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SUSTAINABLE AGRICULTURE PRACTICES AND GREEN SKILLS FORMATION: A NARRATIVE REVIEW

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Abstract:

The global transition toward sustainable food systems necessitates a workforce equipped with complex “green skills”, yet agricultural education often remains tethered to traditional productivism paradigms. This narrative review synthesises contemporary literature to elucidate how engagement in sustainable agricultural practices catalyses the development of green skills. By analysing the intersection of vocational training and social science, the study identifies a fundamental conceptual shift: the redefinition of the agriculturist from a mere technician to a systemic “change agent” capable of navigating socio-ecological complexities. Three dominant themes emerge from the analysis: the prioritisation of affective competencies, such as stewardship and agency, over purely technical skills; the finding that skill acquisition is mediated primarily through immersive, participatory pedagogies rather than passive instruction; and the urgent need to dissolve the historical silos separating agricultural production from environmental education. Addressing the observed “novelty plateau” where competency growth stagnates, this review proposes the Integrated Eco-Social Competency (IESC) Framework. This theoretical contribution advocates for redesigning learning environments into “living labs”, offering a strategic roadmap for policymakers to bridge the gap between sustainability mandates and practical curriculum implementation.

Keyword:

Competency-based Education; Green Skills; Participatory Learning; Sustainable Agriculture; TVET



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Introduction

The transition toward sustainable agricultural systems represents one of the defining challenges of the 21st century. As the global community grapples with the converging crises of climate change, soil degradation, and food insecurity, the agricultural sector is under increasing pressure to pivot from productivity, high-input models to multifunctional, regenerative systems (Sangkapitux et al., 2017). This shift is codified in the United Nations Sustainable Development Goals (SDGs), specifically in SDGs 2 (Zero Hunger) and 12 (Responsible Consumption and Production). However, while significant research has focused on the technological hardware of this transition, such as precision farming tools, organic inputs, and agroecological designs, far less attention has been paid to the “software”: the human capital required to drive it. The urgent question facing educators and policymakers is no longer just what technologies are needed but what competencies are required to implement them effectively.

This gap has given rise to the discourse on “Green Skills”. In the context of agriculture, green skills are increasingly recognised not merely as technical abilities, such as calibrating a sprayer or composting organic waste, but as a complex matrix of transversal competencies. These include systems thinking, environmental stewardship, adaptability, and social agency (Nyamweru et al., 2024). The emergence of these skills suggests that the modern agriculturist must evolve from a technician into a “change agent” capable of navigating the socioecological complexities of sustainable food systems. Despite the theoretical recognition of green skills, there is a palpable disconnect in their implementation, particularly within Agricultural Education and Training (AET) and Technical and Vocational Education and Training (TVET). Historically, agricultural curricula have been siloed, focusing heavily on production efficiency while relegating environmental stewardship to a separate, often peripheral, domain (Reilly et al., 2022). This fragmentation has resulted in a workforce that may be technically proficient but lacks the “environmental literacy” and “solidarity” required for genuine sustainability transitions (Mudokwani & Mukute, 2019).

The current literature indicates that the development of these skills is heavily dependent on the pedagogical approach employed. Nyamweru et al. (2025b) demonstrate that passive instruction is insufficient for fostering complex competencies like “facilitator of change” or “auto determination”. Instead, skill acquisition appears to be mediated by active, participatory engagements, such as T-learning within farmer cooperatives participating in Participatory Integrated Planning (PIP) modules in vocational schools. Similarly, interventions in early childhood education, such as school gardens, have been shown to plant the seeds of eco-social resilience (Aragon & Manzano, 2025). However, these findings remain fragmented across disparate disciplines ranging from vocational psychology to rural sociology, preventing a

unified understanding of how sustainable practices specifically catalyse skill formation. While it is known that active learning is beneficial, the specific mechanism by which engagement in Sustainable Agricultural Practices (SAP) translates into competency development remains under-researched. The literature offers isolated examples of organic farming building social values, precision agriculture building digital literacy, but lacks a cohesive narrative connecting the practice (the agricultural method) to the outcome (the green skill). Furthermore, there is a noted discrepancy between policy formulation and ground-level reality, while curriculum frameworks often claim to address sustainability, stakeholders frequently report a lack of genuine integration (Nyamweru et al., 2025a).

Given the interdisciplinary nature of this topic, spanning agronomy, education, and social science, a Systematic Literature Review (SLR) focusing solely on statistical meta-analysis may fail to capture the nuanced, qualitative evolution of competency definitions. A Narrative Literature Review is, therefore, the most appropriate methodology. It allows for a critical synthesis of diverse theoretical perspectives, enabling the construction of a cohesive story about how green skills are conceptualised, taught, and acquired. This format facilitates the identification of patterns across heterogeneous studies, linking the technical requirements of farming with the pedagogical requirements of education. In the context of agriculture, green skills are increasingly recognised not merely as technical abilities, but as a complex matrix of transversal competencies. While Nyamweru et al. (2024) emphasise the transversality of these skills, Pavlova (2023) offers a more granular typology that is critical for this review. She categorises green skills into four distinct domains: cognitive competencies (e.g., systems analysis), interpersonal skills (e.g., negotiation), intra-personal competencies (e.g., adaptability), and technological skills. Crucially, Pavlova (2023) positions “positive attitudes towards sustainability” and “green mindset: as the foundational layer upon which all specific technical skills are built.

However, a significant challenge persists in translating these competencies into practice. Recent studies in the Malaysian context highlight a persistent gap between awareness and action. Punnisah Jothy and Kamisah Osman (2025) reported that while students demonstrate a high level of environmental knowledge, this does not consistently translate into sustainable practices or behaviour. This mirrors findings by Duran Gabela et al. (2022), who identified a significant dissonance between theoretical agricultural knowledge and its practical application. This “knowledge-behaviour gap” underscores the inadequacy of traditional curricula and underscores the urgent need for the affective-centric pedagogies discussed in this review. The purpose of this review is to synthesise existing literature to clarify the relationship between Sustainable Agricultural Practices and Green Skills Formation. It seeks to answer three primary questions: 1) How are green skills defined within the evolving context of sustainable agriculture? 2) What pedagogical mechanisms facilitate the transfer of these skills? And 3) How can the silos between agricultural and environmental education be collapsed to foster a more resilient workforce? By addressing these questions, this review aims to provide a conceptual framework for educators and policymakers seeking to align agricultural training with the imperatives of sustainability.

Methodology

To provide a comprehensive synthesis of the relationship between sustainable agricultural practices and the formation of green skills, this review adopted a narrative review approach with a systematic search strategy. While distinct from a full Systematic Literature Review

(SLR) in its analytical flexibility, this review employed rigorous search protocols to select high-quality, relevant literature. The methodology was guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines adapted for narrative synthesis.

Search Strategy and Data Sources

A systematic search was conducted in the Scopus database. This database was selected for its extensive coverage of interdisciplinary research bridging agricultural science, education and social sciences. The search strategy utilised a Boolean logic framework combining three core concepts:

1. Context: Sustainable Agriculture (e.g., “agroecology”, “regenerative farming”, “organic agriculture”).
2. Outcome: Green Skills (e.g., “sustainability competencies”, “environmental literacy”, “stewardship”).
3. Setting: Education/Training (e.g., “vocational education”, “curriculum”, “capacity building”).

The search was limited to peer-reviewed journal articles, conference proceedings and book chapters published in English between 2015 and 2025. This timeframe was selected to capture the most recent pedagogical shifts following the launch of the UN Sustainable Development Goals (SDGs) in 2015.

Eligibility Criteria (PCC Framework)

To ensure the relevance of the selected literature, studies were screened based on the Population, Concept, and Context (PCC) Framework. This framework is particularly effective for scoping and narrative reviews as it allows for broad inclusion of diverse study types.

Table 1: Inclusion and Exclusion Criteria based on PCC Framework

Criterion	Inclusion Indicators	Exclusion Indicators
Population	<ul style="list-style-type: none"> • Students (TVET, University, K-12) • Farmers (Smallholders, Cooperatives) • Educators/Trainers • Consumers (as active participants) 	<ul style="list-style-type: none"> • Policy documents without human subjects • Purely biological subjects (e.g., crop yield studies with no human element)
Concept	<ul style="list-style-type: none"> • Green Skills: Technical, affective, or transversal competencies. • Formation: Pedagogies, learning mechanisms, or skill acquisition processes. 	<ul style="list-style-type: none"> • Studies focusing solely on <i>agronomic efficiency</i> (e.g., "Nitrogen use efficiency") without discussing the <i>skill</i> required to achieve it.

Criterion	Inclusion Indicators	Exclusion Indicators
Context	<ul style="list-style-type: none"> • Agency: "Change agents," "stewardship." • Sustainable Agriculture: Organic, Regenerative, Precision Farming, Agroecology. • Learning Environments: Vocational schools, School gardens, Farmer Field Schools (FFS). 	<ul style="list-style-type: none"> • General "sustainability" papers with no educational focus. • Conventional/Industrial agriculture (unless used as a negative control). • Non-agricultural green sectors (e.g., renewable energy engineering, eco-tourism).

Selection Process

Initial search results were exported to reference management software, and duplicates were removed. The remaining titles and abstracts were screened against the PCC criteria. Full-text articles were then retrieved and assessed for quality. Priority was given to empirical studies (both quantitative and qualitative) that provided clear evidence of skill formation, such as the longitudinal interventions by Nyamweru et al. (2025) and the choice experiments by Sangkapitux et al. (2017).

Data Analysis and Synthesis

Given the heterogeneity of the included studies – ranging from psychological surveys to curriculum analyses – a statistical meta-analysis was not feasible. Instead, a Thematic Analysis approach was employed. Data were extracted using a structured form capturing:

- Study context (Geographic location, agricultural practice).
- Methodology (Intervention type, duration)
- Competency Domain (Technical vs Affective).
- Key Findings (Barriers and enablers of skill acquisition).

The extracted data were synthesised narratively to identify recurring patterns, contradictions, and theoretical convergences, resulting in the three primary themes discussed in the subsequent sections.

Thematic Analysis

The synthesis of recent literature reveals that the development of green skills in sustainable agriculture is not merely an additive to existing curricula but represents a fundamental paradigm shift. This review organises the findings into three convergent themes: the evolution of competency definitions, the pedagogical mechanisms of acquisition, and the systemic integration of disciplinary silos.

Theme 1: The Shift from Technical Skills to “Change Agent” Competencies

The traditional agricultural education model, historically rooted in productivist paradigms, focused heavily on domain-specific technical expertise. However, current literature argues that sustainable agricultural practices (SAP) require a broader set of transversal competencies. Nyamweru et al. (2024, 2025) provide a robust evidentiary basis for this shift through a Delphi study of experts and practitioners. Their findings notably rank “facilitator of change” as the single most relevant competency for sustainable agriculture, placing it above purely technical agronomic skills. This signals a theoretical pivot from viewing the agriculturist as a technician to viewing them as a systemic leader capable of navigating complex social-ecological transitions. This prioritisation of the affective and social domains is corroborated by Mudokwani and Mukute (2019) in their analysis of organic farmer associations. They argue that successful transitions to sustainable models rely less on technical inputs and more on “solidarity”, “value creation,” and the collective agency to overcome obstacles. Consequently, the literature redefines “Green Skills” beyond mere knowledge of environmental science to include the capacity for “stewardship”, “auto-determination,” and “innovation” (Nyamweru et al., 2025).

This concept of stewardship is further elaborated by Fauziah et al. (2024) within the context of vocational education, advocating for the integration of values to foster genuine responsibility towards nature. Their findings suggest that infusing these values into the curriculum significantly enhances students’ affective commitment, distinguishing it from purely secular technical training. Supporting this view, Lovren and Jablanovic (2023) provide empirical evidence that neglecting this affective dimension results in a “hollow” environmental education that fails to instigate long-term behavioural change. Thus, forming a “change agent” necessitates a pedagogical approach that addresses the learner’s internal value system alongside their technical proficiency. Despite this academic consensus, a critical disconnect exists in implementation. Nyamweru et al. (2024) identify a significant policy practice gap: while curriculum advisors perceive current vocational programs as adequate, teachers and students report that these critical sustainability competencies are insufficiently addressed. This contradiction highlights a methodological lag-while the definition of green skills has evolved to include complex “change agent” capabilities, the codified curriculum often remains tethered to outdated, competence-based models that fail to capture the nuance of sustainability stewardship.

Theme 2: Active and Participatory Pedagogies as the Primary Mechanism

If the target competencies have shifted toward stewardship and adaptability, the literature overwhelmingly suggests that passive pedagogical models are obsolete. There is strong agreement across studies that green skills are best acquired through active, context-based participation rather than classroom instruction. Nyamweru et al. (2025) offer empirical validation of this through their longitudinal assessment of a “Participatory Integrated Planning (PIP) module. Their findings demonstrate that a curriculum centred on “visioning” and “collaborative planning” significantly fostered skills like systems thinking and leadership. Similarly, Mudokwani and Mukute (2019) describe “T-Learning” (transgressive learning), in which skills are formed through the iterative, real-world struggle of farming groups as they solve collective problems. This suggests a theoretical implication: green skills formation is constructivist and situated – it cannot be “transferred” but must be “experienced”.

However, the synthesis also uncovers critical nuances and limitations in these active methodologies. Nyamweru et al. (2025) observed a “novelty plateau” in which skill acquisition was rapid in the early stages of the intervention but slowed significantly over time. This raises a methodological concern regarding the sustainability of educational interventions; “business-as-usual” inevitably sets in, suggesting that continuous pedagogical innovation is required to maintain the trajectory of skill growth. Furthermore, Aragon and Manzano (2025) caution that mere exposure to “green spaces” (such as school gardens) is insufficient. Their study found that while gardens build environmental awareness, they do not automatically foster social resilience without intentional guided mediation by educators. Thus, the literature concludes that while participation is the *vehicle* for green skills, intentional pedagogical design is the *driver*.

While participation is the vehicle for green skills, the physical learning environment itself acts as a silent pedagogue. Expanding on the role of physical space, Kozłowska et al. (2025) introduce the concept of “green grounds” in primary education, demonstrating that the design of the school environment significantly influences ecological awareness. Their pilot study confirms that daily exposure to well-designed green spaces improves environmental literacy even before formal instruction begins. This aligns with Sohaee and Farsad’s (2025) review of innovative pedagogies, which advocates for shifting learning outcomes from classroom-bound theory to “lived experiences” within these green infrastructures. Therefore, effective green skills formation necessitates not only active methodologies but also an immersive physical setting that reinforces sustainability principles.

Theme 3: Breaking silos: Systematic Integration of Agriculture and Environment

The final theme addresses the discipline's structural boundaries. Historically, Agricultural Education (AE) and Environmental Education (EE) have operated in isolation—one focused on production, the other on conservation. Reilly et al. (2022) argue powerfully for the “collapsing of walls” between these disciplines. They argue that the fragmentation of green skills formation hinders it and call for a collaborative structure that positions agricultural literacy and environmental literacy as mutually reinforcing public goods. This need for systemic integration extends beyond the classroom to the broader market ecosystem. Sangkapitux et al. (2017) expand the scope of “green skills” to include the consumer populace. Their research links the “environmental literacy” of urban citizens directly to their willingness to financially support multifunctional agriculture. This introduces a vital economic dimension to the review: the formation of green skills is not only a supply-side requirement (for farmers to produce sustainably) but a demand-side necessity (for consumers to value the production)

Furthermore, the integration of silos must address the technological dimension of modern agriculture. Yar et al. (2024) emphasise that “Green Technological Skills” cannot be taught in isolation but must be embedded within broader environmental education frameworks. They argue that learners must understand the ecological impact of the technologies they deploy, ensuring that technical proficiency does not come at the expense of environmental integrity. This reinforces the need for the interdisciplinary approach proposed in the IESC Framework, in which agronomy, ecology, and technology are taught as a unified system rather than as disparate disciplines. The theoretical implication here is that green skills must be viewed through a “food systems” lens rather than a “farm-level” lens. Integrating “interdisciplinarity”, a competency explicitly highlighted by Nyamweru et al. (2025) into curricula, allows learners to connect agronomic practices with broader economic and ecological realities. However, the

literature reveals a gap in connecting the urban-consumer perspective (Sangkapitux et al., 2017) with the rural producer reality (Mudokwani & Mukute, 2019), suggesting that future research must address how to synchronise skill formation across these divided demographics to create a truly resilient agricultural sector.

Critical Analysis

The body of literature reviewed presents a compelling, albeit fragmented, argument for the centrality of human capital in the transition to sustainable agriculture. While existing research successfully establishes a theoretical link between sustainable practices and the formation of green skills, a critical examination reveals significant variations in methodological rigour, geographical focus, and the conceptual boundaries of the skills themselves. The most robust strength of the current discourse is its decisive move away from reductionist, production-oriented pedagogies. There is a unified voice across the studies from the vocational centres of Burundi (Nyamweru et al., 2024) to the organic cooperatives of Zimbabwe (Mudokwani & Mukute, 2019). That “technical competence” is insufficient for sustainability. The literature successfully redefines the agricultural practitioner not as a mere technician but as a “change agent”. This refocusing on the affective domain, prioritizing solidarity, stewardship, and auto-determination, provides a more holistic framework for educational policy than previous decades of agronomic research. Furthermore, the emergence of longitudinal data, specifically the work by Nyamweru et al. (2025), moves the field beyond theoretical posturing to provide empirical evidence that participatory interventions can actively construct these complex competencies over time.

Despite these strengths, the field is characterised by notable methodological limitations. A significant portion of the data relies on self-reported surveys and perception-based indices. For instance, while Nyamweru et al. (2024) track the development of competencies, the measurement often relies on students’ self-assessment or teachers’ perceptions rather than on objective, field-based performance metrics. There is a scarcity of studies that correlate the acquisition of these “green skills” with tangible agricultural outcomes such as improved soil health or yield stability. Furthermore, a geographical bifurcation is evident. Research from the Global South (e.g., Burundi & Zimbabwe) tends to focus on vocational training and direct farmer-survival strategies, treating green skills as a necessity for livelihood. In contrast, research from the Global North (e.g., USA & Spain) often frames these skills within the context of “literacy”, “school gardens”, or “consumer preference” (Reilly et al., 2017; Aragon & Manzano, 202).

This creates a context bias in which “green skills” are operationally defined differently depending on the region's economic development: pragmatic and vocational in developing economies, versus aspirational and civic in developed ones. Perhaps the most critical gap lies in the disconnect between policy formulation and classroom reality. The literature highlights a “policy illusion” where curriculum advisors believe sustainability competencies are adequately embedded, while practitioners on the ground report a severe deficit (Nyamweru et al., 2024). This suggests that while the vocabulary of green skills has permeated high-level policy, the pedagogical infrastructure to deliver them is lagging. Additionally, there is a theoretical gap between the “producer” and the “consumer”. While Sangkapitux et al. (2017) discuss the environmental literacy of urban consumers and other studies focus on the skills of rural farmers, there is little research integrating these two. A truly sustainable agricultural system requires a feedback loop where an educated consumer base supports an educated producer base. The

current literature treats these as separate domains, failing to address how the formation of green skills on one side of the supply chain influences the other. Finally, the “novelty plateau” identified in long-term interventions suggests that current pedagogical models may lack the durability required for lifelong learning, highlighting the need for research into the sustainability of the education itself.

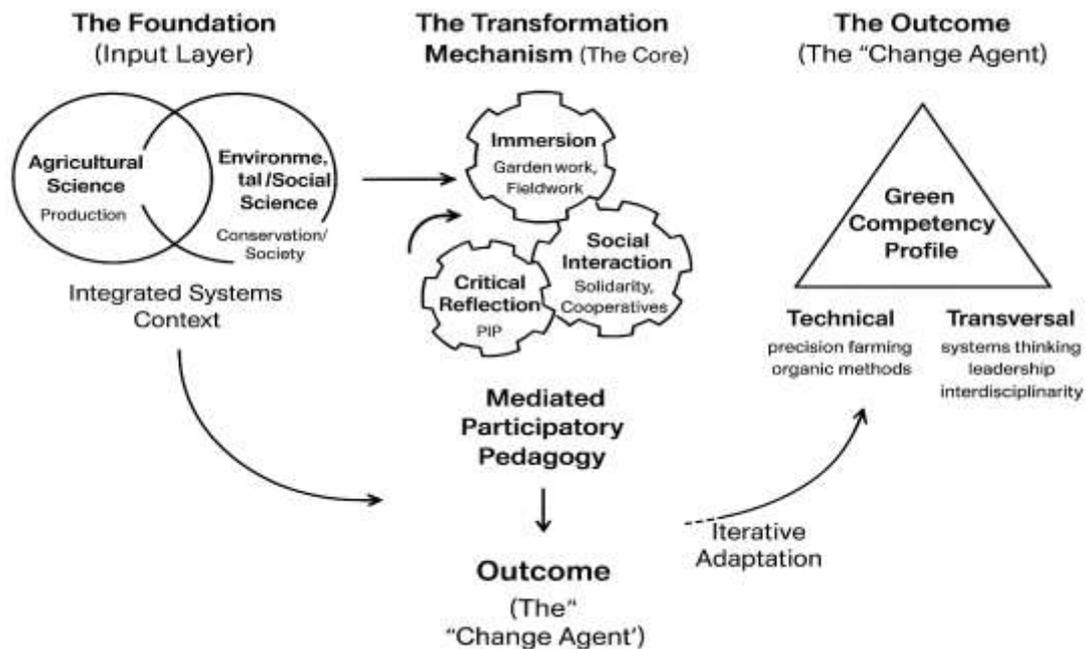


Figure 1: IESC Framework

Narrative Explanation

The IESC Framework posits that “Green Skills” are not inherent to agricultural machinery or seeds; they are socially constructed traits. The process begins with the Integration of Silos. As noted by Reilly et al. (2022) and Sangkapitux et al. (2017), the learner must be situated in a context where “production” and “conservation” are not opposing forces but a unified system. The core driver of skill formation is Mediated Participatory Pedagogy. Passive knowledge transmission fails to build complex sustainability skills. Instead, as evidenced by Nyamweru et al. (2025) and Mudokwani & Mukute (2019), the learner must engage in “T-learning” (Transgressive learning) or Participatory Integrated Planning (PIP). This mechanism involves doing (Immersion), collaborating (social interaction), and planning (Critical Reflection). The result is not just a skilled farmer but a “change agent”. This agent possesses a triad of competencies: Technical (knowing how), Transversal (knowing why and connecting systems), and Affective (caring about the outcome). Finally, the framework acknowledges a Temporal Dimension. Skill acquisition is not a one-time event. The “novelty plateau” identified by Nyamweru et al. (2024) requires that the pedagogical mechanism must evolve; as the learner matures, the complexity of the participation must increase to sustain skill growth.

The conceptual components of the proposed framework are rigorously grounded in recent empirical findings. The foundation's premise of integrating agricultural and environmental systems addresses the historical fragmentation highlighted by Reilly et al. (2022), who argue that the disciplinary separation of Agricultural Education (AE) and Environmental Education

(EE) significantly hinders the development of holistic literacy. Consequently, the framework mandates the collapse of these silos into a unified starting point. The designation of participatory pedagogy as the central transformation mechanism is empirically justified by Nyamweru et al. (2025b), who conducted a longitudinal analysis demonstrating that the Participatory Integrated Planning (PIP) module significantly enhanced sustainability competencies, even where traditional instruction methods failed. This is further corroborated by Aragon and Manzano (2025), who found that it is the active use of learning spaces, such as school gardens, rather than their mere physical existence, that drives genuine learning. Regarding outcomes, the framework's specific inclusion of affective and social competencies is drawn from Mudokwani and Mukute (2019). Their research identifies "solidarity" and "value creation" as the primary determinants of success within organic farming groups, providing evidence that effective green skills are fundamentally socio-emotional rather than purely agronomic. Finally, the incorporation of an iterative feedback loop is necessitated by the findings of Nyamweru et al. (2025b), who observed that skill acquisition rates plateaued after the initial intervention phase. A linear framework would fail to account for this degradation, validating the need for a cyclical structure that represents the imperative for continuous curriculum renewal.

The implementation of the proposed framework reveals three distinct avenues for future empirical inquiry. First, to address the "competency plateau" observed in longitudinal interventions, research must rigorously investigate the temporal dynamics of skill retention by testing the feedback loop. Future longitudinal studies should compare the efficacy of intermittent versus continuous participatory interventions to determine whether periodic reinforcement, effectively "topping up" the learning modules, can prevent stagnation in skill growth and ensure the sustainability of the learning process. Second, the framework's application should be extended to the "consumer agent," as suggested by Sangkapitux et al. (2017). Researchers should explore whether participatory pedagogies, such as active involvement in Community Supported Agriculture (CSA), can transform urban consumers into active "change agents" characterised by a heightened willingness to pay for sustainable agricultural outputs. Finally, there is an urgent methodological necessity to operationalise the "invisible" affective skills highlighted by the framework, such as stewardship and auto-determination. Scholarship must move beyond a reliance on self-reported data toward the development and validation of robust psychometric measures capable of quantifying these subjective, high-level traits within diverse agricultural settings.

Conclusion

The narrative review underscores a critical paradigm shift in the educational landscape: the transition of the agricultural practitioner from a technical producer to a systemic "change agent". The synthesis reveals that Sustainable Agricultural Practices (SAP) serve as potent vehicles for acquiring green skills but only when mediated through active, participatory pedagogies rather than passive instruction. The primary contribution of this review is the conceptual expansion of "Green Skills". The literature demonstrates that these skills are not merely technical (e.g., soil management) but are fundamentally transversal and affective, encompassing stewardship, systems thinking, and social solidarity. Theoretically, this establishes that skill formation is distinct from curriculum content; it is a product of the methodology. The proposed Integrated Eco-Social Competency (IESC) Framework suggests that the "silos" of agricultural and environmental education must be collapsed to foster true sustainability literacy.

For policymakers and educators, the implications are clear: current competence-based curricula are often too rigid to capture the nuance of sustainability. Institutions must pivot towards “living labs” that incorporate school gardens, participatory integrated planning (PIP), and community-based research to simulate real-world complexity. The curriculum must prioritize problem-solving over memorizing solutions. Future empirical research must address the “novelty plateau” identified in longitudinal interventions, investigating how to sustain engagement once the initial innovation of a new module fade. Additionally, there is an urgent need to develop validated psychometric instruments to quantify the “affective” dimensions of green skills (e.g., resilience and empathy), which currently rely heavily on self-reporting. Finally, research should expand the lens to include the consumer, exploring how urban engagement with food systems can foster a society-wide green competency profile.

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