

Supply Chains as Instruments of Nutritional Justice: Sustainable Supply Chain Management, Hidden Hunger, and the Imperative of Accelerated SDG 12.3 Delivery in Developing Economies

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ABSTRACT

Hidden hunger, the clinically silent yet epidemiologically catastrophic deficiency of essential micronutrients, afflicts an estimated two billion people globally, with sub-Saharan Africa and other developing regions bearing a disproportionate burden. This article advances the argument that sustainable supply chain management (SSCM), as both a theoretical construct and an operational discipline, constitutes an underutilised yet structurally decisive lever for ameliorating micronutrient deficiency. Grounded in stakeholder theory, legitimacy theory, and the triple bottom line (TBL) framework, each explicitly deployed in both the conceptual and empirical sections of this article, this paper critically examines the architecture of food supply chains in developing economies, interrogating how systemic inefficiencies compound nutritional deprivation. The paper advances the argument that accelerated delivery of UN SDG Target 12.3 constitutes a first-order nutritional health intervention, not merely a waste-management prerogative.

Using South Africa as the primary case context, with comparative analysis extending to the African diaspora in high-income host nations and to successful cold-chain governance models in Kenya and Rwanda, the article proposes an integrated policy architecture. Critically, this revised analysis incorporates the gender dimensions of supply-chain nutritional failure, the political economy of smallholder integration, food sovereignty as a rights-based governance framework, and concrete monitoring and evaluation mechanisms. The article concludes that unless the SDG 12.3 delivery timeline is treated as a mandatory structural intervention, backed by binding legislation, gender-responsive policy design, and a transnational governance architecture, the intergenerational consequences for human capital, economic productivity, and public health across the Global South will be severe and irrecoverable.

Keywords: sustainable supply chain management (SSCM), hidden hunger, micronutrient deficiency, SDG 12.3, food loss and waste (FLW), developing economies, South Africa, nutritional justice, gender-responsive supply chains, food sovereignty, smallholder integration, African diaspora, post-harvest loss.

INTRODUCTION

The Invisible Crisis and the Supply Chain Imperative:

There is a paradox at the heart of global food systems: the world produces enough calories to feed its entire population, yet more than two billion people remain chronically deficient in the vitamins and minerals essential for cognitive development, immune function, reproductive health, and productive longevity (Black et al., 2013; Kumar et al., 2023). This condition, commonly known as "hidden hunger", is insidious because it does not announce itself through the visible spectacle of emaciation and stunting (Scott-Smith, 2020). Instead, it silently erodes human capital, diminishes economic productivity, and perpetuates cycles of poverty across generations (Pinstrup-Andersen, 2007; Bhutta et al., 2013). The global economy loses an estimated US\$1 trillion annually in productivity attributable to undernutrition and micronutrient deficiencies (Sakai, 2026),

while the World Bank has quantified human capital losses at US\$ 21 trillion when broader nutritional inadequacy is taken into account (IFPRI, 2025).

Sub-Saharan Africa is at the epicentre of this crisis. As of 2024, an estimated 307 million people on the African continent, more than 20 per cent of its population, experienced hunger, an increase of 113 million since the adoption of the 2030 Agenda for Sustainable Development in 2015 (FAO et al., 2025). The African Regional Overview of Food Security and Nutrition (FAO et al., 2023) further reveals that approximately 78 per cent of Africa's population were unable to afford a healthy diet in 2021, compared with 42 per cent globally. These are not marginal statistics. They represent a structural indictment of the food systems architecture through which nutrients, or more precisely, their absence, travel from soil to cell.

Sustainable supply chain management (SSCM) has emerged as a significant domain of scholarly and practitioner inquiry over the past two decades, evolving from its roots in environmental management and corporate social responsibility into a multidimensional framework that integrates the ecological, social, and economic pillars articulated in Elkington's (1997) triple bottom line. Carter and Rogers (2008) formalised this integration within SCM theory, establishing that truly sustainable supply chains must balance economic performance with environmental stewardship and social equity. Yet the application of SSCM frameworks to the specific problem of nutritional outcomes, particularly hidden hunger, remains underdeveloped in the literature. The dominant scholarly conversation around SSCM in developing economies has centred on environmental compliance and labour standards, while the nutritional consequences of supply chain design choices have received scant systematic attention (Sheahan & Barrett, 2017; Munuhwa, 2024).

This article seeks to address that gap with analytical rigour and policy urgency. It argues that SDG Target 12.3, the commitment to halve per capita food waste at retail and consumer levels and reduce food losses along production and supply chains by 2030, is not merely a waste-management objective. When properly understood, it is a first-order nutritional health intervention. Accelerating the delivery of SDG 12.3 therefore involves intervening directly in the causal chain of micronutrient deficiency. This article develops that argument systematically, grounds it in South Africa's specific policy landscape, extends its analysis to the African diaspora in high-income countries and to comparative governance models, and concludes with a policy framework designed for institutional adoption at the national, continental, and transnational levels.

Conceptual Framework: SSCM, Legitimacy Theory, Stakeholder Theory, and Nutritional Equity

The theoretical architecture of this article draws on three interrelated frameworks: the triple bottom line (Elkington, 1997), stakeholder theory (Freeman et al., 2010), and legitimacy theory (Suchman, 1995). The article's critical methodological commitment is to deploy these frameworks not merely as background orientation but as analytical lenses, applied explicitly throughout the empirical sections. This section sets out their content and logic; subsequent sections apply them systematically.

Elkington's (1997) triple bottom line, encompassing economic, social, and environmental dimensions, was most comprehensively operationalised within supply chain theory by Carter and Rogers (2008), who argued for an integrated model in which sustainability is a strategic configuration. Applied to food supply chains, the TBL requires evaluation not only of financial efficiency or carbon intensity but also of nutritional output for vulnerable populations. Extending the TBL into a "nutritional bottom line" is analytically novel and practically necessary: supply chains that are financially profitable and environmentally compliant yet nutritionally depleting cannot be genuinely sustainable in any meaningful sense (Gómez & Ricketts, 2013; Munuhwa, 2024). This nutritional bottom line, which measures the micronutrient impact of supply chain design choices, will be applied specifically to South Africa's cold chain failures and smallholder exclusion patterns in Sections 3 and 5.

Stakeholder theory, as articulated by Freeman et al. (2010), places organisations within a web of relationships that generate obligations beyond those owed to shareholders. In the food supply chain, consumers, particularly those in low-income communities with limited market power, constitute a stakeholder group whose nutritional interests are structurally subordinated to the preferences of commercially dominant actors (Tuomala and Grant, 2022). As Suchman (1995) argues, legitimacy theory explains why supply chain actors are unlikely to address

this failure voluntarily: legitimacy is secured through conformity to prevailing social norms, and in markets where micronutrient deficiency is normalised, as in South Africa's townships and in African diaspora communities in Europe, there is no legitimacy penalty for nutritionally inadequate supply chains. Section 5 applies this logic to explain why South Africa's voluntary agreement model has attracted only 100 signatories in five years: absent a legitimacy penalty, the supply chain system has no structural incentive to reform.

These frameworks converge on a critical insight: the nutritional failure of supply chains in developing economies is not an accident of market dynamics but a structured outcome of institutional misalignment. Correcting it requires governance-level intervention, regulatory mandates, public procurement criteria, and fiscal incentive architectures that sufficiently alter the legitimacy landscape to make nutritional outcomes a core supply chain performance metric. Accelerated SDG 12.3 delivery is one such intervention mechanism, and food sovereignty, the right of peoples to define their own food and agricultural systems (Sampson, Cely-Santos, Gemmill-Herren, Babin, Bernhart, Bezner, Kerr, Blesh, Bowness, Feldman, Gonçalves, James, Kerksen, Klassen, Wezel & Wittman, 2021; Canfield, 2022), provides the rights-based governance framework through which the nutritional bottom line can be institutionalised.

The Architecture of Loss

How Supply Chain Failures Compound Hidden Hunger

Sub-Saharan Africa records the highest food loss rate of any global region: 23.0 per cent as of 2023, up from 22.1 per cent in 2015, the baseline year for SDG monitoring (FAO, 2026). This trajectory runs counter to what SDG 12.3 demands. More critically, losses are concentrated in the food categories most nutritionally consequential for micronutrient deficiency: fruits and vegetables (25.4 per cent loss globally in 2023), animal proteins, and roots and tubers, the dietary sources of vitamins A, C, and B-complex, iron, zinc, iodine, and folate, whose deficiency defines hidden hunger (Black et al., 2013; Kumar et al., 2023). From a nutritional bottom-line lens, these losses are not simply waste statistics; they are quantified withdrawals from the dietary micronutrient supply of the world's most nutritionally vulnerable populations.

The structural drivers of post-harvest loss in sub-Saharan Africa are well documented and mutually reinforcing. FAO (2019) identifies the absence of reliable cold chain infrastructure as a primary cause of loss for perishable products, estimating losses of 25 to 30 per cent for animal products and 40 to 50 per cent for roots, tubers, fruits, and vegetables. In sub-Saharan Africa, where over 60 per cent of the population are smallholder farmers, inadequate cold chain facilities significantly compound these losses (García, Giraldo, & Vilardell, 2024). A 2 per cent farm-level loss of sweet potato production in Nigeria represents the destruction of approximately 59.34 billion kilocalories, food that could have sustained 65,000 individuals for a full year (Khan, Siddiqui, Siddique, Bobo, & Ali, 2024).

Stathers et al. (2020) established that post-harvest losses in sub-Saharan Africa disproportionately affect nutrient-dense commodities. Elolu et al. (2023) demonstrated that African indigenous vegetables, among the most micronutrient-dense foods available to poor rural consumers, incur post-harvest losses of up to 50 per cent across their value chains, largely due to inadequate storage, handling, and market-linkage infrastructure. A 2025 *Frontiers in Public Health* study confirmed that sub-Saharan Africa loses up to 50 per cent of fruits and vegetables annually, with most losses (approximately 90 per cent) occurring along the food value chain rather than at the farm gate, implicating supply chain design directly (Twum-Dei, Lutterodt, Annan, & Aduku, 2025).

James, James & Purnell (2024) found that optimising cold chain utilisation could prevent more than 700 million metric tonnes of CO₂-equivalent emissions annually in sub-Saharan Africa, while simultaneously reducing the physical loss of nutrient-dense commodities at scale. Furthermore, IOP Sciences modelling demonstrated that localised, farm-to-table supply chains, in which market distances are shortened and intermediary nodes reduced, could save more micronutrient-dense food than cold chain optimisation alone (James et al., 2024). This finding has direct policy implications: supply chain redesign constitutes a nutritional intervention, not merely a logistical improvement. The World Bank (2025) estimates that transport inefficiencies account for up to 30 per cent of the final cost of goods in sub-Saharan Africa, making nutritious foods unaffordable for millions of low-income families, even where physical food loss is contained. This cost-

access nexus is a direct manifestation of the stakeholder theory failure identified in Section 2: the commercial interests of supply chain intermediaries are prioritised over low-income consumers' nutritional access, whose market power is insufficient to discipline the system.

SDG 12.3: From Waste Reduction Mandate to Nutritional Intervention

SDG Target 12.3, adopted as part of the 2030 Agenda for Sustainable Development in September 2015, commits member states to halving per capita global food waste at the retail and consumer levels and to reducing food losses along production and supply chains, including post-harvest losses, by 2030 (United Nations, 2015). The target is monitored through Indicator 12.3.1(a), the Food Loss Index measured by FAO, and Indicator 12.3.1(b), the Food Waste Index measured by UNEP (UNEP, 2025).

The 2025 Progress Report of Champions 12.3 delivers a damning assessment: global progress towards SDG 12.3 has been insufficient, with sub-Saharan Africa's food loss rates increasing rather than declining since the 2015 baseline (Champions 12.3, 2025). The FAO (2026) confirms that the global food loss rate in 2023 stood at 13.3 per cent, marginally above the 2015 baseline, with sub-Saharan Africa remaining the highest-loss region at 23.0 per cent. The Champions 12.3 Report further notes that countries including Chile, Colombia, the UK, Japan, and Spain have begun incorporating food loss and waste reduction into their revised Nationally Determined Contributions, while the African Union and European Union have demonstrated how regional bodies can motivate member-state action (Champions 12.3, 2025). South Africa has yet to achieve either milestone.

The argument advanced here goes beyond prevailing discourse: accelerating SDG 12.3 delivery is not merely compatible with addressing hidden hunger in developing economies; it is one of the most structurally powerful mechanisms available for doing so. The foods most at risk of loss, namely fruits, vegetables, legumes, and animal proteins, are precisely the foods whose absence from diets drives iron, zinc, vitamin A, folate, and iodine deficiency. Martin and Vos (2024) concluded that the desired food system transformation remains achievable but requires policy ambition and investment substantially beyond current trajectories. IFPRI (2025) identified nutrition-sensitive food systems governance as a critical accelerator, noting that the world loses an estimated \$21 trillion in human capital productivity due to inadequate nutrition.

The reframing proposed here, treating SDG 12.3 as a nutritional health intervention, requires implementation strategies to embed nutritional outcome indicators alongside the Food Loss Index and Food Waste Index as standard monitoring metrics. Food system monitoring that captures only caloric or monetary loss systematically underestimates the public health stakes of supply chain failure. A Food Loss Nutritional Impact Index (FLNII), which weights commodity losses by their micronutrient density and the nutritional vulnerability of proximate populations, would provide a more accurate picture of the true cost of SDG 12.3 non-delivery. This is not a data aspiration; it is a governance requirement for informed policy design.

South Africa: A Case Study in Structural Nutritional Failure, Policy Ambivalence, and Legitimacy Collapse

South Africa is a particularly instructive case study because it is both a major food producer and a country where hidden hunger is a pervasive and worsening public health crisis. The government's National Food and Nutrition Security Plan (NFNSP) acknowledged that the country has undergone a nutritional transition characterised by the triple burden of malnutrition: concurrent undernutrition, hidden hunger, and overweight/obesity resulting from the consumption of nutrient-poor diets (Republic of South Africa, 2018).

Applying legitimacy theory to South Africa's supply chain governance failures is analytically illuminating. Suchman's (1995) framework distinguishes between pragmatic, moral, and cognitive legitimacy. In South Africa's food supply chain, cognitive legitimacy, the taken-for-granted normalisation of existing arrangements, explains the persistence of nutritionally inadequate supply chains despite widespread knowledge of their consequences. When micronutrient deficiency is structurally normalised, embedded in dietary patterns, retail pricing structures, and spatial configurations of food access, it becomes invisible as a governance failure. The IDS (2022) documented this dynamic precisely: the NFNSP had not been funded and had failed to convene its

multi-sectoral Council by mid-2022, despite nominal political commitment. This is not merely a resource failure; it reflects the absence of a legitimacy penalty for non-implementation.

Applying stakeholder theory further reveals the power asymmetries that sustain this failure. The formal South African food retail supply chain, dominated by large supermarket chains with limited presence in townships and rural areas, serves the nutritional interests of middle- and upper-income consumers who have sufficient market power to demand product quality. Spaza shops, which are the primary food access point for millions of township residents, are structurally excluded from formal supply chain systems and consequently stock the cheapest, most nutritionally depleted products (Tuomala & Grant, 2022). Low-income consumers, the stakeholder group most nutritionally vulnerable, lack the purchasing power, geographic access, and collective voice to discipline the supply chain system. This is a first-order failure of stakeholder theory: the interests of the most affected stakeholders are systematically excluded from supply chain governance.

South Africa's Draft Strategy for Reducing Food Losses and Waste (DFFE, 2023), which aligns with SDG 12.3 and has attracted 67 core and 33 associate signatories to its voluntary agreement, represents a more operationally grounded intervention. However, the critical weakness is precisely what this article identifies as the dominant gap in the global SDG 12.3 discourse: the absence of an explicit nutritional health objective embedded within the food loss and waste reduction mandate. The strategy treats food loss and waste as a sustainability and circular economy problem, not a nutritional health intervention. Yet the food lost along South African supply chains, including fresh produce, protein-rich foods, and nutrient-dense smallholder crops, is disproportionately drawn from the dietary categories that drive the micronutrient deficiencies observed in the NFNSP's epidemiological data.

The limitations of the voluntary agreement model are therefore substantively significant, particularly when food loss and waste (FLW) is treated not merely as an environmental problem but as a food-security, nutritional and public-policy challenge. South Africa's Food Loss and Waste Voluntary Agreement (FLWA) was established in 2020 as a collaborative initiative involving the Consumer Goods Council of South Africa (CGCSA), government and other stakeholders, with the objective of supporting Sustainable Development Goal (SDG) 12.3 and achieving a 50 per cent reduction in food loss and waste by 2030 (Department of Forestry, Fisheries and the Environment (DFFE), 2020; United Nations, 2015). The initiative represents an important form of collaborative governance because it creates a platform through which firms can measure waste, share knowledge, develop interventions and collectively address a problem that spans the food supply chain. Indeed, the initiative has subsequently developed standardised measurement and reporting mechanisms, and the number of participating organisations has increased substantially since its establishment (Consumer Goods Council of South Africa (CGCSA), 2025). Nevertheless, participation and institutional activity should not automatically be equated with sufficient behavioural change or with achieving the national reduction target.

From a legitimacy theory perspective, organisations are motivated to align their activities with prevailing societal expectations because their continued legitimacy depends, at least in part, on maintaining acceptance from key stakeholders (Suchman, 1995). Voluntary sustainability commitments can therefore be understood as mechanisms through which organisations demonstrate conformity with socially desirable norms. In this respect, participation in the South African FLWA can generate reputational benefits by signalling that a firm recognises the environmental, social and food-security consequences of FLW and is willing to take corrective

action. Such mechanisms are not insignificant. Voluntary programmes can raise awareness, facilitate collective learning, establish measurement practices and encourage firms to move beyond compliance with existing legal requirements (de Vries et al., 2012). They may also be particularly useful in the early stages of policy development, when governments and industry are still developing common definitions, measurement methodologies and practical interventions.

The central limitation, however, is that legitimacy-based motivation depends on the strength of the institutional and reputational pressures surrounding the issue. Where stakeholders can observe, evaluate and sanction corporate behaviour, reputational legitimacy can become a meaningful behavioural constraint. Where non-compliance is difficult to observe, difficult to attribute and unlikely to generate an immediate reputational cost, the incentive to incur the financial and operational costs associated with substantive change becomes

considerably weaker (Suchman, 1995). This distinction is particularly important in relation to FLW. Unlike visible environmental pollution or a product-safety failure, much food waste occurs within complex supply-chain processes involving forecasting, procurement, production planning, inventory management, cold-chain performance, distribution, retail operations and consumer behaviour. The resulting social and nutritional costs are consequently distributed across society rather than borne exclusively by the organisation generating the waste.

This creates a classic collective-action problem. An individual organisation may incur high costs to reduce FLW, for example, through improved forecasting systems, inventory controls, cold-chain investment, packaging redesign, supplier collaboration, redistribution infrastructure and enhanced data collection, while a substantial proportion of the benefits accrues to society through improved resource efficiency, reduced environmental impacts and greater availability of edible food. In economic terms, this creates an incentive for free-riding: organisations can benefit from sector-wide improvements without necessarily bearing the full cost of generating them (de Vries et al., 2012). Voluntary agreements are particularly vulnerable to this problem because participation and implementation are not necessarily synonymous.

The South African experience illustrates this distinction. The FLWA has achieved considerable growth in participation: the initiative reports that its signatory base increased from 16 organisations in 2020 to 135 in 2025, with the 2024 core signatory base representing approximately 44 per cent of the formal food value chain (CGCSA, 2025). However, a sizeable signatory base, in itself, does not demonstrate that the national food system is on the required trajectory of reduction. Earlier government documentation recorded 67 core and 33 associate signatories as of November 2022, while more recent initiative reporting indicates that only a subset of participating organisations has been contributing data and strategic action plans (DFFE, 2023; CGCSA, 2025). This is an important analytical distinction: the breadth of commitment is an input into governance; measurable reduction in FLW is the desired outcome.

The problem becomes even more consequential when FLW is linked to nutrition and food security. South Africa is characterised by the simultaneous presence of substantial food waste and significant food insecurity. The CGCSA estimates that approximately 10.3 million tonnes of food and beverages are wasted annually, while millions of South Africans experience food insecurity (CGCSA, 2025). Consequently, food waste is not simply a matter of inefficient resource utilisation. It represents the destruction of food that has already consumed land, water, energy, labour, capital and other resources throughout the supply chain. When edible, nutritionally valuable food is lost, the opportunity cost extends beyond economic value to include the nutritional value that could have contributed to food and nutrition security (UNEP, 2024). This makes the governance of FLW particularly important within the broader sustainable supply chain management agenda.

The legitimacy argument is therefore particularly relevant because the nutritional consequences of supply-chain failure are largely diffuse, delayed and relatively invisible. A consumer may observe an empty supermarket shelf or a food-safety incident, but is unlikely to observe the nutritional value lost due to cumulative forecasting errors, rejected produce, overproduction, short shelf life, damaged packaging, inventory obsolescence, or upstream distribution inefficiencies. Nor is it straightforward to attribute a specific nutritional deprivation to a particular instance of supply-chain waste. The absence of direct attribution weakens the reputational mechanism on which purely voluntary governance depends. Where the social harm cannot easily be traced to an individual corporate actor, the reputational penalty associated with inaction may be insufficient to induce the level of investment and organisational transformation required.

Empirical research on voluntary environmental agreements reinforces this concern. Although voluntary agreements can yield positive outcomes under certain institutional conditions, their effectiveness depends substantially on programme design, participation incentives, monitoring, and the presence of credible external pressures (de Vries et al., 2012). Earlier empirical work also shows that voluntary initiatives can elicit varying levels of substantive commitment among participating firms, and that the absence of sanctioning mechanisms can limit their ability to deliver consistent environmental improvements across an entire sector (Delmas & Montes-Sancho, 2010). In other words, voluntary participation should not be taken as evidence that all participants face equivalent incentives to implement substantive change.

This does not mean that voluntary agreements are inherently ineffective. Rather, their effectiveness is conditional. Voluntary arrangements are more likely to yield meaningful outcomes when they operate alongside credible regulatory institutions, transparent measurement and reporting requirements, stakeholder scrutiny, and incentives for superior performance. Research on voluntary environmental programmes, for example, has shown that firms may respond positively when voluntary participation is linked to regulatory incentives or credible enforcement structures (Innes & Sam, 2008). Conversely, voluntary regulation can struggle where institutional capacity is weak or where firms have limited incentives to make costly investments without corresponding external pressure (Blackman & Sisto, 2006).

The South African policy trajectory increasingly recognises that voluntary action needs to be situated within a broader governance architecture. The country's 2025-2030 Strategy for Reducing Food Losses and Waste identifies the CGCSA-led voluntary agreement as one component of a wider national response and places FLW reduction within the context of resource efficiency, circular-economy approaches, food security and environmental protection (Republic of South Africa, 2025). This suggests that the policy question should not be framed as a binary choice between voluntary agreements and regulation. Rather, voluntary agreements can provide the collaborative infrastructure, industry knowledge, measurement capability and experimentation necessary for implementation, while regulation can set minimum expectations, reporting obligations and consequences for persistent non-performance.

Accordingly, the principal weakness of the voluntary agreement model is not that voluntary participation lacks value, but that voluntarism alone provides an insufficient accountability mechanism for a systemic problem with significant externalities. A governance system that depends primarily on corporate goodwill assumes that reputational incentives will be strong enough to outweigh the private costs of changing established supply-chain practices. Legitimacy theory suggests that this assumption weakens when societal expectations are poorly institutionalised, stakeholder monitoring is limited, and the consequences of non-compliance are diffuse or difficult to observe (Suchman, 1995). In the South African FLW context, these conditions are particularly important because the environmental, economic and nutritional consequences of waste are distributed throughout the food system rather than immediately visible at the point of corporate decision-making.

The implication is that South Africa requires a hybrid governance model that retains voluntary collaboration but embeds it within progressively stronger regulatory accountability. Voluntary agreements can remain valuable as mechanisms for innovation, industry collaboration, knowledge sharing, capacity development and early adoption. However, measurable targets, standardised reporting, independent verification, transparent disclosure, and enforceable minimum requirements are necessary for voluntary commitments to translate into system-wide outcomes. Such an approach would shift FLW governance from a model based predominantly on commitment towards one grounded in commitment, measurement, accountability and consequence.

The theoretical contribution of this argument is that legitimacy should not be conceptualised solely as a reputational incentive for firms to participate in voluntary sustainability initiatives. Legitimacy can also be institutionalised through public policy, mandatory disclosure and regulatory enforcement. When voluntary mechanisms generate insufficient pressure for substantive change, regulation can alter the legitimacy environment by making previously discretionary sustainability expectations institutionally obligatory. In this sense, binding regulation does not necessarily replace collaborative governance; rather, it can provide the institutional floor upon which collaborative and voluntary initiatives operate. For FLW, particularly where food waste is conceptualised as an environmental, economic and nutritional sustainability challenge, such a hybrid approach offers a more credible pathway towards achieving SDG 12.3 than reliance on voluntary commitment alone (United Nations, 2015; UNEP, 2024).

The South African case therefore offers a critical governance lesson: the growth in voluntary participation signals greater institutional recognition of the FLW problem, but it is not evidence of sufficient system transformation. The progression from 16 signatories at inception to 135 in 2025 shows that the issue has gained legitimacy within the formal food value chain; however, the ultimate test of legitimacy-based governance is not whether organisations publicly associate themselves with the desired norm, but whether their operational practices deliver measurable reductions in food loss and waste. The gap between symbolic

commitment and substantive performance is therefore where the case for stronger accountability becomes most compelling (Delmas & Montes-Sancho, 2010; Suchman, 1995).

The Gender Dimension: Women, Post-Harvest Loss, and the Hidden Hunger Burden

A significant omission in the SSCM and SDG 12.3 literature, and in the initial framing of this article, is the gender dimension of supply chain nutritional failure. This gap has material consequences: the nutritional vulnerability of women is both a cause and a consequence of supply chain failures in developing economies, and gender-blind supply chain policy systematically misallocates interventions.

In sub-Saharan Africa's agrifood systems, women constitute approximately 70 per cent of the agricultural workforce, providing most of the labour for planting, weeding, harvesting, and post-harvest handling (USAID, 2024; FAO, 2023). Despite this, 64.2 per cent of women in sub-Saharan Africa experienced moderate or severe food insecurity in 2024, compared with 62.7 per cent of men, representing 11.2 million more women affected than men (FAO, 2026). This disparity is not incidental; it reflects women's limited access to productive resources, market information, and cold chain infrastructure, precisely at the supply chain stages where they are most active.

Twum-Dei et al. (2025) documented the direct relationship between post-harvest losses of fruits and vegetables and the nutritional status of women and children, the two population groups most vulnerable to hidden hunger. The study confirmed that income losses from post-harvest losses fall disproportionately on smallholder women, with at least 15 per cent of income lost reported across an estimated 470 million smallholder farmers and value chain actors globally, the majority of whom are women in sub-Saharan Africa. This creates a compounding vulnerability: the same supply chain failures that destroy nutrient-dense foods also destroy the income women use to purchase those foods for household consumption.

The gender productivity gap in African agriculture, estimated at between 6 and 66 per cent, depending on country and commodity, and generating losses ranging from \$100 million in Malawi to \$2.3 billion in Nigeria (Brixi & van Nieuwkoop, 2024), is largely attributable to women's limited access to post-harvest technology, cold chain infrastructure, finance, and market information. A Malabo Montpellier Panel (MAMO Panel) (2023) report found that women's inability to access finance is projected to reduce Africa's GDP by US\$316 billion by 2025, while unequal access to land, finance, and information curbs women's agency in food system transformation. FAO (2022) estimated that closing the gender gap in farm productivity and wages alone could reduce the number of food-insecure people globally by 45 million.

Gender-responsive supply chain policy must therefore address the specific vulnerabilities women face in post-harvest management, including targeted training programmes in hermetic storage, solar-powered cold rooms, and digital market linkage systems; preferential procurement for women-led smallholder enterprises within public food procurement frameworks; gender-disaggregated monitoring of supply chain nutritional outcomes; and the inclusion of women's organisations in national food loss and waste governance structures. The South African NFNSP's silence on gender-differentiated supply chain interventions represents a significant policy gap that the revised Draft Strategy for Reducing Food Losses and Waste (DFFE, 2023) must explicitly address.

The Smallholder Integration Challenge: Political Economy and Inclusion Limits

The structural exclusion of smallholder producers from formal supply chains in developing economies concentrates the highest post-harvest loss rates at the production stage. However, the recommendation for "mandatory inclusive sourcing standards" requires critical engagement with the political economy of smallholder integration, including the risks of elite capture, the tensions between inclusion and efficiency, and the limitations of market-based approaches.

The literature on contract farming, the dominant commercial mechanism for smallholder integration, reveals mixed outcomes. While Lashitew, Methvin & Surmeir (2024) documented successful examples of large food and beverage companies integrating smallholder farmers through contract farming arrangements in Africa, including Heineken's malt barley sourcing in Ethiopia, the empirical evidence on inclusiveness remains contested. Research on the political economy of contract farming consistently finds that contracting firms

prefer larger, better-resourced growers who can meet quality and volume specifications, and that true smallholder inclusion depends critically on firms' capacity and commitment to design contracts with embedded support services (Poku et al., cited in Inclusive Agri-Entrepreneurship, 2025).

The risk of elite capture in smallholder integration programmes, where benefits accrue primarily to better-resourced farmers, farmer organisation leaders, or local political intermediaries, is well documented in the development literature. Kilelu et al. (2024), studying cold chain investment and smallholder integration in Kenya's Kiambu County horticultural value chains, found that formal supply chain integration tends to benefit farmers already connected to organised market systems, while the most food-insecure smallholders, frequently women, elderly farmers, and geographically remote producers, remain structurally excluded even when integration programmes are nominally inclusive.

Alternative approaches to smallholder integration offer partial solutions to these limitations. Producer cooperatives, collective marketing arrangements, and public procurement programmes that prioritise smallholder sourcing are more inclusive than contract farming models reliant on bilateral firm-farmer relationships (FAO, 2025). The SPOKE Programme and the Africa Centre of Excellence for Sustainable Cooling and Cold-Chain's community-level cold chain initiative in Kenya and Rwanda demonstrate that cooperative cold chain access, structured as a viable business rather than a grant-dependent project, can expand participation among smallholder farmers while achieving measurable reductions in post-harvest losses (Nkurunziza, 2026). In Lari, Kenya, farm-gate prices rose by more than 50 per cent, and post-harvest losses fell to single digits within one year of SPOKE implementation, with cooperative membership expanding from 20 to 240 farmers. This model, community-owned cold chain infrastructure financed as a blended investment, is the governance architecture that South Africa's smallholder integration strategy requires.

As reviewed by DeSilva, Jayamaha and Garnevska (2026), supply chain capability building must address farmer segmentation by capability, asset base, gender, and geography, rather than treating smallholders as a homogeneous category. The IFC (2023) Working with Smallholders handbook provides a governance framework for responsible contract farming that explicitly addresses the tensions between inclusion and efficiency. South Africa's Preferential Procurement framework should extend these principles by mandating that food sector companies demonstrate measurable smallholder inclusion, not merely sourcing volume targets, as a B-BBEE compliance criterion, with independent verification of post-harvest loss reduction outcomes.

The African Diaspora Dimension: Nutritional Continuity and Transnational Governance

The analysis of hidden hunger in developing economies has conventionally treated micronutrient deficiency as a domestic phenomenon, a condition of origin countries, rather than as a transnational challenge that travels with people across borders. The African diaspora in high-income countries comprises tens of millions who carry both the biological legacy of micronutrient deficiency and the structural vulnerability of navigating unfamiliar food systems, in which culturally appropriate, nutritionally adequate food is often inaccessible or unaffordable.

The literature on dietary acculturation among sub-Saharan African immigrants in high-income countries documents a consistent pattern: upon migration, African immigrants experience a dietary transition away from traditional, nutrient-dense foods towards cheaper, more readily available processed foods (Omache, Miltenburg, & Neufeld, 2025). Ngongalah et al. (2023) documented that cultural food practices among pregnant and postnatal African migrant women in the United Kingdom are systematically unsupported by host country health and food systems. The Cambridge Nutrition Society analysis (2022) confirmed that shifting food environments have direct implications for non-communicable disease risk among African migrants, including anaemia, type 2 diabetes, and hypertension, all of which are mediated by micronutrient deficiency.

Frontiers in Nutrition (2025) identified micronutrient inadequacy as a significant yet under-recognised issue in Europe, with immigrants among the most vulnerable subgroups. The ScienceDirect (2025) study of migrant children in Europe documented the triple burden of malnutrition among refugee and asylum-seeking children, confirming that 80 per cent of the world's displaced people originate from locations experiencing acute malnutrition or food insecurity. The concept of "nutritional continuity", the persistence of micronutrient

deficiency across migration, mediated by supply chain structures in both origin and host countries, offers a productive framework for understanding these patterns. Food sovereignty theory provides the rights-based language to demand that the nutritional interests of diaspora communities be structurally accommodated within food system governance in both origin and host countries (Sampson et al., 2021; Canfield, 2022).

The supply chain barriers facing African diaspora communities in high-income host countries include the exclusion of ethnic food suppliers from formal distribution networks, the concentration of ethnic food retail in marginalised communities with limited logistics infrastructure and import restrictions on micronutrient-dense traditional African foodstuffs. These barriers are structurally analogous to the smallholder exclusion patterns documented in South Africa: in both cases, the food supply chain serves the nutritional interests of commercially dominant consumers while structurally excluding the nutritionally most vulnerable. A transnational nutritional equity framework, embedded within the AfCFTA food systems governance architecture and bilateral agricultural trade agreements, would address these barriers simultaneously from the origin and host-country ends.

Specific data on the prevalence of hidden hunger among African diaspora populations in Europe and North America remain limited, representing a research gap that this article explicitly identifies. What is documented is the supply chain-mediated nutritional vulnerability: when ethnic food suppliers, who typically source directly from producers in the country of origin and deliver micronutrient-dense traditional foods to diaspora communities, are excluded from formal distribution networks, the result is higher prices, lower availability, and lower quality of traditional foods that are substantially micronutrient-dense. Addressing this requires host-country mandates to include ethnic suppliers in formal supply chain systems and a supply chain equity measure with directly measurable nutritional consequences.

Pathways to Acceleration: SSCM as a Nutritional Policy Instrument

Embedding a Nutritional Mandate in SDG 12.3 Implementation Plans

South Africa's Draft Strategy for Reducing Food Losses and Waste (DFFE, 2023) must be revised to include measurable nutritional outcome targets alongside its waste-reduction metrics. The FLNII, which weights food losses by micronutrient density and population nutritional vulnerability, should be adopted as a standard monitoring metric across all national SDG 12.3 implementation plans in the African Union. Champions 12.3 (2025) recommends that countries include food loss and waste reduction in revised Nationally Determined Contributions; this article further recommends that such inclusions be explicitly framed as nutritional health interventions with measurable human capital targets.

Binding Cold Chain Investment Standards with DFI Co-financing: Voluntary cold chain investment has proven insufficient. Kenya's experience is instructive: post-harvest losses of 30 to 40 per cent for cold-chain-dependent products, including mangoes and avocados, persisted despite a cold chain market valued at KES 40 billion in 2023, because investment remained concentrated in export channels rather than in the domestic smallholder supply (Fresh Plaza, 2026; Kilelu et al., 2024). Rwanda's cold chain development, supported by World Bank-FAO co-investment and structured as the Commercialisation and De-risking for Agricultural Transformation Project, demonstrates the required governance mechanism: mandatory investment targets, public co-financing, and independent performance monitoring (World Bank/FAO, 2023). South Africa's IDC and DBSA should establish dedicated cold chain financing windows, with disbursements conditioned on demonstrated reductions in post-harvest losses and monitoring of nutritional outcomes. The ARCH Cold Chain Solutions East Africa Fund, which targets 100,000 tons of cold storage capacity across Kenya, Rwanda, Tanzania, Uganda, and Ethiopia, provides a replicable financing architecture (ALLAFRICA, 2021; GCCA, 2025).

Gender-Responsive Smallholder Integration

Smallholder integration policy must be gender-disaggregated by design. This includes preferential procurement criteria that explicitly prioritise women-led smallholder enterprises; targeted post-harvest management training for women producers, including hermetic storage, solar cold rooms, and digital market linkage systems; support for farmer organisation development that builds women's leadership capacity within

cooperatives; and gender-disaggregated monitoring of post-harvest loss reduction and nutritional outcome metrics. The SPOKE programme's community cold chain model, which has achieved 50 per cent income increases and near-single-digit post-harvest losses in Kenya, should be adapted for South Africa's smallholder contexts in Limpopo, KwaZulu-Natal, and the Eastern Cape, with explicit gender inclusion criteria built into cooperative membership and governance structures.

Food Sovereignty as a Governance Framework for Nutritional Supply Chain Reform

Food sovereignty, the right of peoples to define their own food and agricultural systems (La Via Campesina, 1996; Sampson et al., 2021), provides both the normative foundation and the institutional vocabulary for mandatory nutritional reform in supply chains. Canfield (2022) demonstrated that food sovereignty activists are increasingly leveraging transnational governance frameworks to advance nutritional justice claims. In the South African context, the constitutional right to food, embedded in Section 27 of the Constitution, provides justiciable grounds for mandating that supply chain governance achieve measurable outcomes of nutritional equity. A food sovereignty governance framework would require that South Africa's food loss reduction strategy be developed through the direct participation of food-insecure communities, smallholder producers, women's organisations, and diaspora food networks, rather than solely through formal-sector industry signatories.

Transnational Policy Architecture for Diaspora Nutritional Equity

Addressing the burden of hidden hunger in African diaspora communities requires both bilateral and multilateral policy engagement. Specific measures include: bilateral agricultural trade agreements that reduce import barriers for micronutrient-dense traditional African foods; host-country mandates to include ethnic food suppliers in formal supply chain distribution networks; diaspora remittance facilitation mechanisms that support nutritional food purchases in origin countries; and the integration of diaspora nutritional equity objectives into the AfCFTA food systems governance framework. The Nutrition for Growth Summit in Paris (March 2025) and IFPRI's subsequent research agenda on nutrition-sensitive food systems (IFPRI, 2025) provide a multilateral platform through which transnational commitments to nutritional equity could be formalised.

Monitoring, Evaluation, and Accountability

Supply chain-mediated nutritional outcomes require a dedicated monitoring and evaluation architecture. Specifically, this article proposes: (1) mandatory reporting by food-sector companies on post-harvest losses, disaggregated by commodity type, supply chain stage, and micronutrient density, and incorporated into B-BBEE compliance frameworks; (2) independent regulatory oversight of cold-chain investment compliance, achieved through an expanded mandate for existing bodies such as the Competition Commission and the National Consumer Commission; (3) annual government reporting to Parliament on NFNSP nutritional outcome indicators, including micronutrient deficiency prevalence data disaggregated by province, gender, and income quintile; and (4) integration of the FLNII into the National Treasury's Government-Wide Monitoring and Evaluation Framework, enabling cross-departmental accountability for nutritional supply chain outcomes. Without such architecture, the gap between policy ambition and execution, as documented in the 2023 NFNSP Implementation Evaluation (Parliamentary Monitoring Group, 2025), will persist.

Limitations of the Proposed Approach

Intellectual honesty requires explicit acknowledgement of the limitations of the supply chain reform framework proposed in this article. Supply chain reform alone cannot address all dimensions of hidden hunger. Complementary interventions in dietary behaviour change, social protection systems, primary healthcare nutrition services, and agricultural research and development are also required. The National School Nutrition Programme, cited by Parliamentary Committee members as underfunded in provinces including the Northern Cape (PMG, 2025), is a critical complementary intervention that supply chain reform cannot replace.

The potential unintended consequences of mandatory supply chain regulation warrant attention. Binding cold chain investment standards may inadvertently favour large, capitalised supply chain actors, accelerating the

consolidation of market power in the formal sector and further marginalising informal sector food suppliers and smallholder producers who lack the financial capacity to comply. Regulatory design must therefore be graduated and differentiated: large formal sector actors should be subject to full mandatory standards, with financial and technical support programmes enabling smaller actors to achieve compliance over an extended implementation period.

Finally, the limitations of the available data on supply chain-mediated nutritional outcomes, both in South Africa and in the African diaspora, constrain the precision of the nutritional bottom-line analysis presented in this article. The absence of systematic, disaggregated data on micronutrient losses at each stage of the supply chain and on the prevalence of hidden hunger among diaspora populations represents a research gap that future empirical work must address before the FLNII can be operationalised with the precision required for regulatory application.

Theoretical Contributions and Future Research Agenda

This article makes several contributions to the theoretical and empirical literature. First, it extends the TBL framework, as applied in SSCM, to incorporate a nutritional bottom line, advancing the argument that supply chains cannot be genuinely sustainable in developing-economy contexts unless their nutritional output for low-income populations is explicitly measured and managed. This extension responds to Elkington's (1997) original intent and aligns with the emerging literature on nutrition-sensitive supply chain management (Gómez & Ricketts, 2013).

Second, the article argues that SDG 12.3 constitutes a nutritional health intervention, not merely a waste management objective, when implemented in developing-economy food systems characterised by high post-harvest losses of micronutrient-dense commodities. This reframing has direct implications for how the SDG 12.3 measurement framework is constructed and for how implementation strategies are designed.

Third, the article explicitly integrates legitimacy theory and stakeholder theory throughout the empirical analysis, not merely as background, demonstrating that South Africa's voluntary agreement model is structurally inadequate from a governance-theory perspective and that both frameworks advance the argument for binding regulation as the minimum governance requirement for supply chain nutritional reform.

Fourth, the transnational extension of the hidden hunger analysis to the African diaspora introduces the concept of "nutritional continuity" and frames governance of the diaspora's food supply chain as a legitimate domain of nutritional equity policy. Fifth, the explicit integration of gender dimensions, smallholder political economy, and food sovereignty as a rights-based framework into the SSCM analysis of hidden hunger constitutes a genuinely novel theoretical configuration not previously assembled in the literature.

Future research should pursue: (1) empirical measurement of micronutrient-specific losses at each stage of the supply chain in sub-Saharan Africa, disaggregated by producer gender; (2) experimental evaluation of the nutritional health impact of SDG 12.3-compliant supply chain interventions, including longitudinal tracking of micronutrient deficiency outcomes in communities served by reformed supply chains; (3) comparative governance analysis of binding versus voluntary food loss reduction frameworks across developing-economy contexts; and (4) ethnographic and survey-based research on supply chain-mediated nutritional vulnerabilities of sub-Saharan African diaspora communities in high-income host countries, including specific data on hidden hunger prevalence.

Conflict of interest

The author received no payment or funding for this article.

CONCLUSION

Supply Chains as Instruments of Nutritional Justice

The argument of this article is, finally and essentially, about justice. The hidden hunger that afflicts two billion people is not a natural condition of scarcity; it is a structured outcome of supply chain architectures,

governance failures, and institutional incentives that systematically fail the nutritional interests of the world's poorest people. Applied through the triple bottom line, stakeholder theory, and legitimacy theory, the analysis reveals that these failures are not accidents; they are predictable outcomes of supply chain systems governed by cognitive legitimacy frameworks that normalise micronutrient deficiency and by stakeholder power configurations that exclude the most nutritionally vulnerable from governance.

Sustainable supply chain management provides the conceptual architecture and operational vocabulary for transformation. But theory without governance is aspiration. Accelerating SDG 12.3 delivery through binding national legislation, mandatory cold-chain investment with DFI co-financing, gender-responsive integration of smallholders, food sovereignty governance frameworks, monitoring and evaluation systems with teeth, and a transnational policy architecture for diaspora nutritional equity is the governance intervention that translates aspiration into structural change. Kenya's SPOKE programme and Rwanda's cold chain governance demonstrate that this transformation is achievable within the relevant institutional contexts.

South Africa stands at a consequential inflection point. Its constitutional right to food, NFNSP, Draft Strategy for Reducing Food Losses and Waste, and B-BBEE procurement framework provide a policy foundation that can support genuine transformation. What remains lacking is the political will to fund, mandate, integrate, and monitor these instruments as a coherent nutritional equity framework with enforceable accountability mechanisms. Children who will experience the cognitive consequences of iron and zinc deficiency in 2025 and 2026 cannot wait for the next voluntary agreement cycle. They require supply chain reform that treats hidden hunger as the governance emergency it is, one whose resolution is simultaneously an act of nutritional science, institutional design, and moral reckoning.

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