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THE CONCEPT OF VALUE CHAINS IN AGRICULTURE, CLIMATE ACTION AND ENVIRONMENTAL RESOURCES (GLOBAL ISSUES & LOCAL PERSPECTIVES)

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Green Food Value Chains: Towards Sustainable Agricultural Practices

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Preface

This book adopts an exegetical approach as well as a pedagogic model, making it attractive agriculture and environmental economics teachers, professional practitioners and scholars. It is eschews pedantry and lays bars the issues in such clarity that conduces to learning. The book elaborates on contemporaneous *The Concept of Value Chains in Agriculture, Climate Action and Environmental Resources* issues of global significance and at the same time, is mindful of local or national perspectives making it appealing both to international and national interests. The book explores the ways in which climate change, food security, national security and environmental resources issues are and should be presented to increase the public's stock of knowledge, increase awareness about burning issues and empower the scholars and public to engage in the participatory dialogue climate change, food security, national security and environmental resources necessary in policy making process that will stimulate increase in food production and environmental sustainability.

The Concept of Value Chains in Agriculture, Climate Action and Environmental Resources: Global issues and Local Perspectives is organized in three parts. Part One deals with The Concept of Value Chains in Agriculture, Part Two is concerned with The Concept of Climate Actions and Part Three deals with the Concept of Value Chains and Environmental Resources.

Eteyen Nyong/ Ignatius Onimawo

April 2025

Chapter Thirty

Green Food Value Chains: Towards Sustainable Agricultural Practices

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1.0 Introduction

Green food value chains (GFVC) involve the incorporation of environmentally friendly practices throughout all phases of food production and distribution (Foroozesh, Karimi, and Mousavi, 2022). GFVC is a system for food production and delivery aimed at reducing environmental harm, improving resource efficiency, and fostering social and economic sustainability at every step. It integrates sustainable approaches from input supply, production, processing, distribution, retail, and consumption, ensuring that food is produced and delivered with minimal negative impact on the environment (Hilmi, 2020). The green food value chain emphasizes the proactive prevention and reduction of natural resource usage to lessen or even eliminate adverse effects on food value chain operations and processes. This strategy also outlines waste disposal and recycling methods to reclaim value at every phase of the food value chain, thereby further minimizing environmental impact (Hilmi, 2019).

According to the Food and Agriculture Organization (FAO, 2025), a sustainable food value chain is economically viable at each stage (economic sustainability), yields widespread benefits for the community (social sustainability), and has a neutral or beneficial effect on the environment (environmental sustainability). The "green" element specifically emphasizes the reduction of resource consumption, the minimization of waste, and the implementation of environmentally friendly technologies to secure long-term sustainability in the development of food value chains (Toussaint, Cabanelas, and Muñoz-Dueñas, 2022).

Sustainable food value chains are essential for tackling global issues like climate change, depletion of resources, and food insecurity (Polyportis, De Keyzer, van Prooijen, Peiffer, and Wang, 2024). Transitioning from conventional food systems to sustainable alternatives is critical for meeting the United Nations' Sustainable Development Goals (SDGs), especially those focused on eliminating hunger, promoting responsible consumption, and advancing climate action (Canton, 2021). By lowering greenhouse gas emissions, preserving biodiversity, and encouraging effective resource utilization, sustainable food value chains help to alleviate the negative impacts **SAEREM BOOK CHAPTERS First Published 2025 ISBN 978-978-60709-7-1**

of climate change (Heydari, 2024). Furthermore, they improve the robustness of food systems, ensuring their capacity to endure environmental challenges and pressures.

The concept of GFVC emphasizes on reducing environmental impact while maintaining economic viability and social equity. Circular economy, resource efficiency, and eco-friendly practices are key concepts on which the green food value chain is based (FAO, 2025). The circular economy model aims to minimize waste and maximize resource efficiency by creating closed-loop systems where materials are reused, recycled, or repurposed (Gonçalves and Maximo, 2023). In the context of food value chains, this involves reducing food waste, utilizing by-products, and designing processes that prioritize sustainability. For example, agricultural residues can be converted into bioenergy or organic fertilizers, contributing to a more sustainable production cycle (Gonçalves and Maximo, 2023). Resource efficiency focuses on optimizing the use of natural resources such as water, energy, and soil to achieve higher productivity with minimal environmental impact. Techniques like precision agriculture and renewable energy integration are pivotal in enhancing resource efficiency within green food value chains (Hilmi, 2020; Canton, 2021). Eco-friendly practices encompass a wide range of actions, including the adoption of sustainable farming methods, the use of biodegradable packaging, and the implementation of lowcarbon transportation systems. These practices not only reduce the environmental footprint of food production but also align with consumer demand for sustainable and ethically produced goods (Hamam, D'Amico, Zarbà, Chinnici, and Tóth, 2022).

Moreover, food systems contribute an estimated 19 to 29 percent of global anthropogenic greenhouse gas emissions. Most of these emissions (80 to 86 percent) are released during the production phase (Zhang, 2023). However, the relative contribution of global greenhouse gas emissions from food systems is highly variable depending on the region, country, sector, commodity, and production system. Emissions are generated, for example, through the use of fossil fuels across all stages of the food value chains – from production to consumption – that make up food systems, as well as in the extended value chain through the provision of services and inputs

like the manufacturing of chemical fertilizers (FAO, 2025). From post-harvest to distribution, losses of this production are estimated in up to 25%, depending on the food chain (FAO, 2020). Indeed, food chains are responsible for the generation of a large amount of waste, as well as environmental impacts along their productive stages. This includes land production, animal farming, food processing, transport, market, and consumption, responsible for the disposal of organic residues, packages, greenhouse gases, waste waters, among others, throughout the route, representing wasted potential resources (Gonçalves and Maximo, 2023).

Moreover, the effects of climate change threaten every level of food value chains and the entire food system (Zhang, 2023). As a result, each tier of the food system provides various opportunities to enhance green food systems and their value chains, making them more resilient and contributing to improved global food security. It is crucial to adopt a comprehensive, systemic perspective on the risks and consequences of climate change when formulating climate-smart agricultural strategies for sustainable food systems (FAO, 2025). Consequently, this chapter aims to elucidate the significant role and comprehensive approach to green food value chains, highlighting their vital potential to transform the global ecosystem and food system, thereby making them more sustainable and resilient.

2.0 Core Components of Green Food Value Chains

Green Food Value Chains (GFVC) are essential for promoting global sustainability in environmental and food systems. Five core components have been identified as the key drivers of GFVC and are discussed as thus:

2.1. Sustainable Farming Practices

Sustainable farming practices aim to balance productivity with environmental stewardship. These practices include crop rotation, organic farming, and agroecology, which enhance soil health, reduce chemical inputs, and promote biodiversity. According to a study in renewable agriculture and food systems, sustainable agriculture can mitigate resource depletion and environmental **SAEREM BOOK CHAPTERS First Published 2025 ISBN 978-978-60709-7-1**

degradation while supporting rural livelihoods (Serebrennikov, Thorne, Kallas, & McCarthy, 2020; Anibaldi, Rundle-Thiele, David, & Roemer, 2021).

2.2 Reduction of Carbon Footprint in Food Production

Reducing the carbon footprint involves minimizing greenhouse gas emissions throughout the food production process. This can be achieved through renewable energy use, precision agriculture, and reduced reliance on synthetic fertilizers. Research highlights that agriculture contributes over 30% of global greenhouse gas emissions, emphasizing the need for transformative approaches to achieve sustainability (Mechri, Hanisch, & Hänke, 2023). Adoption of site-specific and science-based and sustainable management practices are critical to reducing CFP of agriculture/FSs, and leading to adaptation and mitigation of climate change, reducing per capita land use, and attaining the operating space within the planetary boundaries (Lal, 2022).

2.3 Responsible Sourcing of Raw Materials

Responsible sourcing ensures that raw materials are obtained in ways that respect environmental and social standards. This includes fair trade practices and sourcing from suppliers who adhere to sustainable practices. The concept of transformative value chains, as reviewed by Tabe-Ojong, Nana, Zimmermann, and Jafari, (2024), underscores the importance of ethical sourcing of raw materials to address food security and environmental challenges.

2.4 Eco-Friendly Processing and Packaging

Eco-friendly processing and packaging reduce waste and environmental impact. and innovations such as biodegradable packaging and energy-efficient processing technologies are pivotal (Hamam et al., 2022). Studies suggest that integrating eco-friendly practices into value chains can **SAEREM BOOK CHAPTERS** First Published 2025 ISBN 978-978-60709-7-1

significantly reduce the environmental footprint of food systems (Gonçalves and Maximo, 2023; Heydari, 2024).

2.5 Efficient Logistics and Distribution

Efficient logistics and distribution minimize food waste and energy consumption. This involves optimizing supply chains, using low-emission transportation, and implementing cold chain technologies. Transformative food value chains emphasize the role of efficient logistics in creating resilient and sustainable food systems (Toussaint et al., 2022; Mechri et al., 2023).

These core components of GFVC collectively contribute to the transformation of both the environment and food systems hence, ensuring they are more sustainable, equitable, and resilient.

3.0 Green Food Value Chain Development Framework

A green food value chain is one that must generate both economic and social benefits at every phase by actively minimizing the consumption of the natural environment to lessen or counteract negative effects, or even create positive outcomes. Additionally, it should take into account the disposal and recycling methods for waste produced, aiming to reclaim value at each step of the food value chain, thereby further decreasing environmental impact (FAO, 2014; Hilmi 2020). This definition establishes a foundation for creating a conceptual framework aimed at developing sustainable food value chains. The framework, illustrated in Figure 1, facilitates a circular (and open-ended) nonlinear movement of both forward and reverse food values that flow from the natural environment to end markets. The forward movements enhance not only the economic value of food but also its environmental, social, and cultural significance; any food value that is lost is retrieved through reverse flows that redefine such value from economic, environmental, social, and cultural perspectives. The goal is to establish a comprehensive, circular, and open-ended framework that naturally reduces impacts on the environment, seeks to adapt to changes, and

simultaneously works to restore what has been utilized or consumed from the natural world (Hilmi, 2019, 2020).



Figure 1. Developmental Framework for Green Food Value Chain (Source: Hilmi, 2020).

4.0 The Stages in the Development Process of the Green Food Value Chain.

The development process of a Green Food Value Chain (GFVC) typically involves several key stages, each aimed at enhancing sustainability and reducing environmental impact. The method involves a gradual process that seeks to gain insights from practical experiences and from resourceful innovations, incorporating this knowledge into the procedure. A summarized version of this sequential process is presented in Figure 2. For a more comprehensive explanation of the process, refer to Hilmi (2018).



Figure 2: The Stages in the Development Process of the GFVC

5.0 Tripartite Strategies for Green Food Value Chain Development

Green food value chain development involves adopting strategies that minimize environmental impact while ensuring economic and social sustainability. This tripartite approach provides a holistic framework for greening food value chains, ensuring environmental sustainability, economic viability, and social equity. The tripartite approach—Preventive, Reduction, and Recapturing strategies—offers a comprehensive framework for achieving these goals and are described in Figure 3 and further explained below (as reviewed by Hilmi, 2018, 2019, 2020).

5.1 Preventive Strategies

Preventive strategies focus on avoiding environmental harm at the source. These strategies emphasize sustainable practices that reduce the need for corrective actions later. Key aspects include:

-Sustainable Farming Practices: Implementing techniques like crop rotation, agroforestry, and organic farming to maintain soil health and biodiversity.

-Efficient Resource Use: Utilizing precision agriculture technologies to optimize water, fertilizer, and pesticide use, thereby reducing waste and pollution.

-Eco-Friendly Inputs: Promoting the use of renewable energy and biodegradable materials in food production and processing.

Preventive strategies are proactive and aim to integrate sustainability into the design and operation of food value chains.

5.2 Reduction Strategies

Reduction strategies aim to minimize waste and inefficiencies throughout the food value chain. These strategies focus on:

-Reducing Food Loss and Waste: Implementing better storage, transportation, and processing methods to prevent spoilage and waste.

-Energy Efficiency: Adopting energy-efficient technologies and practices in food production, processing, and distribution.

-Carbon Footprint Reduction: Transitioning to low-carbon transportation and logistics systems to decrease greenhouse gas emissions.

By addressing inefficiencies, reduction strategies enhance the overall sustainability and resilience of food systems

5.3 Recapturing Strategies

Recapturing strategies involve recovering value from waste and by-products generated within the food value chain. These strategies include:

- Waste Valorization: Converting agricultural and food waste into valuable products such as bioenergy, compost, or animal feed.

- Recycling and Reuse: Encouraging the recycling of packaging materials and the reuse of water in food processing.

- Circular Economy Practices: Designing systems that enable the continuous reuse of resources, thereby closing the loop in the value chain (Gonçalves and Maximo, 2023).

Recapturing strategies not only reduce environmental impact but also create economic opportunities by turning waste into resources.



Figure 3. The tripartite strategies for green food value chain development

6.0 Challenges and Opportunities in Green Food Value Chains (GFVC)

6.1 Environmental, Economic, and Social Challenges in Implementing Green Practices

- Environmental challenges: Implementing green practices often requires addressing complex environmental issues such as biodiversity loss, water scarcity, and soil degradation (Polyportis, De **SAEREM BOOK CHAPTERS First Published 2025 ISBN 978-978-60709-7-1**

Keyzer, van Prooijen, Peiffer, and Wang, 2024). These challenges are exacerbated by climate change, which impacts agricultural productivity and resource availability.

-Economic challenges: Transitioning to sustainable practices can be costly, particularly for smallscale farmers and businesses. High initial investments in technology, infrastructure, and training are significant barriers. Additionally, the lack of financial incentives or subsidies for green practices can deter adoption (Zhang, 2023).

- Social challenges: Social inequalities within value chains, such as unequal access to resources and markets, can hinder the adoption of green practices. Resistance to change among stakeholders, including cultural and behavioral barriers, also poses challenges (Polyportis et al., 2024).

6.2 Opportunities for Innovation and Entrepreneurship within Green Food Value Chains

-Innovation Opportunities: Green Food value chains open avenues for technological advancements, such as precision agriculture, renewable energy integration, and eco-friendly packaging solutions. These innovations can enhance efficiency and reduce environmental impact (Constantin, Strat, Deaconu, and Pătărlăgeanu, 2021; Hamam et al., 2022).

-Entrepreneurship Opportunities: The shift towards sustainability creates opportunities for startups and small businesses to develop eco-friendly products and services. For instance, circular economy principles encourage resource recovery and waste reduction, providing a fertile ground for green entrepreneurship (El Ayoubi & Radmehr, 2023; Gonçalves & Maximo, 2023).

-Youth Engagement: Programs like the NewGen Renewable Energy Accelerator highlight the potential for youth-led innovations to drive the green transition, fostering a new generation of eco-conscious entrepreneurs.

6.3 Policy and Regulatory Frameworks Needed to Support Green Food Value Chains

-Supportive Policies: Governments need to establish policies that incentivize sustainable practices, such as subsidies for renewable energy and tax breaks for eco-friendly businesses. Regulatory coherence across regions can also reduce trade barriers and promote green value chains (Izdori, Mkwambisi, Karuaihe, and Papargyropoulou, 2025).

-International Collaboration: Global frameworks, such as those for green hydrogen and renewable energy, emphasize the importance of international cooperation in setting standards and sharing best practices (Izdori et al., 2023).

-Balancing Trade-offs: Policymakers must navigate trade-offs between economic growth and environmental sustainability. This includes deciding whether to prioritize domestic industries or rely on imports for green technologies (Izdori et al., 2023).

7.0 Future Perspectives of the Global Green Food Value Chain

The global green food value chain holds significant promise for transforming how we produce, process, distribute, and consume food. As we look toward the future, several key trends and developments will shape its trajectory. Emerging Trends and Strategies

The global green food value chain is evolving rapidly, driven by technological advancements, consumer preferences, and policy shifts. Key emerging trends and strategies that will play a major role in shaping GFVC include: i) the use of digital technologies like blockchain, IoT, and AI are enhancing traceability, transparency, and efficiency in food value chains (Kumar, Choubey, Raut, and Jagtap, 2023; Wendt and Sigurjonsson, 2024); ii) Sustainable Packaging: Innovations in biodegradable and compostable packaging materials are reducing the environmental footprint of food products (Simões, Soares, and Santos, 2023); iii) the rise of plant-based and lab-grown proteins is reshaping food production, offering sustainable alternatives to traditional animal-based products (Polyportis et al., 2024); iv) Practices that restore soil health, enhance biodiversity, and sequester carbon are gaining traction as a cornerstone of sustainable farming (Polyportis et al., 2024) and v) Emphasis on reducing waste and reusing resources is becoming central to green food **SAEREM BOOK CHAPTERS First Published 2025 ISBN 978-978-60709-7-1**

value chains. For example, food waste is being converted into bioenergy or animal feed (Kumari, Singh, Sharma, and Malaviya, 2024). The proposed vision for Fully Green Food Systems (FGFS) by 2050 is a global food system which targets elements such as *Healthy and Nutritious Food for All, Net-Zero Emissions, Biodiversity Conservation* and *Equitable Value Chains*. Therefore this ambitious vision requires concerted efforts from all stakeholders, leveraging innovation, policy, and consumer behavior to create a sustainable and inclusive food system.

8.0 Conclusion

The green food value chain represents a transformative approach to addressing the intertwined challenges of environmental sustainability, global food security, and social equity. By prioritizing eco-friendly practices, resource efficiency, and circular economy principles, green food value chains offer a pathway to reducing the ecological footprint of food systems while ensuring economic viability and inclusivity. They play a vital role in mitigating climate change, conserving biodiversity, and enhancing the resilience of food systems in the face of global environmental and socio-economic pressures. As the world strives to meet the United Nations' Sustainable Development Goals, the adoption and expansion of green food value chains are imperative. Their significance extends beyond environmental conservation to encompass economic empowerment, improved livelihoods for smallholder farmers, and the delivery of safe, nutritious food for all. The journey toward fully green food systems will require innovation, policy reforms, and active participation from all stakeholders. However, the potential benefits viz: a healthier planet, more resilient food systems, and improved quality of life make this an achievable and worthwhile goal. By fostering collaboration among governments, businesses, consumers, and academic institutions, green food value chains hold the potential to revolutionize how we produce, distribute, and consume food, paving the way for a sustainable and equitable future for generations to come.

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