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Reframing food systems

resilience: towards a global
Sustainable Development Agenda
SDG 2 (Zero Hunger)

**Reformulação da resiliência
dos sistemas alimentares:**

rumo a uma Agenda Global de
Desenvolvimento Sustentável –
ODS 2 (Zero Fome)

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Reframing food systems resilience: towards a global Sustainable Development Agenda SDG 2 (Zero Hunger)*

Reformulação da resiliência dos sistemas alimentares: rumo a uma Agenda Global de Desenvolvimento Sustentável – ODS 2 (Zero Fome)

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Saurabh Chandra***

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Abstract

The food system includes all of the operations that go into growing, distributing, and preparing food as well as the labor force and other components needed to get a specific food item from the farm to the table. A food system's resilience is defined as its capacity to adjust and maintain the long-term provision of sufficient, suitable, and acceptable food for all individuals, even in the face of unforeseen disruptions. In a nutshell, it's about making sure food is always available despite continual disturbances. Disruptions can be man-made or natural, and they can manifest as stresses, which are slow degradations, or shocks, which are abrupt disturbances to the food chain. For instance, long-term droughts that function as stressors or extreme weather events that operate as shocks might result from climate change, progressively changing the environment and the food chain. This paper comprehensively explores the various dimensions of the food systems resilience towards a global Sustainable Development Agenda SDG 2 (Zero Hunger).

Keywords: food system; resilience; Zero Hunger; social inequities; food insecurity; sustainable agriculture; technological solutions.

Resumo

O sistema alimentar inclui todas as operações de cultivo, distribuição e preparação de alimentos, bem como a força de trabalho e outros componentes necessários para levar um item alimentar específico da fazenda à mesa. A resiliência de um sistema alimentar é definida como sua capacidade de ajustar e manter o fornecimento de longo prazo de alimentos suficientes, adequados e aceitáveis para todos os indivíduos, mesmo diante de interrupções imprevistas. Em suma, trata-se de garantir que os alimentos estejam sempre disponíveis, apesar dos distúrbios contínuos. As perturbações podem ser naturais ou causadas pelo homem e podem se manifestar como estresses, que são degradações lentas, ou choques, que são perturbações abruptas na

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cadeia alimentar. Por exemplo, secas de longo prazo que funcionam como estressores ou eventos climáticos extremos que funcionam como choques podem resultar de mudanças climáticas, alterando progressivamente o ambiente e a cadeia alimentar. Este documento explora de forma abrangente as várias dimensões da resiliência dos sistemas alimentares em direção à Agenda de Desenvolvimento Sustentável global SDG 2 (Zero Fome).

Palavras-chave: sistema alimentar; resiliência; Zero Fome; desigualdades sociais; insegurança alimentar; agricultura sustentável; soluções tecnológicas.

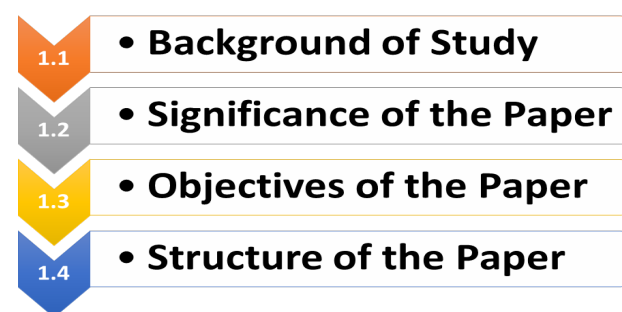
1 Introduction

Resilient food systems can endure both short-term and long-term shocks and stressors, such as natural disasters and extreme weather events. They are characterized as diverse, integrated, self-regulating, adaptive, inclusive, and equitable. Examples of food system resilience, including food sovereignty, are found worldwide, often led by civil society and Indigenous peoples¹. These systems ensure and protect people's ability and right to define their own models of food production, distribution, and consumption. Disasters have the potential to short-term disrupt food availability and earnings, long-term harm individuals and systems involved in food production and distribution, and stretch food system enterprises and safety net programs to breaking point. For underprivileged populations, these effects are frequently more severe because of racism and institutional injustices. The risks are many and frequently happen all at once². These risks include pandemics, supply chain disruptions, increased food and production material prices (such fertilizer), labor shortages, disputes, and more.

A robust food system is capable of withstanding and rebounding from such disturbances, guaranteeing an adequate amount of palatable and easily available food for every individual. Possible human-caused disruptions include wars or international conflicts, inflation that drives up food prices and restricts access to credit, and

political upheaval. Even if these problems arise distant from places where people typically buy food, like supermarkets or farmers markets, they can still have an effect on the food chain³. Local food supply and access can be impacted by the ripple effects of global disruptions at several levels. Resilience of the food system takes several forms. It examines how various communities define resilience and draw on ideas related to the food system and resilience. The enhancing of the resilience of food system results is the main goal, necessitating activity adaptation from food system participants⁴. When there are changes in the drivers, whether they opportunities or dangers, these actions adapt accordingly. Enhancing resilience, however, calls for making normative decisions and negotiating trade-offs between the results of the food system for different stakeholders. To create food systems that are better prepared to handle difficulties in the future, new approaches that take into account the aims and viewpoints of various food system players are required⁵.

Figure 1 – Share the Landscapes of Introduction Split Sections



Source: Original.

1.1 Background of study

There are studies on the resilience of food systems are using more and more of the conceptual models of food systems that have been created for planning and research reasons. Few studies have gone beyond defining resilience to give appropriate dimensions or case-study examples, despite the rising attention being

¹ KOSHARIYA, A. K. *et al.* Waste to energy: an experimental study on hydrogen production from food waste gasification. *International Journal of Hydrogen Energy*, v. 54, p. 1-12, 2024.

² GATTO, A.; CHEPELIEV, M. Global food loss and waste estimates show increasing nutritional and environmental pressures. *Nature Food*, v. 5, p. 136-147, 2024.

³ AXMANN, H. B. *et al.* Mitigate+: food loss and waste country profile Colombia: estimates of food loss and waste, associated GHG emissions, nutritional losses, land use and water footprints. [S. l.]: CGIAR, 2024.

⁴ LAWAL, I. M. *et al.* Proximate analysis of waste-to-energy potential of municipal solid waste for sustainable renewable energy generation. *Ain Shams Engineering Journal*, v. 15, n. 1, p. 102357, 2024.

⁵ FONT, X. *et al.* Responsible consumption and production of food: opportunities and challenges for hospitality practitioners. 2023.

paid to food system resilience⁶. When it comes to creating workable solutions for boosting resilience, this gap is especially noticeable when resilience principles are applied to food system frameworks. This raises an important question: What component of the food system do we want to strengthen? Which is it, the system's function (how it works) or the system's function (the results). If this is the case, how do we strike a balance between the resilience of favorable outcomes like food security, employment, and social capital and unfavorable ones like excessive resource exploitation, pollution, habitat degradation, greenhouse gas emissions, diet-related illnesses, an increase in zoonotic diseases, and other detrimental socioeconomic effects like the erasure of traditional knowledge, farming methods, institutions, and skills, modern slavery, and the loss of cultural heritage⁷. It is critical to decide which beneficial outcomes for resilience in our food systems should be given priority and to weigh their relative relevance when making policy decisions e.g., should job creation objectives take precedence over nutrition goals. Resilience and food system principles have been combined due to the growing interest in food system resilience.

1.2 Significance of the paper

Food-system resilience starts with supporting sustainable farming businesses that prioritize both environmental and human health. Over the past century, global competition has led to significant consolidation in agricultural production. The large industrial farms which often lack diversity and focus on one or two commodity crops, degrade soil health, reduce biodiversity, pollute water, threaten local food security, limit employment opportunities, and exploit farm workers. In contrast, micro, small, and mid-sized sustainable farms contribute to a vibrant agricultural economy with more farmers and local jobs, keep more money circulating within regional economies, and reduce greenhouse gas emissions and other off-site environmental impacts. They can also reduce food safety risks for consumers⁸.

Micro, small, and mid-sized farms need access to markets, capital, and technical assistance to achieve viability, which is based on farm productivity, profitability, maintaining land in long-term agricultural use, and ecological land stewardship. Viable farm businesses strengthen local and regional communities and economies, promote sustainable and ecological production practices, facilitate equitable food access, and increase wealth for socially disadvantaged populations, all of which enhance food-system resilience. Comprehensive, culturally responsive technical assistance is necessary to support farmers in expanding their enterprises and leveraging government programs for conservation and sustainable agricultural practices⁹.

1.3 Objectives of the paper

This paper has the following objectives to:

- give a thorough explanation and definition of food system resilience, highlighting its significance and applicability in the context of accomplishing the Sustainable Development Goals (SDGs), particularly SDG 2 (Zero Hunger).
- delineate and expound upon the principal aspects and constituents of food system resilience, encompassing favorable consequences such as job creation and food security, as well as unfavorable effects like pollution and overuse of resources.
- create workable frameworks and strategies for boosting food systems' resilience by addressing a variety of risks, shocks, and stressors by applying the three-Rs approach (robustness, recovery, and reorientation).
- explore how improving food system resilience may have trade-offs and policy implications, looking at how various good outcomes might be prioritized and balanced to promote SDG 2.
- incorporate global viewpoints and case studies from various research projects and experiences throughout the globe, emphasizing the versatility of resilience

⁶ DELGADO, A.; RODRIGUEZ, R.; STASZEWSKA, A. Tackling food waste in the tourism sector: towards a responsible consumption trend. *Sustainability*, v. 15, n. 17, p. 13226, 2023.

⁷ PIVARSKI, B. K. *et al.* Characteristics of traditional food products as a segment of sustainable consumption in Vojvodina's hospitality industry. *Sustainability*, v. 14, n. 20, p. 13553, 2022.

⁸ LUND-DURLACHER, D.; ANTONSCHMIDT, H. Towards a framework for sustainable and responsible food operations in the

holiday context and implementation approaches in the travel industry. In: LUND-DURLACHER, D. *et al.* (ed.). *Corporate sustainability and responsibility in tourism: a transformative concept*. Cham: Springer, 2019. p. 327-341.

⁹ OZTURKCAN, S.; KITAPCI, O. A sustainable solution for the hospitality industry: the QR code menus. *Journal of Information Technology Teaching Cases*, v. 0, n. 0, p. 1-6, 2023.

ce principles in many settings and supporting an international agenda for sustainable development.

Figure 2 – Displays the Objectives of the Paper

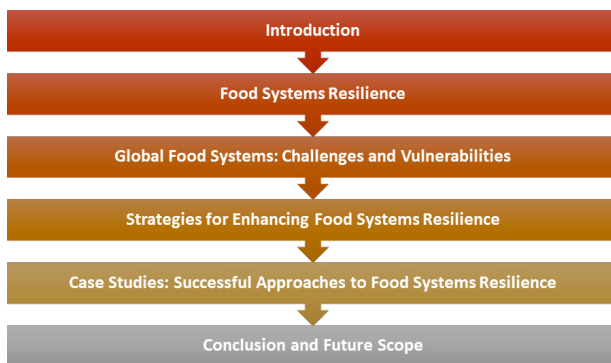


Source: Original.

1.4 Structure of the paper

This paper deeply dives into the diverse arena of Reframing Food Systems Resilience: Towards a Global Sustainable Development Agenda SDG 2 (Zero Hunger). Section 2 elaborates the Importance of SDG 2 and Food Systems Resilience. Section 3 explores the Global Food Systems: Challenges and Vulnerabilities. Section 4 lays down the Strategies for Enhancing Food Systems Resilience. Section 5 highlights the Case Studies: Successful Approaches to Food Systems Resilience. Finally, Section 6 Conclude the Paper with Future Scope.

Figure 3 – Express the Flow of this Paper



Source: Original.

1.4.1 Methodological section: data selection and analysis techniques

A framework of this nature is important for studying resilience and food security, as it demands a systematic process of data selection, data collection, and

data analysis to reach sound conclusions that are warranted by the evidence¹⁰. In this section, we outline the data sources, selection criteria, and analysis methods (metrics) used to evaluate resilience of food systems in terms thereof.

Data Selection and Sources

A mixed-method data sources is used to address resilience and food security, including both qualitative and narrative data. The data is collected from various primary and secondary sources:

Primary Data Sources

Household surveys and structured questionnaires to assess food access, dietary diversity and coping mechanisms during food crises.

Interviews with key informants including farmers, policymakers, and food security experts on local resilience strategies.

Focus group discussions (FGDs) at community level to assess social networks, adaptive capacities, and knowledge sharing for food security.

Using remote sensing and geospatial data to study agricultural productivity, land-use patterns, and climate impacts.

Secondary Data Sources

FAO, WFP, World Bank: datasets from international organizations

Reports, policy documents, etc. on food security programs and resilience-building initiatives.

Case studies mainly from peer-reviewed literature targeting resilient and food security in various socio-economic and environmental conditions.

Climate and meteorological data from agencies like the Intergovernmental Panel on Climate Change (IPCC) as part of the process of assessing climate-related risks to food production.

The data sources are selected based on a set of pre-determined inclusion criteria, such as relevance, reliability, and comparability across the world and over time. Preference will be given to data sets that offer longi-

¹⁰ HAN, H. *et al.* Effect of environmental corporate social responsibility on green attitude and norm activation process for sustainable consumption: airline versus restaurant. *Corporate Social Responsibility and Environmental Management*, v. 27, n. 4, p. 1851-1864, 2020.

tudinal information to better understand food security trends and resilience indicators¹¹.

Analytical Techniques

Recent advancements in open-source tools, where freely available and powerful computing is applied to core principles of statistical analysis, geospatial analysis, and qualitative content analysis, are applied to ensure resilience and food security is answered holistically across multiple articles.

Quantitative Data Analysis

This paper present descriptive statistics summarizing markers like food availability, household income, dietary diversity scores, and agricultural yields.

Regression analysis uses to find relationships between resilience factors (social safety nets, climate adaptation measures) and food security outcomes.

Time-series analysis allows the researchers to follow how food security indicators change over time, especially in response to climate events, economic shocks or policy interventions¹².

The application of machine learning models including decision trees and neural networks to predict food insecurity risks using both historical and real-time data may also be explored.

Qualitative Data Analysis

Qualitative thematic analysis is performed on both interviews and focus group discussions to highlight the themes in community resilience strategies and policy effectiveness.

Policy documents and reports are subjected to content analysis to evaluate government- and international-level responses to food security threats.

Network analysis studies the role of social networks and information-sharing mechanisms for building resilience among smallholder farmers¹³.

¹¹ RIVA, F. *et al.* Green consumerism, green perceived value, and restaurant revisit intention: millennials' sustainable consumption with moderating effect of green perceived quality. *Business Strategy and the Environment*, v. 31, n. 7, p. 2807-2819, 2022.

¹² BĂLTESCU, C. A. Exploring younger generation sustainable consumption in the restaurant industry. In: PAMFILIE, R. *et al.* (ed.). *8th BASIQ International Conference on New Trends in Sustainable Business and Consumption*. Graz, 2022. p. 560-566.

¹³ HWANG, J.; KIM, J. J. Edible insects: how to increase the sustainable consumption behavior among restaurant consumers. *International Journal of Environmental Research and Public Health*, v. 18, n. 12,

Geospatial and Climate Data Analysis

Interest of the GIS: (1) mapping of hotspots food-security (2) Land Use changes (3) visualizing vulnerabilities in climate

Crop conditions, drought impacts and rates of deforestation affecting food production are monitored with satellite imagery.

Remote sensing models such as Normalized Difference Vegetation Index (NDVI) monitor vegetation health and forecast agricultural results trends.

Ethical Considerations and Limitations

This raises the issue of ethics, which are carefully followed by obtaining informed consent from survey respondents and interview participants Data privacy is preserved using anonymization methods. However, Generating a consistent complete picture worldwide has limitations such as data availability constraints, potential biases in self-reported surveys, and integrating heterogeneous data from diverse sources of different regions. Through this innovative methodological strategy, the study successfully captures the multidimensionality of resilience and food security, allowing for actionable recommendations for policymakers, researchers and practitioners¹⁴.

2 Importance of SDG 2 and food systems resilience

In the year 2015, the United Nations adopted Sustainable Development Goals that vowed to provide with an extensive and global framework to address the global challenges and attain a harmonised sustainable development, inclusive of climate actions, gender equality, poverty eradication, hunger index, food security etc. Food security, being one of the essential components of SDGs is vital for eradicating poverty and the overall well-being of humans as it would ensure access to adequate, nutritious, and safe food in meeting the dietary preferences and requirements of public at large¹⁵.

p. 6520, 2021.

¹⁴ HAN, H. Consumer behavior and environmental sustainability in tourism and hospitality: a review of theories, concepts, and latest research. *Journal of Sustainable Tourism*, v. 29, n. 7, p. 1021-1042, 2021.

¹⁵ VOUKKALI, I. *et al.* The importance of KPIs to calibrate waste strategy in hospitality sector. *Energy Nexus*, v. 11, p. 100211, 2023.

The Sustainable Development Goal-2 clearly aims on achieving food security, ending hunger, significant improvement in nutrition and above all promoting sustainable agriculture. SDG-2 lays down explicit strategies to achieve sustainable agriculture by improving nutrition, limiting food waste, and providing equitable access to land and resources. The importance of Sustainable Development Goal-2 is directly proportional to the hunger and undernourishment of people, as it makes them less productive and more vulnerable to diseases and medical complications¹⁶. The agricultural and food industry is a key player in eradicating poverty and hunger as under better and responsible management they could foster development among below poverty line society and rural sectors.

2.1 Key concepts related to resilience and food security

The relationship between resilience and food security is a key economic concept for sustainable food systems and food crisis vulnerabilities. The ability of individuals, communities, and systems to prepare for, absorb, recover from, and adapt to shocks and stresses, including those that result from climate change, economic instability, and conflicts. Resilience, as it pertains to food security, is critical for ensuring stability of the supply of food and access to food in times of crisis. Food security is defined by the Food and Agriculture Organization (FAO) as existing when “all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life.” There is a need to delve into the dimensions, linkages and underpinnings of a number of different, important concepts that are used in relation to both resilience and food security¹⁷.

Availability of the food is underlying determinants of food security is defined as the amount of food available in a given country or region, either through domestic production, imports, or food assistance. It is heavily determined by agricultural productivity, climate

patterns and the supply chain infrastructure¹⁸. Access, however, is another key pillar, where individuals and households have the means to obtain food, via income, social protection programs or local markets. Utilization deals with how food is digested, absorbed, and metabolized in the body, emphasizing nutrition, hygiene, and food safety¹⁹. The final pillar, stability, stresses the need for consistent food availability and access over time, especially in the context of external shocks as economic downturns, pandemic, extremes of weather, etc.

The ability for agricultural communities and stakeholders to respond effectively to the challenges they face builds resilience in food systems. It can mean climate-resilience in agriculture which comprises sustainable practices like agroecology, precision farming and use of climate smart-technology to reduce the impact of such extreme events like droughts, floods and extreme heat. The economic resilience signifies the capability of both food producers and consumers to weather market shocks, inflation and trade interruptions by relying on diversified income sources, financial back stops, and state support policies. Social resilience is just as crucial, including community networks, knowledge, and governance systems that strengthen group responses²⁰.

The base of food security is preventing food system vulnerabilities by reducing dependence on monoculture cultivation, trimming reliance on global supply networks and strengthening social safety nets. Agricultural innovation, in the form of genetic advances in crops, vertical farming and regenerative agriculture, strengthens long-term food security. Subsidies for smallholder farmers, investment in rural infrastructure, social protection programs using food assistance and feeding programs in schools: all policy interventions important to equitable food access. Resilience and food security are ecological and are evolving in the process and are intertwined and need an integrated approach to thick a

¹⁶ BUX, C.; AMICARELLI, V. Circular economy and sustainable strategies in the hospitality industry: current trends and empirical implications. *Tourism and Hospitality Research*, v. 23, n. 4, p. 624-636, 2022.

¹⁷ CHAWLA, G.; LUGOSI, P.; HAWKINS, R. Factors influencing hospitality employees' pro-environmental behaviours toward food waste. *Sustainability*, v. 14, n. 15, p. 9015, 2022.

¹⁸ ALVAREZ-RISCO, A.; ESTRADA-MERINO, A.; PEREZ-LUYO, R. *Sustainable hospitality management: designing meaningful encounters with talent and technology*. Leeds: Emerald Publishing Limited, 2020.

¹⁹ AMICARELLI, V. *et al.* How to manage and minimize food waste in the hotel industry: an exploratory research. *International Journal of Culture, Tourism and Hospitality Research*, v. 16, n. 1, p. 152-167, 2022.

²⁰ LEGRAND, W.; CHEN, J. S.; LAEIS, G. C. *Sustainability in the hospitality industry: principles of sustainable operations*. London: Routledge, 2022.; ELSHAFEI, R. Managers' risk perception and the adoption of sustainable consumption strategies in the hospitality sector: the moderating role of stakeholder salience attributes. *Smart and Sustainable Built Environment*, v. 11, n. 1, p. 1-18, 2022.

link between environment sustainability, technological aspects, economic policies and social inclusion²¹. The resilience of food systems can play a crucial role in protecting food security and enabling societies to better prepare for the challenges of today and tomorrow.

3 Global food systems: challenges and vulnerabilities

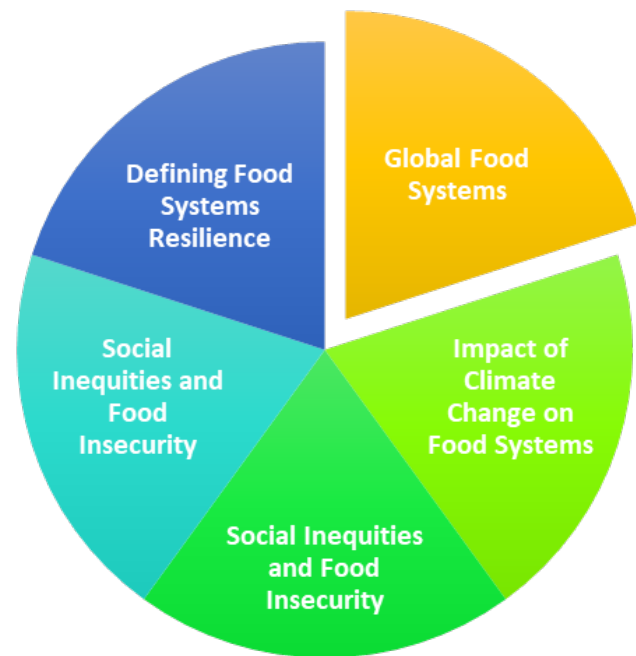
There are various challenges and vulnerabilities encountered by the global food system. It is estimated that by year 2050 the world population would exceed 10 billion which would eventually create an increased food demand and laying a pressure on the limited finite resources, i.e. approximately less than 25% of land for growing crops²². According to the UN report one third of the food production goes to waste and as per Food and Agriculture Organisation approximately 700 million people were subject to famine. Further, other factors such as over-fishing, soil erosion, water shortages, draught would cater in unsustainability of food production. The increased frequency of climatic change such as storms, flood, and other extreme weather conditions would also be major contributor in unsustainable food system throughout different regions of the world²³.

²¹ LEE, S.; BAE, G.; KIM, H. A study on the sustainable use intention of restaurant companies using the information attributes of SNS: the dual process theory. *Sustainability*, v. 13, n. 22, p. 12922, 2021.

²² CHUNG, K. C. Green marketing orientation: achieving sustainable development in green hotel management. *Journal of Hospitality Marketing & Management*, v. 29, n. 6, p. 722-738, 2020.

²³ MALHEIRO, A.; SOUSA, B. B.; LIBERATO, D.; LIBERATO, P. Sustainability in tourism and hospitality: trends and challenges. In: IBIMA CONFERENCE EDUCATION EXCELLENCE AND INNOVATION MANAGEMENT: A 2025 VISION TO SUSTAIN ECONOMIC DEVELOPMENT DURING GLOBAL CHALLENGES, 35. *Anais [...]*. IBIMA, 2020. p. 15545-15555.

Figure 4 – Showcase the Diverse Aspects of Global Food Systems



Source: Original.

3.1 Defining food systems resilience

A food system is an exhaustive process which includes production, consumption and transportation of food and the workers involved. On the hindsight, resiliency is the capacity and capability to provide appropriate, sufficient, and acceptable food to people in the event of major or extreme unavoidable disasters. It involves and allows the food system to tackle the disaster commotions, recover from the disturbances and provide for an alternative suitable solution before or after the disruptions²⁴. Resilience is essential for ensuring food security sustainable in the events of geopolitical, environmental, economic, and social disruptions that could expose the food systems to vulnerability.

3.2 Impact of climate change on food systems

Climatic changes pose an extreme challenge and threat to the global food system with across-the-board consequences for food security, human health, and nutrition²⁵. The primary concerns for food system with

²⁴ YOON, B.; CHUNG, Y.; JUN, K. Restaurant industry practices to promote healthy sustainable eating: a content analysis of restaurant websites using the value chain approach. *Sustainability*, v. 12, n. 17, p. 7127, 2020.

²⁵ MIRELA, S.; BORZA, M. Measures concerning sustainable con-

regards climatic change is its significant impact on the agricultural production. Extreme weather conditions like drought, flood, storms, heatwaves etc., rise in temperature, disturbing precipitation patterns has affected in reduction of crop yielding and livestock productivity and various regions. The extreme climate behaviour further affects the nutritional quality and value of food such as increased atmospheric carbon dioxide level leads to micronutrients deficiency, decreasing the protein content of crops and many other factors.

3.3 Social inequities and food insecurity

Social inequities and food insecurity are interlinked with the rural sector encountering the challenges associated with access of adequate and nutritional food. The main underlying link between social inequities and food insecurity is the poverty, as the rural and poverty ridden sector often lack financial recourses to afford sufficient and nutritious food²⁶. Social inequities also include discrimination and marginalization that further worsen the food security. Further, loss of jobs and economic interruption due to pandemic has further elevated and impacted the marginalized groups leading to a rise in food insecurity²⁷.

3.4 Geopolitical tensions and supply chain disruptions

The world's global food systems often reflect the vulnerability due to the geo-political tension. Ranging from trade wars to armed conflicts, these disturbances have created a ripple effect impacting the agricultural commodity supply chain as well²⁸. For instance, the Russia-Ukraine war has restricted the flow of vital supplies of fertilizers from Belarus and wheat from Ukraine, which in turn has led to increase in the food

prices. The conflict zones further elevate the disruption in transportation eventually leading to delay in deliveries and rise in cost. Also, the political instability dampens the investment in research and agricultural infrastructure that has a long-term consequence on the production capacity and technological advancement²⁹.

4 Strategies for enhancing food systems resilience

Food Systems Resilience through technological advancement, science & communication, redundancy of activities and networks are some of the significant elements to enhance the food system resilience.

- Versatility, self-sufficiency, and profitable production are one of the major factors to enhance food system resilience³⁰. The elevated self-sufficiency in protein crops would act as catalyst in diminishing the food system's vulnerability to market fluctuation. Further, enhancement of soil fertility would be beneficial in adaptation and preparation for climate change.

- The role of dialogue and co-operation between stakeholders in the global food system would enable in the creation of innovations to tackle disturbances and adapt to changes in operating environment.

- In critical times, the sufficient reserve food stock would assist in tackling disruptions, as the increase in renewable energy's production would secure access to energy and in turn would contribute in stable food availability.

- A comprehensive food system policy is the need of the hour directed towards the shortcomings and disturbances in food systems³¹. A holistic and comprehensive food system policy that acknowledges the resiliency in food systems is required.

sumption in hotels. *Acta Universitatis Danubius: Economica*, v. 10, n. 3, p. 82-90, 2014.

²⁶ SHARMA, A.; SAULAI, L.; HUANG, Y. Sustainable consumer choices: critical reflection on hospitality and tourism. *International Journal of Contemporary Hospitality Management*, v. 36, n. 6, p. 1784-1797, 2023.

²⁷ BARRETT, M.; MARINO, M.; BRKIC, F.; PRATESI, C. A. *How to create a sustainable food industry: a practical guide to perfect food*. London: Routledge, 2023.

²⁸ LABADI, S.; GILIBERTO, F.; ROSETTI, I.; SHETABI, L.; YILDIRIM, E. *Heritage and the sustainable development goals: policy guidance for heritage and development actors*. Ottawa: ICOMOS, 2021.

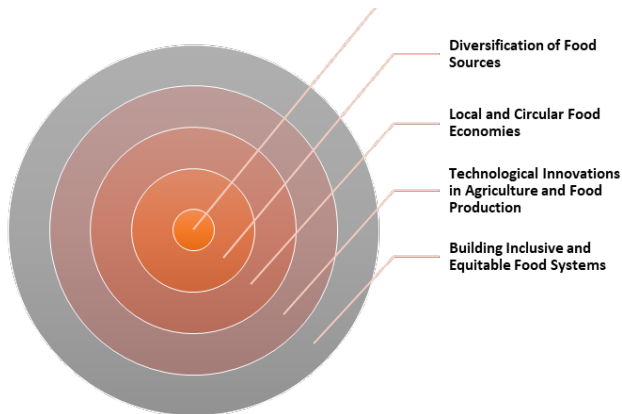
²⁹ ARAUJO, C. M. L. D. *The effects of retail sustainable strategies on the sustainability of the food value chain*. 2023. Tese (Doutorado em Administração de Empresas) – Escola de Administração de Empresas de São Paulo, Fundação Getúlio Vargas, São Paulo, 2023.

³⁰ SHAMS, S. R. et al. (ed.). *Technology, business and sustainable development: advances for people, planet and profit*. London: Routledge, 2023.

³¹ NATHALANG, S. *The environmental management approach for small hotel in Koh Chang (Chang Island), Trat province*. 2019. Dissertation (Doctor of Philosophy) – Graduate School of Environmental Development Administration, National Institute of Development Administration, Bangkok, 2019.

• Integration of modern technological advancement like Artificial Intelligence, Machine Learning, Deep Learning, and Internet of Things (IoT) in the Global Food System would be beneficial in crop management, forecasting food crisis and predicting market price.

Figure 5 - Highlights the Strategies for Enhancing Food Systems Resilience



Source: Original.

4.1 Sustainable agriculture and regenerative practices

For enhanced and sustainable global system, the regenerative agriculture practise is essential for soil growth and production of crops³². Regenerative agriculture practice is a farming concept that aims to naturalize soil and keep it productive for a longer period of time to evade any expansion of new areas at the cost of deforestation. This modern concept of soil fertility is not only beneficial for growing crops to support humans but extends its benefits in providing forage to cattle as well. The United Nations Human Rights Council issued a report calling for an end to industrial agriculture and make a shift to regenerative agriculture³³.

4.2 Diversification of food sources

Diversification of food resources is extremely essential to form a sustainable global food system. Diversifying livestock and crops productions instead of relying on only major crops, would enhance resilience

to weather and extreme climate change and disruptions. Diversification of global trade and markets for staple food would improve food security and in turn would reduce the over reliance of major food exporters. The increase in diversification of diet of people at large would improve their health and nutrition³⁴.

4.3 Local and circular food economies

The concept of circular food system includes practices that reforms production, consumption, and distribution of food to diminish waste and improve resource value. The concept of circular food system relies and focuses on modern sophisticated technologies like blockchain, artificial intelligence and Internet of Things along with regenerative agriculture. Whereas, local sourcing is essential to regenerative farming as it enhances the food supply resilience³⁵.

4.4 Technological innovations in agriculture and food production

Integration of modern technological advancement like Artificial Intelligence, Machine Learning, Deep Learning, and Internet of Things (IoT) in the Global Food System would be beneficial in crop management, forecasting food crisis and predicting market price. For instance, smart agriculture would use sensors and AI to analyse data on soils and provide valuable insight on crops and their growth. Hence, technological innovations like smart farming, precision agriculture etc are some of the efficient ways to enhance the food system resilient globally³⁶.

4.5 Building inclusive and equitable food systems

Building effective, efficient, inclusive, and equitable global food system to ensure food security is the need of the hour. World Economic Forum made a significant

³² FITCHUK, C. *Creating a sustainable business strategy for a SME*. 2021. Thesis (Bachelor of Business Administration) – School of Business & Culture, Seinäjoki University of Applied Sciences, Seinäjoki, 2021.

³³ SARTOR, D. *An exploratory study of Woolworths consumer's post-Covid food waste behaviour*. 2021.

³⁴ VOORHOEVE, J. *Fighting poverty and violence: how basic human needs could be met*. Hague: Eleven, 2021.

³⁵ SINGH, B. Blockchain technology in renovating healthcare: legal and future perspectives. In: KAUSHIK, Keshav *et al.* (ed.). *Revolutionizing healthcare through artificial intelligence and internet of things applications*. New York: IGI Global, 2023. p. 177-186.

³⁶ HUNTER, D. *et al.* (ed.). *Agrobiodiversity, school gardens and healthy diets: promoting biodiversity, food and sustainable nutrition*. London: Routledge, 2020.

approach signifying the need for demand driven and inclusive principles globally to build a sustainable food system. Similarly, International Food Policy Research Institute (IFPRI) in its report highlighted the importance of transformation of food system to encourage healthy diet and balanced nutrition for individuals³⁷.

5 Case studies: successful approaches to food systems resilience

The case study methodology effectively highlights that enhanced food resilience systems is crucial for achieving the Sustainable Development Goal of Zero Hunger (SDG 2)³⁸. It has the capacity of holding food system to withstand, adapt, and transform in the period of various shocks and stress such as climate change, economic disruptions, and social conflicts³⁹.

5.1 Community-led sustainable agriculture in Africa

The concept of Equity and resilience can be examined in the light of local urban food system (LFS) with the constraints of equity and resilience⁴⁰. The study conducted among African countries found that equity was a more familiar concept among LFS stakeholders, resilience was not taken into consideration effectively. Increasing financial support, reaching different populations, food preferences relating cultural background, are amongst Equity-focused initiatives⁴¹. On the other hand, the participants not mentioned the current measures ensuring LFS resilience, only while considering disturbance like the COVID- 19 pandemics. The study

outlines the need to better understand and quantify resilience aiming to achieving equity to strengthen local foods systems.

5.2 Fostering resilience in vulnerable and fragile regions

Evident research shows that resilient food system is very important for building and maintaining stability in region which are in a vulnerable state and in conflict with environmental shocks, it requires special investments and funding⁴². The strategically important aspect of enhancing resilience in this particular context includes promoting a diversity of nutritious crops and animal foods, along with farming practices and business models that mitigate the external need for better inputs and build soil ecosystem health⁴³. This diversification aims to the higher diversity of responses of shocks and disturbances which ultimately contributes and stabilize the national food supplies.

5.3 Highlights from Sub-Saharan Africa's resilient food systems program

The implementation of resilient food system (RFS) program in Sub-Sahara Africa highlights valuable insights for building resilient food system such as-

1. The important aspect of well defined division of labour, clarity in the rules and responsibility which flows with the accountability framework among the stakeholders.
2. The importance of connected approach which integrates food security agriculture environment social economic and climatic considerations.
3. The system-based approach is an advantages collaboration that promotes knowledge sharing across multiple levels between various stakeholders⁴⁴.

³⁷ BISARIA, P. *Environmental issues and corporate social responsibility*. 2022.

³⁸ SINGH, B. Federated learning for envision future trajectory smart transport system for climate preservation and smart green planet: insights into global governance and SDG-9 (Industry, Innovation and Infrastructure). *National Journal of Environmental Law*, v. 6, n. 2, p. 6-17, 2023.

³⁹ ATSER, G. *et al. Transforming oyo state to an agribusiness hub: (our vision, our plan)* 2019-2023. Ibadan: IITA, 2019.

⁴⁰ SHARMA, A.; SINGH, B. Measuring impact of e-commerce on small scale business: a systematic review. *Journal of Corporate Governance and International Business Law*, v. 5, n. 1, 2022.; TICE, P. H. *The race to zero: how ESG investing will crater the global financial system*. New York: Encounter Books, 2024.

⁴¹ TOIVONEN, A. *Sustainable space tourism: an introduction*. Bristol: Channel View Publications, 2020. v. 3.

⁴² SINGH, B. Relevance of agriculture-nutrition linkage for human healthcare: a conceptual legal framework of implication and pathways. *Justice and Law Bulletin*, v. 1, n. 1, p. 44-49, 2022.

⁴³ MICONI, M. *The approach to sustainability policies in family firms: how this phenomenon has impacted management remuneration*. 2022. Thesis (Master in Financial Statement Analysis) – Department of Business and Management, Libera Università Internazionale Degli Studi Sociali, Rome, 2022.

⁴⁴ VIND, D. L. *Danish design heritage and global sustainability*. London: Routledge, 2022.

5.4 Regenerative practices in South America

The highlighted points presented in several successful approaches while implementing regenerative practices in South America, particularly in the Gran Chaco region spanning Argentina, Bolivia, and Paraguay. The farmer association actively participating with Solidariad Network in the field of proper implementation in regenerative agriculture practices that can help to restore degraded forest lands⁴⁵. There are key strategies which include:

1. Grazing on rotational basis: creating land into padlock with the fences and cycling livestock through them, which allow areas to naturally regenerate. Soil Fertility and water-holding capacity targeted to improve.
2. Improved animal husbandry: the focus on providing proper veterinary and preliminary medical care, sorting unproductive animals, and optimising herd management, promisingly reduces the pressure on forest resources.
3. Investing in water infrastructure: the construction of dams and wells targets to improve availability in the semi-arid the region.

5.5 Local food initiatives in Asia: incorporating equity and resilience in local urban food system in China

China examines the concepts of equity and resilience via local urban food system (LFS)⁴⁶. The economy favours more in equity concept as the population is diverse and with culturally diversified food need. The study resulted equal importance should be given to resilience alongside equity to strengthen local food system⁴⁷.

The case study of promoting agrees food system resilience via ICT in Bangladesh. The study in Bangladesh

examines the potential of agriculture information and communication technologies (ICTs) to promote resilience in agri-food systems. There are some key points include-

1. Actively using of ICTs for precise farm management, which engages proper soil moisture monitoring and pest infestations.
2. Depending digital platforms to improve supply chain participation and market access for farmers.
3. Deploying ICT enabled early warning system in the respond of sudden extreme weather condition.

By integrating latest technology-based solution agri-food system have shown increased capacity to withstand and adapt various destructions⁴⁸.

5.6 Technological solutions in Europe

5.6.1 Leveraging inter institutional collaborations for food system education

The important aspect of UK is the inter disciplinary food system training and learning program (IFSTAL), the initiative offers proper linkage between institution focusing on health, environmental sciences, economic policies, governance, and food supply chain analysis. The highly collaborative model has successfully trained professional, quantifying cross institutional values, endeavours in preparing well trained food system work force.

The case study of precision farming in Europe by integrating digital technology and the potentials of agriculture information and communication technology highlighted in the following points-

1. The usage of soil moisture sensors in precision farming technology, pest monitoring systems to optimise resources and reduce the inputs.
2. The improved coordination between supply chain management, market access and traceability of farmers can be achieved

⁴⁵ SINGH, B. COVID-19 pandemic and public healthcare: endless downward spiral or solution via rapid legal and health services implementation with patient monitoring program. *Justice and Law Bulletin*, v. 1, n. 1, p. 1-7, 2022.

⁴⁶ SPIESS-KNAFL, W. *Artificial intelligence and blockchain for social impact: social business models and impact finance*. London: Routledge, 2022.

⁴⁷ KILIBARDA, N.; DJOKOVIC, F.; SUZIC, R. Food waste management: reducing and managing food waste in hospitality. *Scientific Journal Meat Technology*, v. 60, n. 2, p. 134-142, 2019.

⁴⁸ MUNIR, K. Sustainable food waste management strategies by applying practice theory in hospitality and food services: a systematic literature review. *Journal of Cleaner Production*, v. 331, p. 129991, 2022.

with digital platforms⁴⁹.

3. The usage of early warning systems empowered by satellite data and weather forecast in mitigating the risk of sudden climatic changes.

5.6.2 Catalysing inter disciplinary collaboration in food system education

In US there are two complementary programs initiative. First Land Grant University and the other within a school of public health focuses on the potentials in food system education. The program highlights opportunities by continuous limiting the issues involving proper interdisciplinary management by promoting learning and knowledge sharing⁵⁰.

5.6.3 Collaboration of artificial intelligence to produce sustainable food

Applying machine learning and artificial intelligence (AI) has evolved into an indispensable instrument for changing European agricultural systems to be more sustainable. The effectiveness of these strategies fragmented the importance of Predicting crop yields, optimising irrigation, and early pest and disease identification is achievable with AI-powered predictive analytics⁵¹. Combining deep learning and computer vision to automate tasks like monitoring livestock and weed identification utilizing AI-powered decision support tools to assist farmers in carrying out regenerative and climate-smart agricultural practices⁵². These AI-enabled technologies are contributing to the resilience of the European agricultural industry overall, as well as to productivity gains and environmental impact improvements.

⁴⁹ GOH, E.; JIE, F. To waste or not to waste: exploring motivational factors of Generation Z hospitality employees towards food wastage in the hospitality industry. *International Journal of Hospitality Management*, v. 80, p. 126-135, 2019.

⁵⁰ SINGH, B. Profiling public healthcare: a comparative analysis based on the multidimensional healthcare management and legal approach. *Indian Journal of Health and Medical Law*, v. 2, n. 2, p. 1-5, 2019.

⁵¹ GOH, E. *et al.* Managing food wastage in hotels: discrepancies between injunctive and descriptive norms amongst hotel food and beverage managers. *British Food Journal*, v. 124, n. 12, p. 4666-4685, 2022.

⁵² ADITYA, A.; KURNIAWATI, K. Food waste management challenges and strategies in the hotel industry in Jakarta. *Journal of Social Research*, v. 2, n. 9, p. 2983-2989, 2023.

5.7 Case studies that illustrate theoretical concepts on resilience and food security

Devise practical and theoretical answers to broad problems of resilience and food security and to the many axes interactively integrated into their understanding⁵³. Case studies from various regions of the world provide evidence of how communities, governments, and international organizations create resiliency in food systems in order to adapt to shocks and stresses. These cases provide key theoretical examples of adaptive capacity, social capital, technological innovation, and policy interventions that help bolster food security. A well-known example is Ethiopia's Productive Safety Net Program (PSNP), which shines a spotlight on social protection as a resilience-building tool. Launched in 2005, the PSNP gives cash or food transfers to at-risk families to help satisfy immediate food requirements while also fostering long-term resilience through public works initiatives like those including soil conservation and irrigation systems. In theory, this is in line with Amartya Sen's entitlement theory, which asserts that food security is not just about availability but about people's capacity to access food⁵⁴. The PSNP decreases reliance on emergency assistance and allows families to rebound from droughts and economic shocks which reflects economic resilience and institutional support of food security.

The other example is the adaptation to climate change in Bangladesh, particularly with flood-resistant agriculture, which demonstrates climate resilience and technological innovation. Being a country susceptible to extreme weather events, Bangladesh has introduced floating gardens, salt tolerant rice varieties and better water management systems to support agricultural productivity⁵⁵. These approaches are within the framework of climate-smart agriculture (CSA) which combines productivity, adaptation and mitigation approaches. The case demonstrates how such adaptive capacity can help

⁵³ KASAVAN, S. *et al.* Drivers of food waste generation and best practice towards sustainable food waste management in the hotel sector: a systematic review. *Environmental Science and Pollution Research*, v. 29, n. 32, p. 48152-48167, 2022.

⁵⁴ KATUWAL, S.; AFZAL, M. *A framework for managing food waste: strategies to promote recycling and sustainability in the hotel industry*. 2022. Thesis (Bachelor in Tourism) – Kajaani University of Applied Sciences, Kajaani, 2022.

⁵⁵ FILIMONAU, V. *et al.* Restaurant management and food waste reduction: factors affecting attitudes and intentions in restaurants of Spain. *International Journal of Contemporary Hospitality Management*, v. 34, n. 3, p. 1177-1203, 2022.

communities to continue to provide food security in the face of uncertain climatic conditions.

In Latin America, the Food Sovereignty Movement, led by countries including Brazil and Bolivia, emphasizes local governance and community empowerment as a solution to food security. This movement, grounded in the theory of food sovereignty, challenges industrialized agriculture by advocating for local food production, agroecology, and equitable distribution systems. Programs like Brazil's Fome Zero (Zero Hunger) campaign combine government policy, farmer cooperatives and nutrition education to decrease food insecurity⁵⁶. This case illustrates the relevance of participatory governance, sustainable agriculture and food culture in a long-term perspective when thinking about food security⁵⁷.

The global case of resilience in food security is the challenge of food supply chains across the world during the COVID-19 pandemic, which stirred vulnerabilities of food systems yet also demonstrated adaptive responses⁵⁸. Countries with diversified supply chains, resilient digital infrastructure and local food production networks fared better with disruptions. Singapore's "30 by 30" initiative a goal of growing 30% of local nutritional needs domestically by 2030, for example is a demonstration of strategic resilience planning⁵⁹. This echoes the theory of systemic resilience, which states that healthy and diverse systems bounce back more quickly to shocks⁶⁰. These case studies capture how theoretical frameworks like food sovereignty, climate-smart agriculture, entitlement theory, and systemic resilience are enacted in practice⁶¹. This body of knowledge can

help policymakers and stakeholders devise more effective approaches to building resilience and food security to promote sustainable and equitable food systems for generations to come⁶².

6 Conclusion and future scope

The sustainable agricultural value chain includes all the actors and interlinked processes involved in the production, aggregation, processing, distribution, consumption, and sustainable disposal of food products and byproducts⁶³. In contrast, industrial food systems have significantly lengthened supply chains in terms of physical distance from farm to plate, with increasingly stringent food-safety and -quality requirements⁶⁴. Any disruption in the system can lead to the food waste, delayed delivery, or food safety issues. In emerging markets, agriculture and food systems are central to promoting inclusive economic growth and reducing poverty. In developed markets, investments in agriculture and food systems can support vibrant rural economies⁶⁵. Sustainable and resilient food value chains that are profitable and equitable can provide broad-based benefits for society and have a positive or neutral environmental impact. Responsible investments that enhance collaboration and communication along value chains enable institutional solutions, including markets, farmer organizations, contractual arrangements, and infrastructure, as well as technological solutions such as digital technologies and novel financial mechanisms.

⁵⁶ OZDEMIR, G.; GUICER, E. Food waste management within sustainability perspective: a study on five-star chain hotels. *Journal of Tourism & Gastronomy Studies*, v. 6, n. 1, p. 280-299, 2018.

⁵⁷ DHIR, A. *et al.* Food waste in hospitality and food services: a systematic literature review and framework development approach. *Journal of Cleaner Production*, v. 270, p. 122861, 2020.

⁵⁸ KASAVAN, S.; MOHAMED, A. F.; HALIM, S. A. Drivers of food waste generation: case study of island-based hotels in Langkawi, Malaysia. *Waste Management*, v. 91, p. 72-79, 2019.

⁵⁹ LUU, T. T. Reducing food waste behavior among hospitality employees through communication: dual mediation paths. *International Journal of Contemporary Hospitality Management*, v. 32, n. 5, p. 1881-1904, 2020.

⁶⁰ CHALAK, A.; ABOU-DAHER, C.; ABIAD, M. G. Generation of food waste in the hospitality and food retail and wholesale sectors: lessons from developed economies. *Food Security*, v. 10, p. 1279-1290, 2018.

⁶¹ RUIZ-MOLINA, M. E. *et al.* Addressing sustainable food management in hotels: proposing a framework and examining hotel groups. *British Food Journal*, v. 124, n. 2, p. 462-492, 2022.

⁶² LEE, H. H.; HUANG, P. Y. Food waste and environmental sustainability of the hotel industry in Taiwan. *Sustainability*, v. 15, n. 21, p. 15459, 2023.

⁶³ LAGIOIA, G. *et al.* Sustainable and circular practices in the hotel industry in Southern Italy: opportunities, barriers and trends in food waste management. *British Food Journal*, v. 126, n. 1, p. 428-452, 2023.

⁶⁴ DE VISSER-AMUNDSON, A. A multi-stakeholder partnership to fight food waste in the hospitality industry: a contribution to the United Nations Sustainable Development Goals 12 and 17. *Journal of Sustainable Tourism*, v. 30, n. 10, p. 2448-2475, 2022.

⁶⁵ ISLAM, J. U.; NAZIR, O.; RAHMAN, Z. Sustainably engaging employees in food wastage reduction: a conscious capitalism perspective. *Journal of Cleaner Production*, v. 389, p. 136091, 2023.; SHARMA, T. What a waste: confronting consumer food waste behavior in hospitality settings. *Advances in Hospitality and Leisure*, v. 16, p. 167-176, 2020.

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