



# The role of food industries in sustainability transition: a review

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## Abstract

The global food industry is crucial in promoting sustainability, contributing to environmental degradation but also driving positive change. This review paper explores the significance, methodologies and recent research of food industries in promoting sustainability. The food industry faces sustainability challenges due to climate change, resource depletion, food security and health concerns. Policy makers, consumers and stakeholders are pushing businesses to reduce carbon footprint, adopt ethical sourcing, minimize waste and improve nutritional quality. This paper presents a compiled information of review of literature related to sustainability transition in food industry published worldwide. Shifting consumer preferences towards sustainable and healthy diets is a crucial aspect of the food industry's role in sustainable transition. Promoting plant based diets, reduced food waste and adopting circular economy principles can significantly contribute to sustainable consumption patterns. The food industry is making significant strides in sustainability, reducing greenhouse gas emissions, improving supply chain transparency and promoting responsible sourcing, but challenges persist. This review paper serves as both a clarion call and a roadmap, emphasizing the inextricable link between the food industry and sustainability.

**Keywords** Clean energy integration · Climate change mitigation · Plant-based diets · Reduced food waste · Sustainable food · Sustainable packaging

## 1 Introduction

The food industry plays a crucial role in shaping a sustainable future, as it plays a vital role in the production, distribution and consumption of food. However, conventional practices have led to environmental issues such as greenhouse gas emissions, deforestation, soil degradation and excessive water consumption (Rejeb et al., 2020). Social issues include labour

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rights violations, unequal access to nutritious food and strained relationships between industry stakeholders and local communities. Consumers demand food products that are safe, nutritious, ethically and environmentally sound (Alonso et al., 2020). Sustainability in the food industry involves a holistic approach that considers economic viability, environmental stewardship and social equity. This transition requires a collective reimagining of production methods, supply chain logistics, consumption patterns and regulatory frameworks. This explores the role of the food industry in this sustainable transition, examining the challenges, opportunities, innovations and policy considerations that characterize the industry's journey towards sustainability (Lajoie et al., 2020). It highlights that the food industry's evolution towards sustainability is not just a matter of corporate responsibility but an imperative that resonates with global aspirations for a balanced, just and habitable planet. By analysing environmental impacts, economic implications, ethical considerations, technological innovations, policy frameworks and industry initiatives, a nuanced understanding of the way forward will emerge, illuminating the potential for harmonizing humanity's nourishment with the planet's well-being (Yigitcanlar et al., 2021). The food industry is a vital lifeline and contributor to the ecological, social and economic fabric of our world. The growing global population and climate change have led to a profound transformation that seeks to harmonize nourishment with sustainability principles. The interconnected web of the food industry touches all corners of the globe, shaping landscapes, livelihoods and health outcomes (Tomich et al., 2019).

Sustainability in the context of the food industry is more than just a buzzword; it encapsulates a paradigm shift that transcends traditional definitions of success. It embodies the commitment to balance economic viability with environmental stewardship and societal well-being, ensuring that present actions do not compromise resources available for future generations. Unsustainable food practices have wide-ranging consequences, including exacerbating climate change through deforestation and carbon emissions, polluting water bodies with chemical runoff and depleting precious arable land (Pacoureaux et al., 2023). The social fabric of communities tied to agriculture and food production is often frayed by exploitation, unequal access to resources and lack of fair labour practices. (Spiegel et al., 2020) also concluded the multifaceted significance of sustainability within the contemporary food industry landscape, exploring the interconnectedness of ecological health, social justice and economic resilience within the sector. By examining the repercussions of unsustainable practices and delving into the transformative potential of sustainable alternatives, the paper endeavours to illuminate the path forward, ensuring food security, mitigating environmental harm and fostering vibrant communities.

By examining the environmental impacts, social implications, economic considerations and technological innovations that shape the sector's dynamics, the urgency of aligning industry practices with sustainable principles, not just as a choice but as an ethical obligation to the planet (Lau et al., 2021). The current impact of climate change worldwide has gathered the attention for mitigating these changes. Few examples across the globe includes a report from Kastamonu, a city in northern Turkey, which has a humid subtropical climate. The high humidity levels, especially when combined with high temperatures and wind patterns can affect human comfort. Urbanization can also impact local climate conditions, leading to higher temperatures due to the urban heat island effect Adigüzel and Çetin (2022). The other few reports includes study on bioclimate discomfort through climate change in various cities including effect of urban planning on urban formations in Bursa city (Cetin,

2019); determination of bioclimatic comfort areas in landscape planning at Cide Coastline (Adiguzel et al., 2022); impact of building density in urban management and planning for Burdur, Turkey (Zeren et al., 2023) and the climate comfort depending on different altitudes and land use in the urban areas in Kahramanmaraş city (Dutal, 2023).

The aim of this paper is to explore the complex factors surrounding the sustainable transition within the food industry, as the world faces increasing environmental challenges, social inequities and economic uncertainties. It aims to provide a foundational understanding of the challenges, opportunities and solutions that characterize the industry's pursuit of sustainability, concludes and delves into the historical evolution of the food industry and its relationship with the environment, society and economy, tracing the origins of unsustainable practices that have led to ecological degradation, social injustices and economic volatility. It also highlights the emergent narratives of change agents and pioneers within the industry who have embraced sustainability principles, signalling a transformative shift in paradigms. It critically analyses the challenges encountered and the innovations deployed to unravel strategies that have the potential to steer the industry toward a more sustainable trajectory. The synthesis of diverse perspectives, empirical evidence, and scholarly insights aims to offer a holistic panorama of the sustainable transition within the food industry, serving as a resource for policymakers, industry stakeholders, academics and concerned citizens. The purpose is to foster informed discourse, inspire positive change and contribute to the ongoing dialogue on the role of the food industry in shaping a more sustainable and resilient global future.

## 2 Key concepts and definitions

### 2.1 Sustainability and food industry

Sustainability in the food industry is a holistic framework that aims to balance economic viability, environmental integrity and social equity across the entire food system. It transcends short-term gains and embraces a long-term perspective, acknowledging the interdependence of ecological health, societal well-being and economic prosperity. An example of sustainable, circular, economic and environmental safe food chain approach is converting food industry byproducts (wastes such as Molasses, eggshells and citrus peels) into value added products (Fahmy 2007; Fahmy 2007a; Abouzeid et al., 2022). The latest study presented molasses as an addition in papermaking for the first time ever in history. When molasses was added to papermaking, paper composites with molasses as an ingredient had longer breaking lengths and much higher water retention values (WRV) than paper without molasses (Fahmy and Mobarak 2009; Fahmy and Mobarak 2014; Fahmy 2017). For the primary types of pulp used in the paper industry, eggshell waste was introduced in a related study. It gives eggshells, a significant byproduct of the food industry, a new purpose. This encourages the paper and food industries to be sustainable. Bagasse, a significant industrial crop waste, was selected as a model to explore the possibilities of eggshell waste for paper manufacture. The primary material of an eggshell is calcium carbonate. Additionally, eggshells have trace amounts of carbohydrates and proteins. Recent research has demonstrated that proteins and carbohydrates can increase the mechanical strength qualities of paper

while also improving the retention of inorganic fillers. These details inspired the writers to present eggshell to the paper industry (Fahmy et al., 2020).

Sustainability in the food industry focuses on fair pricing, transparent supply chains and investments in resilient agricultural practices that ensure profitability for producers and contribute to local economies and long-term stability (Barcaccia et al., 2020). Environmental stewardship is central to sustainability in the food industry, focusing on reducing greenhouse gas emissions, minimizing chemical inputs, promoting soil health, conserving water and preserving biodiversity. Regenerative and organic farming practices, sustainable land use management and responsible waste management are vital components of this aspect (Giller et al., 2021). Social equity encompasses the well-being of all individuals involved, including farmers, laborers and consumers. It requires upholding fair labour practices, ensuring safe working conditions and addressing food security and equitable access to nutritious food (Baur, 2022). Cultural and ethical considerations play a role in defining sustainability within the food industry, with respecting diverse food traditions, supporting indigenous knowledge and embracing humane treatment of animals. Long-term resilience is essential, as it envisions a future characterized by resilience and adaptability. This includes investing in research and innovation to develop sustainable agricultural practices, efficient supply chain logistics and innovative food technologies that can withstand uncertainties posed by climate change, resource scarcity and evolving consumer preferences (Dolan et al., 2021).

## 2.2 The triple bottom line

The triple bottom line (TBL) is a framework for evaluating and achieving sustainability in various sectors, including the food industry. It encompasses three interconnected dimensions: economic, environmental and social sustainability (Thanh & Lan, 2022). Economic sustainability involves fair and ethical financial practices, responsible resource allocation, efficient supply chain management and investments in research and development. Environmental sustainability focuses on minimizing negative impacts on the natural world and preserving ecosystems for current and future generations (Kumar et al., 2021). In the food industry, this includes reducing the ecological footprint of production, distribution and consumption processes, adopting practices that minimize pollution, conserve resources, protect biodiversity and mitigate climate change. Social sustainability emphasizes the well-being and equitable treatment of people involved in the food industry, including fair labor practices, safe working conditions, access to education and health care and the empowerment of marginalized groups (Jamatia, 2022). The triple bottom line framework recognizes that these three dimensions are interconnected and interdependent and achieving true sustainability requires a balanced approach that optimizes all three dimensions simultaneously. Implementing the triple bottom line approach requires a shift in mind-set and a commitment to integrated decision-making. Organizations that embrace this framework actively seek opportunities to create value across all three dimensions, understanding that a thriving business must contribute positively to society, the environment and the economy (Ferns et al., 2019). By aligning economic, environmental and social sustainability, the food industry can forge a path toward a more balanced and resilient future that benefits all stakeholders and respects the planet's finite resources.

## **2.3 Clarifying terms like organic, local, fair trade and circular economy in relation to food sustainability**

Food sustainability encompasses various terms and concepts that represent ethical, environmental and social responsibility within the food industry (Vuong et al., 2021). Organic farming practices prioritize soil health, biodiversity and sustainable resource management, while local food focuses on products produced and consumed within a small geographic radius (Kpienbaareh et al., 2020). Fair trade certification ensures farmers receive fair prices, workers are treated ethically and communities benefit from social development projects funded by premiums from fair trade sales. The circular economy model aims to eliminate waste and minimize resource consumption, while sustainable agriculture promotes long-term ecosystem health, support local communities and viable food production for present and future generations (Avraamidou et al., 2020). Food miles refer to the distance food travels from production to consumption, highlighting the environmental impact of transportation. Farm-to-table emphasizes direct sourcing of food from local farmers and producers to consumers, minimizing intermediaries in the supply chain. Regenerative agriculture aims to improve soil health, restore ecosystems and enhance biodiversity. Biodiversity conservation preserves plant and animal species within ecosystems, contributing to overall ecosystem health. Reducing the carbon footprint of food involves minimizing emissions associated with production, transportation and related activities. Understanding these terms helps individuals and industries make informed decisions about food choices and practices that align with sustainability principles (Monterrosa et al., 2020).

## **3 Environmental challenges and impacts**

### **3.1 Greenhouse gas emissions**

The food industry significantly contributes to global greenhouse gas emissions, playing a significant role in climate change. These emissions result from various stages of the food supply chain, including agricultural production, processing, transportation, storage and waste management (Panchasara et al., 2021). Key sources of greenhouse gas emissions include enteric fermentation, manure management, deforestation, fertilizer use, energy use in processing and transportation, food transportation, food waste decomposition, refrigeration and cold storage, packaging and deforestation for agriculture (Crippa et al., 2021). To mitigate the food industry's greenhouse gas emissions, a multifaceted approach is required. Strategies include sustainable agriculture, reducing food waste, efficient transportation, renewable energy, circular economy principles and plant-based diets. Implementing these strategies will help create a more sustainable and climate-resilient food system that contributes to global efforts to combat climate change. By promoting sustainable practices, reducing food waste and embracing circular economy principles, the food industry can contribute to a more sustainable and climate-resilient food system (Oruma et al., 2021).

### 3.2 Land and water usage

Land and water usage are crucial in food production, as they impact the environment, society and the sustainability of global food systems. Key issues related to land and water usage include habitat loss, land degradation, competition for land, land-intensive animal agriculture, water scarcity, irrigation practices, pollution, groundwater depletion and virtual water trade. Deforestation and habitat loss are caused by clearing forests for agriculture, which disrupts ecosystems and contributes to biodiversity loss. Land degradation occurs due to unsustainable agricultural practices, such as intensive monoculture farming and excessive tillage, which threatens the long-term viability of agricultural land (Francaviglia et al., 2023). Competition for land increases due to population growth, urban development and conservation efforts, leading to conflicts and displacement of communities. Water scarcity is a significant issue, with conflicts between agricultural, industrial and domestic water needs. Inefficient irrigation methods can lead to water wastage and salinization of soils (Mohanavelu et al., 2021). Pollution and contamination from runoff from agricultural fields can harm aquatic ecosystems, wildlife and human health. Groundwater depletion can result from over-extraction of groundwater for irrigation, reducing water availability for future generations and causing land subsidence. To address these challenges, sustainable practices, policies and technological innovations are needed. Solutions include agro ecology, crop rotation, efficient irrigation, agroforestry, water conservation, land-use planning and integrated water management. By addressing these challenges, the food industry can contribute to a more resilient and environmentally responsible food system that balances the needs of present and future generations (Pereira et al., 2020).

### 3.3 Biodiversity loss and ecosystem degradation

The food industry is causing biodiversity loss and ecosystem degradation, causing significant environmental concerns. The expansion of agricultural activities, unsustainable land use practices and intensification of food production have led to the degradation of natural habitats and the decline of biodiversity (Balogh and Jamber 2020). The food industry contributes to these issues through habitat conversion, monoculture farming, pesticide and chemical use, genetic erosion, soil degradation, water pollution, loss of pollinators, disruption of nutrient cycling and carbon sequestration. To address these issues, a holistic approach that considers ecological, social and economic factors is needed. Strategies include agroecological or natural farming, biodiversity-friendly policies, sustainable land use planning, support for indigenous knowledge and ecosystem restoration (Watson et al., 2019). By integrating these strategies into agricultural and food production practices, the food industry can contribute to the preservation of biodiversity, the restoration of ecosystems and the creation of a more sustainable and resilient food system.

### 3.4 Waste generation and management

Waste generation and management in food processing and distribution are complex issues with significant environmental, economic and social implications. The food industry produces significant amounts of waste at various stages of the supply chain, from production to consumption (Ncube et al., 2021). Effective waste management strategies are essential to

reduce environmental impact, conserve resources and minimize landfill space strain. Waste generation includes food loss and waste, packaging waste, by-products and scraps, expired and unsold products and source reduction. Source reduction involves preventing waste generation through better inventory management, production planning and consumer education. Donation and redistribution of surplus food can help address food insecurity (Huang et al., 2021). Composting and anaerobic digestion can process organic food waste, while recycling materials like cardboard, paper and certain plastics can reduce environmental impact. Upcycling involves repurposing food by-products and scraps into new products, while waste-to-energy technologies can convert non-recyclable waste into energy. Regulations and policies can encourage waste reduction, promote recycling and discourage wasteful practices. Consumer education can raise awareness about the environmental impact of food waste and lead to more responsible consumption habits. Collaboration among stakeholders, including producers, processors, distributors, retailers, consumers and policymakers is crucial for reducing waste footprint and contributing to a more sustainable and circular economy (Alonso et al., 2021).

### **3.5 Economic considerations**

#### **3.5.1 Economic benefits of sustainable practices**

Sustainable practices in the food industry offer numerous economic benefits, including cost savings, improved operational efficiency, risk reduction, market differentiation, access to new markets, innovation and research, supply chain resilience, long-term viability, employee engagement, reduced regulatory costs and investor appeal. These practices reduce resource consumption, operational efficiency, risk reduction, market differentiation, access to new markets and promote sustainable packaging, renewable energy integration and waste reduction (Shad et al., 2019). By focusing on these practices, businesses can reduce resource depletion and environmental degradation, ensure long-term viability of natural resources, attract and retain motivated workforce and align with evolving regulations. Additionally, adopting sustainable practices can help businesses align with evolving regulations, avoiding potential fines or penalties. Overall, adopting sustainable practices in the food industry can lead to increased profitability, operational efficiency and market competitiveness (Benton & Bailey, 2019).

#### **3.6 Consumer demand for ethically and sustainably produced food**

Consumer demand for ethically and sustainably produced food has grown significantly in recent years, driven by increasing awareness of environmental and social issues. This trend has influenced the food industry, influencing purchasing decisions and supply chain practices (Baiano, 2021). Factors driving this demand include environmental concerns, climate change awareness, animal welfare, health and nutrition, transparency and traceability, local and community support, social responsibility, organic and non-Genetically Modified Organism (GMO) preferences, circular economy principles, Millennials and Generation Z (Gen Z) influence, and online information and social media. Environmental concerns include deforestation, greenhouse gas emissions and water pollution, while climate change awareness emphasizes sustainable farming practices and reduced emissions (Hrustek, 2020).

Animal welfare, health and nutrition, transparency, local and community support, social responsibility, organic and non-Genetically Modified Organism (GMO) preferences, circular economy principles, and the influence of Millennials and Generation Z (GenZ). To meet the growing demand for ethically and sustainably produced food, the food industry must adapt its practices and supply chains, adopting sustainable farming methods, implementing responsible sourcing strategies, improving transparency and accurately labelling products. Businesses that align with consumer values and cater to their preferences are likely to succeed in a market that increasingly values ethical and sustainable food options (Lehoux et al., 2021) (Fig. 1).

### 3.7 Case studies of companies successfully integrating sustainability for economic growth

Various food companies have successfully integrated sustainability practices into their operations, leading to economic growth and positive impacts. Danone, a multinational food and beverage company, has embraced sustainability through its “One Planet One Health” vision, promoting healthier food choices, reducing its carbon footprint and supporting regenerative agriculture. WhiteWave Foods, a plant-based food and beverage company, has focused on producing dairy alternatives and organic products, aligning with changing consumer preferences. In 2017, Danone acquired WhiteWave Foods, recognizing its growth potential in the sustainable food sector (Kraak et al., 2019). Nestlé, a global food and beverage company, prioritizes sustainability by reducing greenhouse gas emissions, improving water efficiency and sourcing sustainable ingredients. Eosta, an international distributor of organic and fair-trade fruits and vegetables, has implemented sustainable packaging solutions and transparency initiatives, fostering consumer trust and increased demand for its products (Caratas, 2023). BrewDog, a craft beer company, has incorporated sustainability into its business model by focusing on energy efficiency and carbon reduction (Cunningham & Barclay, 2020). Green Chef, a meal kit delivery service, emphasizes sustainability by sourcing organic ingredients and minimizing food waste (Yang, 2022).

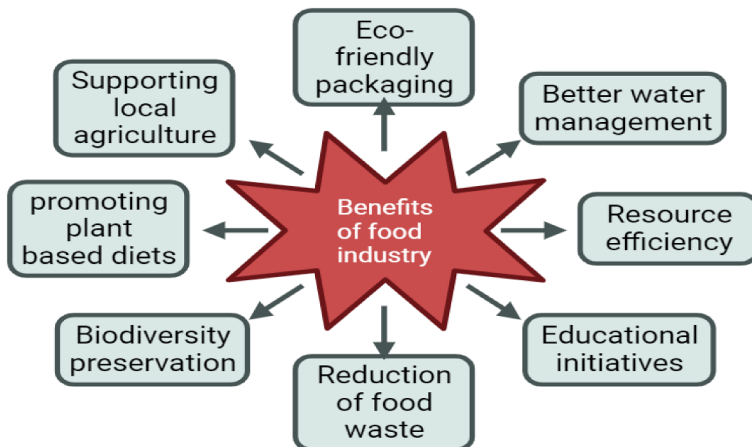


Fig. 1 Benefits of food industry



### **3.8 Social and ethical dimensions**

#### **3.8.1 Labour rights and fair working conditions**

Labour rights and fair working conditions are crucial for the well-being and dignity of workers in the food industry, which encompasses agriculture, processing, packaging, distribution and retail (Ariza et al., 2019). Key points to consider include fair wages, a safe working environment, reasonable working hours, the elimination of child labour, protection of migrant workers, collective bargaining, non-discrimination and equal treatment, access to healthcare and social benefits, regular inspections and enforcement, transparency and accountability and certification and labels (Bruzelius and Seeleib 2023). These factors help ensure workers' rights are respected and protected and employers should provide adequate healthcare and social benefits to workers exposed to potential health risks. Regular inspections and enforcement are essential to ensure compliance with labor laws and fair working conditions (Warhurst & Knox, 2022). Companies should disclose information about their supply chains, labor practices, and efforts to ensure fair working conditions, allowing consumers to make informed choices and support businesses that prioritize ethical practices. Certifications and labels, such as Fair Trade, Organic or Ethical Trade, can help consumers identify products produced under better labour conditions, but it is essential to verify the credibility of these labels (Vázquez & Lanero, 2021).

#### **3.8.2 Impact on local communities**

The food industry has both positive and negative impacts on local communities, depending on the type of food production, processing and distribution practices (Cottrell et al., 2019). Positive impacts include employment opportunities, income generation, market access, cultural preservation, community engagement and tourism and culinary identity. Negative impacts include environmental degradation, land displacement, water scarcity, health concerns, loss of biodiversity, labour exploitation, food insecurity and cultural erosion. By addressing these issues, the food industry can contribute to economic growth, reduce unemployment and foster a more sustainable and vibrant community.

#### **3.8.3 Food insecurity and equitable access to nutritious food**

Addressing food insecurity and ensuring equitable access to nutritious food is a multifaceted challenge that requires coordinated efforts from governments, organizations, communities and individuals (El Bilali et al., 2019). Strategies to tackle these issues include implementing social safety nets, promoting agricultural development, developing food distribution and infrastructure, educating communities about balanced diets, nutrition, food preparation, reducing food waste, promoting community gardens and urban agriculture, implementing school meal programs, empowering women, promoting financial inclusion, food security and nutrition, developing disaster preparedness plans and collaborating internationally to ensure equitable access to food for all. By implementing these strategies, we can work towards a more sustainable and equitable food system for all (Pawlak & Kołodziejczak, 2020).

### 3.9 Technological innovations and solutions

#### 3.9.1 Sustainable agricultural practices: precision farming, agroecology, vertical farming

Sustainable agricultural practices are crucial for maintaining the planet's long-term health, food security and minimizing environmental impacts. Three sustainable agricultural practices are precision farming, agroecology or natural farming and vertical farming (Shafi et al., 2019). Precision farming uses advanced technology and data-driven approaches to optimize practices at the field level, increasing crop productivity, improving resource efficiency and minimizing environmental impacts. Key components of precision farming include data collection, data analysis, variable rate application, smart machinery and decision support systems (Chawade et al., 2019). Agroecology or natural farming is a holistic approach that integrates ecological principles, focusing on sustainability, biodiversity conservation and the well-being of farmers and local communities. Key principles include biodiversity, soil health, natural pest management, local knowledge and reduced chemical inputs (Yadav et al., 2023). Vertical farming, on the other hand, is an innovative approach that grows crops in stacked layers or vertically inclined surfaces, offering space efficiency, resource efficiency, year-round production, reduced food miles and reduced soil erosion. These practices aim to promote local food production, reduce carbon emissions and promote sustainable agriculture (Jarzębowski et al., 2020).

#### 3.9.2 Reduced food waste through smart packaging and logistics

Reducing food waste is essential for sustainable food systems, and smart packaging and logistics play a significant role in achieving this objective. Smart packaging uses advanced technologies to extend product shelf life, monitor freshness and provide consumer information (Chen et al., 2020). Examples include Time-Temperature Indicators (TTIs), Freshness Sensors, Radio frequency Identification (RFID) tags, interactive labels and portion control packaging. Smart logistics optimizes the supply chain and minimizes food losses by utilizing real-time monitoring, route optimization, demand forecasting, cold chain management and collaborative platforms. Real-time monitoring allows for timely corrective actions, while route optimization uses real-time traffic and weather data to optimize delivery routes (Sahal et al., 2021). Demand forecasting helps suppliers and retailers plan inventory, reducing the risk of overstocking or understocking perishable goods. Cold chain management ensures temperature-sensitive products are transported and stored within recommended temperature ranges (Kartoglu & Ames, 2022). Collaborative platforms facilitate better communication, coordination and information sharing, leading to more efficient logistics and reduced waste. Overall, smart packaging and logistics strategies play a crucial role in achieving sustainable food systems and reducing food waste (Khan et al., 2021).

#### 3.9.3 Clean energy integration in food processing and distribution

Integrating clean energy solutions into food processing and distribution can significantly reduce greenhouse gas emissions, lower operational costs and promote sustainability within the food industry (Acosta et al., 2019). Renewable energy sources include solar panels, wind

turbines and biomass energy. Energy efficiency improvements include energy audits, light-emitting diode (LED) lighting, Heating, ventilation, and air conditioning (HVAC) upgrades, and combining heat and power (CHP) systems like cogeneration and passive design. Green building design principles, such as energy-efficient heating, cooling and lighting can minimize energy consumption (Negi, 2021). Energy management systems, such as monitoring and control, can help identify patterns of wastage and optimize energy use.

### **3.10 Regulatory and Policy frameworks**

#### **3.10.1 International agreements and initiatives**

International agreements and initiatives have been established to promote food sustainability, address food security and encourage responsible agricultural practices. These agreements aim to foster collaboration among nations, organizations and stakeholders to achieve sustainable food systems and protect the environment (Bazaluk et al., 2020). Some notable examples include the United Nations Sustainable Development Goals (SDGs), The Paris Agreement, Food and Agriculture Organization's (FAO) Global Initiative on Food Loss and Waste Reduction, 2030 Water Resources Group (2030 WRG), Global Agriculture and Food Security Program (GAFSP), Climate-Smart Agriculture (CSA), World Food Programme's Zero Hunger Challenge, Aichi Biodiversity Targets, One Health Initiative and the Sustainable Development Goals Summit (Tolliver et al., 2019). These agreements aim to end hunger, achieve food security, promote sustainable agriculture and ensure responsible consumption and production patterns. The One Health Initiative promotes sustainable agricultural practices that safeguard human and animal health.

#### **3.10.2 National and regional regulations**

National and regional regulations significantly influence the sustainability efforts of the food industry, providing a framework for responsible practices, environmental protection and overall sustainability (Caraka et al., 2020). Examples include Environmental Regulations, Food Safety Regulations, Sustainable Agriculture Regulations, Energy Efficiency Regulations, Packaging and Waste Regulations, Climate Change Regulations, Carbon Pricing, Renewable Energy Targets, Trade and Import Regulations, Sustainable Sourcing Requirements, Labour and Social Regulations and Social Responsibility Requirements (Jakob et al., 2022). These regulations aim to minimize waste, protect air, water, soil quality, ensure food safety and promote accurate and informative food labelling. Additionally, they encourage the use of organic certification, Integrated Pest Management (IPM) guidelines and energy efficiency standards in food processing facilities (Morrison et al., 2021). Regulations also encourage the adoption of sustainable packaging options, extended producer responsibility (EPR) laws and climate change policies, such as carbon pricing, renewable energy targets and sustainable sourcing requirements. Trade and import regulations may also require businesses to meet environmental and ethical standards, while labour and social regulations promote fair labour practices and protect workers' rights. Overall, these regulations play a crucial role in shaping the food industry's sustainability efforts and promoting responsible practices within the National and regional regulations significantly influence the sustainability efforts of the food industry, providing a framework for responsible practices,

environmental protection and overall sustainability (Tsalis et al., 2020). Examples include Environmental Regulations, Food Safety Regulations, Sustainable Agriculture Regulations, Energy Efficiency Regulations, Packaging and Waste Regulations, Climate Change Regulations, Carbon Pricing, Renewable Energy Targets, Trade and Import Regulations, Sustainable Sourcing Requirements, Labour and Social Regulations and Social Responsibility Requirements (Ankersmit, 2020).

### 3.10.3 Challenges and opportunities in aligning industry practices with regulatory goals

Aligning industry practices with regulatory goals can be challenging but also full of opportunities. Factors that can influence the extent to which industries can effectively align with these goals include cost implications, resistance to change, complexity of compliance, lack of awareness, competing priorities, global variability, market access and reputation (Asiaei et al., 2022). Opportunities include market access, reputation, innovation, efficiency, competitive advantage, risk mitigation, resource conservation, long-term viability, collaboration and partnerships. Challenges include significant investments in new technologies, equipment, training and infrastructure, resistance to change, complexity of compliance, lack of awareness, competing priorities and global variability. By aligning with regulatory goals, industries can gain a competitive advantage, avoid legal and financial risks associated with non-compliance and achieve long-term viability. Collaboration and partnerships with stakeholders, such as governments, non-governmental organizations (NGO) and local communities, can foster positive relationships and mutual benefits (Bandari, 2021).

## 3.11 Corporate initiatives and industry leadership

### 3.11.1 Profiles of food companies embracing sustainable practices

Food companies have made significant efforts to embrace sustainable practices in their operations, focusing on environmental stewardship, social responsibility and ethical business practices. Some of these companies include Patagonia Provisions, Ben & Jerry's, Danone, Whole Foods Market, Eosta, Mars, Incorporated (Mars, Inc.), Organic and Stonyfield Organic. Patagonia Provisions focuses on producing responsibly sourced and regenerative farmed food products, focusing on organic and regenerative agricultural practices, sustainable seafood sourcing and reducing their carbon footprint (Macarthur & Heading, 2019). Ben & Jerry's supports climate action and social justice through their products and campaigns. Danone, a multinational food company, has a comprehensive sustainability strategy called "One Planet. One Health," focusing on sustainable sourcing, reducing greenhouse gas emissions, promoting circular economy practices and supporting local communities (Hua et al., 2019). Whole Foods Market is known for its commitment to organic and local products, promoting ethical sourcing, sustainable seafood options and responsible animal welfare practices. Eosta is an international distributor of organic fruits and vegetables, pioneering the "True Cost of Food" concept and promoting "Nature & More" labelling system. Mars, Inc., a global food conglomerate, has set sustainability goals aligned with the United Nations Sustainable Development Goals, aiming to reduce carbon footprint, improve water efficiency and promote responsible sourcing of raw materials. Stonyfield Organic, a well-

known brand in the organic dairy industry, prioritizes organic farming, sustainable packaging and animal welfare (Autio & Iivonen, 2021).

### 3.11.2 Collaboration and partnerships for industry-wide sustainability improvements

Collaboration and partnerships are crucial for achieving industry-wide sustainability improvements in the food industry. These partnerships involve multi-stakeholder initiatives, supply chain collaboration, research and development collaborations, public-private partnerships, cross-industry alliances, consumer engagement partnerships, impact investing, certification and standards organizations, technology and innovation partnerships and knowledge sharing and capacity building (Krmela et al., 2022). Multi-stakeholder initiatives involve government agencies, industry associations, NGOs, academia and businesses, while supply chain collaboration fosters transparency, accountability and shared goals. Research and development collaborations between food companies and research institutions can lead to innovative technologies, practices and products that promote sustainability. Public-private partnerships combine public resources, private sector expertise and social goals to address issues like food security, water management and climate resilience (Sedykh et al., 2020). Cross-industry alliances create opportunities for knowledge sharing and cross-pollination of ideas, while consumer engagement partnerships help spread awareness about sustainable choices and encourage demand for environmentally friendly products. Impact investing drives sustainability improvements by allocating funds to companies and projects that prioritize environmental, social and governance factors (Brill et al., 2020). Certification and standards organizations provide credibility and accountability to sustainability claims. Technology and innovation partnerships help food industry players adopt advanced solutions for energy efficiency, supply chain optimization and waste reduction. Knowledge sharing and capacity building platforms help food companies learn from each other and improve their sustainability strategies.

### 3.11.3 Role of certification programs and standards in guiding sustainable practices

Certification programs and standards are essential in promoting sustainable practices across industries, including the food industry. They provide a framework for defining, measuring and verifying various aspects of sustainability, helping businesses, consumers, stakeholders identify products and practices that align with specific environmental, social and ethical criteria (Jamal et al., 2021). These programs establish credibility and trust by providing third-party verification of claims made by businesses, ensuring consumers, investors and other stakeholders can trust that certified products meet specific sustainability criteria. Certification programs set clear and consistent benchmarks for businesses to measure their performance against recognized criteria, allowing for meaningful comparisons across companies and products. They also provide improvement guidance, incentives for adoption, consumer awareness and education, supply chain transparency, addressing complex issues like fair labour practices, responsible land use, biodiversity conservation, climate impact, collaboration and stakeholder engagement (Kouhizadeh, 2021). Continuous improvement is encouraged through renewal processes, promoting businesses to maintain and improve their sustainable practices over time. Market access and preference can be enhanced by certification, providing access to specific markets or buyers who prioritize sustainability. Industry

transformation can also be driven by certification programs, driving positive changes within industries by setting a higher bar for sustainable practices and encouraging businesses to innovate to meet those standards. Examples of widely recognized certification programs and standards in the food industry include United States Department of Agriculture (USDA) Organic, Fair Trade, Rainforest Alliance, Non-Genetically Modified Organism (GMO) Project Verified and seafood sustainability certifications like Marine Stewardship Council (MSC) and Aquaculture Stewardship Council (ASC) (Sigurdsson et al., 2023).

### **3.12 Barriers and challenges**

#### **3.12.1 Identifying obstacles to implementing sustainable practices**

Sustainable practices in the food industry face various obstacles, including economic challenges, lack of awareness and education, regulatory and policy barriers, market dynamics, supply chain complexity, resource constraints, cultural and behavioural factors, technical challenges, scale and complexity of food systems, market competition, cultural and behavioural factors. Economic challenges include initial costs, lack of awareness and education, regulatory and policy barriers, market dynamics, consumer demand, price sensitivity, supply chain complexity, resource constraints and access to capital (Hartley et al., 2022). Market dynamics include consumer demand, price sensitivity, supply chain complexity, traceability challenges, resource constraints, cultural and behavioural factors. Technical challenges include innovation barriers, compatibility, scale and complexity of food systems, market competition and price competition. The interconnectedness of the global food system makes it challenging to address sustainability holistically and changes in one area can have unintended consequences elsewhere. By addressing these challenges, businesses can work towards a more sustainable future in the food industry.

#### **3.12.2 Balancing sustainability with cost-effectiveness and market competitiveness**

Balancing sustainability with cost-effectiveness and market competitiveness is a complex challenge faced by businesses in the food industry. To achieve this, businesses can conduct a lifecycle cost analysis, integrate innovation, efficiency and implement cost reduction strategies (Correani et al., 2020). Marketing and value propositions can attract environmentally conscious consumers willing to pay a premium for eco-friendly products. Collaboration and partnerships can help reduce costs along the supply chain. A long-term strategy should consider sustainability as part of a business strategy, as it can enhance brand reputation, customer loyalty and market resilience. Competitive analysis should assess competitors' sustainability practices and their impact on pricing, finding a balance between sustainable practices and pricing strategies that maintain competitiveness within the market. External funding and incentives can offset initial costs (Reguero et al., 2020). Incremental implementation can be initiated gradually, starting with smaller initiatives with lower costs and immediate impact. Communicating value and focusing on cost-efficient sustainable practices can help reduce environmental impact and improve product quality. Continuous improvement is crucial for long-term cost savings and improved competitiveness. By implementing these strategies, businesses can achieve long-term benefits and competitiveness in the food industry (Mykhailichenko et al., 2021).

### **3.12.3 Overcoming resistance to change within the industry**

To overcome resistance to change in the food industry, strategies include clear communication, education, leadership and stakeholder engagement. Clear communication should clearly communicate the reasons for the proposed changes, their benefits and alignment with the company's goals and values (Errida & Lotfi, 2021). Education and awareness should be provided, with training sessions, workshops and resources explaining the rationale behind the changes and their impact on business outcomes. Stakeholder engagement should be involved, with leaders buying in and leading by example. Pilot projects can demonstrate the feasibility and benefits of the proposed changes on a smaller scale. Addressing concerns and showing empathy can build trust and encourage productive discussions. Empowering change agents, sharing success stories and showcasing benefits can help spread positive messages and address doubts within teams. Fear of the unknown should be addressed, providing information about the changes, implementation and support available (Ceder, 2021). Small steps and celebrations can help break down the change process into manageable steps, creating a sense of ownership among employees. Establishing a continuous feedback loop and emphasizing the vision can inspire individuals to work toward a shared goal. By implementing these strategies, the food industry can overcome resistance and work towards sustainable practices.

## **3.13 Outlook and recommendations**

### **3.13.1 Anticipated trends in the food industry's sustainable transition**

The food industry is undergoing a rapid sustainable transition to address environmental, social and economic challenges. Trends expected to shape this transition include plant-based and alternative protein sources, circular economy practices, precision agriculture and Agricultural Technology (AgTech), sustainable packaging innovations, carbon-neutral and net-zero initiatives, food waste reduction, biodiversity and regenerative agriculture, digital transparency and traceability, water management and conservation, social responsibility and fair labour practices, consumer education and awareness, and government regulations and incentives (Asif et al., 2023). These trends will drive increased demand for eco-friendly products and practices, while also promoting circular economy principles, precision agriculture, sustainable packaging and reducing environmental impact. Companies are also focusing on reducing food waste through real-time monitoring, better inventory management and innovative food recovery solutions (Annosi et al., 2021). Additionally, the food industry is focusing on water management and conservation, ensuring efficient irrigation practices, water-saving technologies and waste water treatment. Social responsibility and fair labor practices will also be prioritized, with businesses working to ensure fair labour practices, support local communities and promote equitable supply chain relationships (Santos, 2023).

### **3.13.2 Strategies for scaling up sustainable practices across the industry**

Scaling up sustainable practices in the food industry requires a strategic approach that involves multiple stakeholders, clear goals and effective implementation. Strategies include setting clear sustainability goals, obtaining leadership commitment, cross-functional col-

laboration, engaging suppliers and partners, pilot projects, technology and innovation, data-driven decision-making, training and education, communication and transparency, incentives and recognition (Hassen et al., 2021). By implementing these strategies, organizations can improve their sustainability efforts, reduce carbon emissions, minimize waste and improve water management. By implementing these strategies, organizations can increase efficiency, effectiveness and customer loyalty, ultimately leading to a more sustainable and sustainable food industry (Jung et al., 2020).

### 3.13.3 Recommendations for policy makers, businesses and consumers to drive positive change

The food industry needs collective efforts from policy makers, businesses and consumers to drive positive change. To achieve this, policy makers should enact and strengthen regulations that promote sustainable practices, food safety, responsible sourcing and environmental protection (Siwandeti et al., 2023). Businesses should provide incentives, promote transparency, invest in research and innovation and raise awareness about sustainable food choices. Businesses should set clear sustainability goals, led by example, invest in innovation, collaborate across the supply chain and publish transparent reporting (Brun et al., 2020). Consumers should make informed choices, demand transparency, reduce food waste, support local and sustainable foods and advocate for change. By educating themselves about the environmental and social impacts of food choices, supporting businesses that provide transparent information, reducing food waste, prioritizing local and sustainably produced foods and advocating for change, the food industry can work towards a more sustainable and responsible food system (Herrero et al., 2020).

## 4 Conclusion

Through the systematic evaluation of the literature, we have presented an overview and an update of recent conceptualizations and elaborations on the role of the food industries in the sustainability transition. This review paper serves as both a clarion call and a roadmap, emphasizing the inextricable link between the food industry and sustainability. It presents a case for redefining norms of consumption, production and waste management, driving systemic change and fostering a more harmonious relationship between humans and the environment. The food industry is a dynamic and interconnected web that significantly impacts the nutritional well-being of individuals and the ecological health of our planet. Its practices, including sourcing ingredients, packaging, distribution and waste management, intertwine with global sustainability goals. The industry has the potential to act as a catalytic force, driving transformative changes beyond its immediate boundaries. Despite challenges such as complex supply chains, resource limitations and economic considerations, the industry is poised to be a driving force behind the sustainable transition. Collaborative action is essential as governments, industry players, consumers and advocacy groups must collaborate to set new benchmarks, policies and standards that align with sustainable development. This synergy has the potential to transcend barriers and cultivate a new era of responsible business practices that transcend traditional boundaries. Our findings are predicated on global environmentally friendly production. To extrapolate processes of



change, additional case studies are required. Additional research could concentrate on the agricultural and food industrial sectors in various geographic regions, as well as on various food production systems and associated business models that could yield various ecological or financial advantages. Additionally, more research might concentrate on various transition models to examine sustainability transitions in the sector of the agricultural and food-based industries, as well as the function of ecology in these models.

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