follow a structured protocol with predefined rating scales, guided discussion prompts, and a standardised instrument to ensure comparability of data across participants.

4.3.2 Participant Selection and Composition

Ten participants were selected through purposive sampling across five complementary knowledge domains, consistent with Delphi methodology conventions (Hasson et al., 2000). The five domains were identified deductively from the study's research questions: sustainability practice and fashion materials supply chains; impact investment and venture capital; development finance and project preparation; programme design and monitoring; and enterprise founding in Global South sustainable fashion contexts. Table 3 presents the full panel composition.

Table 3 *Particiapant Composition*

ID	Professional Role	Organisation / Context	Primary Knowledge Domain
P1	Founder, Sustainable Fashion Enterprise	Manifiesta, Colombia (Youth4Climate case study)	Enterprise founder; circular production; Global South
P2	Founder, Community Textile Enterprise	Inkaya-Community Studio, Zambia (Youth4Climate case study)	Enterprise founder; indigenous materials; off-grid production
P3	Carbon Markets Founder; Venture Capital (VC) Investor	BlockCarbon; Harvard VC Club; Shell M&A (London)	Carbon credit verification; climate finance; energy transition
P4	Programme Director, Environmental Non-profit	Yunus Environmental Hub; former Amazon Logistics	Environmental KPI design; social business programme monitoring
P5	Managing Partner; ESG Advisor	Mbhazi Advisory; Nishati Initiative East Africa	ESG advisory; impact investment; African enterprise development
P6	Communications Lead, Development Programme	UNDP Youth4Climate, Rome	Communications; private sector engagement; Youth4Climate project knowledge
P7	Venture Capitalist; Accelerator Director	Wrk.Flo; gener8tor accelerator programmes	Early-stage VC; investment screening; accelerator
P8	Finance Specialist, Climate Finance	UNDP Platform for Investment Support and Technical Assistance (PISTA); former International Finance Corporation (IFC) World Bank Group	Development finance; financial readiness; IFC Performance Standards
P9	R&D Materials Specialist	Vivienne Westwood (luxury fashion)	Fashion materials; supply chain; chemical compliance
P10	Founder, Artisanal Textile Enterprise	IZZA BERBER, Morocco (Berber rug cooperative)	Artisanal production; natural fibres; cooperative model

The participant composition reflects these five domains. Sustainability practitioners (P5, P9) were selected to assess the environmental credibility and technical adequacy of each indicator from within fashion supply chain and ESG advisory practice. Impact investors and venture capitalists (P3, P7) evaluate financial decision-usefulness, directly operationalising the study's bankability argument. Development finance professionals (P8) provide grounding for the financial readiness dimension, with P8's PISTA role and prior IFC experience across Sub-Saharan Africa and South Asia offering the most directly relevant practitioner expertise available. Programme design experts (P4) assess feasibility and accountability from a portfolio monitoring perspective. The communications professional (P6) evaluates how indicators function as credibility signals in partner and funder engagement. The two enterprise founders (P1 and P2) provide operational ground-truth on feasibility from within enterprises structurally identical to those the framework is designed to serve. Geographically, the panel spans Colombia, Zambia, Morocco, Italy, East Africa, the United Kingdom, the United States, and international development institutions in Rome. This is a deliberate criterion to test whether the framework's feasibility assumptions hold across diverse enterprise settings, supply chain contexts, and regulatory environments.

4.3.3 Delphi Procedure

The validation process proceeds in two rounds. Round 1 involves individual structured consultations in which each participant scores the five proposed indicators on two dimensions:

- relevance (1-5 scale: 1 = not relevant, 5 = highly relevant)
- feasibility (1-5 scale: 1 = not feasible, 5 = highly feasible)

Participants also provide qualitative commentary on indicator definitions, data sources, and potential modifications through the interview. Indicators scoring a mean of 3.5 or above on both dimensions proceed to Round 2; indicators below this threshold are modified based on qualitative feedback or dropped. Round 2 involves distribution of an individual scoring sheet to each participant electronically, presenting the aggregated Round 1 group means and the revised indicator definitions. Participants revise their assessments independently in light of this information. Consensus is defined as a mean score of 4.0 or above on both dimensions. Indicators meeting this threshold form the validated short list.

4.3.4 Data Quality Score Validation

In addition to indicator relevance and feasibility, the Delphi process validates the three-tier Data Quality Score mechanism:

- Bronze: Estimated
- Silver: Documented
- Gold: Verified

Participants are asked to assess whether each tier adequately differentiates data quality in a way that is both meaningful and practically distinguishable in enterprise settings. Qualitative feedback on the naming, thresholds, and communication of the Data Quality Score is gathered during Round 1 and incorporated into the refined mechanism presented for reassessment in Round 2. This validation step is motivated by Watson and Wiedemann's (2019) finding that data quality transparency is a critical but frequently absent feature of existing fashion sustainability tools.

4.4 Stage 3: Embedded Comparative Case Studies

4.4.1 Case Selection Rationale

The selection of Manifiesta (Colombia) and Inkaya - Community Studio (Zambia) as embedded case studies follow the logic of theoretical replication described by Yin (2018). The two cases are selected because they share sufficient structural similarity to permit meaningful comparison, both are early-stage, mission-driven fashion enterprises operating within the UNDP Youth4Climate programme, while contrasting in ways that are analytically productive for testing the framework's robustness and transferability. Table 4 summarises the key theoretical contrasts between the cases.

Table 4 *Theoretical Contrasts Between Manifiesta and Inkaya - Community Studio*

Dimension	Manifiesta (Colombia)	Inkaya - Community Studio (Zambia)
Production system	Small-batch artisanal production; mix of natural and synthetic fibres; formal supply chain documentation	Community-based textile manufacturing; indigenous natural fibre traditions (BaTonga); informal documentation practices
Regulatory context	Latin American regulatory environment; partial REACH-equivalent chemical regulations	Sub-Saharan African regulatory environment; limited formal chemical compliance infrastructure
Data infrastructure	Relatively higher: digital records, supplier invoices, formal procurement	Relatively lower: oral knowledge transmission, limited formal digital documentation
Primary environmental focus	Material GWP reduction (sustainable fibre substitution); waste efficiency	Natural dye use; water management; community-scale resource stewardship
Theoretical replication role	Literal replication: expected to demonstrate higher framework applicability given stronger data infrastructure	Theoretical replication: expected to reveal framework adaptation requirements in lower data infrastructure context

4.4.2 Case Data Collection

Data collection for each case follows a structured protocol applying the validated indicator framework to available organisational data. Primary data is collected through semi-structured interviews with enterprise founders and focal points, using an indicator-specific question guide that asks about each indicator category: (a) What data is available? (b) In what format is it held? (c) What is the data source (supplier spec, invoice, certification, estimate)? (d) What are the main gaps or uncertainties? Secondary data includes publicly available UNDP programme documentation, enterprise websites, and any available supplier certificates or product specifications. For each indicator, a Data Quality Score is assigned based on the nature of the data source: 'Estimated' where enterprise relies on industry average benchmarks; 'Documented' where specific supplier specifications or transaction records are available; 'Verified' where third-party certificates or accredited reports are provided.

4.4.3 Cross-Case Analysis

Cross-case analysis employs Yin's (2018) pattern-matching approach, comparing the indicator framework's performance, in terms of feasibility, data quality achievable, and interpretability, across the two cases. The analysis seeks to identify: (a) which indicators are robustly feasible across both cases (strong candidates for the core framework); (b) which indicators require contextual adaptation (candidates for case-specific guidance); and (c) which indicators face systematic feasibility barriers that warrant removal or replacement. The cross-case synthesis also generates the "hotspot narrative", which is a qualitative description of each enterprise's primary environmental impact profile, that functions as the complementary qualitative layer of the indicator framework alongside the quantitative scores.

4.5 Stage 4: Translation Layer Development

A critical practical output of the study is a "translation layer" that maps the validated environmental indicators onto forms legible to two distinct external audiences: (1) impact investors and impact measurement practitioners using standard IMM frameworks such as Impact Reporting and Investment Standards (IRIS+) and the United Nations Sustainable Development Goals (UN SDGs) indicators; and (2) UNDP Youth4Climate monitoring staff using programme-level reporting templates. The translation layer is developed through a combination of desk review of published IMM frameworks (GIIN, 2020; IRIS+) and iterative consultation with UNDP programme staff during the Delphi process. The goal is not to replace existing reporting frameworks but to establish explicit crosswalks between the simplified environmental indicators and the metrics that impact-oriented audiences are already using, reducing the reporting burden on enterprise founders while increasing the legibility of environmental performance data to investors and programme monitors.

4.6 Data Quality, Validity, and Reliability

Internal validity in the case study phase is addressed through triangulation, which combines interview data, document review, and indicator application results to cross-check findings , and through member checking, in which preliminary case findings are reviewed by enterprise founders before finalisation. Construct validity is addressed through the explicit operationalisation of each indicator (precise definition, formula, data source, and reporting unit), reducing the risk that different researchers or enterprises would measure different phenomena under the same indicator label.

Moreover, external validity, the transferability of findings beyond the two cases, is addressed through the theoretical replication design: by demonstrating how and why the framework performs differently in contrasting contexts, the study provides a theoretical basis for predicting performance in other contexts, which is the appropriate form of generalisation for case study research (Yin, 2018). Reliability is addressed through the detailed protocol documentation provided in Annex A, which enables replication of the data collection and analysis procedures by other researchers.

On the other hand, ethical validity, ensuring that the research process respects participant rights and interests, is addressed through the ethical provisions described in Section 1.4, including informed consent, anonymisation, commercial data protection, and reflexive attention to researcher positionality.

4.7 Proposed Indicator Framework: Overview

Based on the literature review findings and the screening rubric application, four core indicator categories are proposed for Delphi validation. Table 5 presents an overview of the proposed indicators, their impact categories, measurement approaches, and data quality score mechanisms.

Table 5 *Proposed Core Indicator Framework (Pre-Delphi Validation)*

Indicator	Impact Category	Measurement Approach	Functional Unit	Data Quality Score Tiers
Material Carbon Intensity	Global Warming Potential (GWP)	% deviation from industry benchmark GWP for equivalent fibre type, using published emission factors (Watson & Wiedemann, 2019)	kg CO_2e / kg fibre	Estimated: industry average factor; Documented: supplier composition spec; Verified: mill LCA or Thermal Coal (TC)
Water Risk Tier	Water Scarcity	Categorical risk rating based on fibre type origin and processing geography, using published water stress indices	Categorical (Low / Medium/ High)	Estimated: fibre type only; Documented: country of origin confirmed; Verified: watershed-level data
Chemistry Compliance Level	Ecotoxicity/ Human Health	Tiered certification-based proxy: Level 1 (undocumented), Level 2 (REACH/Prop 65	Tier (1–3)	Estimated: founder declaration; Documented: compliance

		compliant), Level 3 (Bluesign® or OEKO-TEX® certified)		statement from supplier; Verified: valid certificate uploaded
Renewable Energy Share	Energy Use/ GWP (Manufacturing)	% of assembly factory's power from onsite renewable generation or verified green tariff	% renewable	Estimated: factory self-report; Documented: utility invoice or tariff agreement; Verified: third-party energy audit
Fabric Utilisation Rate	Material Efficiency/ Solid Waste	(Weight of finished garments produced) ÷ (Weight of fabric purchased) × 100	%	Estimated: approximate founder calculation; Documented: production records with fabric intake and garment weights; Verified: audited production log

These five indicators are designed to address the most environmentally significant and financially material dimensions of the fashion value chain within the cradle-to-gate boundary, while remaining operationally feasible for enterprises with limited data infrastructure. Together they cover the four impact categories identified through the literature review as most critical: climate (GWP), water, chemical hazard, and resource efficiency. The Delphi validation process will assess whether this set should be narrowed, expanded, or modified based on expert assessment of relevance and feasibility in practice.

5 Findings/Results & Analysis

This chapter presents and describes the findings from the modified Delphi expert consultation (Round 1 and 2) and the embedded comparative case studies of Manifiesta and Inkaya - Community Studio.

5.1 Round 1 Delphi Findings: Indicator-by-Indicator Assessment

5.1.1 Overview of Round 1 scores

Table 5.2 presents the full Round 1 scoring matrix across all ten participants. Mean Relevance (R) and Feasibility (F) scores are calculated across the panel. The threshold for Round 2 progression is: mean ≥ 3.5 on both dimensions to Proceed; mean 3.0–3.49 on either to Modify; mean < 3.0 on either to flag for potential exclusion.

Table 6 *Round 1 Delphi Scoring Matrix*

Indicator	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	Mean R	Mean F
	R / F	R / F	R / F	R / F	R / F	R / F	R / F	R / F	R / F	R / F		
1. Material Carbon Intensity	3/3	5/3	5/3	5/3	4/5	4/2	4/3	5/3	5/3	5/2	**4.5**	**3.0**
2. Water Risk Tier	5/2	5/3	4/5	4/4	4/4	4/2	4/4	5/3	1/1	4/2	**4.0**	**3.0**
3. Chemistry Compliance Level	4/2	5/3	4/3	5/3	3/2	4/3	5/4	5/2	5/1	4/3	**4.4**	**2.6**
4. Renewable Energy Share	5/4	5/5	4/3	4/3	3/3	3/4	3/3	3/1	3/1	3/2	**3.6**	**2.9**
5. Fabric Utilisation Rate	–	5/5	5/5	5/4	5/4	5/4	5/4	3/3	5/3	5/5	**4.8**	**4.1**
Round 2 Decision	**Modify**	**Modify**	**Modify**	**Modify**	**PROCEED**							

Notes: R = Relevance; F = Feasibility; scale 1–5. Indicator 5 mean calculated on N=9 (P1 score not recorded for this indicator). Thresholds: ≥3.5 on both = Proceed; 3.0–3.49 on either = Modify; <3.0 on either = flag for potential exclusion.

All five indicators achieve mean Relevance scores above 3.5, which confirms that the four environmental impact categories selected through the literature review (climate, water, chemical safety, and resource efficiency) are judged as relevant by the expert participants. The primary source of variation lies in the Feasibility dimension, where structural barriers related to supply chain informality, supplier transparency, and certification accessibility drive scores below the 3.5

threshold for four of the five indicators. Only Indicator 5, Fabric Utilisation Rate, achieves the consensus threshold on both dimensions without modification.

5.1.2 Indicator 1: Material Carbon Intensity

Indicator 1 achieves the highest mean Relevance score (R = 4.5). This reflects an almost universal agreement that material choice is the most strategically important environmental decision for an early-stage fashion enterprise. P7, a venture capital investor and accelerator director, stated: *"A material carbon intensity score expressed as X% better than the conventional baseline would be meaningful, it shows that the founder is thinking in terms of measurable performance rather than brand narrative"* (P7, VC Investor and Accelerator Director, April 2026). P3, with experience building a carbon credit verification platform, noted: *"The core challenge is analogous to carbon markets, trust is created through methodology, evidence, and verification. The logic is very similar"* (P3, Carbon Markets Founder and VC Investor, April 2026).

Moreover, two outlier scores are noted. P1, the Manifiesta founder, gave the lowest Relevance score of any participant (R=3), characterising formal carbon accounting as important globally but *"not among current priorities"* given the enterprise's operational stage and context, and describing it as *"a very Western approach"* that may not reflect the most pressing concerns for early-stage founders in Colombia (P1, Founder, April 2026). This response surfaces an important tension between the theoretical case for carbon measurement and the operational realities of early-stage enterprises that is explored further in the case study section.

Mean Feasibility of 3.0 places this indicator in the Modify category. The primary barrier identified across multiple participant categories is supplier transparency. P5, advising enterprises across East Africa, described the systemic constraint: *"Suppliers often lack fibre-level carbon data. The barriers are lack of structured documentation, low data literacy across supply chains, and absence of standard reporting systems"* (P5, Managing Partner and ESG Advisor, April 2026). P9, working in luxury fashion materials R&D, confirmed from within the supply chain: suppliers *"usually present technical and compliance information only. The recycled or organic portion is only mentioned in the composition without any details"* (P9, R&D Materials Specialist, April 2026).

The benchmark comparison approach, which expresses carbon intensity as a percentage deviation from an industry baseline, received broad validation as appropriate for early-stage contexts, though P3 raised an integrity concern noting that credibility *"depends entirely on the underlying data, which is often weak or not locally representative"* (P3, Carbon Markets Founder and VC Investor, April 2026). Based on Round 1 qualitative feedback, the modification proposed for Round 2 is to clarify that the Bronze/Estimated tier is the explicit default starting point, with the industry benchmark drawn from a named published source, and to add measurement guidance for deadstock and industrial waste recovery material contexts.

5.1.3 Indicator 2: Water Risk Tier

Indicator 2 achieves a mean Relevance score of 4.0 and mean Feasibility of 3.0. The single outlier, P9 (R=1, F=1), reflects a sector-specific contextual constraint: P9 noted that for leather goods, processing location is not consistently disclosed by suppliers who *"usually buy hides already processed"* (P9, R&D Materials Specialist, April 2026). Excluding this outlier, the remaining nine participants give a mean Relevance of 4.4.

Among participants working in African and Global South contexts, water risk was consistently identified as particularly urgent. P5 observed: *"Water stress is a major issue across many African regions, especially in agriculture-linked supply chains like cotton. It is often under-discussed compared to carbon but locally* *can be just as critical'* (P5, Managing Partner and ESG Advisor, April 2026). P8, drawing on IFC investment experience across Sub-Saharan Africa and South Asia, noted that water risk appears in both environmental and operational due diligence: *"If a company has a single-source supply in a high-stress region, then all of my financed business is at risk"* (P8, Finance Specialist, April 2026).

Futhermore, feasibility of 3.0 reflects the practical accessibility of the country-of-origin proxy approach while acknowledging a key limitation: country-level water stress indices may obscure significant within-country variation. P8 noted that for large geographically diverse countries, a national-level risk label is insufficiently precise and should be adjusted to the sub-regional level where supply originates (P8, Finance Specialist, April 2026). Both case study founders confirmed partial origin knowledge but limited sub-regional visibility. The modification proposed for Round 2 strengthens the guidance to encourage sub-national specification where available, retains country-level data as a valid Bronze tier input, and reframes the indicator explicitly as a risk screening proxy rather than a precise water footprint measurement.

5.1.4 Indicator 3: Chemistry Compliance Level

Indicator 3 achieves strong mean Relevance (R = 4.4) but the lowest mean Feasibility (F = 2.6) of any indicator, placing it in the most challenging position for Round 2 progression. The qualitative findings reveal that the feasibility barrier is primarily structural and geographic rather than conceptual, and that there is a clear modification path involving recalibration of the certification tier structure for Global South contexts.

Multiple participants confirmed chemical compliance as a material regulatory and financial concern. P7 described it as *"one of the most important indicators in the framework. It connects environmental impact, human health, consumer safety, regulatory risk, and brand reputation"* (P7, VC Investor and Accelerator Director, April 2026). P8 noted that chemical safety assessment is *"very central"* to Environmental and Social Impact Assessments under IFC Performance Standards (P8, Finance Specialist, April 2026). P9 confirmed that REACH compliance is a standard baseline for Italian suppliers, while documentation practices vary significantly for suppliers outside European regulatory frameworks.

Moreover, the most significant qualitative finding for this indicator concerns the accessibility of the Level 3 certification tier in Global South contexts. P5 stated: *"Standards like OEKO-TEX or Bluesign are expensive and not widely adopted, especially among small or community-based producers. Using them as the highest tier creates a system that most enterprises cannot access"* (P5, Managing Partner and ESG Advisor, April 2026). P2, the Inkaya founder, confirmed that such certifications are *"typically designed for large-scale industrial production systems and are not readily accessible or practical for small, community-based enterprises working within informal or semi-formal economies"* (P2, Enterprise Founder, personal communication, April 2026).

P9 identified relevant additional standards from non-European markets, citing Chinese national standards (GB 18401 for fabrics; GB 20400 for leather) as widely required that should be incorporated into the tier structure (P9, R&D Materials Specialist, April 2026). Several participants also noted that a large proportion of early-stage enterprises in developing contexts would fall at Level 1 (undocumented), and raised the observation that this reflects supply chain opacity rather than necessarily high chemical risk, a distinction particularly relevant for enterprises using natural dye processes with inherently low chemical inputs. The modification proposed for Round 2 expands Level 2 to include national equivalent standards, documented natural dye processes with identified botanical inputs, and Global Organic Textile Standards (GOTS) certification at Level 3.

5.1.5 Indicator 4: Renewable Energy Share

Indicator 4 presents the most divergent Round 1 findings, with mean Relevance of 3.6 and mean Feasibility of 2.9. A clear pattern emerges between founder participants and finance or advisory participants in their relevance assessments. Both enterprise founders (P1, R=5; P2, R=5) rated this indicator as highly relevant, specifically because they have made deliberate investments in renewable energy, P1 has solar panels installed in one workshop, and P2 has designed the Chisakila studio to operate entirely on off-grid solar as 'a core principle' (P2, Enterprise Founder, April 2026). Finance and advisory participants scored Relevance lower, reflecting the view that energy share may be difficult for enterprises to influence when using third-party manufacturers on a national grid whose composition is outside enterprise control.

P5 identified a positive strategic dimension not fully captured by the indicator as designed: in African enterprise contexts, documented off-grid solar adoption can function as an energy independence and resilience signal that is particularly relevant to international impact investors: *'Enterprises using solar or off-grid energy solutions can position that as both an environmental and resilience advantage. It shows reduced dependency on unreliable grids and can signal operational stability'* (P5, Managing Partner and ESG Advisor, April 2026).

Moreover, feasibility challenges are systematic. P8 assigned Feasibility 1, the lowest in the panel and noted that for enterprises connected to a national grid, electricity attribution depends on grid-average statistics rather than plant-level metering (P8, Finance Specialist, April 2026). P3 raised a verification concern rooted in carbon market experience: a standard electricity bill documents consumption volume but does not necessarily establish the renewable attribute without a specific green tariff agreement or renewable energy certificate (P3, Carbon Markets Founder and VC Investor, April 2026). The modification proposed for Round 2 distinguishes three enterprise energy configurations, namely captive generation, green tariff or Power Purchase Agreement (PPA), and national grid estimation, and adds explicit positive framing for off-grid solar adoption in energy-constrained contexts.

5.1.6 Indicator 5: Fabric Utilisation Rate

Indicator 5 is the only indicator to achieve the consensus threshold on both dimensions, with mean Relevance of 4.8 (N=9) and mean Feasibility of 4.1, and progresses to Round 2 without modification. The near-unanimous endorsement across all participant categories was consistent in its reasoning: multiple participants identified the simultaneous environmental and financial character of the indicator as particularly compelling.

P7 articulated this clearly: *"Fabric utilisation rate links environmental performance directly to business performance. Investors care about margins, waste, inventory efficiency, and operational discipline. Lower fabric waste means lower material costs and better gross margin. That dual nature makes it more compelling, not less"* (P7, VC Investor and Accelerator Director, April 2026). P8 noted the indicator's strength from an operational efficiency perspective: *"Because it directly impacts the operations positively, I would also see that as a reason why one should look at it positively as a financier, because it affects the financials and creates a positive impact"* (P8, Finance Specialist, April 2026).

Futhermore, feasibility endorsement was strong among founder participants. P2 confirmed that material waste minimisation is actively practiced, where in offcuts are integrated into patchwork items, experimental designs, and internal components, though formal weight-based tracking is not yet in place (P2, Enterprise Founder, April 2026). P10 confirmed that *"artisans are careful to minimise waste due to the cost and value of raw materials"* and that leftover yarn and materials are routinely reused, though without formal measurement (P10, Artisanal Founder, April 2026).

P9 raised a sector-specific refinement: leather offcuts used in trimmings and small leather goods should be counted as utilised material, *'Trimming and SLGs are utilised materials as well as the main ones'* (P9, R&D Materials Specialist, April 2026). This is incorporated as a measurement guidance note. No structural modification to the indicator definition is required.

5.1.7 Data Quality Score Validation

The three-tier Data Quality Score mechanism, Bronze (Estimated), Silver (Documented), Gold (Verified), was presented to all participants and validated as part of the Round 1 process. No participant recommended its removal. The mechanism received endorsement across participant categories, with the most substantive validation coming from participants with direct experience in capital allocation and environmental verification.

P3 offered: *"The Bronze/Silver/Gold Data Quality Score serves a function analogous to the difference between unverified and verified carbon claims. It tells the reader whether the indicator is based on a founder estimate, a supplier-specific record, or independent verification. That reduces ambiguity and makes the data more decision-useful"* (P3, Carbon Markets Founder and VC Investor, April 2026). P7 confirmed*: "A Bronze score is better than a missing score if it is clearly labelled as estimated. I would rather see a founder say this is an estimate based on industry averages, and here is how we plan to improve the data quality, than see no measurement at all"* (P7, VC Investor and Accelerator Director, April 2026).

P8 provided a tier-threshold mapping from a development finance perspective: Bronze is sufficient to start the conversation at early stage; Silver is where data starts to carry real weight in investment diligence; Gold provides the highest confidence for institutional capital (P8, Finance Specialist, April 2026). P6, from a communications and partner engagement perspective, noted: *"Being transparent about data quality makes the framework more credible. Transparent uncertainty is often more convincing than presenting everything with the same level of confidence"* (P6, Communications Professional, April 2026).

Based on participant feedback suggesting the label 'Bronze' carries negative connotations relative to Gold, the DQS labels are clarified for Round 2 as: Bronze is Estimated (explicitly described as a legitimate starting point); Silver is Documented; Gold is Verified. The underlying tier structure and criteria remain unchanged.

5.2 Summary of Round 1 Findings and Proposed Round 2 Modifications

Table 7 *Round 1 Summary and Proposed Round 2 Modifications*

Indicator	Mean R	Mean F	Decision	Key modification for Round 2
1. Material Carbon Intensity	4.5	3.0	**Modify**	Clarify Bronze as default starting point. Benchmark from named source. Add guidance for deadstock and waste-material recovery contexts.
2. Water Risk Tier	4.0	3.0	**Modify**	Encourage sub-national specification where available. Retain country-level as Bronze. Reframe as risk screening proxy.
3. Chemistry Compliance Level	4.4	2.6	**Modify**	Expand Level 2 to include national equivalent standards and documented

				natural dye processes. Expand Level 3 to include GOTS.
4. Renewable Energy Share	3.6	2.9	**Modify**	Distinguish captive generation, green tariff/PPA, and national grid configurations. Add positive framing for off-grid solar.
5. Fabric Utilisation Rate	4.8	4.1	**Proceed**	Minor clarification: secondary uses of cutting waste count as utilised material. Add formula adaptation note for non-garment products.

5.3 Round 2 Delphi Findings: Consensus Validation

Round 2 scoring was completed by all ten participants, wherein the consensus threshold was set at a mean score of ≥4.0 on both Relevance and Feasibility. Table 8 presents Round 1 and Round 2 means side by side for all five indicators.

Table 8 *Round 1 and Round 2 Delphi Means (Comparison and Consensus Outcomes)*

Indicator	R1 R	R1 F	R2 R	R2 F	Δ R	Δ F	Consensus
1. Material Carbon Intensity	4.5	3	4.6	3.9	+0.1	+0.9	**Not validated F=3.9**
2. Water Risk Tier	4	3	4.5	4	+0.5	+1.0	**VALIDATED**
3. Chemistry Compliance Level	4.4	2.6	4.5	3.2	+0.1	+0.6	**Not validated F=3.2**
4. Renewable Energy Share	3.6	2.9	4.3	4	+0.7	+1.1	**VALIDATED**
5. Fabric Utilisation Rate	4.8	4.1	4.8	4.2	0.0	+0.1	**VALIDATED (confirmed)**

5.3.1 Consensus Outcomes

Three indicators achieved consensus in Round 2. Water Risk Tier (R2 R=4.5, F=4.0) and Renewable Energy Share (R2 R=4.3, F=4.0) both reached the ≥4.0 threshold on both dimensions following modification, representing Feasibility score improvements of +1.0 and +1.1 respectively from Round 1, which is the largest improvements in the dataset. Fabric Utilisation Rate (R2 R=4.8, F=4.2) confirmed its Round 1 consensus, with scores remaining effectively stable across rounds.

Two indicators did not achieve consensus. Material Carbon Intensity achieved strong Relevance (R2 R=4.6) but a Feasibility score of 3.9, a margin of 0.1 below the threshold. Chemistry Compliance Level similarly achieved high Relevance (R2 R=4.5) but a Feasibility score of 3.2. This reflects the continued panel concern about the accessibility of chemical documentation in informal and semi-formal supply chains, even following the Level 2 expansion to include documented natural dye processes and national equivalent standards.

5.3.2 Score Movement Analysis

The pattern of score movement between rounds is analytically significant. Feasibility scores improved across all five indicators, confirming that the Round 1 modifications successfully addressed the panel's concerns. Relevance scores, by contrast, were notably stable, no indicator shifted by more than +0.7, suggesting that relevance was already well-calibrated in Round 1 and was not meaningfully affected by the definition changes.

The largest feasibility gains came from the two indicators that underwent the most substantial structural changes. Renewable Energy Share improved by +1.1, following the introduction of a three-configuration distinction, captive generation, green tariff/PPA, and national grid, that resolved the attribution ambiguity flagged in Round 1. One participant captured this well in a Round 2 comment: *"Captive generation and PPAs can be documented relatively well, while grid-average proxies are acceptable for early-stage reporting"* (P3, Carbon Markets Founder and VC, April 2026). Water Risk Tier improved by +1.0 after being explicitly reframed as a risk screening proxy rather than a precise water footprint measurement. This is a distinction that made the indicator considerably more tractable for early-stage enterprises.

The persistent feasibility gap for Material Carbon Intensity (F=3.9) and Chemistry Compliance Level (F=3.2) is harder to resolve through definition changes alone, because it stems from the nature of the data these indicators require rather than how they are framed. P3 acknowledged that the Chemistry Compliance Level expansion *"makes the indicator more realistic for Asian suppliers and smaller enterprises"* (P3, Carbon Markets Founder and VC, April 2026), yet their score still reflected how difficult it remains to obtain chemical documentation from suppliers operating entirely outside formal certification systems.

5.3.3 The Supplier-Dependency Finding

The pattern across Round 2 consensus outcomes points to a consistent structural distinction that was not fully visible from Round 1 data alone. The three validated indicators (Water Risk Tier, Renewable Energy Share, and Fabric Utilisation Rate) share a common characteristic: they can all be measured using information the enterprise already holds or can readily observe, namely the country of fibre origin, its own energy setup, and its own production inputs and outputs. The two non-validated indicators, Material Carbon Intensity and Chemistry Compliance Level, are a different story. Both depend on upstream data that suppliers must voluntarily disclose, and in informal and semi-formal supply chains, that disclosure rarely happens.

This supplier-dependency distinction is the central empirical finding of the Round 2 stage. It sharpens the feasibility constraint identified in Round 1 considerably: the barrier is not about data complexity, enterprise size, or technical expertise. It is specifically about how much the measurement process relies on voluntary disclosure from upstream suppliers, a factor largely outside the enterprise's control.

5.3.4 Final Validated Framework

Table 9 *Final Validated Indicator Framework*

Indicator	R2 R	R2 F	Status	Implementation guidance
1. Material Carbon Intensity	4.6	3.9	**Provisional: aspirational**	Supplier carbon data not yet accessible in most early-stage supply chains. Bronze-tier estimation using named

				published benchmark recommended as starting point. Upgrade to Silver as supplier relationships develop.
2. Water Risk Tier	4.5	4.0	Validated	Country-level water stress proxy using World Resources Institute (WRI) Aqueduct or equivalent. Confirmed as risk screening tool, not water footprint measurement.
3. Chemistry Compliance Level	4.5	3.2	Provisional: aspirational	Supplier chemical documentation structurally inaccessible in most early-stage informal supply chains. Natural dye enterprises may document botanical inputs to achieve Level 2. Certification upgrade a longer-term goal.
4. Renewable Energy Share	4.3	4.0	Validated	Three configurations distinguished: captive generation, green tariff/PPA, national grid proxy. Off-grid solar explicitly valued as resilience and environmental signal.
5. Fabric Utilisation Rate	4.8	4.2	Validated: core anchor	Internally measurable from enterprise's own production records. Secondary uses of cutting waste count as utilised. Formula adapted for non-garment products.

5.4 Detailed Case Study Analysis: Framework Application and Hotspot Narratives

This section deepens the case study findings by applying the Round 2 validated framework to each enterprise. For each enterprise, the analysis presents the indicator application with assigned Data Quality Scores, a hotspot narrative, and a DQS upgrade pathway.

5.4.1 Manifiesta (Colombia)

Manifiesta acquires deadstock and reject fabrics from industrial producers, upcycles used corporate uniforms, and redistributes offcuts to partner cooperatives. Six percent of sales revenue funds an ecological restoration project near the Amazon led by former combatants. Production is cut-and-sew only, no wet processing or dyeing is performed by the enterprise itself. The table below presents the full indicator application with Data Quality Scores and upgrade pathways.

Table 10 *Manifiesta: Indicator Application, DQS and Upgrade Pathways*

Indicator	Value / Tier	DQS	Data basis	Upgrade pathway to Silver
1. Material Carbon Intensity	*Below baseline; not quantified*	Bronze: Estimated	Deadstock and reject fabrics; recycled polyester and cotton. No supplier carbon data. Composition known broadly only.	Apply GWP benchmark for recycled vs virgin fibre (Watson & Wiedemann, 2019) to known fibre type. Request composition spec from one key supplier for Silver.
2. Water Risk Tier	*Low (own operations); Medium upstream*	Bronze: Estimated	No dyeing or wet processing by Manifiesta. Suppliers in Colombia, country level only. No sub-regional data.	Confirm region of primary fabric suppliers within Colombia. Country-level Bronze valid; sub-regional specification achieves Silver.
3. Chemistry Compliance Level	*Level 1: No documentation*	Bronze: Estimated	No chemical documentation from suppliers. No certifications held. Shift away from polyester	Request REACH compliance statement from one cotton supplier. Most Colombian textile suppliers can provide this declaration, minimum effort for Level 2 (Silver).

			toward cotton made on toxicity concern grounds.	
4. Renewable Energy Share	*Partial: one workshop solar-powered*	**Silver: Documented**	Solar panels on one production workshop confirmed by founder with direct infrastructure knowledge. National grid elsewhere.	Already Silver. Obtain installer documentation or energy meter record to strengthen evidence. Track each additional solar installation as it is added.
5. Fabric Utilisation Rate	*High: estimated; not formally tracked*	**Bronze: Estimated**	Deadstock model maximises utilisation. Offcuts redistributed to cooperatives. Pattern optimisation practised. Fabric purchased in metres, not weight.	Begin recording fabric weight purchased alongside metre-based purchasing. One production cycle of weight-in/weight-out tracking achieves Silver. Redistributed offcut weight counts as utilised material.

Across the five indicators, Manifiesta sits primarily at the Bronze/Estimated tier, with Indicator 4 being the exception, reaching Silver on the strength of its confirmed solar installation. Notably, the enterprise's most distinctive environmental practice, its circular material acquisition model, is only partially captured within the framework's cradle-to-gate boundary. On the other hand, Fabric Utilisation Rate tells the strongest environmental story: deadstock sourcing, near-zero cutting waste, and cooperative offcut redistribution together form a near-circular material system that is estimated to achieve a very high utilisation rate, even if it has not yet been formally measured. Chemistry Compliance represents the most actionable gap. The enterprise's deliberate shift away from polyester toward cotton, driven by toxicity concerns, already reflects active chemical risk management; a single REACH compliance statement from a supplier would be enough to formally document it. The most immediately communicable claim, however, remains the solar-powered production workshop. Already at Silver, it is specific, verifiable, and needs no technical translation for partner or investor audiences.

5.4.2 Inkaya – Community Studio (Zambia)

Inkaya produces natural-dyed textiles using plant-based dyes from Miombo woodland botanical materials, glass beadwork through local artisanal processes, and small-batch garments from second-hand and deadstock markets. The Chisakila studio is designed from inception to operate entirely on off-grid solar energy. As the founder described: *"From the outset, our approach has been to rely on off-grid renewable energy systems to support low-impact, community-based production"* (P2, Enterprise Founder). Table 14 presents the full indicator application.

Table 11 *Inkaya: Indicator Application, DQS and Upgrade Pathways*

Indicator	Value / Tier	DQS	Data basis	Upgrade pathway to Silver
1. Material Carbon Intensity	*Low relative to conventional; not quantified*	**Bronze: Estimated**	Natural dye materials: locally gathered from Miombo woodland (full traceability). Base fabrics: second-hand via charity shops. Glass beads: artisanal, local. No supplier carbon data from any channel.	Apply GWP benchmark for natural plant dye vs synthetic dye equivalent. Botanical dye ingredient documentation, already maintained informally, can serve as the material specification for Silver tier.

2. Water Risk Tier	*Medium: Zambia country level; small-scale use*	**Bronze: Estimated**	Dyeing at artisanal scale using plant-based inputs. Water from community access points. Zambia: Medium water stress country-level (WRI Aqueduct). Total consumption low relative to industrial processes.	Confirm region of Chisakila studio and primary dye production within Zambia. Sub-regional specification achieves Silver and may lower the risk tier in lower-stress provinces.
3. Chemistry Compliance Level	*Between Level 1 and 2: natural process, undocumented*	**Bronze: Estimated**	Primary dye inputs: Miombo woodland plant-based medicinal dyes, non-toxic, no synthetic fixatives. Second-hand base fabrics: original chemical history unknown. No certifications held.	Document the botanical dye process: species used, preparation method, mordant materials if any. This constitutes a documented natural dye process with identified botanical inputs, the Level 2 pathway added in Round 2 specifically for enterprises like Inkaya. Achievable with minimal effort.
4. Renewable Energy Share	*~95-100% (Chisakila); partial (Sishemo Beads)*	**Silver: Documented**	Chisakila studio: entirely off-grid solar by founding design (confirmed by Bungee). Sishemo Beads partner group: national grid. Two distinct configurations within the enterprise ecosystem.	Already Silver. Document solar system specifications (capacity, installation date). Track Sishemo Beads grid usage separately. Gold tier achievable with independent energy assessment of Chisakila installation.
5. Fabric Utilisation Rate	*Very high: near-zero-waste in practice*	**Bronze: Estimated**	Offcuts integrated into patchwork, experimental items, internal stuffing components. Workshop scraps used as training materials. Highly intentional near-circular system. No formal weight tracking in place.	Record material intake weight and finished product weight for one complete production cycle. Given embedded near-zero-waste practice, utilisation rate is estimated above 90%. Formula adapted for mixed product range (textiles, beadwork tracked separately).

The most significant finding from applying the framework to Inkaya concerns Chemistry Compliance Level. Under the original tier structure, the enterprise's natural dye system was classified at Level 1 (undocumented, high risk) despite relying on plant-based Miombo woodland botanical dyes that are inherently non-toxic and involve no industrial chemical inputs. As the founder put it: *"The dye processes are non-toxic and carried out at a small artisanal scale. We prioritise sourcing undyed materials wherever possible to maintain greater control over the dyeing process and reduce reliance on industrial chemical treatments"* (P2, Enterprise Founder, April 2026). This case directly motivated the Level 2 expansion adopted in the Round 2 modification, which now recognises documented natural dye processes with identified botanical inputs. Reaching Level 2 is well within Inkaya's reach, it simply requires recording existing dye knowledge in a structured ingredient list, with no intensive documentation effort needed.

On stronger ground, Renewable Energy Share is Inkaya's most immediately communicable environmental claim. Near-100% solar production, built into the enterprise's founding design, already sits at Silver tier and represents both an environmental and operational resilience asset with clear value for investor and partner communications. Fabric Utilisation Rate, meanwhile, reflects a near-zero-waste practice that is deeply embedded in how the enterprise operates, as the founder noted, *"almost everything retains potential for reuse or transformation"* (P2, Enterprise Founder, April 2026), but has not yet been formally measured. As with Manifiesta, tracking a single production cycle would be enough to move this indicator from a Bronze estimate to a documented Silver score.

5.4.3 Cross-Case DQS Profile

Table 12 *Cross-Case DQS Profile Comparison*

Indicator	Manifiesta DQS	Effort	Inkaya DQS	Effort	Cross-case note
1. Material Carbon Intensity	**Bronze: Estimated**	**Medium**	**Bronze: Estimated**	**Medium**	Both: supplier carbon data absent. Deadstock/second-hand contexts require adapted benchmark calculation.
2. Water Risk Tier	**Bronze: Estimated**	**Low**	**Bronze: Estimated**	**Low**	Country-level Bronze valid in both. Sub-national confirmation achieves Silver in both cases.
3. Chemistry Compliance Level	**Bronze: Level 1**	**Medium**	**Bronze: Between L1–2**	**Low**	Key distinction: Inkaya's natural dye system is inherently low-risk; Level 2 achievable with botanical documentation. Manifiesta needs supplier REACH statement.
4. Renewable Energy Share	**Silver: Documented**	**Low**	**Silver: Documented**	**Low**	Both at Silver. Inkaya: 95-100% solar, founding principle. Manifiesta: partial (one workshop). Both can document further.
5. Fabric Utilisation Rate	**Bronze: Estimated**	**Low**	**Bronze: Estimated**	**Low**	Both: strong near-zero-waste practice embedded. One tracked production cycle achieves Silver for both.

The cross-case DQS profile confirms that all five indicators are applicable at the Bronze tier in both enterprise contexts, and that both enterprises have Low-to-Medium effort upgrade pathways for all indicators. The single structural distinction between cases is Indicator 3 (Chemistry Compliance Level): Manifiesta's Level 1 classification is accurate and requires supplier engagement to resolve, while Inkaya's placement between Level 1 and Level 2 reflects a misclassification of inherently low-risk practice as high-risk due to the absence of documentation rather than the presence of chemical hazard. This distinction has implications for how the framework's Chemistry Compliance indicator should be applied and communicated across different production contexts.

6 Discussion

This chapter interprets and reflects on the findings presented in Chapter 5. It discusses the findings against existing knowledge and reflects on the study's methodological and analytical choices, the legitimacy of the research questions, and the generalisability of the results.

6.1 Discussing results against existing knowledge

6.1.1 The Relevance-Feasibility Gap

The most consistent pattern across the Round 1 Delphi findings was the combination of high Relevance scores for all five indicators and lower Feasibility scores for four of them. This supports and extends the existing SME sustainability indicator literature. Feil et al. (2015) argue that micro and small enterprises need right-sized measurement frameworks due to resource and data constraints, while Clarke-Sather et al. (2011) emphasise the importance of adaptability and contextual sensitivity. The Round 1 findings empirically support both arguments: the four environmental impact categories identified through the literature review (climate, water, chemical safety, and resource efficiency) were all considered relevant by the expert panel, confirming the validity of the double materiality selection approach. However, the Feasibility scores show that the main challenge is not selecting the right categories, but operationalising them within informal supply chains and limited data infrastructures, particularly at the indicator level.

Moreover, the findings that Relevance is consistently high while Feasibility is the constraining dimension is not what the literature would straightforwardly predict. The SME indicator literature tends to treat relevance and feasibility as jointly constrained, that is, a relevant indicator that is infeasible should simply be replaced with a lower-relevance but more feasible proxy. However, the Round 1 findings suggest a more nuanced picture. All five indicators were considered genuinely relevant, while the feasibility barriers were largely structural, such as supplier opacity, inaccessible certifications, and difficulties in energy attribution, rather than flaws in the indicators themselves. This suggests that the solution is not to replace indicators, but to create graduated measurement pathways, such as the Bronze/Silver/Gold Data Quality Score mechanism, that allow enterprises to begin with estimates and progressively improve data quality over time. This design principle is a contribution not clearly articulated in the existing literature.

6.1.2 Design-Phase Lock-in

The eco-design literature argues that upstream material and design decisions largely determine a product's environmental footprint before manufacturing begins (Finkbeiner, 2014; Niinimäki et al., 2020; Fletcher, 2014), and this was strongly reflected in the case study findings. Both Manifiesta and Inkaya showed that the most significant environmental decisions occur at the material sourcing and production model stage. Manifiesta's use of deadstock and industrial reject fabrics, and Inkaya's reliance on plant-based natural dyes from locally sourced botanical materials, demonstrate how early design choices can have greater environmental impact than post-production interventions. The high Relevance scores for Indicator 1 (Material Carbon Intensity, R=4.5) and Indicator 3 (Chemistry Compliance Level, R=4.4) further confirm that experts across different fields view upstream decisions as the main environmental leverage point.

However, the case study findings reveal a gap in the design-phase lock-in literature's practical application: both enterprises have locked in strong environmental choices without the ability to document or quantify them. The theory predicts that early-stage environmental measurement has high decision value that enables founders to choose between Material A and Material B before production commitments are made. Both case enterprises demonstrate that this decision-making process can occur and produce strong environmental outcomes through practice and values rather than through formal measurement. This observation does not undermine the case for environmental measurement; rather, it refines the argument by suggesting that the primary value of the framework for enterprises like Manifiesta and Inkaya is not decision support, but external credibility and documentation of practices that already exist.

6.1.3 Information Asymmetry

Akerlof's (1970) theory of information asymmetry predicts that markets systematically undervalue quality goods when buyers cannot verify quality claims, creating adverse selection risk. Spence's (1973) signalling theory specifies the conditions under which credible signals reduce this asymmetry: signals must be observable, differentially costly for lower-quality providers to fake, and grounded in verifiable evidence. The Round 1 Delphi findings confirm that both theoretical propositions apply to early-stage sustainable fashion enterprises in development finance contexts.

P8's description of PISTA's financial readiness criteria provides direct empirical confirmation that structured environmental data functions as a prerequisite for development finance access rather than a supplementary consideration. P7's observation that a Bronze/Estimated score with transparent labelling is more credible to investors than absent environmental data is consistent with Spence's (1973) prediction that observable signals reduce asymmetry when they are honestly presented. The finding that both case enterprises have strong environmental practices that are currently undocumented is a manifestation of the adverse selection problem: credible sustainability performance exists but cannot be verified, resulting in difficulty demonstrating impact to funders and partners.

Moreover, one notable difference from the theoretical prediction concerns scale. Akerlof's original model does not identify a minimum information-quality threshold below which signals become ineffective. However, the findings suggest that in development finance contexts, such a threshold does exist. Simplified indicators alone may not function as credible signals for institutional capital when the quality and depth of data remain too limited. The results therefore refine signaling theory by introducing a more graduated access mechanism. Bronze-level indicators appear sufficient for initiating conversations with SME-oriented impact investors, while institutional development finance actors typically require Silver- or Gold-level data to meaningfully reduce information asymmetry. The Round 1 findings, particularly P8's description of PISTA's typical project scale, further highlight how financing requirements differ according to project size and investor type, an aspect that remains largely absent from the existing literature.

6.1.4 Global South Certification Bias

The Chemistry Compliance Level indicator generated the study's most significant finding that diverges from prior literature. The existing framework for chemical safety assessment in fashion, including the work of Watson and Wiedemann (2019), Textile Exchange (2025), and Sahimaa et al. (2023), implicitly assumes that chemical management is assessed through European or North American certification standards (REACH, Bluesign, OEKO-TEX). The Round 1 panel, particularly P5 (ESG advisor, East Africa), raised this as a systemic design flaw for Global South enterprises, and the Inkaya case study confirmed it empirically: the enterprise's natural dye system achieves inherently low chemical risk through the use of plant-based Miombo woodland botanical materials, but is classified at Level 1 (undocumented: high risk) under the original tier structure.

This finding has not been described in the simplified LCA or SME sustainability indicator literature. Watson and Wiedemann (2019) identify chemical management as a priority for simplified proxy indicators but do not address how artisanal or indigenous production processes, where low chemical risk is achieved through material choice and practice rather than documentation, should be accommodated. The proposed Level 2 expansion to include documented natural dye processes with identified botanical inputs represents a methodological contribution that extends beyond the fashion sector to any context where traditional or community-based production practices need to be assessed within formal environmental frameworks.

6.1.5 The Supplier-Dependency Distinction

The Round 2 consensus findings provide the study's clearest empirical contribution to the simplified LCA and SME sustainability indicator literature. The three indicators that reached consensus can be measured using information that enterprises already possess or can directly observe. In contrast, the two indicators that did not reach consensus depend on upstream data that must be voluntarily disclosed by suppliers and is often unavailable in the informal or semi-formal supply chains common among early-stage enterprises in the Global South. This finding highlights the structural realities of these supply chains rather than weaknesses in the indicators themselves.

Feil et al. (2015) identify adaptability and contextual sensitivity as key design features for indicators aimed at micro and small enterprises. The Round 2 findings make these concepts more concrete in the context of development finance. Here, adaptability means creating measurement approaches that can provide initial estimates even without supplier cooperation, while contextual sensitivity means recognising supply chain informality as a structural reality rather than a problem to be eliminated. The Bronze/Estimated tier of the Data Quality Score reflects both principles by allowing enterprises to begin with observable proxy data and gradually progress toward more documented and verified scores as supplier relationships improve.

Furthermore, the information asymmetry argument underlying the bankability dimension of this study is further refined by these findings. The original proposition, that structured environmental data can reduce information asymmetry between enterprises and investors, is supported by the Round 2 validated indicators, which are the indicators enterprises can measure and communicate independently. However, the two non-validated indicators reveal a second layer of information asymmetry between enterprises and their suppliers, where environmental data remains inaccessible even when requested. This upstream asymmetry reflects a structural feature of informal supply chains that cannot be solved by enterprise-level measurement frameworks alone. Instead, it points to the need for broader interventions such as improved supplier transparency, traceability systems, and capacity-building initiatives. Identifying this limitation is itself an important empirical contribution that is not clearly addressed in the simplified fashion LCA literature.

The near-miss of Material Carbon Intensity, which fell short of consensus by only 0.1 on Feasibility (F=3.9 against the 4.0 threshold), is particularly worth noting. In Round 2, P3 endorsed the revised indicator definition, while P4 and P7 also gave higher Feasibility scores following the Bronze/Estimated clarification. Rather than indicating rejection, the 0.1 gap suggests remaining uncertainty among participants. Combined with the 0.9-point increase in Feasibility from Round 1 to Round 2, the findings suggest that the Bronze-tier starting point significantly improves feasibility, although supplier-level carbon data remains difficult for most enterprises to access. As P6 noted, *"The main risk is still that some indicators remain a bit technical, but as long as they are explained properly, it should be fine".* This concern applies most clearly to Material Carbon Intensity and Chemistry Compliance Level, supporting the recommendation in Chapter 7 for partner-facing translation guidance alongside the framework.

6.2 Reflecting on the results of the study

6.2.1 Methodological and Theoretical Choices

The modified Delphi method, adapted from Feil et al.'s (2015) precedent for SME indicator validation, proved suitable for the validation objectives of this study. Conducting consultations individually rather than as a group Open Forum, a shift from the original plan, made for practical reasons and to avoid group dominance effects, allowed for deeper qualitative exploration of each indicator's feasibility constraints and modification paths. Sending preparation materials (research brief) in advance allowed participants to provide more informed and substantial responses. The approach also accommodated participants across multiple time zones and schedules more effectively than a simultaneous group session would have.

That said, this methodological choice carries a notable trade-off worth acknowledging. Because Round 1 consensus was reached without real-time group deliberation, certain patterns may not have surfaced with the weight they might have in a group setting. The chemistry compliance outlier, the recognition that European certifications are largely inaccessible to Global South enterprises, is a case in point; collective discussion might have drawn this out more forcefully and influenced Round 1 scores before the between-round analysis. While individual consultations preserve independent judgment, which is methodologically sound, the modifications proposed for Round 2 are necessarily more researcher-interpreted than they would have been had participants shaped them together.

Moreover, The combination of five interlocking theoretical perspectives, life-cycle epistemology, sustainability indicator theory, double materiality, information asymmetry theory, and replication logic, proved to be a productive analytical foundation. Each lens addressed a distinct dimension of the research problem: life-cycle epistemology justified the cradle-to-gate boundary; sustainability indicator theory set normative criteria for indicator design; double materiality guided the selection process; information asymmetry theory underpinned the bankability argument; and replication logic supported the two-case comparative design. Taken together, no other theoretical combination found in the literature would have addressed all four research sub-questions as cohesively.

Where the framework falls short, however, is in its treatment of social sustainability. Dimensions such as social LCA, community wellbeing, and indigenous knowledge systems were not captured, and both case study founders pointed to these as meaningful parts of their enterprises' sustainability identity. This is a gap worth addressing in future research. Extending the framework to incorporate social sustainability indicators would be well served by drawing on social LCA literature alongside the life-cycle epistemology and indicator theory components used here.

6.2.2 Legitimacy of the Research Questions

The main research question, how environmental impact indicators can be designed to credibly measure sustainability performance while remaining feasible under data and capacity constraints, held up well as an organising framework throughout the study. All four sub-questions yielded findings that were both empirically substantive and theoretically meaningful. That said, Sub-question 4, concerning the bankability mechanism, remains only partially answered by the data collected. P8's Round 1 findings offer the most direct empirical grounding for the information asymmetry argument, but a fuller answer would require longitudinal data tracking whether enterprises that adopt the framework actually gain improved access to impact capital, which a question that exceeds the scope of a single master's thesis and is better suited to future research.

Beyond the original research questions, one significant question emerged through the research process itself: at what stage of enterprise development does each indicator become decision-relevant, and should the framework offer staged implementation guidance rather than presenting all five indicators as equally applicable from the outset? This was not something the study set out to answer, and while the practical recommendations in Chapter 7 gesture toward it, the question deserves more systematic investigation than was possible here.

6.2.3 Generalisability

Following Yin's (2018) replication logic, this study makes no claim to statistical generalisability from two case enterprises or a ten-participant Delphi panel. The appropriate standard here is analytic generalization, using carefully selected, contrasting cases to test theoretical propositions against empirical evidence. The two cases were chosen precisely because they differ along the dimensions most relevant to the framework's portability: production system, material base, regulatory context, and data infrastructure. The finding that all five indicators are applicable at the Bronze tier across both cases, and that a specific adaptation is needed for Chemistry Compliance Level in artisanal natural dye contexts, offers a theoretically grounded basis for anticipating how the framework might perform in other settings.

In terms of who the framework speaks to most directly, enterprises resembling Manifiesta and Inkaya are the clearest fit: early-stage (under five years), mission-driven, operating in Global South contexts with informal or semi-formal supply chains, and under pressure from development finance or impact investors to demonstrate environmental performance. Enterprises with more formalised supply chains, stronger supplier data-sharing norms, or access to European certification pathways will likely find Silver and Gold tier achievement more within reach than either case enterprise did. That said, the Bronze-tier entry point is designed to be accessible well beyond the specific enterprise profiles studied here.

6.2.4 Limitations

There the two limitations worth flagging. First, while a ten-participant Delphi panel is appropriate for the methodology, it is small enough that individual outlier scores carry disproportionate weight on the means. P9's Water Risk Tier score of 1/1, for instance, reflects a genuine boundary condition specific to the leather-goods sector, yet it pulls the mean noticeably downward. Round 1 means should therefore be read as directional rather than precisely calibrated, and it bears noting that the qualitative analysis treats outliers as analytically informative rather than smoothing them out through averaging.

Second, both case enterprises currently operate at the Bronze/Estimated Data Quality Score tier, largely because formal environmental documentation systems are not yet in place. The case study findings accurately reflect what data is available now, but they do not show what the framework is capable of once enterprises have had time to build out their documentation practices. A longitudinal follow-up with the same enterprises in two to three years, after the framework has been applied and data systems have matured, would offer a much fuller picture of its developmental trajectory.

7 Conclusions

This chapter presents the study's conclusions across empirical, methodological, theoretical, and practical dimensions, closing with recommendations for future research. At its core, the study addressed a structural gap between what rigorous environmental measurement demands and what early-stage sustainable fashion enterprises in Global South contexts can realistically deliver. The central question guiding this inquiry was how indicators can be designed to credibly measure sustainability performance without exceeding the data and capacity constraints these enterprises actually face.

7.1 Empirical Conclusions

- **All five environmental impact categories are validated as relevant by the expert panel, confirming the double materiality selection criterion.** Mean Relevance scores across both rounds range from 4.3 to 4.8 for all five indicators, reflecting universal expert agreement that global warming potential, water scarcity, chemical safety, resource efficiency, and manufacturing energy use are the right environmental categories to measure for early-stage sustainable fashion enterprises.
- **Feasibility, not relevance, is the binding constraint on environmental indicator adoption for early-stage enterprises.** Four of the five indicators fell below the 3.5 feasibility threshold in Round 1, and two, Material Carbon Intensity (F=3.9) and Chemistry Compliance Level (F=3.2), did not reach the ≥4.0 consensus threshold in Round 2 despite strong relevance scores. The challenge, in other words, is not identifying which environmental categories matter, but how to operationalize these measurements under informal supply chain.
- **Fabric Utilisation Rate achieved consensus validation without any modification, making it the framework's most robust anchor indicator.** Its near-unanimous endorsement across all participant categories reflects an unusual alignment between environmental and financial performance as less fabric waste simultaneously reduces environmental impact and lowers cost of goods.
- **Both case enterprises demonstrate strong environmental practice with inadequate environmental documentation, confirming the documentation-practice gap as a systemic characteristic of early-stage sustainable fashion enterprises in Global South contexts.** Manifiesta's near-circular material acquisition strategy and Inkaya's natural dye system and off-grid solar commitment represent genuinely strong environmental performance, yet neither is documented to Silver or Gold tier standard. This gap is precisely the information asymmetry problem the framework is designed to address.
- **The feasibility barrier is specifically about supplier-dependent data, not about data the enterprise itself can observe.** The three indicators that reached Round 2 consensus (Water Risk Tier (F=4.0), Renewable Energy Share (F=4.0), and Fabric Utilisation Rate (F=4.2)) can all be measured using information the enterprise already holds or can directly observe. The two non-validated indicators, Material Carbon Intensity and Chemistry Compliance Level, both hinge on upstream data that suppliers must voluntarily disclose. It is worth noting that Material Carbon Intensity missed the consensus threshold by just 0.1 on Feasibility, placing it closer to a near-access position than an outright structural rejection.

7.2 Theoretical and Conceptual Conclusions

- **The information asymmetry mechanism does operate in development finance contexts for early-stage fashion enterprises, but at a scale threshold above where very early-stage enterprises currently stand.** Structured environmental data functions as a credibility signal in line with Spence's (1973) signalling theory. However, evidence from P8's role at PISTA suggests that institutional development finance operates at a threshold above what Bronze/Estimated tier data can meet. The framework's bankability contribution is most immediate for SME-oriented impact investors, and becomes progressively more relevant as enterprises build toward Silver and Gold tier documentation.
- **Western certification bias systematically misrepresents enterprises whose low environmental risk is achieved through traditional or indigenous production practices.** This is a new conceptual finding not described in the simplified LCA or SME sustainability indicator literature. The Chemistry Compliance Level expansion, which recognise documented natural dye processes as a valid Level 2 pathway, addresses this bias for artisanal textile contexts and has implications for any certification-based proxy framework applied in Global South settings.
- **The Bronze/Estimated Data Quality Score tier is a legitimate starting point, not a deficient state.** Enterprises beginning at Bronze and progressing to Silver and Gold generate a visible improvement trajectory that functions as a credibility signal in its own right, which demonstrates measurement maturity over time. This graduated approach also satisfies Feil et al.'s (2015) criteria of adaptability and contextual sensitivity for SME-oriented frameworks.

7.3 Policy and Practice Conclusions

- **A five-indicator LCA-lite framework with an explicit Data Quality Score is feasible for early-stage sustainable fashion enterprises in Global South contexts.** All five indicators apply at Bronze in both case enterprises. Three are fully validated for immediate adoption. Two are retained as aspirational indicators with clear upgrade pathways as supplier data infrastructure develops.
- **The framework requires contextual adaptation for enterprises using artisanal or indigenous production practices. These adaptations are design improvements, not concessions.** The modified Chemistry Compliance Level tier and the Renewable Energy Share off-grid solar framing are more accurate representations of actual environmental risk and performance. The Inkaya case demonstrates that the framework can accommodate diverse production models without abandoning the boundary discipline of life-cycle epistemology.

7.4 Practical implications and Recommendations

The table below maps the five indicators onto IRIS+, SDG targets, and UNDP reporting language, providing the translation layer that makes the framework legible within existing institutional reporting systems.

Table 13 *Indicator Crosswalk of IRIS+, SDG Targets, and UNDP Reporting Language*

Indicator	IRIS+ Metric	SDG Target	UNDP Social and Environmental Standards (SES) Standard and Objective	Example Disclosure Language
1. Material Carbon Intensity	IRIS+: OI5732 GHG Emissions (Scope 3, Upstream)	SDG 13.2 Climate action	**SES Standard 2: Climate Change and Disaster Risks** Reduce project-related Geenhouse Gass (GHG) emissions and intensity; advance low-emission and risk-informed development pathways	Example: "Our primary material has [X]% lower carbon intensity than the conventional [fibre] baseline, based on published emission factor data."
2. Water Risk Tier	IRIS+: OI0263 Water Withdrawal (Supply chain)	SDG 6.4 Water use efficiency	**SES Standard 8: Pollution Prevention and Resource** Promote more sustainable use of resources including water; avoid adverse impacts on human health and the environment from pollution	Example: "Our primary fibre is sourced from a [Low/Medium/High] water stress region, based on the WRI Aqueduct water risk index."
3. Chemistry Compliance Level	IRIS+: OI5942 Toxic Materials (Supply chain)	SDG 3.9 Reduce chemical illness; SDG 12.4 Chemical management	**SES Standard 8: Pollution Prevention and Resource** Avoid/minimise generation of hazardous substances and wastes; promote a human rights-based approach to management and disposal of hazardous substances	Example: "Our materials meet [REACH/national equivalent] / are certified by [OEKO-TEX/GOTS/Bluesign] / use documented plant-based natural dye processes free from synthetic chemical inputs."
4. Renewable Energy Share	IRIS+: OI2496 Energy generated for use: Renewables	SDG 7.2 Renewable energy share	**SES Standard 2: Climate Change and Disaster Risks** Adopt renewable or low-carbon energy sources and energy efficiency measures to avoid unwarranted increases in GHG emissions; aligns also with Standard 8 on resource efficiency	Example: "[X]% of our production electricity comes from [solar/green tariff/renewable sources]. Our primary studio operates entirely on off-grid solar energy."
5. Fabric Utilisation Rate	IRIS+: OI7920 Waste Reduced	SDG 12.5 Reduce waste through prevention and reuse	**SES Standard 8: Pollution Prevention and Resource** Promote more sustainable use of resources; avoid/minimise generation of non-hazardous wastes; promote resource efficiency as a core element of sustainable development	Example: "[X]% of our purchased fabric ends up in finished products. Offcuts are reintegrated as trimmings, components, or accessories, minimising production waste."

Notes: IRIS+ codes are indicative; confirm against the current IRIS+ catalogue. UNDP SES Standard references are drawn from UNDP's Social and Environmental Standards Programme monitoring language is illustrative (UNDP, 2021). Example disclosure language should be adapted to each enterprise's DQS tier and production context.

7.4.1 For Early-Stage Enterprise Founders

- **Start at Bronze and build progressively.** Both Manifiesta and Inkaya can apply the framework immediately using data they already have. The goal is not Gold verification from the outset. It is beginning a measurement trajectory that demonstrates intent, builds documentation discipline, and generates increasingly credible environmental claims over time.
- **Prioritise Fabric Utilisation Rate first.** It is the only indicator most enterprises can reach at Silver tier with minimal additional effort by simply adding weight tracking to existing purchase records, or converting metre-based purchasing to weight using supplier gsm data. Its financial co-benefit makes it doubly worthwhile: the same data that supports environmental reporting also has direct cost management value.

- **Use Renewable Energy Share as the most immediately communicable claim where applicable.** Both case enterprises already sit at Silver on this indicator. For any enterprise that has made a deliberate energy investment, solar panels, a green tariff, this is specific, verifiable, and needs no technical translation for partner or investor audiences.
- **The upgrade from Level 1 to Level 2 on Chemistry Compliance is more accessible than it looks.** A single REACH compliance declaration from a fabric supplier, or a documented botanical ingredient list for a natural dye process, is enough to constitute Silver-tier evidence. The barrier here is awareness of the pathway, not the difficulty of obtaining the data.
- **Pair indicator scores with a short qualitative hotspot narrative.** Two to three sentences describing the enterprise's most significant environmental practice and strongest environmental story go a long way. Quantitative scores and qualitative narrative together communicate more credibly than either does alone.

7.4.2 For Impact Investors and Development Finance Institutions

- **Treat Bronze/Estimated data as a productive starting point, not a disqualifying condition.** A transparent Bronze-tier estimate is more decision-useful than no environmental data at all. The crosswalk in Table 13 maps Bronze-tier scores onto IRIS+ metrics and SDG targets, making early-stage environmental data legible within institutional reporting systems without requiring Silver or Gold verification first.
- **Use the Data Quality Score as a maturation tracking tool across investment periods.** Monitoring the progression from Estimated to Documented to Verified across successive reporting periods is a more meaningful signal of environmental management maturity than any single-point assessment. An enterprise that starts at Bronze and reaches Silver on three of five indicators within twelve months is demonstrating measurement discipline, and that has positive implications for operational quality more broadly.
- **For Material Carbon Intensity and Chemistry Compliance Level, treat Bronze-tier scores as conversation starters rather than definitive assessments.** A Bronze score on Material Carbon Intensity, using published fibre emission factors, is enough to flag material selection as an environmental priority and prompt a supplier engagement plan. The fact that this indicator narrowly missed consensus (F=3.9) suggests that modest improvements in supplier transparency could bring it within the validated range.
- **For enterprises in energy-constrained Global South contexts, documented off-grid solar adoption deserves to be weighted positively beyond its environmental value.** It signals reduced dependency on unreliable national grids and a capacity for forward-looking infrastructure investment, both of which are meaningful indicators of operational resilience.

7.4.3 For UNDP Staff

- **Integrate the five-indicator framework as a programme-level environmental monitoring tool** alongside existing financial and community impact reporting. Even a simple annual self-assessment at Bronze tier, required across all supported enterprises, would generate a programme-level environmental dataset that currently does not exist and enable aggregated reporting on the Youth4Climate portfolio's environmental performance.

- **Use the crosswalk in Table 13 to bridge the gap between indicator scores and partner-facing communication.** It maps each indicator onto UNDP reporting categories and provides example disclosure language that founders can use directly in funding applications and partner communications. As P6 noted in Round 2, *"guidance on how to translate each indicator into partner-friendly language would probably increase the framework's usefulness more than expanding the list"* (P6, May 2026), and that is precisely what Table 13 provides in a format programme staff can share directly with founders.
- **Apply the Round 2 expanded definition of Chemistry Compliance Level.** Projects that use artisanal or botanical production practices that are inherently low-risk but would be incorrectly classified at Level 1 under the original definition. The expanded definition, which recognises documented natural dye processes as a valid Level 2 pathway, corrects this systematically.
- **Frame the framework as a practice improvement tool, not a compliance checklist.** Both case enterprise founders said the framework would be most useful if it walks alongside enterprises rather than evaluating them from the outside. Used this way, indicator-based self-assessment becomes a conversation. This will help founders identify their strongest environmental stories and the most actionable next steps for documentation.

7.4.4 For Academic Researchers

- **The framework and its validated indicator set are offered as a starting point for replication, extension, and critique.** Researchers working with enterprises in other sectors, geographies, or development stages are well-positioned to test whether the Relevance and Feasibility patterns identified here hold, shift, or require different adaptations. The supplier-dependency finding, that indicators measuring enterprise-observable data reach consensus while those requiring voluntary upstream disclosure do not, is also worth testing across a larger and more geographically diverse sample.
- **The IRIS+/SDG crosswalk in Table 13 opens a productive line of inquiry into how simplified LCA-lite frameworks can be integrated into institutional impact reporting systems.** Whether Bronze-tier estimates are accepted within IRIS+-aligned investment screening processes in practice remains an open empirical question, and one that warrants direct investigation with institutional investors.

7.5 Recommendations for Future Research

Four directions for future research are recommended on the basis of gaps surfaced by this study.

First, the framework should be tested with a larger and more geographically diverse enterprise sample, including South and Southeast Asia, where the majority of global textile production is concentrated. This would allow more precise mapping of where the supplier-dependency feasibility barrier is most and least severe.

Second, the bankability mechanism should be studied longitudinally, tracking whether enterprises that improve DQS tier scores over time experience measurable improvements in access to impact capital. The causal chain from structured environmental data to reduced information asymmetry to improved investment access is theoretically supported but empirically underspecified.

Third, the framework's scope should be extended to incorporate social sustainability dimensions, such as community wellbeing, labour rights, indigenous knowledge systems, peacebuilding co-benefits, that both case founders identified as central to their sustainability identity but outside the current environmental-only scope. Use-phase indicators, particularly product durability, were also noted as meaningful omissions by participants.

Fourth, the potential connection between simplified environmental indicator frameworks and emerging environmental credit market infrastructure, which was identified by P3 on the basis of parallels between the DQS mechanism and carbon credit verification tiers, also warrants dedicated future research attention.

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Annex A: Delphi Validation Protocol

Overview

This annex provides the detailed protocol for the two-round Modified Delphi validation process, including scoring instruments, researcher guidance, consensus thresholds, and data recording procedures. The protocol follows the structured Delphi methodology described by Hasson et al. (2000) and is adapted from the SME indicator validation approach developed by Feil et al. (2015).

Participant Information and Consent

All participants receive a plain-language information sheet describing the study's purpose, their role in the Delphi process, how their contributions will be used and anonymised, their right to withdraw at any time, and contact information for the researcher and supervisor. Written informed consent is obtained before interview. Participants are informed that their individual scores will not be attributed to them by name in any publication.

Round 1 Procedure

Round 1 is conducted as individual structured consultations with each participant, delivered through a combination of live interviews (in-person or via video call). Each consultation presents the five candidate indicators with, for each: (a) name and definition; (b) impact category and life-cycle stage addressed; (c) measurement approach and formula; (d) proposed Data Quality Score tiers; and (e) data source requirements.

Participants score each indicator on two dimensions using a five-point Likert scale:

- **Relevance:** 1 = Not relevant to fashion sustainability/5 = Highly relevant and decision-critical
- **Feasibility:** 1 = Not feasible for early-stage enterprises/5 = Fully feasible with commonly available data

Following scoring, the consultation explores: rationale for scores; suggested modifications to indicator definitions or data requirements; identification of missing indicators not included in the proposed set; and assessment of the Data Quality Score mechanism. Live interviews are conducted using a structured interview guide and researcher script. All responses are recorded through researcher notes and, where consent is given, audio recording of live sessions.

Between-Round Analysis

Between Rounds 1 and 2, the researcher calculates mean scores for each indicator on each dimension. Indicators are classified as: "Proceed" (mean $\geq$ 3.5 on both dimensions); "Modify" (mean 3.0–3.4 on either dimension, with clear modification direction from qualitative feedback); or "Drop" (mean $<$ 3.0 on either dimension with no clear modification path). Modified indicators are redefined based on qualitative feedback and returned for Round 2 scoring.

Round 2 Procedure

Round 2 is conducted via individual scoring sheets distributed electronically to all Round 1 participants. Participants receive their own Round 1 scores alongside the anonymised group means, enabling them to revise their assessments in light of collective expert judgment. Consensus is defined as a mean score of 4.0 or above on both relevance and feasibility dimensions. Indicators meeting this threshold form the validated short list for inclusion in the final framework.

Data Recording and Analysis

All scoring data are recorded in a structured spreadsheet with columns for participant ID (anonymised), category (practitioner/UNDP staff/founder), round, indicator ID, relevance score, feasibility score, and qualitative comments. Mean scores are calculated per indicator per round. Qualitative comments are thematically coded to identify recurrent refinement suggestions. The final indicator framework documentation records, for each indicator, its Round 1 and Round 2 mean scores, consensus status, and any modifications made between rounds.

Table 14 *Summary of Data Collection Methods and Sources*

Stage	Method	Participants/Sources	Data Type	Analysis Approach
Lit. Review	Systematic database search	Google Scholar; grey literature	Secondary; documentary	Thematic synthesis; screening rubric application
Delphi R1	Interview	12–18 experts (3 categories)	Quantitative scores + qualitative comments	Descriptive stats; thematic coding of comments
Delphi R2	Individual scoring sheet	Same participants as R1	Quantitative scores + brief comments	Consensus assessment (mean ≥ 4.0 on both dimensions)
Case: Manifiesta	Semi-structured interview + document review	Founders; focal points; supplier docs; certifications	Qualitative + semi-quantitative	Indicator application; DQS assignment; feasibility narrative

Case: Inkaya	Semi-structured interview + document review	Founders; focal points; UNDP programme docs	Qualitative + semi-quantitative	Indicator application; DQS assignment; feasibility narrative
Cross-case synthesis	Pattern matching; translation layer development	Aggregated case evidence; IMM literature	Qualitative + analytical	Replication logic analysis; framework refinement; ESG crosswalk

Annex B: Consent Form

Please read each statement carefully and tick the box if you agree. You must tick all boxes to participate.

☐ I have read and understood the Participant Information Sheet.

☐ I understand that my participation is voluntary and that I may withdraw at any time without consequence.

☐ I understand that my individual scores and comments will be fully anonymised and only aggregated results will be reported.

☐ I understand that my data will be stored securely and used only for this research study.

☐ I agree to participate in the expert consultation and the follow-up scoring sheet.

Recording consent (please tick ONE):

☐ I consent to this session being recorded via Zoom for note-taking purposes only. I understand the recording will not be shared and will be deleted after notes are finalised.

☐ I do not consent to recording. I understand the researcher will take written notes only.

Acknowledgement in research outputs (optional):

☐ I am happy to be acknowledged by name and role in the research outputs (thesis, Policy Brief).

☐ I prefer to remain anonymous. Please acknowledge me only by role description (e.g. Sustainability Practitioner).

PARTICIPANTS DETAILS:

Full name: ____

Professional role / Organization: ______________________________________

Email address: _____________________________________

____

Date & Signature

Please return the completed consent form to the researcher by email before your session.

Annex C: Round 1 Questionnaire or Interview Guide and Scoring Sheet

Section A - Opening (5 minutes)

"Thank you for making time for this. My name is Nikka Gerona and I am a master's student at IIIEE, Lund University. This consultation is part of my thesis research on environmental impact measurement for early-stage sustainable fashion enterprises. I am proposing a small set of five environmental indicators and I need expert judgment to assess whether they are the right ones, both environmentally meaningful and practically measurable for founders who have limited data and technical capacity. There are no right or wrong answers. I am interested in your genuine professional experience and judgment. The session will take about 45 to 60 minutes. With your consent, I will take notes during our conversation. Individual responses will be fully anonymised in any publication."

Notes on participant background/opening observations:

Section B - Warm-Up (5 minutes)

The following questions is to help understand the participant's professional context before moving to the indicators.

- Could you briefly describe your current role and how it relates to environmental measurement or sustainability assessment in fashion or a related sector?
- In your experience, what is the biggest practical obstacle for small or early-stage fashion enterprises when it comes to measuring their environmental impact?

Warm-up notes:

Section C - Indicator Assessment (35–45 minutes)

Introduce the indicator set briefly before beginning:

"I am going to walk you through five proposed indicators one by one. For each one, I will describe what it measures and how. I will ask you first to give me a score from 1 to 5 for Relevance*, how environmentally meaningful and decision-useful you think this indicator is, and then a separate score from 1 to 5 for Feasibility, how realistic it is for an early-stage enterprise to actually collect this data. After I have your scores, I would like to hear your reasoning and any suggestions for improvement."*

Scoring scale reminder:
Relevance: 1 = Not relevant | 3 = Somewhat relevant | 5 = Highly relevant (critical environmental hotspot)
Feasibility: 1 = Not feasible | 3 = Feasible with some effort | 5 = Fully feasible (data readily available)

Indicator 1 - Material Carbon Intensity (Global Warming Potential)

What it measures: The carbon footprint of the primary material used, expressed as a percentage deviation from the industry benchmark GWP for the same fibre type.

How it is measured: Using published emission factors (e.g. Watson & Wiedemann, 2019) to compare the enterprise's chosen fibre against the conventional baseline. For example: if they use recycled polyester instead of virgin polyester, the indicator shows the % GWP reduction.

Boundary: Cradle-to-gate (fibre production and processing). Data source: supplier composition specification or published material database.

Indicator 1- Scoring	Relevance (1-5)	Feasibility (1-5)
Score entered by participant:	________	________

Discussion questions

- Does this indicator capture something that genuinely matters for fashion's environmental footprint? Is GWP the right place to focus for early-stage enterprises?
- How realistic is it for an early-stage fashion founder to obtain the data needed for this indicator?
- Is there anything about the definition or measurement approach that you would change to make this indicator more credible, more useful, or more feasible?

Notes on Indicator 1:

Indicator 2 - Water Risk Tier (Water Scarcity)

What it measures: The water scarcity risk associated with the enterprise's primary fibre origin and processing geography, expressed as a categorical tier: Low, Medium, or High.

How it is measured: Using published water stress indices (e.g. WRI Aqueduct) to assign a risk tier based on the country or region where fibre is grown or processed. For example: cotton from Pakistan = High; cotton from Sweden = Low.

Boundary: Cradle-to-gate (fibre origin and processing). Data source: country of fibre origin confirmed by supplier.

Indicator 2 - Scoring	Relevance (1-5)	Feasibility (1-5)
Score entered by participant:	________	________

Discussion questions

- Is water scarcity a sufficiently important environmental issue in fashion to warrant a standalone indicator? Is it more or less important than GWP from your perspective?
- How feasible is it for a founder to identify where their fibres come from with enough precision to assign a water risk tier?
- Would you modify this indicator in any way, in its definition, scale, or data requirements?

Notes on Indicator 2:

Indicator 3 - Chemistry Compliance Level (Ecotoxicity/Human Health)

What it measures: The level of chemical management safety in the enterprise's supply chain, assessed through a tiered certification-based proxy.

How it is measured: A three-level scale: Level 1 = no documentation (high risk); Level 2 = REACH compliant or equivalent (minimum standard); Level 3 = Bluesign® or OEKO-TEX® certified (comprehensive standard). The level is determined by the documentation the enterprise can provide from its supplier.

Boundary: Cradle-to-gate (chemical management in production). Data source: supplier compliance statement or third-party certificate.

Indicator 3 - Scoring	Relevance (1-5)	Feasibility (1-5)
Score entered by participant:	________	________

Discussion questions

- Does a certification-based proxy adequately capture the chemical safety dimension of fashion's environmental impact? Is this a credible substitute for laboratory ecotoxicity measurement?

- For early-stage enterprises operating in diverse contexts, including the Global South, is Level 1 (undocumented) too common to be a useful differentiator? And is Level 3 (Bluesign/OEKO-TEX) realistically achievable for small brands?
- Would you modify the scale, the reference certifications, or the framing of this indicator in any way?

Notes on Indicator 3:

Indicator 4 - Renewable Energy Share (Manufacturing Energy Use)

What it measures: The proportion of the assembly factory's electricity that comes from renewable sources, expressed as a percentage.

How it is measured: Based on self-report from the Tier 1 assembly factory, verified where possible by utility invoice or energy audit. For example: a factory with 100% onsite solar = 100%; a factory on a standard national grid with no green tariff = 0%.

Boundary: Gate (assembly manufacturing stage only). Data source: factory self-report, utility invoice, or green tariff agreement.

Indicator 4 — Scoring	Relevance (1–5)	Feasibility (1–5)
Score entered by participant:	________	________

Discussion questions

- Is renewable energy share at the assembly stage a meaningful indicator of fashion's manufacturing environmental impact? Does it capture something important that the other indicators miss?
- How realistic is it for an early-stage founder to obtain renewable energy data from their Tier 1 factory? Is this information suppliers are willing or able to provide?
- Would you modify how this indicator is defined, measured, or reported?

Notes on Indicator 4:

Indicator 5 - Fabric Utilisation Rate (Material Efficiency/Solid Waste)

What it measures: The proportion of purchased fabric that ends up in finished garments, expressed as a percentage. A higher rate means less fabric waste during cutting and production.

How it is measured: (Weight of finished garments produced ÷ weight of fabric purchased) × 100. For example: if a brand buys 100 kg of fabric and produces garments weighing 85 kg in total, the utilisation rate is 85%.

Boundary: Gate (production/cutting stage). Data source: production records showing fabric intake and finished garment weights.

Indicator 5 - Scoring	Relevance (1-5)	Feasibility (1-5)
Score entered by participant:	________	________

Discussion questions

- Is fabric waste during production a sufficiently significant environmental issue in early-stage fashion to warrant a standalone indicator? Or is it too minor relative to material and processing impacts?
- How feasible is it for a small or early-stage fashion brand to track fabric weight in and garment weight out? Do they typically keep these records?
- Would you modify the formula, the scope, or the communication of this indicator in any way?

Notes on Indicator 5:

Section D - Cross-Cutting Questions (10 minutes)
These questions are asked after all five indicators have been assessed. They invite the participant to reflect on the framework as a whole.

Overall framework assessment

- Q18. Looking at the five indicators as a set, do they collectively cover the most important environmental dimensions of early-stage fashion enterprise impact? What, if anything, is missing?
- Q19. Is the cradle-to-gate system boundary, covering material production through to manufacturing, but excluding consumer use and end-of-life, the right choice for this type of enterprise and audience? Why or why not?

Data Quality Score validation
Describe the Data Quality Score mechanism to the participant:

"Each indicator also carries a Data Quality Score that signals how the data was obtained: Bronze means the founder used an industry average or estimate; Silver means they used a specific supplier specification or transaction record; Gold means they have a third-party certificate or accredited report. The idea is to make the evidential basis of each indicator explicit and auditable, so investors and programme monitors can assess the reliability of the claim themselves."

- Does the three-tier Data Quality Score mechanism make sense as a way of communicating data provenance? Is the distinction between Bronze, Silver, and Gold meaningful and practically distinguishable in your professional context?

- From your professional perspective, as someone who works with investors, programme monitors, or enterprises, would a simplified indicator set like this one, accompanied by Data Quality Scores, be decision-useful? Would you trust it enough to act on it?

Notes on cross-cutting questions:

Section E - Wrap-Up (5 minutes)
Is there anything else about the proposed indicators, the Data Quality Score, or the overall approach that you would like to add, anything that has not come up in our conversation that you think is important for this research?

"Thank you so much for your time and your insights. This has been incredibly valuable. Within the next five to seven days I will send you a short follow-up scoring sheet by email. You will also receive a brief summary of the aggregated Round 1 results so you can see how your scores compare with the group.

Notes:

SCORING SUMMARY SHEET

Participant ID (anonymised): _______________
Participant category:
☐ Sustainability practitioner ☐ Impact investor / ESG ☐ Development programme staff
☐ Enterprise founder
Date of session: _______________ | Duration: _______________ minutes

#	Indicator	Relevance (1-5)	Feasibility (1-5)	Key modification suggested
1	Material Carbon Intensity	/5	/5	
2	Water Risk Tier	/5	/5	
3	Chemistry Compliance Level	/5	/5	
4	Renewable Energy Share	/5	/5	
5	Fabric Utilisation Rate	/5	/5	

Summary:

DQS mechanism:
☐ Clear and meaningful ☐ Needs refinement ☐ Not sufficiently credible

Overall framework:
☐ Decision-useful as designed ☐ Useful with modifications ☐ Fundamental concerns raised

Follow-up items to clarify in Round 2 or case analysis:

Researcher notes:

Annex D: Round 2 Survey Form

This is the final round with estimated time of 5 minutes to complete

Below are the same five indicators from Round 1, with:

- The anonymised group means from Round 1 (so you can see how the panel scored overall)
- Your own Round 1 scores, pre-filled in the grey [R] and [F] columns
- A brief note on what changed in each indicator's definition based on Round 1 feedback

Please give a new Relevance and Feasibility score (1-5) for each indicator in the green columns. You are free to keep the same score or change it; this is your independent judgment.

Scoring:

- Relevance 1-5 (1 = not relevant, 5 = essential)
- Feasibility 1-5 (1 = not feasible, 5 = fully feasible)

Consensus threshold: *Mean ≥4.0 on BOTH Relevance and Feasibility = validated for the final framework*. Return to: nikka.gerona@mespom.eu Deadline: [DATE]

1. Material Carbon Intensity

▸ **What changed:** *Bronze/Estimated clarified as the default starting point, no supplier data required. Benchmark must reference a named published source (e.g. Watson & Wiedemann 2019; Textile Exchange 2025). Guidance added for deadstock and waste-material recovery contexts.*

	R1 Group Mean		Your Round 1		Your Round 2	
Scale: 1 (low) - 5 (high)	**Relevance**	**Feasibility**	**Relevance**	**Feasibility**	**Relevance**	**Feasibility**
Score	4.5	3	[R]	[F]	___ / 5	___ / 5

Optional comment:

2. Water Risk Tier

▸ **What changed:** *Reframed as a risk screening proxy, not a precise water footprint measurement. Sub-national specification encouraged where supplier traceability allows. Country-level data confirmed as valid Bronze tier.*

	R1 Group Mean		Your Round 1		Your Round 2	
Scale: 1 (low) - 5 (high)	**Relevance**	**Feasibility**	**Relevance**	**Feasibility**	**Relevance**	**Feasibility**
Score	4	3	[R]	[F]	___ / 5	___ / 5

Optional comment:

3. Chemistry Compliance Level

▸ **What changed:** *Level 2 expanded to include: (a) national equivalent standards, GB 18401 (textiles) and GB 20400 (leather); (b) documented natural dye processes with identified botanical inputs. Level 3 expanded to include GOTS alongside Bluesign® and OEKO-TEX®.*

	R1 Group Mean		Your Round 1		Your Round 2	
Scale: 1 (low) - 5 (high)	Relevance	Feasibility	Relevance	Feasibility	Relevance	Feasibility
Score	4.4	2.6	[R]	[F]	___ / 5	___ / 5

Optional comment:

4. Renewable Energy Share

▸ **What changed:** *Three configurations now distinguished: (A) captive generation (solar/micro-hydro, directly measurable); (B) green tariff or PPA (contractually established); (C) national grid (grid-average proxy from published data). Off-grid solar explicitly framed as a high-renewable, resilience-positive result.*

	R1 Group Mean		Your Round 1		Your Round 2	
Scale: 1 (low) - 5 (high)	Relevance	Feasibility	Relevance	Feasibility	Relevance	Feasibility
Score	3.6	2.9	[R]	[F]	___ / 5	___ / 5

Optional comment:

5. Fabric Utilisation Rate

▸ **What changed:** *Reached consensus in Round 1 therefore the definition is unchanged. Minor clarification: cutting waste repurposed as trimmings or accessories counts as utilised material. Formula adaptation note added for non-garment product categories.*

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	R1 Group Mean		Your Round 1		Your Round 2	
Scale: 1 (low) - 5 (high)	Relevance	Feasibility	Relevance	Feasibility	Relevance	Feasibility
Score	4.8	4.1	[R]	[F]	___ / 5	___ / 5

Optional comment:

Additional Questions:

- Having seen the revised definitions, do you consider this a credible and useful framework for early-stage sustainable fashion enterprises operating under real-world data and capacity constraints?
- Is there any indicator you would recommend dropping or adding to the final framework?

Annex E: Declaration of Use of Generative AI (GAI) Tools

Permitted Uses in This Course

Students may use GAI tools for:
- Brainstorming and idea generation
- Planning and outlining
- Language support (grammar, clarity, tone)
- Translation of non-personal, non-sensitive content
- Drafting outlines (not full assignments)

Requirements:
- You must critically review, fact-check, and edit all AI outputs.
- Do not submit unedited AI-generated work.
- Do not input personal, sensitive, or confidential data into GAI tools.

Student Declaration

Project/Assignment title: UNSTITCHED: Rethinking How Environmental Impact Is Measured in Early-Stage Fashion Ventures

Did you use GAI tools for this work? ☒ Yes ☐ No

If Yes, complete the items below.

a) Tools used

List the tools and versions (e.g., "ChatGPT, Claude, DeepL"):

- ChatGPT
- Claude
- Anara

b) What you used them for (check all that apply)

☒ Brainstorming / idea generation
☒ Planning / structuring
☒ Language editing (grammar/clarity)
☐ Translation (non-sensitive content)
☒ Outline drafting
☐ Other (specify): ___________________________________

c) How you used the tools (be specific)

Describe prompts, steps taken, and how you revised the outputs:

During the early conceptualisation phase, I used ChatGPT to support my initial brainstorming. I provided specific topic areas of interest and prompted the tool to identify relevant existing literature and highlight potential research gaps. I also consulted it during the feasibility assessment stage, where I asked questions about possible methodological approaches to help me evaluate which research direction best suited the scope and timeframe of this thesis. I treated this as an exploratory exercise only, it did not replace my own critical evaluation of sources or my independent methodological decisions. I also used ChatGPT on occasion to obtain simplified explanations on technical concepts, particularly around indicator frameworks and measurement terminologies so I have some basic understanding before engaging with the primary academic literature.

Also, I used Claude to improve the grammar and clarity of my writing. My consistent approach was to draft each section fully on my own first, then submit the text to Claude with a prompt to improve grammar and readability. I carefully reviewed every suggested revision and only accepted changes that accurately preserved my intended meaning. The intellectual content, argumentation, and analytical judgements throughout this thesis are entirely my own.

I used Anara as a reading assistance and document management tool during the literature review phase. I used it to generate summaries of individual papers, ask specific comprehension questions about their content, and organise my annotations and highlights. This helped me engage more efficiently with a large body of literature. However, I drew all interpretations and arguments from these sources myself.

d) Your own contributions

What parts are entirely your original work?

This entire thesis is my original work. I developed the research question, theoretical framing, critical analysis, argumentation, and conclusions independently. I used AI tools only as auxiliary aids to support efficiency in comprehension, organisation, and language refinement. They did not generate or shape the intellectual content of this thesis in any way. I made all analytical and interpretive judgements myself and take full responsibility for the content presented herein.

e) Verification and editing

How did you verify accuracy and edit AI output?

I reviewed all grammar suggestions from Claude sentence by sentence against my original draft to ensure no unintended changes in meaning, emphasis, or academic tone were introduced. Where I accepted a suggestion, I edited it further as needed to maintain alignment with my intended argument.

For literature and citations, I verified accuracy by cross-referencing all cited materials directly against the original sources. I maintained downloaded, annotated copies of the key papers throughout the research process and checked all citation details, including author names, publication years, and source content, against these documents rather than relying on AI-generated summaries.

Student signature: ____________________ Date: 01/06/2026