



Ecological Food Practices and Their Impact on Reducing Food Waste

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ABSTRACT

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Food waste has become a major global issue with significant implications for environmental planning, resource management, and sustainable development. Ecological food practices—encompassing sustainable farming, short food supply chains, organic food production, eco-friendly packaging, and responsible consumption—represent an essential approach to reducing waste and improving efficiency throughout the food system. This paper examines how ecological practices can be integrated into environmental and regional planning frameworks to enhance waste prevention and resource optimization. A multidisciplinary review of case studies and scientific literature reveals that such practices contribute not only to minimizing food loss at all stages of production, distribution, and consumption but also to strengthening biodiversity, reducing greenhouse gas emissions, and fostering local economic resilience. Furthermore, consumer education and behavioral change emerge as critical elements in sustaining ecological approaches, as awareness significantly shapes consumption patterns. Despite notable progress, scaling up ecological food systems remains challenged by high production costs, limited market access, and uneven policy support. The study concludes that ecological food practices form a vital component of sustainable development planning, offering both environmental and socio-economic benefits. It recommends stronger policy integration at national and local levels to promote circular economy principles and long-term food system sustainability.

1. INTRODUCTION

Food waste represents one of the most pressing sustainability challenges of the twenty-first century, with far-reaching environmental, economic, and social implications. According to the Food and Agriculture Organization [1], approximately one-third of the world's food production, equivalent to about 1.3 billion tons annually, is lost or wasted throughout the global food supply chain. This inefficiency contributes to nearly 8–10% of global greenhouse gas emissions, while depleting valuable natural resources such as land, water, and energy. Beyond the environmental dimension, food waste also intensifies economic disparities and ethical concerns, as millions of people continue to experience hunger while edible food is discarded. Consequently, the reduction of food waste has become a strategic priority under the United Nations Sustainable Development Goal 12 (SDG 12), which promotes sustainable consumption and production patterns.

In recent years, ecological food practices have emerged as an essential tool for addressing the systemic causes of food waste. These practices encompass sustainable agriculture, organic farming, eco-friendly packaging, short food supply chains, and consumer education programs designed to

promote responsible consumption [2]. By integrating ecological principles into food production and distribution systems, societies can minimize resource inefficiencies, preserve biodiversity, and enhance environmental resilience. Additionally, ecological food systems encourage circular economy principles by reusing organic waste, optimizing logistics, and supporting local economies [3]. When effectively implemented, such practices have been shown to reduce post-harvest losses, extend product shelf life, and foster consumer awareness regarding sustainable food choices.

However, despite growing recognition of their importance, the global adoption of ecological food practices remains limited and uneven. Existing studies tend to examine isolated elements, such as consumer attitudes, agricultural techniques, or waste management policies, rather than evaluating the integrated impact of these practices across the entire food system [4]. Moreover, gaps persist in understanding how ecological food practices translate into measurable waste reduction, particularly in developing and transition economies where food systems face infrastructural and institutional challenges. Addressing these gaps is crucial for designing comprehensive strategies that align environmental objectives with economic sustainability.

The present study seeks to evaluate the impact of ecological food practices on reducing food waste through a multidisciplinary framework that bridges environmental management, food policy, and sustainability science. The main objective is to identify how ecological innovations contribute to reducing waste at various stages of production, distribution, and consumption, while also strengthening the economic and social sustainability of food systems. The study draws upon comparative research, secondary data, and documented case studies to assess the effectiveness of these practices and to highlight policy implications for scaling sustainable food systems.

The remainder of this paper is structured as follows: Section 2 presents a comprehensive literature review of the theoretical foundations, empirical findings, and conceptual frameworks related to ecological food systems and food waste management. Section 3 outlines the research methodology, detailing the analytical approach, data sources, and evaluation criteria. Section 4 presents the results of the analysis, identifying key factors influencing the relationship between ecological practices and waste reduction. Section 5 offers a discussion of results, linking empirical findings to theoretical and policy perspectives. Finally, the Conclusion summarizes the main insights, outlines policy recommendations, and proposes directions for future research.

2. LITERATURE REVIEW

The global academic discourse on food waste reduction has evolved significantly over the past decade, emphasizing the environmental, economic, and ethical dimensions of the problem. Early research primarily framed food waste as a logistical and behavioral challenge linked to inefficiencies in the food supply chain [5]. More recent studies, however, adopt a systemic perspective, recognizing food waste as a structural consequence of unsustainable production and consumption models [6]. This shift has prompted scholars to explore the relationship between ecological food practices and waste reduction, positioning ecological sustainability as both a driver and an outcome of efficient food systems. The concept of “ecological food practices” now encompasses a broad set of strategies aimed at aligning environmental integrity with social responsibility and economic resilience [7].

Within this framework, several studies underscore the centrality of sustainable agriculture and organic production as key pillars of ecological food systems. Sustainable agricultural methods, such as crop diversification, composting, and precision irrigation, are associated with higher resource efficiency and reduced post-harvest losses [8]. Organic farming, in particular, contributes to minimizing chemical inputs and maintaining soil fertility, thereby preventing production-stage waste while preserving ecosystem services [9]. Furthermore, short food supply chains and local food networks have emerged as effective models for reducing waste related to storage and transportation [10]. By shortening the distance between producers and consumers, these systems improve freshness, traceability, and accountability, reducing spoilage and overproduction.

A growing body of literature also addresses the role of circular economy principles in mitigating food waste. Scholars argue that circular models promote resource efficiency by extending the life cycle of food products through reuse, redistribution, and recycling [11]. Initiatives such as

composting organic waste, converting surplus food into animal feed, and developing biodegradable packaging are practical examples of how circularity integrates into ecological food systems. The European Union’s Circular Economy Action [12] has provided a policy framework encouraging member states to embed these principles in national waste prevention strategies. These approaches have been shown to reduce food waste by creating economic incentives for revalorizing by-products and secondary materials [13].

In addition to production and policy dimensions, consumer behavior plays a decisive role in determining the overall effectiveness of ecological food practices. Studies indicate that nearly 50% of total food waste in developed countries occurs at the household level, where purchasing habits, portion sizes, and misinterpretation of expiration labels are key contributing factors [14]. Educational campaigns, digital tools, and labeling reforms have been found to foster pro-environmental attitudes and promote mindful consumption [15]. However, the translation of awareness into consistent behavioral change remains uneven, particularly among low-income and younger demographics. Consequently, researchers emphasize the importance of embedding sustainability education within broader food policies to ensure that behavioral interventions are supported by structural reforms [16].

Regarding food waste, those mentioned above do not all affect it equally and not all are suitable for intervention, but each of them is important, some in reduction and some in management, and their effect depends on their priorities.

Recent interdisciplinary analyses emphasize that ecological food practices can only reach their full potential through integrated governance frameworks. Effective coordination among producers, retailers, consumers, and public institutions ensures that environmental objectives are embedded in all stages of the food chain [17]. The literature also highlights that countries with comprehensive policy integration, combining waste prevention, environmental protection, and agricultural sustainability, demonstrate higher efficiency in achieving food waste reduction targets [18]. Moreover, technological innovations such as blockchain traceability, digital inventory management, and smart packaging are increasingly recognized as enabling tools that support transparency and efficiency in ecological food systems [19]. Despite these advancements, several studies caution that without equitable policy design, ecological food practices risk reproducing socioeconomic inequalities, particularly between developed and developing economies [20].

The literature converges on the conclusion that ecological food practices constitute a transformative pathway toward sustainable food systems. Nevertheless, there remains a research gap in quantifying their direct impact on food waste reduction across diverse socio-economic contexts. Most studies emphasize individual interventions rather than systemic interactions, leaving limited empirical evidence on the cumulative benefits of integrating production, consumption, and policy dimensions. Addressing these gaps requires comprehensive analyses that bridge environmental science, food policy, and behavioral economics to assess the effectiveness and scalability of ecological food practices in mitigating food waste.

3. RESEARCH METHODOLOGY

This study employs a multidisciplinary research design

integrating environmental science, sustainability studies, and food policy analysis to examine the relationship between ecological food practices and food waste reduction. The methodology is grounded in a mixed qualitative-quantitative framework that allows for both contextual understanding and analytical generalization. The approach reflects the principle that food systems are complex socio-ecological structures, where environmental outcomes depend on the interaction between production, distribution, consumption, and governance. The integration of diverse data sources, scientific literature, policy documents, and empirical datasets ensures methodological triangulation and enhances the robustness of findings [21]. This methodological orientation aligns with recent advances in sustainability research, which emphasize the need for holistic, systems-based approaches to capture the multifaceted dynamics of food waste and ecological innovation [22].

Data for this study were collected from a combination of secondary sources, including peer-reviewed journal articles, institutional reports, and global sustainability databases such as the FAO, UNEP, and the European Environment Agency. To analyze the collected data, the study utilized a comparative qualitative synthesis approach, examining convergences and divergences across case studies in both developed and developing contexts. This synthesis method enabled the identification of recurring patterns, effective ecological interventions, and key variables influencing food waste reduction outcomes.

The analytical process followed a three-stage design: descriptive mapping, thematic coding, and inferential evaluation. In the first stage, key ecological food practices were mapped across production, distribution, and consumption phases, capturing measures such as sustainable farming, local food systems, eco-friendly packaging, and consumer education initiatives. In the second stage, thematic coding was applied to identify dominant patterns and conceptual relationships using inductive reasoning. The coding process relied on grounded theory principles to derive categories directly from the data, enhancing validity by reducing researcher bias [23]. Finally, the inferential stage synthesized evidence to explain how the adoption of ecological practices contributes to reducing food waste while supporting broader environmental and socio-economic sustainability objectives. Cross-validation between qualitative themes and quantitative indicators, such as food loss percentages, greenhouse gas emissions, and resource efficiency metrics, was performed to strengthen analytical coherence.

To ensure reliability and validity, the study adhered to key methodological standards for environmental research, including transparency, replicability, and contextual relevance. Triangulation among multiple data sources mitigated the limitations associated with relying solely on self-reported or policy-based data. Furthermore, critical evaluation of case studies allowed for assessing both the scalability and transferability of ecological food practices across different socio-economic environments. The interpretive analysis also incorporated stakeholder perspectives from policy reports and civil society initiatives to capture the social dimension of ecological food systems, reflecting the importance of inclusivity and local knowledge in sustainability transformations [24].

Ethical considerations were central to the research process. As the study relied exclusively on secondary data, no direct

human participation was involved; however, due diligence was maintained to ensure the accurate citation of all sources, respect for intellectual property, and adherence to academic integrity. The study's methodology also acknowledges the ethical imperative of producing policy-relevant research that contributes to Sustainable Development Goals (SDGs), thereby bridging the gap between academic inquiry and societal impact. By employing an interdisciplinary, data-driven, and ethically informed methodology, this research provides a credible foundation for understanding how ecological food practices can serve as a transformative mechanism in global food systems.

4. RESULTS

The findings of this study confirm that ecological food practices exert a measurable and multifaceted impact on reducing food waste across the production, distribution, and consumption stages of the food supply chain. Analysis of empirical and secondary data revealed that the integration of ecological principles into agricultural and food management systems leads to a consistent decline in waste generation, estimated between 18% and 32% in regions with well-established sustainability frameworks [1, 25]. The most significant improvements were observed in local food networks that combine organic farming, short supply chains, and community-based initiatives. These systems reduce overproduction and minimize storage losses by aligning supply more closely with real demand, while simultaneously improving food freshness and consumer trust. The data demonstrate that sustainable production models not only mitigate waste but also enhance soil fertility and water efficiency, creating a feedback loop that strengthens long-term food security and ecological resilience.

Furthermore, results indicate that consumer-driven ecological practices play an equally critical role in reducing post-consumer food waste. Behavioral shifts associated with sustainable consumption, such as preferring locally sourced products, embracing plant-based diets, and purchasing in smaller quantities-were found to reduce household food waste by approximately 25% on average [26]. This effect is magnified when accompanied by educational campaigns and digital awareness initiatives, particularly those emphasizing the environmental footprint of wasted food. The data suggest that awareness alone is insufficient unless supported by institutional incentives such as labeling reforms, tax reductions for sustainable producers, and improved food donation infrastructure. Thus, a systemic approach, where consumer behavior, policy support, and ecological production coexist, is essential for maximizing waste reduction outcomes.

From the production perspective, the adoption of circular economy models within ecological food systems has proven to be one of the most effective strategies. Practices such as composting, biogas conversion, and the revalorization of food by-products into secondary raw materials contribute significantly to waste minimization and resource efficiency. Comparative evidence from European and Asian case studies revealed that circular approaches can divert up to 60% of organic waste from landfills, transforming it into valuable energy or agricultural [11, 13]. Moreover, partnerships between public authorities and private enterprises, particularly within municipal waste management systems, demonstrated the strongest results when governance frameworks explicitly

integrated environmental and economic objectives. This synergy reinforces the concept that ecological food practices should not be viewed solely as environmental tools but as engines for green economic transformation.

Another major result concerns the policy and governance dimension, which emerged as a determining factor in the success of ecological food practices. Countries with comprehensive sustainability strategies, combining agricultural reform, waste management policies, and consumer education, exhibited the highest effectiveness in food waste reduction [17]. The study identified governance indicators such as policy coherence, cross-sector collaboration, and monitoring mechanisms as critical for sustaining ecological practices at scale. For example, the European Union's Farm to Fork Strategy [27] provides a clear institutional framework linking food production, consumption, and waste management under a unified sustainability agenda. This integrated approach was associated with a statistically significant decline in food waste per capita between 2015 and 2022, illustrating the policy's long-term efficacy. Conversely, in contexts where ecological initiatives are fragmented or short-term, waste reduction outcomes remain limited despite positive public awareness.

While policy coherence and institutional coordination are essential for scale, the most cost-effective food waste intervention is expiration-date labeling reform, whereas effective policy design must remain context-specific, reflecting income levels, infrastructure capacity, and dominant sources of waste.

Lastly, the findings highlight the socio-economic co-benefits of ecological food practices. Empirical data and case-based evidence reveal that local food systems and organic cooperatives not only reduce food waste but also stimulate rural employment, encourage entrepreneurship, and promote social inclusion. For instance, community-supported agriculture programs in Central Europe have demonstrated that waste reduction can coincide with economic empowerment of small producers, who gain stability through direct consumer relationships. These models exemplify how ecological food systems operate as catalysts for achieving multiple SDGs, including zero hunger, responsible production, and climate action. However, the results also underscore disparities between high-income and low-income regions, where resource constraints and infrastructural gaps limit the widespread implementation of ecological practices. Bridging this divide requires targeted financial instruments, international cooperation, and the diffusion of green technologies to developing economies.

For ecological practices to be successful, their economic and environmental effectiveness depends on a number of necessary and sufficient conditions, including sustainable demand through direct producer-consumer relationships, such as in community-supported programs, manageable transition costs, and supporting infrastructure. Without these conditions, ecological practices may increase production costs rather than increase economic sustainability, and the burden thus falls on small producers. Furthermore, consumer education influences behavior only when it reduces information asymmetries, consumers have the right to be informed accurately, information is simple and reliable, and social norms are built, enabling a sense of belonging not just visual awareness, when consumers are informed they do not change behavior, so education is effective only when combined with knowledge, reasonable prices, and common ecological opportunities.

The results confirm that ecological food practices represent a transformative mechanism capable of addressing the structural roots of food waste. Their success depends on the synergy between production efficiency, consumer responsibility, and institutional governance. The findings provide empirical evidence that ecological food systems, when systematically supported by policy frameworks and public participation, can lead to measurable reductions in food waste, promote environmental sustainability, and generate socio-economic value across global food networks.

5. DISCUSSION OF RESULTS

The results of this study reaffirm that ecological food practices serve as a fundamental mechanism for achieving both environmental and socio-economic sustainability within modern food systems. The evidence demonstrates that sustainable agricultural models, circular economy initiatives, and consumer behavioral shifts collectively contribute to significant reductions in food waste. These findings align with previous research suggesting that food waste is not merely a logistical issue but a systemic failure in resource governance and consumption behavior [6]. By addressing the structural drivers of inefficiency, overproduction, supply-chain fragmentation, and consumption excess, ecological practices redefine how societies conceptualize and manage food as a renewable but finite resource. This reorientation reflects a transition from linear, production-intensive systems to regenerative, closed-loop models that prioritize balance between economic output and ecological resilience.

A central insight emerging from the analysis is that ecological food practices succeed when sustainability principles are embedded within the governance architecture of food systems. Effective governance ensures that environmental objectives are supported by economic incentives, policy coherence, and stakeholder collaboration. In this regard, the European Union's Farm to Fork Strategy exemplifies how multi-level governance can operationalize sustainability goals by linking production, consumption, and waste management policies under a unified framework [12]. However, in developing contexts, weak regulatory enforcement and limited financial resources often hinder the implementation of similar frameworks [20]. This disparity highlights the importance of adaptive governance models that account for regional differences in institutional capacity, technological infrastructure, and socio-economic priorities. Stronger intergovernmental cooperation and knowledge transfer mechanisms are therefore essential to ensure equitable diffusion of ecological practices across diverse global food systems.

The discussion further underscores that ecological food systems generate co-benefits beyond waste reduction, extending their impact to climate mitigation, public health, and community resilience. The integration of organic farming and localized supply chains reduces carbon emissions associated with long-distance transportation and chemical-intensive production, directly contributing to national climate targets [19]. Simultaneously, promoting plant-based diets and responsible consumption habits aligns with global health strategies aimed at reducing obesity and malnutrition [18]. Importantly, these ecological interventions reinforce social equity by empowering local producers, enhancing rural livelihoods, and promoting fair-trade models that redistribute

value along the supply chain. This interconnection between environmental and social outcomes strengthens the case for mainstreaming ecological food practices as part of comprehensive sustainability policies rather than treating them as isolated or experimental initiatives.

Another critical theme that emerged is the behavioral dimension of ecological transformation. While technological and policy innovations are crucial, the long-term success of ecological food systems depends largely on consumer engagement and societal values. Studies have shown that awareness campaigns, eco-labeling, and digital applications can significantly reduce household waste when they are culturally tailored and supported by institutional frameworks [28]. However, behavioral change is often slow, inconsistent, and influenced by economic constraints. The discussion, therefore, calls for integrating behavioral economics into sustainability policymaking, using incentives and nudges to reshape consumption habits without imposing undue burdens. For instance, dynamic pricing, community composting programs, and food-sharing networks have proven effective in aligning consumer behavior with ecological objectives, particularly in urban environments where waste generation is highest.

From a theoretical perspective, the findings contribute to the ongoing academic debate on the nexus between sustainability and circular economy frameworks. The study supports the argument that ecological food practices function as a bridging mechanism between these paradigms, linking resource efficiency with social innovation [22]. By integrating ecological design, technological innovation, and community participation, these practices operationalize the abstract principles of sustainability into tangible, measurable outcomes. This synthesis challenges the conventional dichotomy between environmental protection and economic growth, demonstrating that circular and ecological systems can achieve both simultaneously when guided by evidence-based policy and inclusive governance. The findings also reinforce the need for further interdisciplinary research exploring the interactions between ecological innovation, digitalization, and policy instruments to accelerate the transition toward sustainable food systems globally.

Nevertheless, the discussion acknowledges several limitations and future research directions. First, variations in data quality and methodological approaches across case studies restrict cross-country comparability. Second, while secondary data provide valuable insights into global trends, primary field studies remain essential for understanding local dynamics and cultural factors influencing ecological adoption. Finally, the role of digital technologies, such as artificial intelligence and blockchain, in improving traceability and minimizing waste remains underexplored and warrants further investigation. Addressing these limitations would enhance the precision and scalability of ecological food practices, allowing policymakers and practitioners to tailor interventions more effectively across different contexts.

The discussion reveals that ecological food practices are more than environmental innovations; they represent a paradigm shift in how societies conceptualize food production, consumption, and governance. Their effectiveness lies in the systemic integration of ecological principles across institutional, economic, and behavioral dimensions. By embedding circularity, inclusivity, and efficiency within food systems, ecological practices can significantly reduce waste while fostering resilience and equity. The implications of these

findings extend beyond food policy, they signal a broader transformation toward sustainability governance that prioritizes long-term planetary health over short-term economic gains.

6. CONCLUSIONS

This study provides empirical and conceptual evidence that ecological food practices represent an essential pathway for reducing global food waste while advancing environmental sustainability, economic efficiency, and social well-being. The analysis demonstrated that integrating ecological principles into food production, distribution, and consumption systems leads to substantial reductions in food losses and waste, measurable across diverse regional contexts. These practices not only prevent inefficiencies in resource use but also promote circularity, enhance biodiversity conservation, and support the transition toward more resilient and equitable food systems. The research confirms that sustainability-oriented reforms in agriculture, supply chains, and consumer behavior collectively yield synergistic outcomes, addressing environmental degradation and food security simultaneously.

The findings contribute to the growing scholarly debate on the systemic transformation of food systems by bridging the gap between ecological theory and practical implementation. By demonstrating how circular economy models, sustainable agriculture, and behavioral change mechanisms interact, this study reinforces the view that food waste reduction cannot be achieved through isolated interventions. Instead, it requires an integrated governance approach, where ecological innovation, consumer awareness, and policy coherence operate in mutual reinforcement. The results affirm that countries and regions with coherent institutional frameworks, such as those inspired by the European Union's sustainability agenda, achieve more consistent and measurable progress toward waste reduction and environmental stewardship.

From a policy and managerial perspective, the research highlights that effective food waste reduction strategies depend on three interdependent pillars: (1) sustainable production systems that reduce inefficiencies at source; (2) circular value chains that transform waste into resources; and (3) informed consumer behavior driven by ecological education and market incentives. Policymakers should therefore prioritize the integration of ecological food practices into national and regional sustainability agendas, while ensuring equitable access to green technologies and capacity-building programs for producers and consumers alike. Furthermore, businesses and local communities should adopt participatory models, such as cooperative farming, local food markets, and digital traceability tools, to enhance transparency and accountability in food systems.

Despite its robust interdisciplinary approach, this study acknowledges several limitations that open pathways for future research. The reliance on secondary data constrains the depth of empirical validation in specific regional contexts, while the absence of longitudinal data limits causal inference regarding long-term effects. Future studies should incorporate primary field research, including surveys, interviews, and experimental interventions, to measure behavioral and policy impacts more precisely. Additionally, the role of emerging digital technologies, such as artificial intelligence, blockchain, and data analytics, in optimizing ecological food practices warrants further examination, particularly concerning

traceability, supply-chain coordination, and predictive waste reduction.

This paper emphasizes that ecological food practices are not merely environmental strategies but a transformative framework for reimagining global food systems. Their effective implementation requires a multidimensional approach, uniting science, policy, and society, to ensure that sustainability goals are translated into measurable actions. By advancing the theoretical understanding and practical application of ecological principles, this study contributes to the broader agenda of sustainable development and provides actionable insights for achieving the global target of halving food waste by 2030 under the United Nations Sustainable Development Goals.

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