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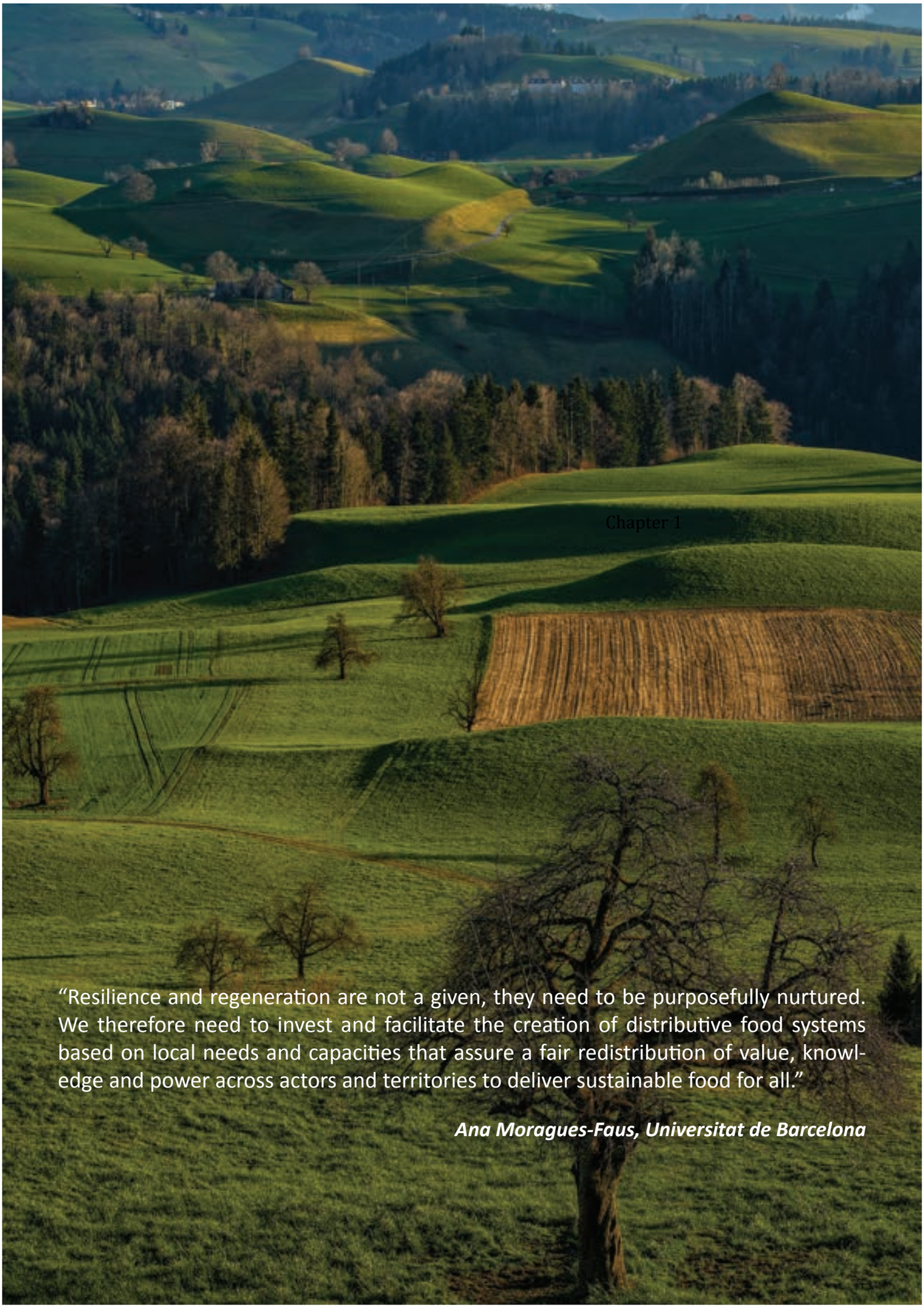
A Knowledge Report on Resilient Food Systems



Chapter 1

"Resilience and regeneration are not a given, they need to be purposefully nurtured. We therefore need to invest and facilitate the creation of distributive food systems based on local needs and capacities that assure a fair redistribution of value, knowledge and power across actors and territories to deliver sustainable food for all."

Ana Moragues-Faus, Universitat de Barcelona

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Message from ASSOCHAM

India, a major food producer globally, faces the crucial task of meeting the nutritional demands of its expanding population while addressing post-harvest losses. These losses, spanning from crop harvesting to consumption, are a significant concern globally, posing threats to food security, economies, and the environment. Factors contributing to post-harvest losses include insufficient infrastructure, limited access to modern storage, and inaccurate market demand forecasts. These losses not only impact farmers economically but also exacerbate food insecurity and impede sustainable development efforts.

One of the primary objectives of post-harvest management is to maintain the quality and safety of the agricultural yield. Besides, post-harvest management is vital in curtailing losses and boosting productivity and profitability. By careful handling and processing the crops, farmers lessen physical damage that may occur during transportation and storage. In the direction of preserving quality, safety, and marketability of harvested crops, post-harvesting management is an essential stage in the agricultural value chain that involves different actions. The aim is to ensure the nutritional value, appearance, and freshness of the product, while minimising losses and maximising the profitability of farmers.

Mr. Deepak Sood

Achieving minimum post harvest losses requires a collaborated approach with governments, international organisations, research institutions, and the private sector, whose collective efforts can mitigate post-harvest losses and build a sustainable and food-secure future for all. The Government of India has taken various measures to create post-harvest infrastructure and processing facilities and enhancing the value addition. Yet many more such efforts are needed to contain the food losses.

Given the significance of the subject, ASSOCHAM jointly with TechSci Research has come out with this report which highlights the importance of sustainable post-harvest practices and various approaches for improving and enabling resilient food systems. We acknowledge the efforts made by the experts in preparing the report being presented at the National Conference on 'Curbing Post Harvest Losses to Enable Resilient Food Systems'.

We hope the report will provide useful information and insight to the policy makers as well as the stakeholders.

Message from Directors Desk

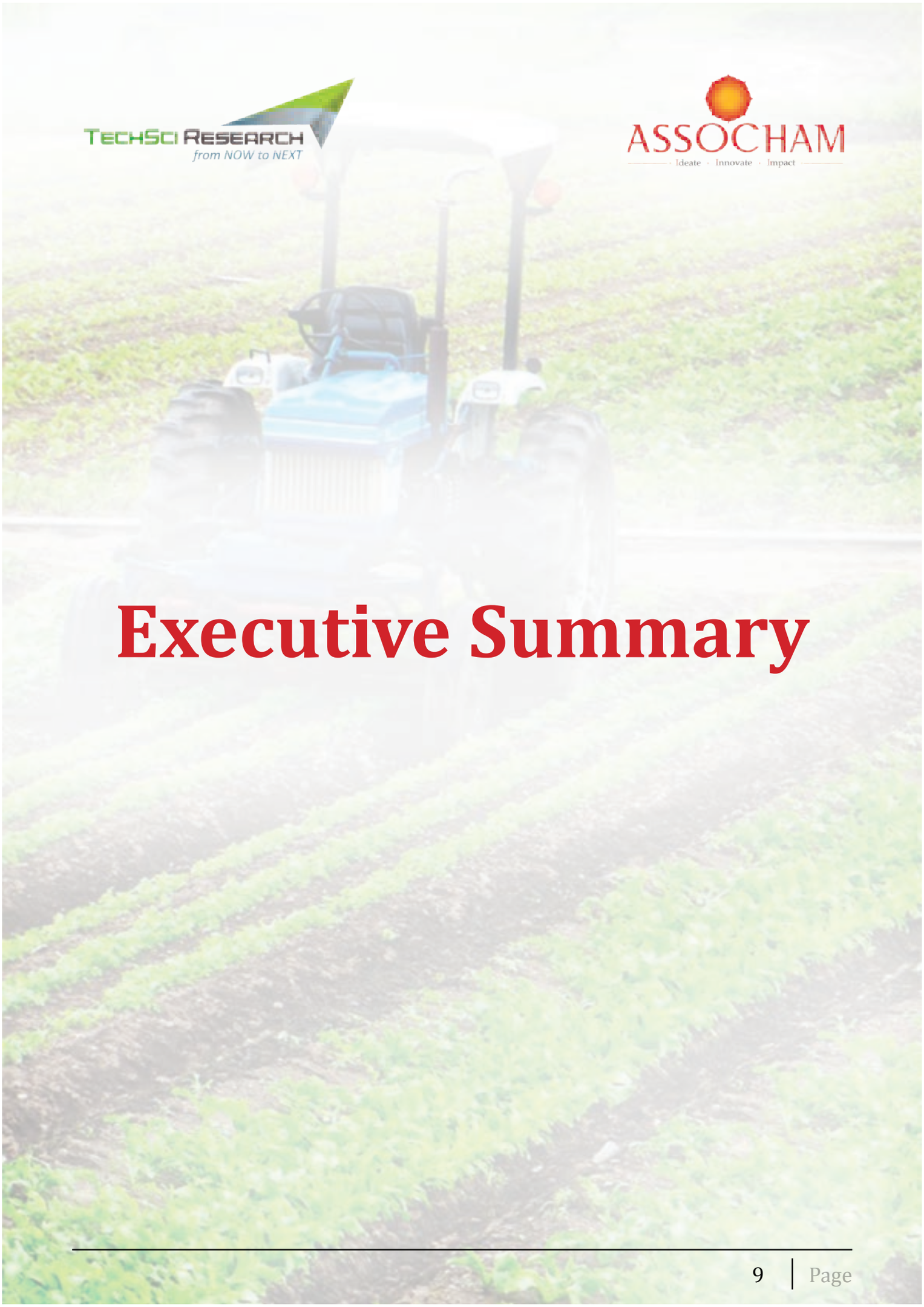
A resilient food supply system is indispensable for addressing multifaceted global challenges, particularly amidst the threats of shifting climate patterns, unpredictable disasters, and economic instability. Unlike conventional methods focused solely on agriculture, resilient systems adopt a comprehensive perspective, recognizing the interdependence between the environment, society, and the economy. Businesses play a crucial role in developing and maintaining robust food supply systems by establishing infrastructure, promoting eco-friendly practices, and innovating across the entire food supply chain. Through investment in diverse crops, livestock, and production techniques, businesses enhance system resilience, ensuring stability in the face of unforeseen challenges.

Mr. Karan Chechi

Achieving business transformation to address global challenges requires adopting a nature-positive approach, emphasizing regeneration, efficiency, collaboration, and growth aligned with social progress and environmental protection. In the context of the 2030 Agenda and its Sustainable Development Goals (SDGs), a shift occurs as the environment becomes foundational support for all living beings. Nature-positive lenses integrate regenerative land management practices into global food systems, aligning with various SDGs spanning environmental and socioeconomic domains.

To catalyze meaningful change across the global food system, genuine collaborative action and investment are imperative, within the food sector and in collaboration with other dependent sectors. Businesses have a crucial responsibility to promote renewable energy use and sustainable infrastructure development, especially in storage and transportation. Companies like Nestle, PepsiCo, Danone, Grupo Bimbo, and Cargill are actively working towards sustainability goals by investing in regenerative agriculture practices. Recent initiatives like Diageo and Cargill's regenerative agriculture program in India showcase how businesses can contribute to a sustainable environment, enhancing resilience and adaptive agriculture methods against potential disruptions.

Ultimately, a strong and resilient food supply system is essential for providing necessary food resources amidst global challenges. Businesses, as key stakeholders, must actively participate in creating and maintaining such systems, playing a pivotal role in ensuring their success.

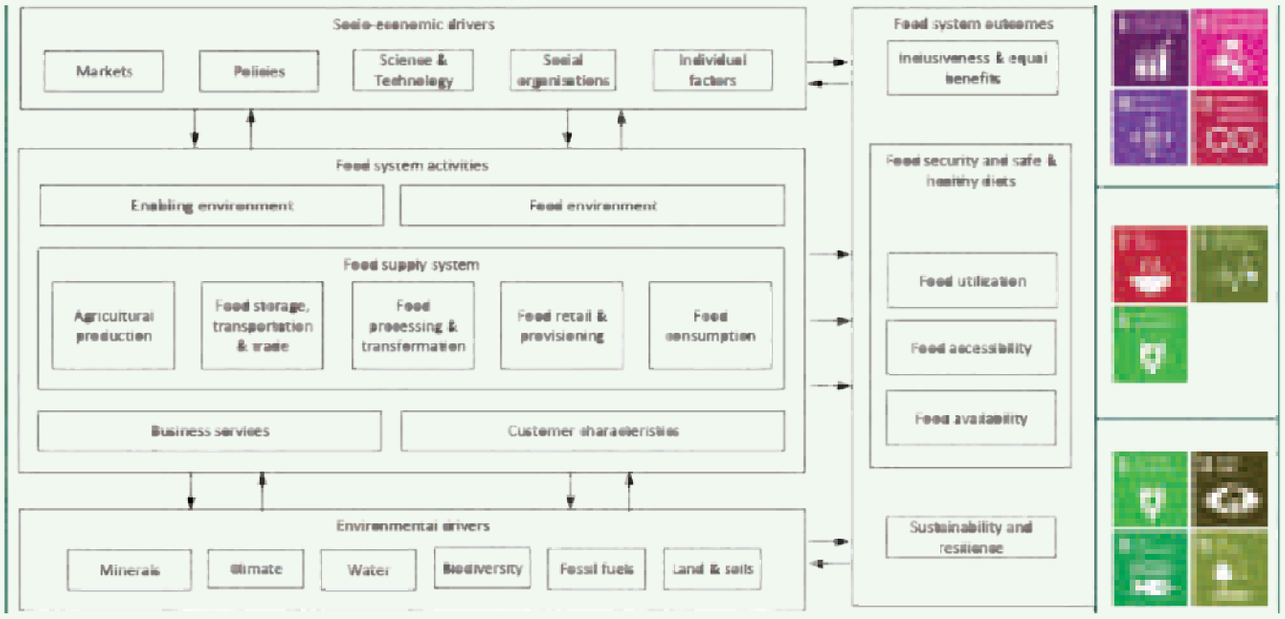


Executive Summary

Executive Summary

In today's world, facing challenges like climate change, natural disasters, and economic uncertainties, resilient food systems have become a source of optimism. Resilient food systems are like well-built structures that endure environmental or human disruptions and provide access to safe and nutritious food for everyone. They are aimed to withstand and adapt to various challenges that ensure the well-being of communities globally. Presently, one in nine individuals faces daily hunger, with 2.5 billion people globally relying on agriculture for their livelihoods. Numerous smallholder farmers exist on the edge of productivity, where even slight shifts in climate and crop growth can lead to immediate and severe consequences.

Food systems framework and the link with the Sustainable Development Goals.[11]



The paper discusses the importance of sustainable agriculture and resilient food systems in the face of environmental challenges, population growth, and climate change. It emphasizes the need to address post-harvest losses, water scarcity, and resource depletion in agriculture. The document highlights the significance of local and sustainable agriculture in empowering communities and ensuring food security. It also addresses the challenges faced by smallholder farmers, including limited access to modern agricultural technologies and insufficient training on sustainable farming practices. The paper emphasizes the role of fair-trade policies in empowering farmers and protecting workers, as well as the importance of government initiatives to modernize infrastructure and reduce post-harvest losses. Additionally, it discusses the impact of economic and political roadblocks on the widespread adoption of sustainable solutions in agriculture. The document also highlights the role of technological advancements, such as IoT and precision agriculture, in reshaping farming operations and enhancing efficiency. Overall, the paper underscores the urgency of transitioning to sustainable resilient food systems and the need for comprehensive approaches focusing on sustainability, resilience, and adaptability to ensure the stability of global food supplies.

1 https://www.mdpi.com/2071-1050/15/5/4475#https://www.mdpi.com/2071-1050/15/5/4475#

Chapter 1

Introduction

"Sustainable agriculture is not just about growing crops, it's about caring for the soil, the water, the air, and all the living things that depend on them."

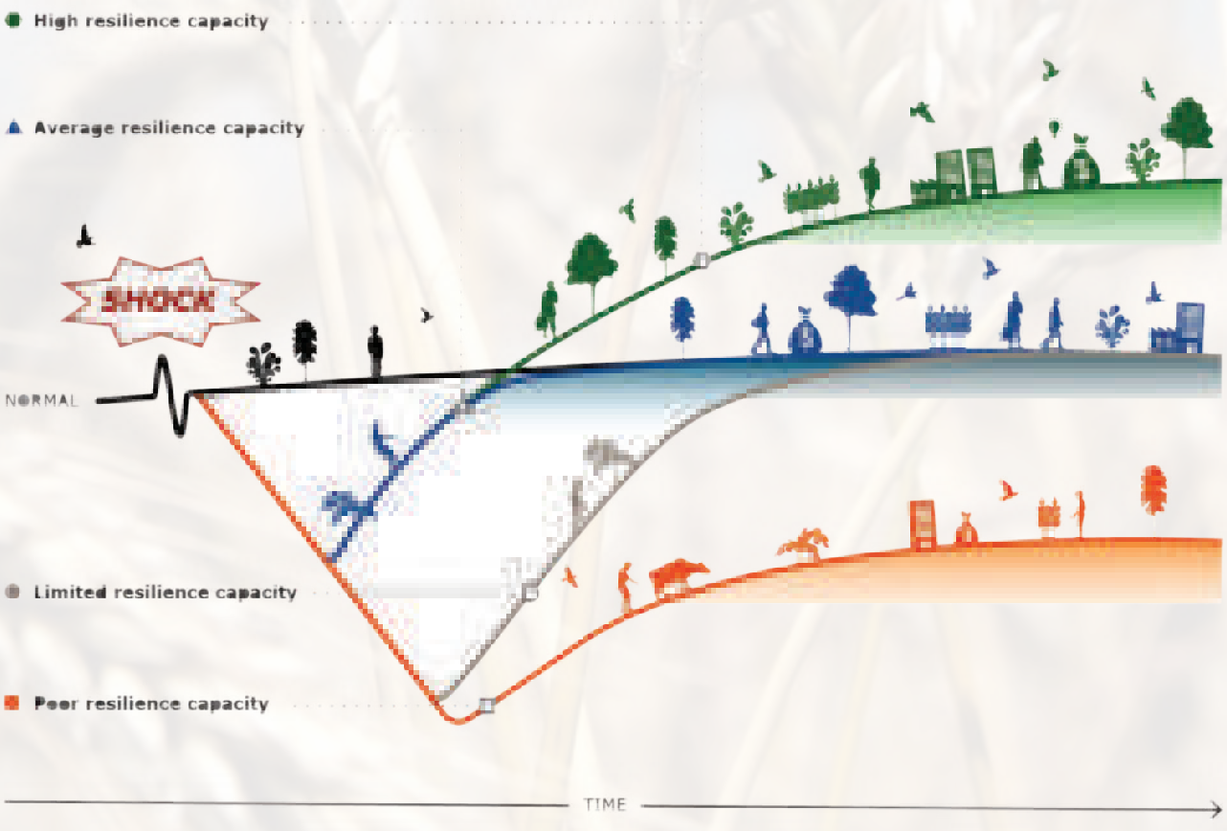
- Vandana Shiva

Defining Resilient Food Systems

Resilient food systems go beyond traditional ideas of farming and food production. They take a holistic approach, considering how the environment, society, and economy are connected. At their core, resilient food systems can absorb shocks, adapt to changes, and continue providing essential food resources to communities.

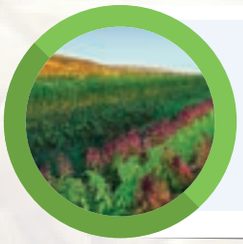
Resilience of Food Systems

What happens to the food system outcomes, i.e. food security & employment, under shocks and stressors?[2]

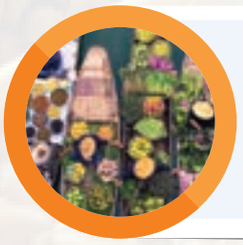


2. https://weblog.wur.eu/fnh-ri/food-system-resilience-towards-a-joint-understanding-and-implications-for-policy/

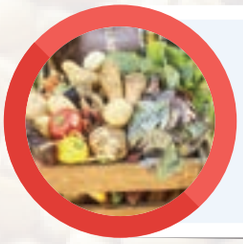
Key Characteristics of Resilient Food Systems



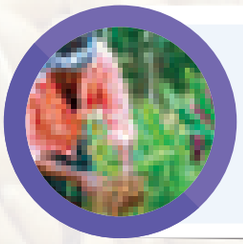
Diversity, is vital for resilient food systems. Like a diverse ecosystem that is more robust than a single-crop system, a food system with various crops, livestock, and production methods can recover better from disruptions. This diversity acts as a buffer, ensuring stability even if one element is affected.



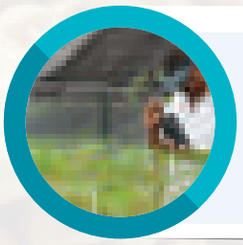
Strong local food systems, where production and consumption happen nearby, are less vulnerable to disruptions in transportation and global supply chains. Initiatives like farmers markets and community-supported agriculture programs connect consumers directly with local producers, reducing dependence on distant sources and building community resilience.



Resilient food systems, prioritize practices that protect the environment. Organic farming, agroforestry, and water conservation are essential for ecological sustainability. These practices build healthy soil, conserve biodiversity, and enhance the system's ability to withstand climate change impacts.



Equity and Fairness, in food systems need to evolve with changing circumstances. Resilient food systems embrace new technologies and practices that improve efficiency, reduce waste, and enhance overall resilience. Precision agriculture tools, innovative food preservation techniques, and data-driven decision-making exemplify adaptability to dynamic challenges.



Innovation and Adaptability, in Resilient food systems are committed to ensuring that everyone has access to nutritious food, regardless of income or location. They advocate for policies promoting fair access to land, water, and other resources, especially for marginalized communities.

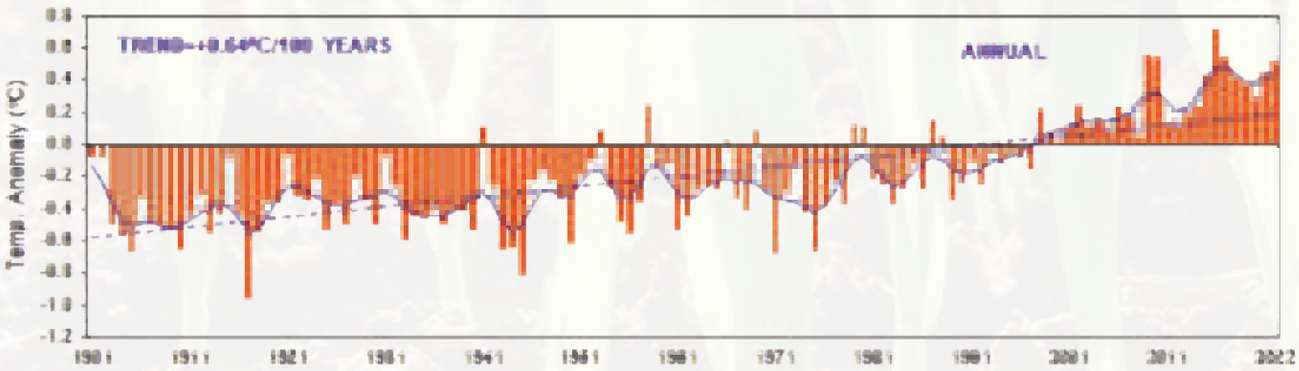
The Urgency and Benefits of Sustainability

In a world grappling with challenges like climate change, environmental concerns, and a growing population, the need for sustainable resilient food systems is more crucial than ever. These systems, built to handle challenges and adapt to changes, play a vital role in ensuring access to safe, healthy food while taking care of our planet.

The Urgency

Climate Change and Environmental Stability

Climate change is a big threat to global food security. Unpredictable weather, extreme events, and rising temperatures can disrupt traditional farming, leading to crop failures and food shortages. Sustainable resilient food systems are crucial in lessening the impact of climate change and ensuring a steady food supply.



Annual mean land surface air temperature anomalies averaged over India for the period 1901- 2022. The anomalies were computed with respect to the base period of 1981-2010. The dotted line indicates the linear trend in the time series. The solid blue curve represents the sub-decadal time scale variation smoothed with a binomial filter.[3]

3. https://mausam.imd.gov.in/Forecast/marquee_data/Statement_climate_of_india_2022_final.pdf

Population Growth and Food Demand

With the world's population steadily increasing, the demand for food is going up. Traditional farming methods often can't meet this demand sustainably. Shifting to resilient food systems that prioritize sustainability and efficiency is vital to guarantee a sufficient and fair food supply for the growing population.

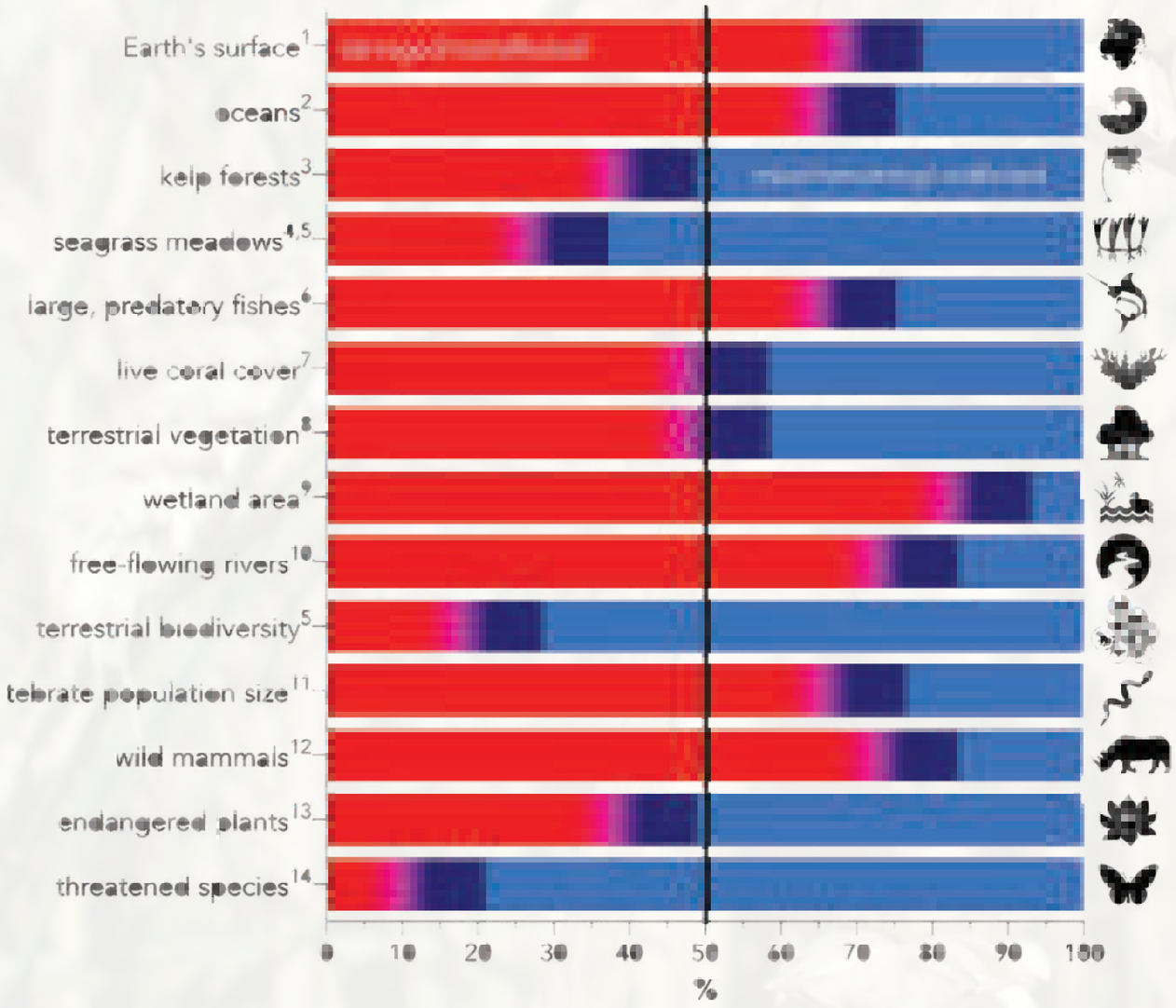
India — Comparison of Population Growth to Agri-Production Growth

Category	Unit	2000	2022	Growth Rate From 2000 to 2022
Population	Billion Persons	1.06	1.41	
Food Grains	Mn Tonnes	187.80	329.68	
Vegetables	Mn Tonnes	94.00	212.91	
Fish	Mn Tonnes	5.68	15.31	
Fruits	Mn Tonnes	43.00	106.34	
Milk	Mn Tonnes	81.00	230.58	
Eggs	Billion Nos.	37.00	118.38	
Poultry	Mn Tons	0.40	4.50	

Source: Area Productivity Statistics 2022, Department of Agriculture and Farmers Welfare

Biodiversity Loss and Ecosystem Damage

Standard farming practices contribute to losing biodiversity and harming ecosystems. Sustainable resilient food systems, using methods like agroecology and organic farming, encourage biodiversity, boost soil health, and protect ecosystems. This fosters a balanced relationship between agriculture and the environment. In Asia, the proportion of cereals in diets decreased from 40% in 1970 to 24% in 2013, with rice consumption per capita showing a stagnant or declining trend in many countries. Roots and tubers declined from 15% to 3%, while non-staples surged from 46% to 74%, illustrating a significant shift in dietary patterns.[4]



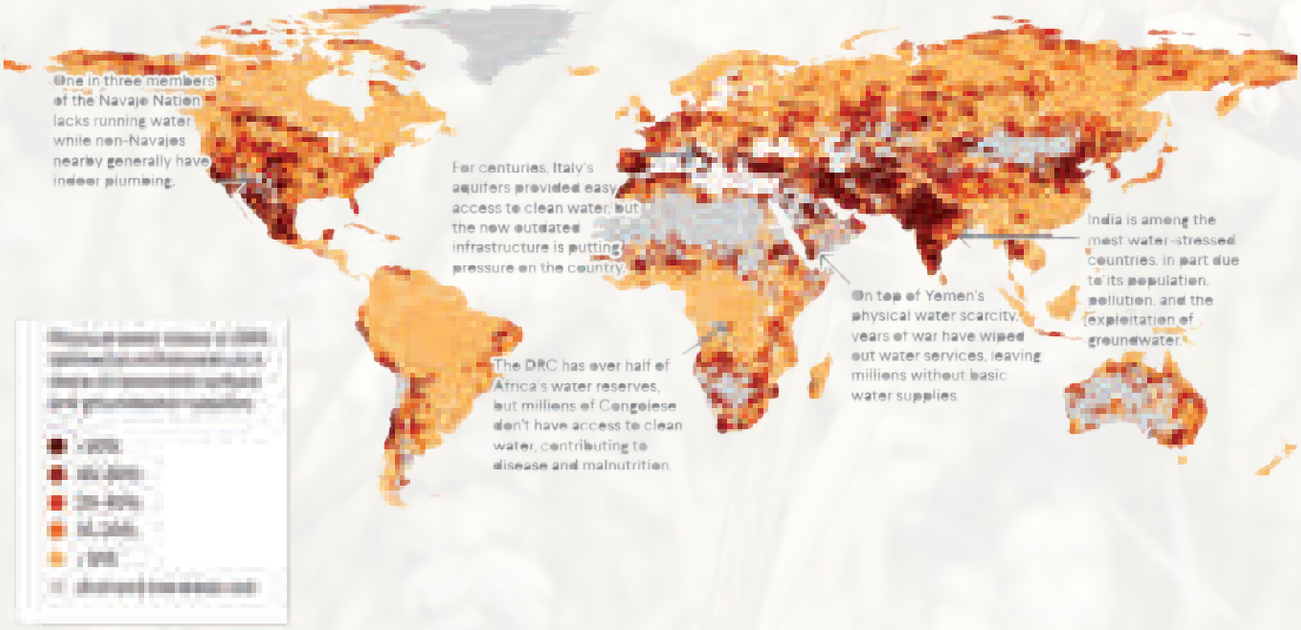
Summary of major environmental-change categories expressed as a percentage change relative to the baseline given in the text. Red indicates the percentage of the category that is damaged, lost, or otherwise affected , whereas blue indicates the percentage that is intact, remaining, or otherwise unaffected.[5]

4. https://www.sciencedirect.com/science/article/abs/pii/S0308521X17308922
5. https://www.frontiersin.org/articles/10.3389/fcosc.2020.615419/full

Water Scarcity and Resource Depletion

Agriculture uses a lot of water, and unsustainable practices contribute to water scarcity and resource depletion. Resilient food systems highlight water-efficient irrigation, soil conservation, and responsible resource management, addressing crucial issues and promoting long-term sustainability. For every 1°C (1.8°F) increase in the global average temperature, UN experts project a 20 percent drop in renewable water resources. Global warming is expected to increase the number of water-stressed areas and heighten water stress in already affected regions.[6]

Water stress on the different part of the earth



The Benefits

Environmental Preservation

Sustainable resilient food systems put a focus on environmental conservation. Practices like organic farming, agroforestry, and crop diversification lead to healthier soils, less reliance on synthetic inputs, and overall ecosystem preservation. This ensures the longevity of agricultural areas and minimizes negative environmental impacts.

Climate Resilience

Climate-resilient agriculture, a key part of sustainable food systems, helps farmers adapt to changing climatic conditions. This includes using resilient crop varieties, innovative water management, and precision farming to optimize resource use, making the sector more able to withstand climate-related challenges.

Social and Economic Stability

Resilient food systems contribute to social and economic stability by supporting local economies and reducing dependence on global supply chains. Initiatives like farmers markets and community-supported agriculture encourage community involvement, support local businesses, and create a more reliable and decentralized food distribution network.

Nutritional Security

Sustainable resilient food systems prioritize diverse and nutritious crops. This not only addresses nutritional gaps but also improves food security by reducing dependence on a few staple crops. A varied and nutrient-rich diet contributes to better public health and resilience to diseases.

Community Empowerment

Local and sustainable agriculture empowers communities by giving them control over their food sources. Community engagement in sustainable farming practices builds a sense of ownership, pride, and shared responsibility, creating resilient communities better equipped to face challenges.

Hence, the urgency of shifting to sustainable resilient food systems cannot be overstated. As the world deals with the impacts of climate change, population growth, and environmental issues, embracing these systems is essential for securing our future. The benefits extend beyond food security to include environmental conservation, social empowerment, and economic stability.

Governments, businesses, NGOs, and individuals all have crucial roles in driving this shift toward sustainability in the agriculture sector. Policies, sustainable farming practices, and consumer choices together contribute to transforming our food systems. By recognizing the urgency and embracing the benefits of sustainable resilient food systems, we pave the way for a more secure, resilient, and sustainable future for everyone.

Chapter 2

The Fragile Harvest:

Challenges to Food System Resilience

Organic agriculture = Seed Sovereignty + Biological Integrity + Food Security Whereas,
Food biotechnology = Food security (at the cost of seed sovereignty and biological integrity)

Environmental Degradation: A Looming Threat

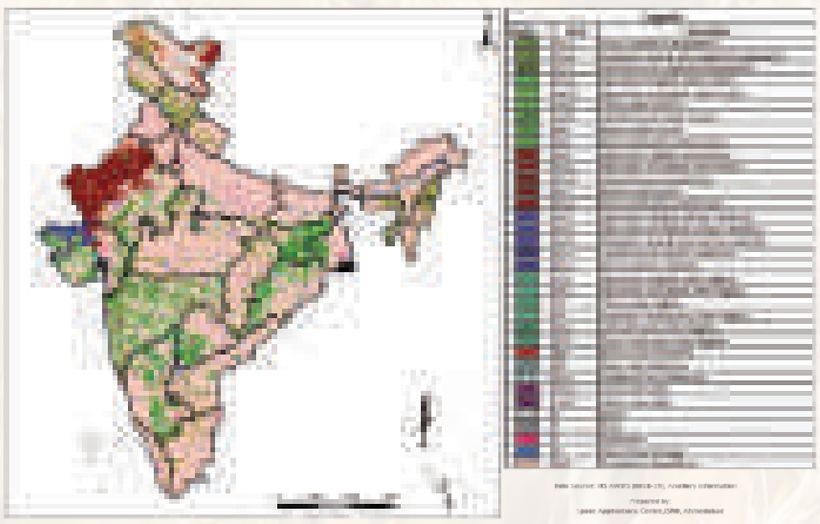
Environmental degradation refers to the deterioration of the environment due to the depletion of resources, including air, water, and soil. It involves the destruction of ecosystems and the extinction of wildlife. The term encompasses any change or disturbance to the environment that is perceived to be harmful or undesirable. The risks to biodiversity, increased severity of climate change, decreased harvests, and an increasing reliance on water resources are merely a few of the numerous problems that threaten the resilience of the food system.

Soil Erosion and Depletion

Soil erosion and depletion pose significant challenges to the resilience of the food system, impacting agricultural productivity, environmental sustainability, and global food security. These interconnected issues demand attention and proactive measures to ensure the long-term viability of the food production systems. The productivity of agricultural land is directly impacted by soil erosion and depletion, which reduces the capacity of soil to provide food for the world's expanding population. A major threat to biodiversity is also posed by declining soil health, since many plant and animal species depend on good soil for survival. Ecosystems' resilience is weakened by this biodiversity loss, making it harder for their inhabitants to adjust to shifting environmental conditions.

Aquatic ecosystems and water quality can be negatively impacted by sedimentation in water bodies caused by soil erosion. Water supplies are further stressed by this, as they are essential for both agricultural irrigation and the preservation of a larger ecological balance. Subsequently, the interconnected issues of erosion and soil depletion contribute to climate change by releasing stored carbon and reducing the land's ability to sequester carbon. This creates a vicious circle of environmental problems for the food chain, whereby soil erosion and depletion are made worse by climate change. A comprehensive and sustainable strategy that includes conservation methods, biodiversity protection, responsible water management, and climate change adaptation and mitigation techniques is needed to address these issues.

DESERTIFICATION / LAND DEGRADATION STATUS MAP OF INDIA - 2018-19

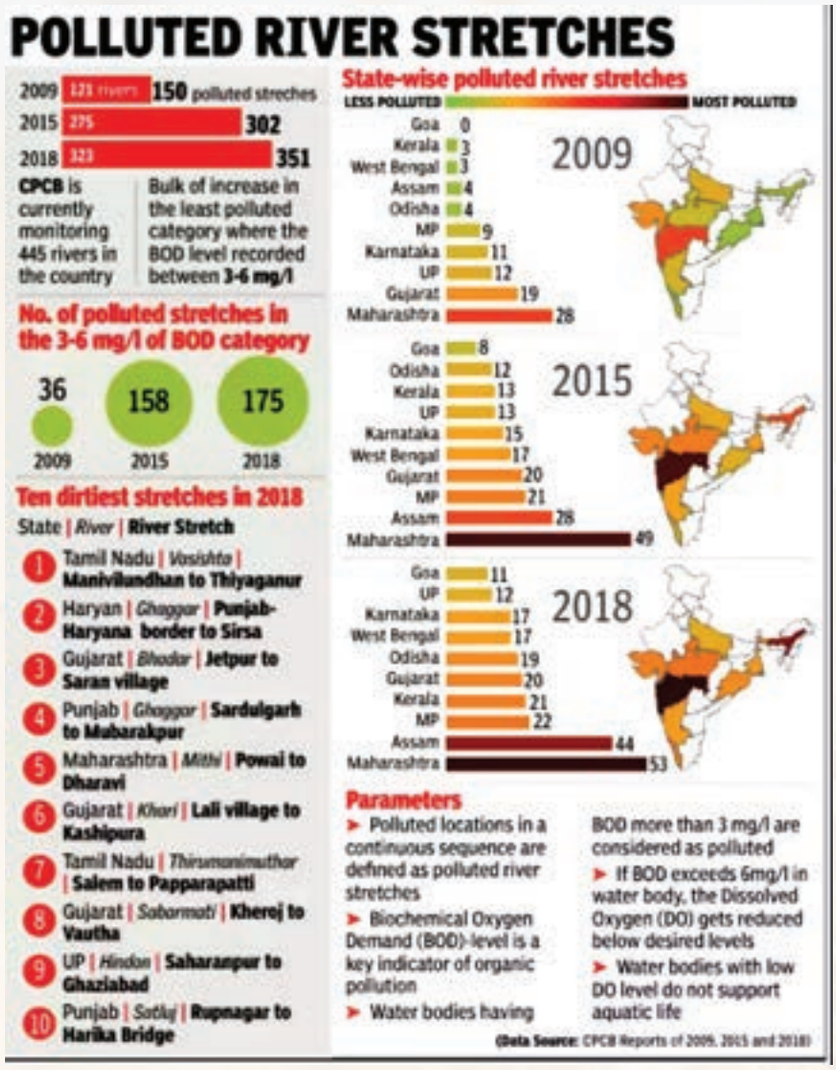


7. https://vedas.sac.gov.in/static/atlas/dsm/DLD_Atlas_SAC_2021.pdf

Water Scarcity and Pollution

Water scarcity and pollution represent critical challenges to the resilience of the food system, posing significant threats to agricultural productivity, environmental sustainability, and global food security. Water scarcity, a critical challenge facing the agricultural sector, significantly impacts the availability of freshwater essential for agricultural irrigation. This limitation poses a threat to crop growth, as insufficient water resources can lead to decreased yields, ultimately affecting the overall productivity of agriculture. The competition for limited water resources intensifies due to factors such as urbanization, industrialization, and increased agricultural demands. This heightened competition exacerbates the difficulties in maintaining adequate water supplies for agriculture, thereby risking the stability of food production.

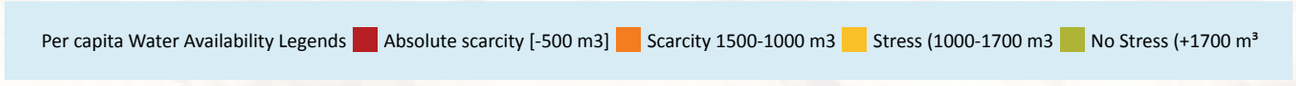
The contamination of water sources is a pressing concern linked to agricultural runoff, industrial discharges, and improper waste disposal. These practices contribute to the pollution of water, posing a direct threat to crops, livestock, and human health. The complexity of this challenge lies in maintaining a safe and sustainable food supply. The impact of water pollution extends to aquatic ecosystems, disrupting their delicate balance and threatening biodiversity. The health of these ecosystems is vital for fisheries, and the declining water quality poses risks to both ecosystems and the broader food system.



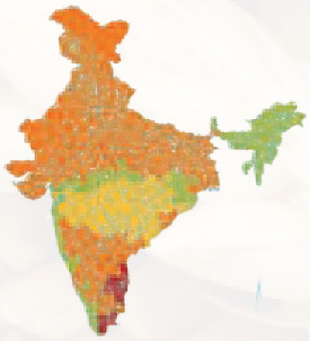
The dual challenges of water scarcity and pollution directly translate into decreased agricultural productivity, creating the potential for food shortages. The inadequate availability of water for irrigation and the compromised quality of water sources contribute to reduced crop yields, posing a significant threat to the overall resilience of the food system. Crop growth is also hindered by air pollution, which diminishes capacity of photosynthesis in plants. The tropospheric ozone alone leads to annual losses of about 110 million tonnes of key staple crops such as wheat, rice, maize, and soybeans. This accounts for approximately 4% of the total annual global crop production and can reach up to 15% in specific regions . A cause for concern is that in numerous Asian regions, particularly in vital agricultural areas like the Indo-Gangetic plain and Eastern China, elevated Ozone (O3) impacts persist. Projected emissions indicate a likelihood of continued high O3 levels in the coming decades, potentially worsening existing challenges and contributing to further yield losses. Additionally, the risks associated with contaminated water sources extend to food safety, as pollutants can infiltrate crops and the food supply chain. Managing the safety of food products is becoming increasingly challenging, impacting consumer health, and eroding trust in the overall food system.

Farmers bear substantial economic burdens as they contend with the challenges posed by water scarcity and pollution. Increased costs are incurred for accessing alternative water sources or implementing water treatment measures to mitigate pollution. These water-related challenges contribute to financial instability for farmers, directly affecting their livelihoods and introducing economic uncertainties. Global crop losses from pollutants can be significantly reduced by 50% by 2050 through the mitigation of methane emissions, a key component in tropospheric ozone formation. The potential losses due to pollution are expected to range from USD 4 to USD 33 billion. The economic impact reverberates through the agricultural sector, underscoring the need for comprehensive strategies to address water-related challenges and ensure the long-term sustainability of agriculture.

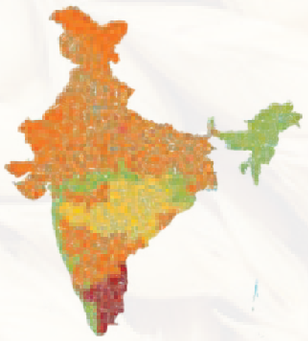
State-wise Per Capita Water Availability in India[9]



Per capita Water Availability 2025



Per capita Water Availability 205O



8. https://www.ccacoalition.org/content/short-lived-climate-pollutants-and-food-security#:~:text=Air%20pollution%20stunts%20crop%20growth,to%2015%25%20in%20some%20regions.

From above chart, it can be easily analyzed that India is going to suffer serious scarcity of water in 2050. Hence, rooftop urban agriculture or reuse of industrial water waste for agriculture purposes has capability to lessen the water scarcity and support in resilient food systems.

Climate Change and Extreme Weather Events

Climate change and extreme weather events present substantial challenges to the resilience of the global food system. The impact of climate-related phenomena, including rising temperatures and altered precipitation patterns, significantly affects agricultural productivity, food security, and the overall stability of the food supply chain. Shifts in optimal agricultural zones, driven by changing climate conditions, necessitate adaptive measures such as the adoption of resilient crop varieties and adjustments in farming practices. Water scarcity and drought, resulting from altered precipitation patterns, disrupt irrigation, and demand the implementation of sustainable water management practices to mitigate their impact on agricultural resilience.

The heightened frequency of extreme events, such as hurricanes and floods, poses a direct threat to crop yields and infrastructure, emphasizing the need for resilient agricultural systems. Climate change also fosters conditions favoring pests and diseases, necessitating integrated pest management strategies and pest-resistant crop varieties. Changes in climate conditions further impact livestock health and disrupt marine ecosystems, affecting fisheries and requiring adaptive animal husbandry and sustainable fishing methods.

Hydro-meteorological disasters, including extensive rainfall and floods, have impacted 33.9 million hectares of India's cultivated land from 2015-16 to 2021-22, according to data presented during the recent monsoon session of parliament by the Ministry of Agriculture. Equally devastating was the impact of drought, resulting from insufficient rainfall. Between 2016-17 and 2021-22, approximately 35 million hectares of cropped area, experiencing a crop loss of 33% and above, suffered damage. Data obtained under the Right to Information (RTI) Act in late October from the Drought Management Cell of the Union Ministry of Agriculture and Farmer Welfare highlighted the widespread consequences.
As per the records, Rajasthan, Karnataka, Madhya Pradesh, and Maharashtra were among the states most severely affected by crop losses due to drought and excessive rainfall. Additionally, Bihar, West Bengal, Uttar Pradesh, Assam, Gujarat, and Odisha experienced significant crop damage attributed to floods and heavy rains.

Additionally, climate change significantly contributes to post-harvest losses, amplifying challenges faced by the food system. Rising temperatures accelerate the deterioration of perishable crops, demanding the implementation of temperature-controlled storage and transportation systems. Altered climate conditions influence pest distribution, requiring integrated pest management practices, and extreme weather events necessitate resilient infrastructure and contingency plans to reduce post-harvest losses. Changes in growing seasons due to climate change may contribute to mismatches in harvesting and processing schedules, emphasizing the importance of improved forecasting and adaptive planning to align agricultural practices with evolving climate conditions and minimize losses. In navigating these challenges, a comprehensive approach focusing on sustainability, resilience, and adaptability is imperative for ensuring the stability of global food supplies.

9. https://iced.niti.gov.in/climate-and-environment/water/per-capita-water-availability
10. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5268357/
11. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5268357/#bib0115

Growing Population and Rising GHG Emission

Agricultural production stands as a significant contributor to greenhouse gas emissions, presently constituting 18% of India's total emissions. Comparing the present scenario, the global food production needs to surge by 70% to meet the anticipated demand of the estimated 9 billion global population by 2050. Below table holds the data of major crops and livestock products by % of total intake and GHG Emission in India.[11]

Major crops and livestock products by % of total intake and GHG Emission in India

Crop/livestock prod.	% of consumption from total food in Indian diets	yield (tonnes/ha)	GHG (kg ha−1)	GHG (kg kg−1 product)
Milk	18.17	-	-	2.42
Wheat	9.42	3.26	977.15	0.34
Paddy Rice	8.97	3.61	8447.59	5.65
Mango	4.6	10.4	750	0.07
Onion	3.72	19.55	1599.65	0.1
Tomato	3.67	130	3000	0.15
Potato	2.69	23.83	3406.46	0.22
Orange	2.57	10.3	1300	0.13
Sugarcane	1.9	79.35	3954.34	0.09
Lentil	1.89	0.9	292.17	0.38
Spinach	1.29	21	1100	0.05
Peas	1.17	1.39	540.09	0.42
Poultry	0.74	-	-	2.59
Egg	0.45	-	-	2.59
Groundnut	0.39	1.36	383.58	0.38
Mutton	0.38	-	-	45.54

India plays a pivotal role in global food supply system and export sizable amount of crops and food materials to different country. Addressing such issues requires diversifying food intake and enhancing the efficient utilization of nutrients and organic matter stocks. Additionally, developing support mechanisms that specifically target products with the highest emissions per unit of production is likely to yield substantial benefits and support resilient food System.

Addressing such issues requires diversifying food intake and enhancing the efficient utilization of nutrients and organic matter stocks. Additionally, developing support mechanisms that specifically target products with the highest emissions per unit of production is likely to yield substantial benefits and also support resilient food System.

8. https://india.mongabay.com/2022/11/in-india-climate-impact-on-agriculture-is-already-a-reality-now/#:~:text=69%20million%20hectares%20of%20crop,recent%20monsoon%20session%20of%20parliament.

The demand for the more is growing which pushes farmers to grow more foods in short span of time the population of the India or world is growing. These factors encourage farmers to increase use pesticides and chemicals in their farmland without proper disposal of residue left after harvesting. Stubble burning is one of these activities that have adverse impacts specially in India extend beyond immediate environmental concerns, posing a significant threat to the country's resilient supply chain. The resultant air pollution can disrupt transportation and logistics, while soil degradation may lead to diminished crop yields. Water pollution, stemming from this practice, has the potential to contaminate food and water supplies, and the associated climate change effects can intensify extreme weather events, causing damage to crop and infrastructure.

The burning events detected between 15 September to 29 October during 2021, 2022 and 2023 in NCR

State	Paddy stubble Burning Events detected between 15 September to 29 October			Percentage Reduction in Paddy Stubble Burning events during 2023	
	2021	2022	2023	In comparison to 2021	In comparison to 2022
Punjab	9001	12112	5254	41.6	56.6
Haryana	2413	1813	1094	54.7	39.7
NCR- Uttar Pradesh	45	33	39	13.3	+18.2
NCR - Rajasthan	2	1	2	0	-
NCT of Delhi	0	5	2	-	60.0
Total	**11461**	**13964**	**6391**	**44.2**	**54.2**

Addressing this issue requires a multifaceted approach, including providing farmers with viable alternatives, enforcing regulations against stubble burning, and raising awareness of its detrimental consequences. Government incentives, technical support, and initiative-taking measures from civil society are essential components in mitigating the impact of stubble burning and fostering a more sustainable agricultural system.

The Glaring Waste: Post-Harvest Losses and Food Insecurity

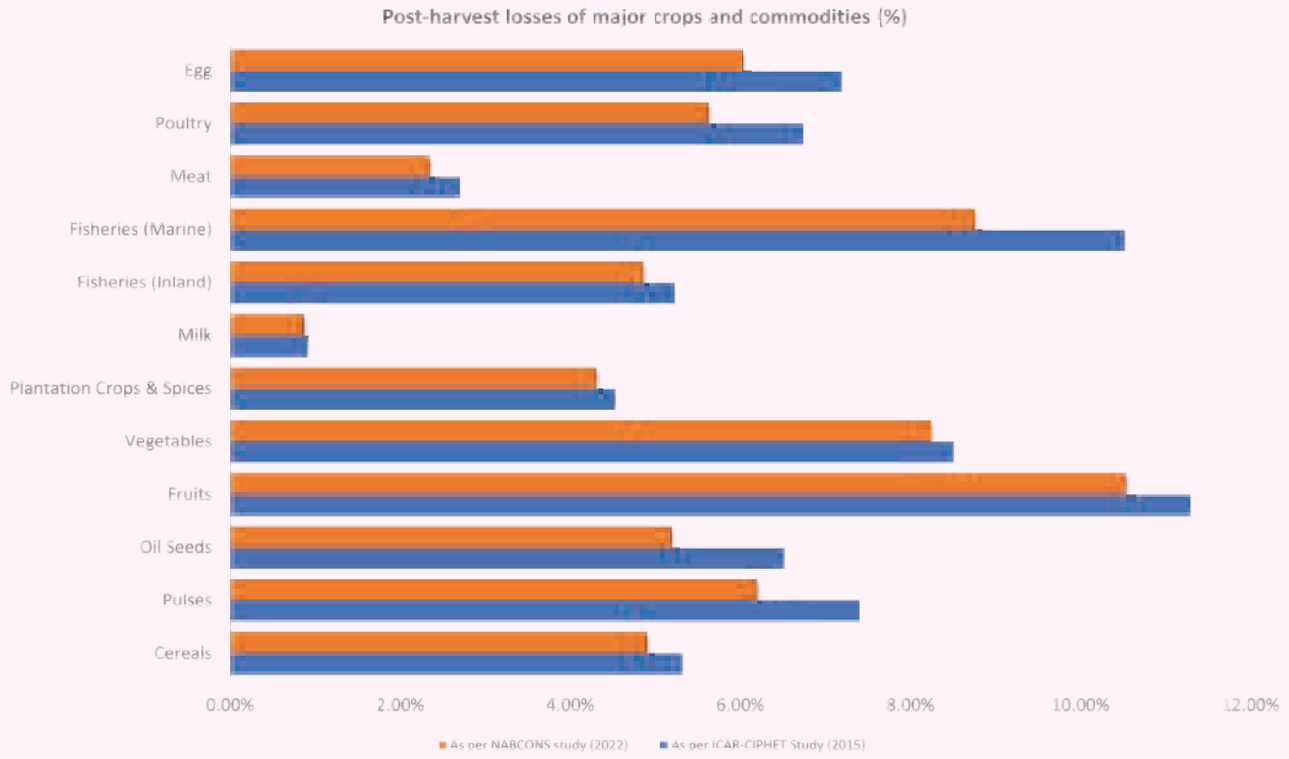
The Scope of the Problem: A Global Concern

The issue of post-harvest losses represents a global scandal that undermines efforts to achieve food security and sustainability. Across the globe, a substantial portion of harvested crops are lost before reaching consumers, creating a significant challenge for both developed and developing nations. The scope of this problem extends beyond the economic losses suffered by farmers to encompass broader implications for global food systems, environmental sustainability, and efforts to alleviate hunger.

Post-harvest losses contribute to a glaring waste of precious resources, including water, energy, and labor invested in agricultural production. This waste exacerbates the problem of food insecurity, especially in regions where access to food is already a critical concern. The loss of perishable crops during storage, transportation, and processing stages represents not only a missed opportunity to address hunger but also a failure in the efficiency of food supply chains.

Post-harvest losses continue to be a major problem for the global food system as per current global stand. A substantial amount of harvested crops, such as fruits, vegetables, and grains, perish from spoiling, decay, or damage before they are consumed, regardless improvements in agricultural technology and methods. Post-harvest losses can be caused by a variety of factors, such as poor storage facilities, ineffective transportation, restricted market access, and inadequate infrastructure in certain regions.

These losses have tangible consequences on both the economic well-being of farmers and the availability of food for communities. Post-harvest waste increases the environmental effect of agriculture by wasting resources that were spent throughout the cultivation, in addition to the financial losses.



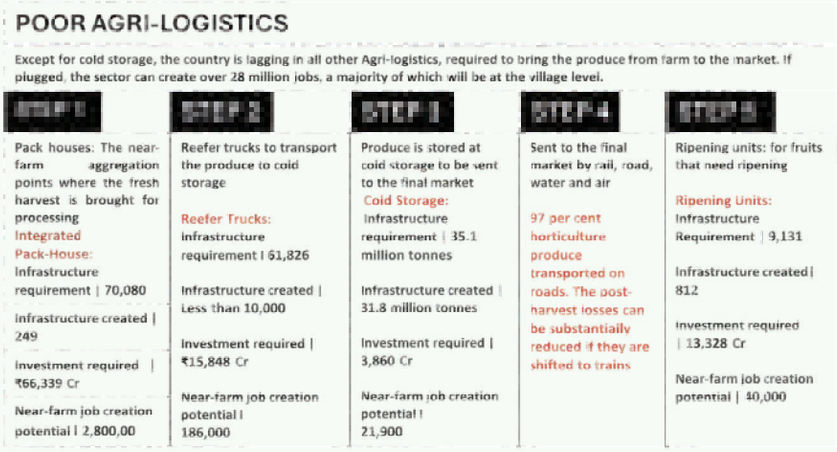
13. https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1885038

Causes and Outcomes: From Farm to Fork

The intricate journey of food from farm to fork involves various stages, each susceptible to factors that contribute to post-harvest losses. Understanding the causes and consequences at each step of this process is crucial for devising effective strategies to minimize waste and enhance the resilience of the global food system. The Ministry of Food Processing Industries reports an annual loss of approximately USD 14 billion in agricultural produce in India due to insufficient post-harvest infrastructure. Insufficient storage and transportation facilities contribute to a staggering 30% loss of the country's total agricultural output each year. A study conducted by the Indian Council of Agricultural Research (ICAR) suggests that implementing proper post-harvest management practices could potentially reduce these losses by 10-15% and simultaneously boost farmers' income by 10-20%.

At the production stage on the farm, factors such as climate conditions, pest infestations, and inadequate harvesting techniques can result in substantial losses. Failure to adopt proper storage methods, transportation challenges, and insufficient infrastructure during the post-harvest handling phase further contribute to the problem. Processing, packaging, and distribution stages also play critical roles, where inefficiencies and lack of technology may lead to additional losses. Finally, at the retail and consumer levels, issues such as improper storage, over-purchasing, and consumer preferences contribute to the overall post-harvest losses.

Post-harvest losses, a pervasive issue in the global food supply chain, stem from a multitude of challenges spanning from inadequate infrastructure to limited technology adoption. The insufficient availability of proper storage, transportation, and processing facilities significantly hampers the preservation of harvested crops. This lack of infrastructure exposes perishable goods to the risk of spoilage, decay, and damage at various stages of the supply chain. Improper storage practices, including inadequate temperature control and ventilation, further contribute to the deterioration of stored crops, making them susceptible to issues like mold, pests, and decay. Inefficient transportation, marked by delays, rough handling, and exposure to adverse weather conditions during transit, exacerbates the problem by causing physical damage and accelerating the deterioration of perishable goods. Farmers facing limited access to broader markets encounter challenges in promptly selling their produce, leading to the risk of overripe or unsold goods. Moreover, the slow adoption of modern technologies for post-harvest management, such as refrigeration and preservation methods, leaves farmers struggling to maintain the quality and market value of their produce. The interconnected nature of these factors underscores the complexity of addressing post-harvest losses and highlights the need for comprehensive strategies throughout the entire supply chain .

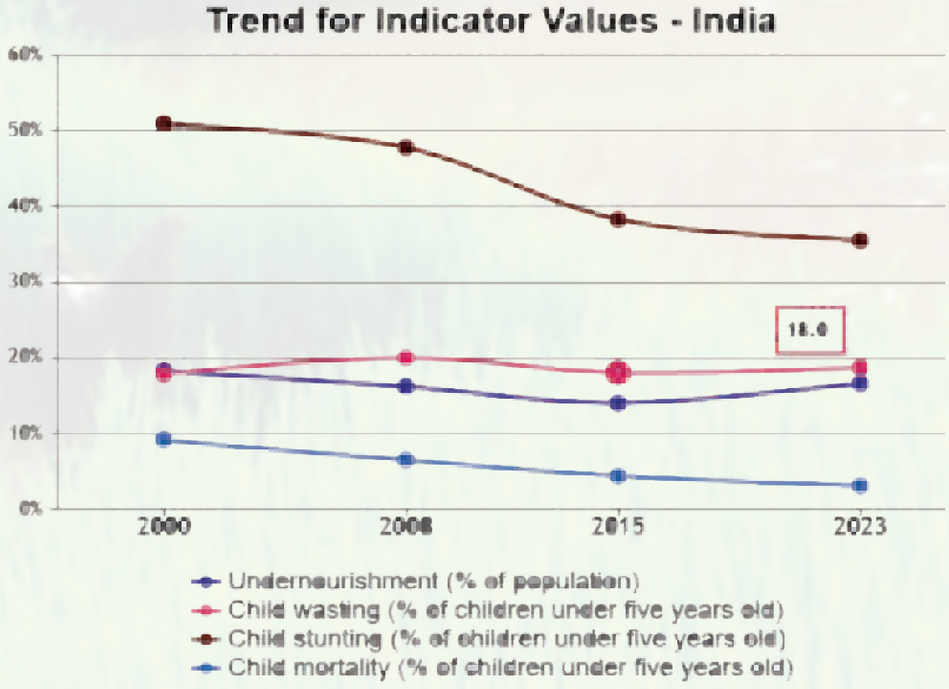


14. https://www.mofpi.gov.in/sites/default/files/study_report_of_post_harvest_losses.pdf

The Human Cost: Hunger and Malnutrition

The intersection of post-harvest losses and food insecurity exacts a profound human cost, manifesting in hunger and malnutrition. While post-harvest losses contribute to a significant portion of wasted food, a parallel crisis unfolds where millions of individuals around the world suffer from inadequate access to nutritious food. The glaring waste resulting from post-harvest losses exacerbates the challenges of addressing hunger and malnutrition. As edible produce is lost during various stages of the supply chain, opportunities to alleviate food shortages and nourish vulnerable populations slip away. This human cost underscores the urgency of implementing effective strategies to minimize post-harvest losses, not only to reduce waste but also as a crucial step toward mitigating the pervasive issues of hunger and malnutrition on a global scale. India ranks 107th among 121 countries in the 2022 Global Hunger Index (GHI), indicating a serious level of hunger with a score of 29.1. This marks a decline of six positions from its 2021 rank of 101. Notably, India holds the highest child wasting rate among all countries covered by the GHI. In comparison to its neighboring countries, India lags with ranks as follows: Pakistan – 99, Sri Lanka – 64, Nepal – 81, and Bangladesh – 84. The only South Asian country with a lower ranking than India on the index is Afghanistan, standing at 109th.

While India has shown improvement in child stunting and child mortality between 2014 and 2023, with a decline from 38.7% to 35.5% in child stunting and a drop from 4.6% to 3.1% in child mortality, there are concerning trends. The prevalence of undernourishment in India has risen from 14.0% in 2015 to 16.6% in 2023, impacting approximately 224.3 million people out of 828 million globally. Furthermore, India's child wasting rate, at 18.7%, surpasses the levels recorded in 2015 (18.0 %) and even 2000 (17.8%), indicating an alarming situation .



15. https://www.downtoearth.org.in/news/agriculture/poor-post-harvest-storage-transportation-facilities-to-cost-farmers-dearly-61047#:~:text=Indian%20farmers%20incur%20Rs%2092%2C651,poor%20storage%20and%20transportation%20facilities.
16. https://www.globalhungerindex.org/

Access and Equity: Barriers to Sustainable Solutions

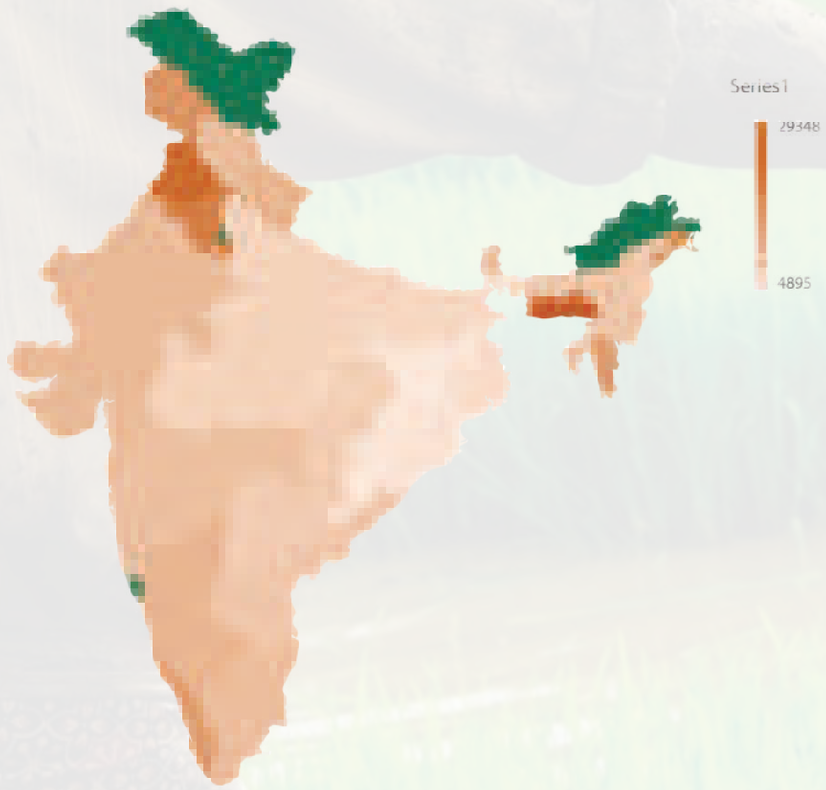
Smallholder Farmers and Limited Resources

Smallholder farmers, who often operate with limited resources, confront unique challenges that can significantly affect the resilience of food systems. Various factors contribute to the vulnerability of smallholder farmers, presenting obstacles to the overall stability and adaptability of the food supply chain.

One of the primary challenges faced by smallholder farmers is the limited access to modern agricultural technologies. This constraint hampers their ability to optimize production, manage resources efficiently, and adapt to changing conditions. Consequently, the restricted adoption of technology diminishes the overall resilience of food systems, as these farmers may encounter difficulties in implementing innovative practices that enhance productivity and sustainability.

Financial constraints represent another significant challenge for smallholder farmers. Operating within tight budgets and limited financial resources restricts their capacity to invest in improved farming practices, machinery, or technologies. This financial burden impedes smallholder farmers' ability to make necessary adjustments to their farming methods, limiting their resilience in the face of challenges such as climate change or market fluctuations.

Average monthly income per agricultural household(₹)



17. https://pib.gov.in/PressReleasePage.aspx?PRID=1884228

Access to broader markets poses another obstacle for smallholder farmers. Challenges related to limited transportation infrastructure, information barriers, and insufficient market linkages hinder their ability to reach wider consumer bases. This limited market access reduces their capacity to diversify income sources and adapt to changing consumer demands, consequently affecting the overall resilience of the food supply chain.

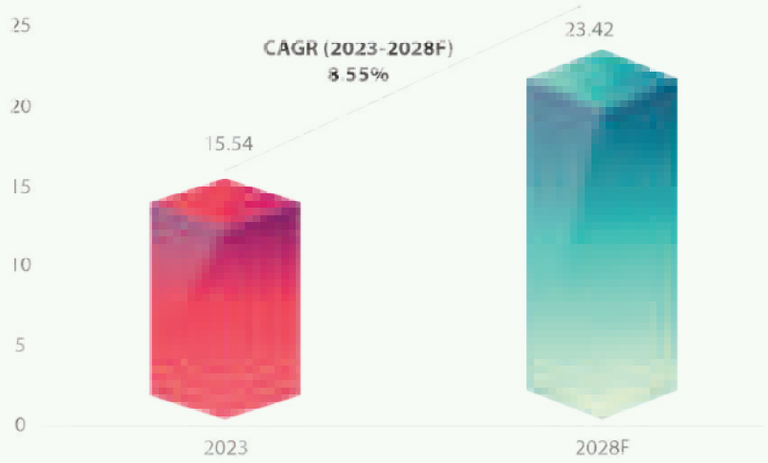
Climate vulnerability is a pressing concern for smallholder farmers, who often rely on rain-fed agriculture and face exposure to extreme weather events. This vulnerability can lead to reduced crop yields and overall food system susceptibility to climate-related challenges such as unpredictable weather patterns or prolonged droughts.

Land tenure issues further contribute to the challenges faced by smallholder farmers. In certain regions, they may experience land tenure insecurity or lack access to sufficient arable land for sustainable agricultural practices. These issues create uncertainties in long-term planning and investments, affecting the ability of smallholder farmers to build resilient and sustainable farming systems.

Knowledge Gaps and Unequal Access to Technology

According to the TechSci Research, the global Smart Harvest Market has valued at USD 14.78 Billion in 2022 and is anticipated to project impressive growth in the forecast period with a CAGR of 8.55% through 2028 where Europe region dominates the market. Over the past decade, Asia dominated in terms of irrigation capacity, accounting for 70% of the world's total with 237 mega hectares (mha), followed by the Americas (16%), Europe (8%), Africa (5%), and Oceania (1%). In the relative share of land equipped for irrigation over cropland, Asia led with 40%, followed by the Americas (13%), Europe (9%), Oceania (7%), and Africa (6%). Per capita cropland availability was smallest in Asia (0.13 hectares per capita), followed by Africa (0.22), the Americas and Europe (0.40), and Oceania (1.21)[22]. The data suggests, it is alarming situation for India, and it needs to actively influence its farmers to use smart technology in farming. Additionally, the presence of knowledge gaps and unequal access to technology presents formidable obstacles to the implementation of sustainable solutions within the agricultural sector. These challenges

Global Smart Harvest Market Size 2023-2028F (USD Billion)



21. https://www.techsciresearch.com/report/smart-harvest-market/7750.html
22. https://www.fao.org/sustainability/news/detail/en/c/1274219/

act as impediments to the widespread adoption of practices that could otherwise amplify the resilience and sustainability of food systems.

In terms of information accessibility, farmers situated in remote or marginalized areas encounter difficulties obtaining crucial insights into sustainable farming practices, emerging technologies, and market trends.The consequence is a struggle for these farmers to optimize their agricultural methods, make informed decisions, and stay current with advancements that hold the potential to fortify the resilience of their farming systems.

Disparities in technological access, especially noticeable between large commercial farms and smallholder farmers, contribute to an imbalance in the adoption of contemporary and sustainable agricultural practices. This discrepancy places smallholder farmers, who often require these technologies the most, at a disadvantage, limiting their capacity to implement resource-efficient and sustainable solutions.

Financial constraints further compound the challenge, as the associated costs linked to the adoption of new technologies and sustainable farming practices act as barriers for numerous farmers, particularly those with limited financial resources. These financial limitations impede the adoption of technologies capable of enhancing productivity, mitigating environmental impact, and contributing to the overall resilience of the food system.

Average monthly income of agricultural households[23]

Year	Average monthly income per agricultural household
2002-03	2,115
2012-13	6,426
2015-16	8,059
2018-19	10,218
2022-23	NA

Insufficient training and educational programs on sustainable farming practices and modern technologies present another challenge. Farmers lacking the necessary skills due to a lack of training face limitations in implementing sustainable solutions effectively, hindering progress toward creating resilient and environmentally friendly agricultural systems.

Technological illiteracy among some farmers adds to the complexity, as challenges in understanding and effectively utilizing modern technologies hinder their ability to fully harness the transformative potential these technologies could offer in terms of agricultural sustainability and resilience.

23. https://prsindia.org/budgets/parliament/demand-for-grants-2023-24-analysis-agriculture-and-farmers-welfare

Economic and Political Roadblocks: Incentives and Power Dynamics

Economic and political roadblocks, influenced by incentives and power dynamics, present substantial hindrances to the widespread adoption of sustainable solutions in agriculture. These challenges act as barriers to the shift towards more resilient and environmentally friendly practices within the food system. One significant challenge lies in the existing incentive structures, where economic incentives predominantly favor conventional and intensive agricultural practices. This bias discourages farmers from transitioning to more sustainable alternatives. The impact is evident as farmers may hesitate to embrace sustainable solutions when economic incentives and subsidies continue to align with practices that potentially compromise long-term environmental sustainability and resilience.

Power dynamics within agricultural supply chains also pose a challenge. Favoring large agribusinesses and processors, these imbalances can influence the adoption of sustainable practices. Smallholder farmers, facing difficulties in accessing markets that reward sustainable practices, may find themselves perpetually dependent on conventional methods, potentially leading to adverse environmental impacts.

Political will and policy ambiguity add to the challenges. The absence of clear policies supporting sustainable agriculture or a lack of political will to drive such initiatives can hinder widespread adoption. Ambiguous or inadequate policies may leave farmers uncertain about the long-term viability of sustainable practices, impacting their willingness to invest in transformative changes.

Moreover, subsidies and financial support systems that currently favor conventional agriculture create another hurdle. Redirecting subsidies toward sustainable practices becomes essential to incentivize farmers to adopt environmentally friendly alternatives and enhance resilience within the broader food system.

Structural barriers, such as high initial costs and complex certification processes for sustainable practices, form another layer of challenges. These barriers, acting as deterrents, create entry challenges, especially for smallholder farmers, preventing them from engaging in sustainable agriculture and reaping the long-term advantages it offers.

Incidence of indebtedness in agricultural households[24]

Year	Number (In Lakh)	% indebted	Average Outstanding loan amount
2003	894	49%	12,585
2013	902	52%	47,000
2019	903	50%	74,121

24. https://prsindia.org/budgets/parliament/demand-for-grants-2023-24-analysis-agriculture-and-farmers-welfare#_edn28

Chapter 3

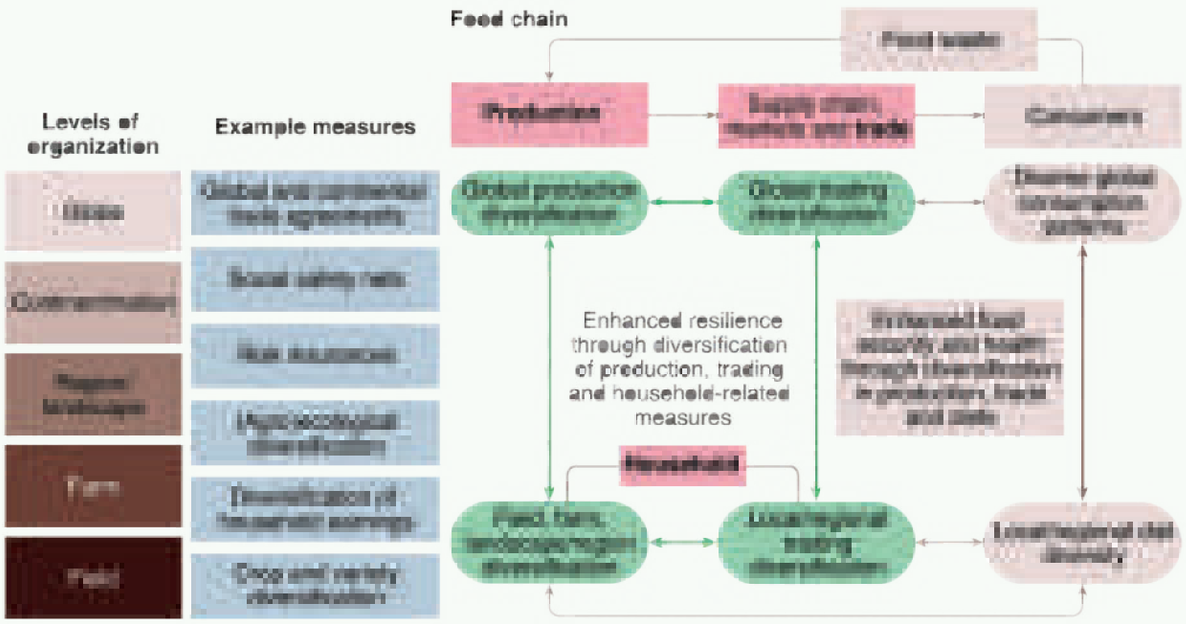
Sowing the Seeds of Change:

Solutions for Resilient Food Systems

"Agriculture is our wisest pursuit because it will in the end contribute most to real wealth, good morals, and happiness."

Thomas Jefferson

Food System Diversification To Enhance Food Systems Resilience



Across levels of organization, from field to global, and along the supply chain, from production to consumption, diversification measures may enhance food systems resilience. Note that diversification of food processing and diets are not addressed in this Comment, but are closely related to diversification of production, household livelihoods and trade. In general, relationships (trade-offs and additional benefits) among diversification measures across scales and along the food supply chain are not yet well understood and deserve more attention.[25]

Agroecology: Cultivating Harmony with Nature

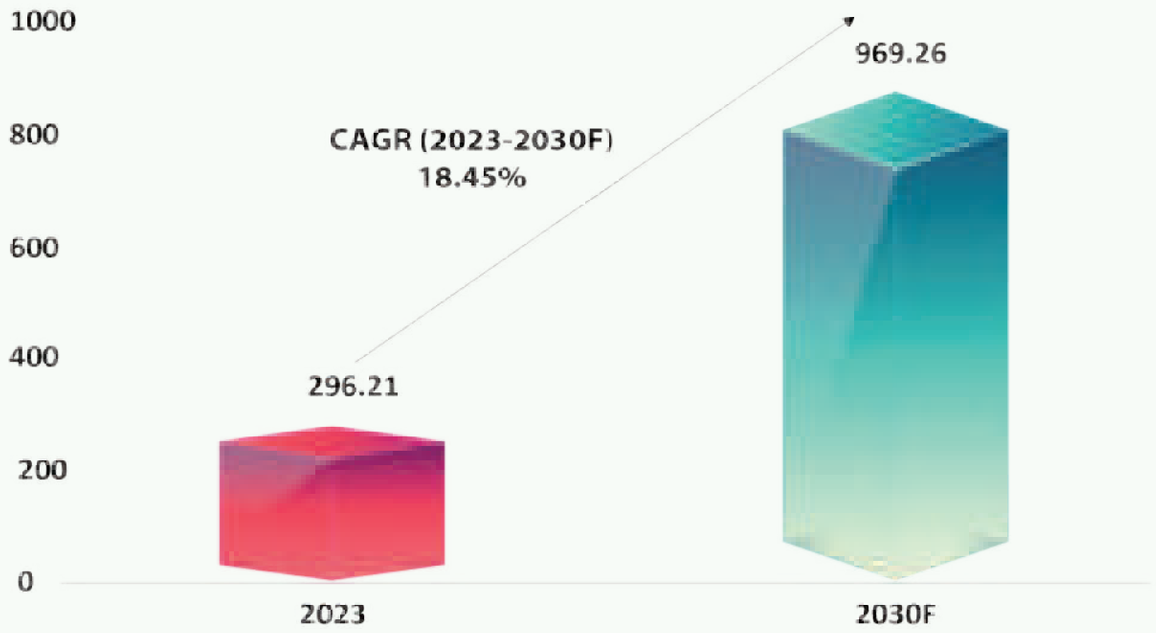
Agroecology, a scientific field, applies ecological principles to manage plant, animal, human, and environmental interactions, aiming to ensure food security. It involves agricultural practices that mimic natural processes, promoting sustainability. Focused on holistic and sustainable farming, agroecology leverages ecosystem dynamics to enhance agricultural resilience and productivity. It balances interactions for the benefit of the environment and food production by comprehending linkages within farming contexts. Agroecology, which emphasizes living in harmony with the environment, uses techniques that mimic natural ecosystems, such as crop diversity and integrated pest management. This method promotes environmentally sound farming practices that are fruitful and promote the long-term health of the earth and the welfare of local communities. For instance, since 2016, the Andhra Pradesh government has been dedicated to promoting "natural farming," which aligns with the principles of regenerative, climate-resilient agriculture managed by local communities. Aligned with the science and practice of agroecology, natural farming emphasizes soil health, landscape regeneration, diversified crop and animal production, and eschews the use of pesticides and chemical fertilizers. With the active participation of 700,000 farmers in April 2020, the initiative aspires to expand to 6 million farmers covering 8 million hectares by 2027. The success of natural farming in Andhra Pradesh has garnered interest from other Indian states, the central government, and national and international institutions.[26]

25. https://www.nature.com/articles/s43016-021-00403-9
26. https://www.cirad.fr/en/worldwide/cirad-worldwide/projects/agroeco2050-project#:~:text=In%20April%202020%2C%20APCNF%20was,and%20national%20and%20international%20institutions.

Regenerative Agriculture: Restoring and Building Soil Health

Global Regenerative Agriculture Market is expected to grow at a CAGR of 14.41% reach USD 16.80 Billion by 2027.[27] Regenerative agriculture stands out as a revolutionary approach to farming, placing a strong emphasis on the rejuvenation and enrichment of soil health. This transformative method centers around sustainable practices with the overarching goal of constructing robust and resilient food systems capable of withstanding environmental adversities. At its core, regenerative agriculture is anchored in the principle of soil health restoration. This involves a dedicated commitment to practices like cover cropping, crop rotation, and reduced tillage, all of which aim to minimize soil disturbance, encourage biodiversity, and cultivate nutrient-rich soils. Another key principle involves the promotion of biodiversity through diverse cropping systems, cover crops, and agroforestry. This deliberate diversification fosters a thriving ecosystem of microorganisms, insects, and plants, significantly enhancing resilience against pests and diseases. According to TechSci Research, the India's Regenerative Agriculture Market is projected to be reach around 969.26 million by 2030

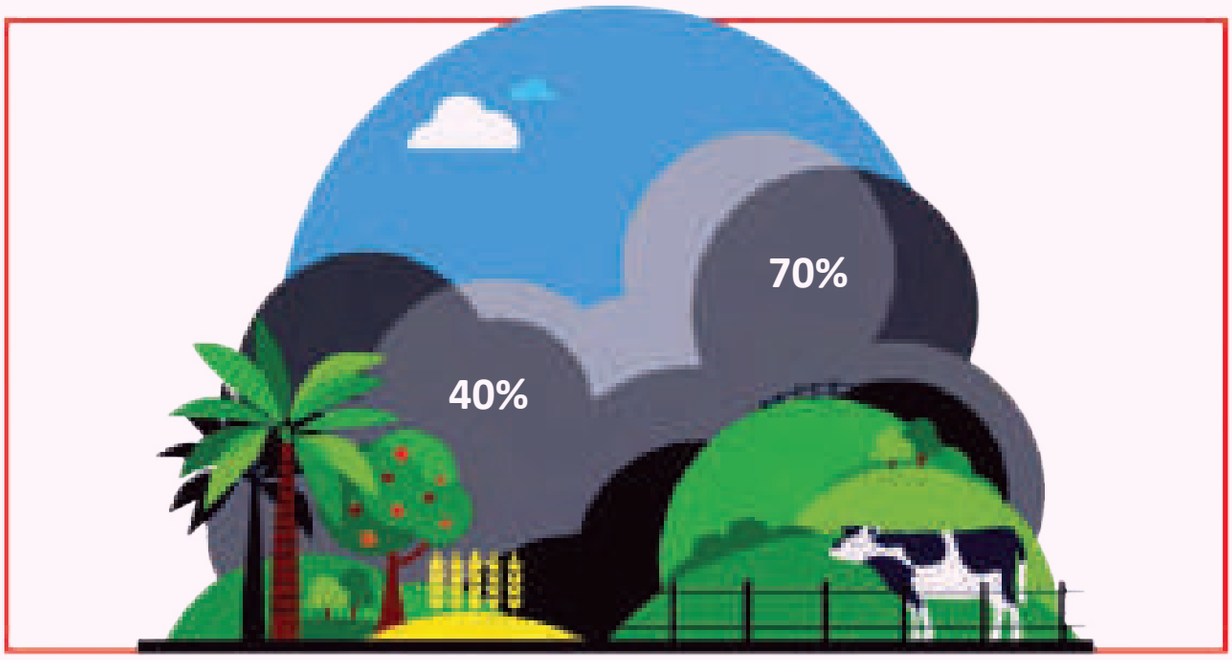
India Regenerative Agriculture Market Size 2023-2030F (USD Billion)



27. https://www.techsciresearch.com/report/regenerative-agriculture-market/7730.html

Regenerative farmers adopt a holistic resource management approach, considering the entire ecosystem in their practices. This entails efficient water management, integrated pest control, and nutrient cycling as central components, ensuring responsible resource utilization and minimal environmental impact. Furthermore, regenerative agriculture actively contributes to global climate change mitigation through carbon sequestration practices. By acting as a carbon sink, healthy soils help reduce atmospheric Co2 levels, aligning with global efforts to combat climate change. According to a sustainbility report prepared by TechSci Research, Nestle SA, Grupo Bimbo Sab de CV, and Unilever Plc are leading in terms of environmental performance and supporting directly or indirectly into regenerative agriculture. These companies have transparently disclosed their emissions in their sustainability reports and have implemented various strategies to mitigate carbon emissions.

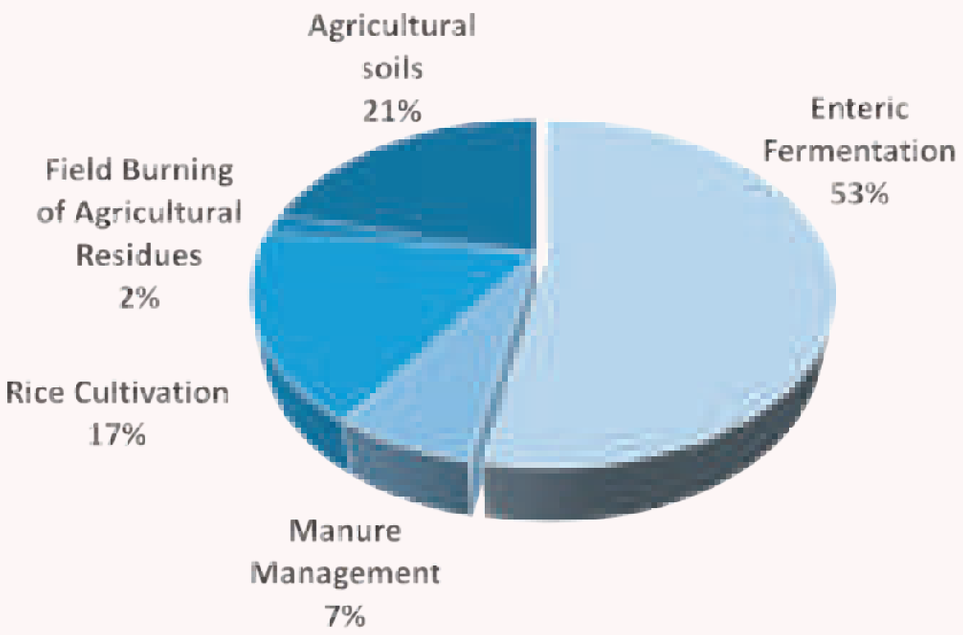
The benefits derived from regenerative agriculture are multi-faceted. Practices focused on soil health enhancement led to improved soil fertility, fostering the growth of beneficial microorganisms, and creating a well-balanced soil structure. This, in turn, translates to increased crop yields and overall productivity. The emphasis on efficient water management within regenerative agriculture also plays a pivotal role in conserving water resources. Techniques such as mulching and cover cropping are employed to reduce water runoff, enhance water retention, and contribute to the overall sustainability of agricultural water usage.



Global Emission Cropland **Global Emission Pastureland**

Transitioning to regenerative models for worldwide cropland and pasture has the potential to lead to an annual negative greenhouse gas (GHG) emissions scenario, possibly sequestering a significant amount. Global cropland, utilized for cultivating plants for materials, energy, or human consumption, accounts for approximately 40% (around 21 GtCo2) of annual GHG emissions. In the case of global pasture, managed for grazing livestock, it constitutes roughly 71% (approximately 37 GtCo2) of annual GHG emissions.

Agriculture Emission Share in 2019 (in Gigagrams)



Moreover, regenerative agriculture builds climate-resilient systems by sequestering carbon and promoting biodiversity. Farmers embracing these practices find themselves better equipped to confront the challenges posed by changing climatic conditions, ensuring consistent and sustainable food production. Importantly, regenerative agriculture is proving to be economically viable in the long run. While the initial transition may involve certain costs, the subsequent benefits, including reduced input costs and improved yields, contribute to the economic sustainability of farms.

Crop Diversification and Intercropping: Ecological Balance and Resilience

Crop diversification and intercropping are ecological farming approaches that promote balance and resilience within food systems, emphasizing sustainability. These practices prioritize biodiversity and efficient resource utilization, contributing to the establishment of robust agricultural systems capable of adapting to dynamic conditions.

In crop diversification, a diverse array of crops is cultivated within a designated area, countering the dominance of monoculture. Intercropping takes this further by concurrently growing different crops in the same field, aiming to enhance biodiversity and create a more intricate and resilient ecosystem. The selection of crops in intercropping involves strategic consideration of their compatibility and mutual benefits, fostering a harmonious environment where each plant contributes to the overall health and productivity of the system.

These practices optimize the utilization of resources such as sunlight, water, and nutrients by leveraging the varied structures and growth patterns of different crops. This resource efficiency minimizes competition among plants and reduces resource wastage, aligning with sustainable farming practices. Furthermore, the disruption of pest and disease buildup is a notable benefit, as diverse plantings in these systems create an environment less favorable to outbreaks, promoting natural pest control and diminishing the need for chemical interventions.

India's tropical and subtropical climate facilitates the cultivation of two or more crops annually. Crop rotations, location-specific and economically driven, vary under diverse socioeconomic and agroecological conditions. Intercropping serves as a hedge against crop failure, particularly in rainfed regions, offering

risk reduction and equitable returns.

The ICAR-Indian Institute of Farming Systems Research (Modipuram) estimates the area under crop rotation at around 30 million hectares, including cereal-cereal cropping systems, with intercropping covering approximately 1 million hectares, excluding horticultural crops. Both small and large farmers in irrigated and rainfed regions, excluding canal-irrigated areas and climatically limited zones, practice crop rotation. Despite mechanization constraints, smallholder farmers engage in intercropping due to its flexibility, risk reduction, and nutritional benefits.

Approximately 12 to 15 million farmers practice crop rotation, and 0.70 to 0.90 million farmers engage in intercropping, according to stakeholders at ICAR-IIFSR. Crop rotation is widespread across India, particularly in the semi-arid tropics, while intercropping is more prevalent in the southern (Karnataka, Telangana, Tamil Nadu, Maharashtra), western (Gujarat), and Madhya Pradesh regions.

Major crop rotations include cereal-based systems like rice-rice, rice-wheat, and maize-wheat, consti-

Intercropping is more predominant in the southern and western regions of the country.

29. https://www.ceew.in/publications/sustainable-agriculture-india/crop-rotation-intercropping

tuting about 74% of the Indian diet's caloric intake. Leguminous crops, crucial for soil health, are often grown before rice planting. Intercropping is practiced with various crops (cereals, pulses, horticulture) and agricultural systems (agroforestry, integrated farming), suitable for wide-spaced crops like maize, cotton, and sugarcane.

Both crop rotation and intercropping are integrated into national and state-level policies and schemes. Programs such as the Soil Health Management under the National Mission for Sustainable Agriculture and the National Food Security Mission Commercial Crops emphasize crop rotation in India. Intercropping is promoted by the National Mission on Oilseeds and Oil Palm, the Agriculture Department in Tamil Nadu, and various state agricultural policies to enhance sustainability and productivity. ICAR's initiatives, like the NICRA project, demonstrate the use of intercropping for livelihood security and climate resilience. The advantages of crop diversification and intercropping extend to resilience against environmental variability, with the diverse array of crops ensuring a more reliable overall yield in the face of specific challenges. Additionally, these practices contribute to improved soil health by preventing nutrient depletion and erosion, while certain crops enhance soil fertility through nitrogen fixation and microbial activity. When well-planned, intercropping can lead to higher overall productivity compared to monoculture, due to complementary growth patterns and efficient resource utilization.

Moreover, the cultivation of a variety of crops provides farmers with diversified income streams, mitigating financial risks associated with market conditions or prices for a particular crop. Crop diversity and intercropping are prime examples of sustainable farming methods that put ecological resilience and balance paramount. By embracing these approaches, farmers contribute to the development of adaptable, environmentally sustainable food systems that are both productive and resilient.

Benefits of Integrated Pest Management

Integrated Pest Management: Natural Solutions for Healthy Yields

Integrated Pest Management (IPM) represents a holistic and sustainable approach to pest control, emphasizing natural solutions for cultivating healthy yields and contributing to the resilience of food systems. Below mentioned are the principles of IPM, highlighting its role in promoting environmentally friendly pest management practices for sustainable agriculture.

30. https://www.ceew.in/publications/sustainable-agriculture-india/crop-rotation-intercropping

Integrated Pest Management (IPM) stands out as a comprehensive and sustainable approach to pest control, placing a strong emphasis on environmental sustainability. The core principle of IPM involves prioritizing ecological balance and minimizing the environmental impact of pest control measures. By favoring natural solutions over excessive chemical use, IPM significantly contributes to the overall sustainability of agriculture.

A key aspect of IPM is the preservation of beneficial organisms through biological control methods. This includes leveraging predatory insects and parasitoids to naturally regulate pest populations. By conserving these natural enemies, IPM ensures ongoing pest regulation without resorting to the overuse of chemical inputs.

Furthermore, IPM strategies play a crucial role in resistance management. Practices like crop rotation and the diverse application of pest control methods help mitigate the development of resistance in pests to chemical treatments. This approach enhances the long-term effectiveness of pest management, contributing to the resilience of agricultural systems.

IPM's positive impact extends to crop health, as the approach promotes practices supporting soil health, crop rotation, and diverse plantings. Healthy plants resulting from t The local food systems exhibit resource efficiency by streamlining supply chains and optimization benefits both producers and consumers, minimizing resource wastage linked to prolonged transportation, storage, and distribution processes. The result is a more sustainable and resource-conscious approach to food production.

Moreover, prioritizing locally sourced food becomes a cornerstone in fortifying the economic viability of local farmers. Consumers, by choosing products from nearby producers, provide direct and impactful support to the local agricultural community. This support not only fosters economic stability but also encourages sustainable farming practices, ensuring the long-term health of the local agricultural landscape. Diversifying income streams is another notable benefit derived from strengthening local economies

through reduced food miles. This diversification enhances economic resilience by mitigating dependence on a singular market or distribution channel, providing farmers and businesses with a more robust financial foundation.

The retention of wealth within the community emerges as a consequential outcome of spending on locally produced food. This economic circulation supports various local businesses and services, creating a positive feedback loop that enriches the overall community.

Job creation is a bonus optimistic consequence of nurturing a robust local food economy. The entire spectrum of the local food system, from farmers and processors to distributors and retailers, contributes to generating employment opportunities within the community. This not only sustains economic health but also promotes community well-being.

In terms of crisis resilience, shortening supply chains enhances the adaptive capacity of local food systems. In times of disruptions, such as natural disasters or global events, resilient local economies ensure a more reliable and responsive food supply, reducing vulnerabilities linked to global supply chains.

Cultural preservation is intertwined with strengthening local economies, as it often involves safeguarding cultural food traditions. Local producers, deeply rooted in the community, are more inclined to cultivate and promote traditional crops and culinary practices, contributing significantly to the preservation of cultural heritage.

Community Supported Agriculture: Connecting Consumers and Producers

Community Supported Agriculture (CSA) emerges as a transformative model fostering connections between consumers and producers, offering a multifaceted solution for building resilient food systems. Prioritizing local, direct relationships, CSA provides benefits across various dimensions. It establishes direct connections between consumers and local farmers, fostering transparency and trust. Embracing localized and seasonal eating, CSA aligns food consumption with natural agricultural cycles, promoting sustainability and reducing carbon footprints.

Members share both risks and rewards, creating a resilient and supportive system. CSA memberships offer upfront financial support, enhancing farmers' economic resilience. Diverse crop varieties and educational opportunities promote ecological resilience and consumer awareness. Active participation in on-farm events builds a sense of community, while the direct nature of transactions minimizes food waste. CSA models showcase flexibility, allowing farmers to adapt to changing circumstances, contributing to overall food system resilience.

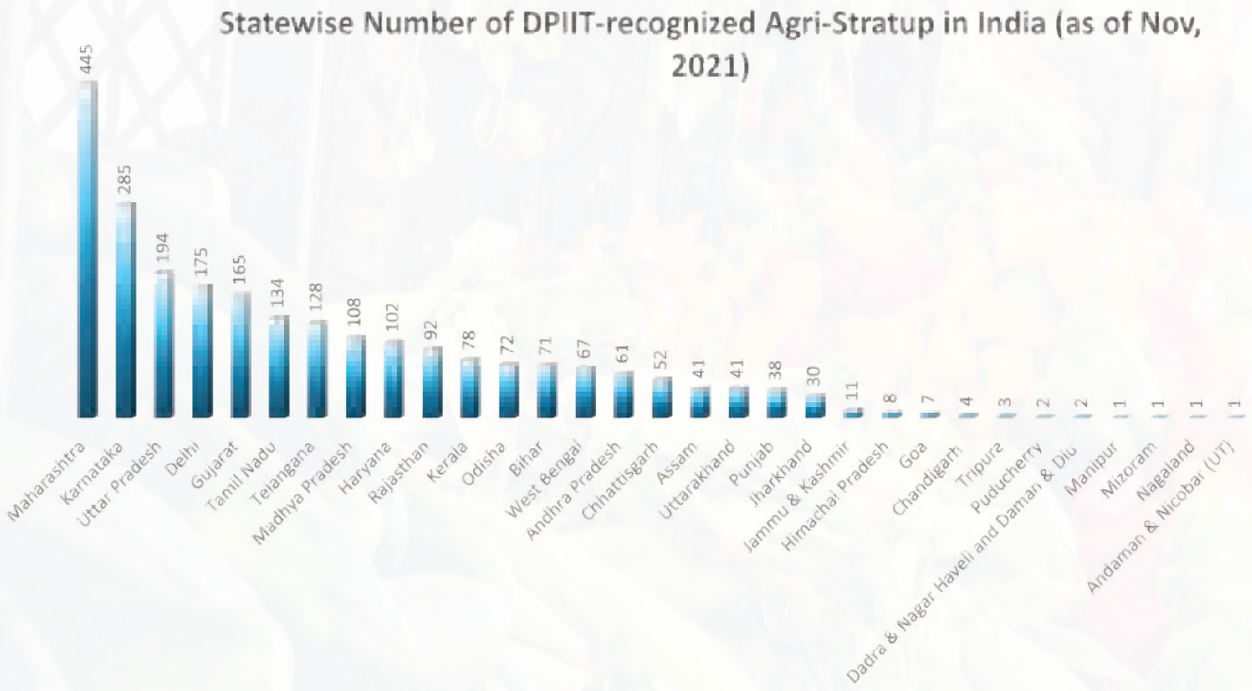
Innovation for Sustainability: Harnessing Technology's Potential

Precision Agriculture: Data-Driven Optimization for Efficiency

Precision Agriculture, characterized by data-driven optimization for efficiency, emerges as a pivotal solution for building resilient food systems. This approach leverages advanced technologies, including the Internet of Things (IoT), Artificial Intelligence (AI), and other emerging innovations, to enhance agricultural practices and minimize losses throughout the production and supply chain. The agricultural industry in India and globally is undergoing a transformation with the integration of IoT (Internet of Things), big data, and cloud computing. The current valuation of data analysis in agriculture worldwide is 565 million USD, and it is projected to reach 1256 million USD by the end of 2023. These technological advancements are reshaping the way farming operations are conducted, enhancing efficiency, productivity, and deci-

sion-making processes in the agricultural sector.

Precision Agriculture relies on the collection and analysis of extensive data to make informed decisions at various stages of the farming process. This includes monitoring soil conditions, crop health, weather patterns, and other relevant variables. By utilizing precision technologies such as sensors, drones, and satellite imagery, farmers can optimize resource use, tailor inputs to specific needs, and enhance overall efficiency.



• IoT in Precision Agriculture

IoT devices, such as soil sensors and weather stations, provide real-time data on environmental conditions. This information helps farmers make timely decisions regarding irrigation, fertilization, and pest control. IoT enables a network of interconnected devices that contribute to a comprehensive understanding of the farming environment.

The adoption of IoT solutions in agriculture is experiencing continuous growth, with COVID-19 exerting a positive influence on the market share. The disruptions in the supply chain and a shortage of skilled labor during the pandemic has contributed to a to an increase in adoption of IoT solutions in agriculture practices.

There have been few successful case scenarios wherein adoption of smart agricultural practices have revolutionized the agricultural sector. For instance, Venkateswara Hatcheries (VH Group), a pioneer in poultry, recognized the need for a robust ERP system tailored to the livestock industry's unique dynamics. In 2011, Uttara Foods and Feeds (UFFL), a Rs 1,000 crore enterprise under VH Group, adopted OpenBravo for efficiency and customization. This move facilitated international expansion, addressing language barriers with its localization pack in 64 languages. OpenBravo's integration of web services allowed mobility solutions, including a sales force mobile app. Despite standardized reporting, UFFL conducted change

management initiatives to align users. The benefits were significant: increased transparency, a desktop app for areas with poor internet connectivity, and improved operational efficiency. OpenBravo positioned UFFL for potential expansion in remote areas, contributing to a resilient poultry industry supply chain.

• AI for Decision Support

AI algorithms analyze large datasets to identify patterns, predict crop yields, and offer decision support to farmers. Machine learning models can provide insights into optimal planting times, disease detection, and resource allocation. This data-driven decision-making enhances productivity and resilience against uncertainties.

Cropin, an Agro technology startup was established in 2020 by Krishna Kumar and Kunal Prasad and serves as an exemplar in leveraging AI for decision support in agriculture. Operating from Bengaluru, this startup's SmartFarm Plus solution integrates data from diverse sources, digitizing farm data comprehensively. These sources encompass third-party ERP solutions, manual inputs through the SmartFarm app, earth observation, satellite-based meteorological data, drones, and other IoT devices. The application of AI and data analytics empowers stakeholders in the agritech ecosystem with real-time information, facilitating sustainable and resilient agricultural practices. By aiding farmers in their decision-making processes, Cropin's innovative use of AI contributes to minimizing greenhouse gas emissions and promoting carbon sequestration in agriculture.

• Drones and Satellite Imaging

Drones equipped with cameras and sensors, along with satellite imaging, offer high-resolution views of fields. This technology aids in crop monitoring, mapping, and early detection of potential issues. Rapid and accurate information from these sources allows for prompt intervention, minimizing losses.

In a significant stride towards promoting precision farming in India, the Union Ministry of Agriculture and Farmers Welfare has introduced groundbreaking guidelines to enhance the affordability and accessibility of drone technology in the agricultural sector. The amendments to the guidelines under the "Sub-Mission on Agricultural Mechanization" (SMAM) are poised to encourage stakeholders in the agriculture domain to embrace drone technology for enhanced efficiency and productivity.

Under the amended guidelines, key institutions such as Farm Machinery Training & Testing Institutes, ICAR institutes, Krishi Vigyan Kendras, and State Agriculture Universities are eligible to receive grants up to 100% of the cost of agriculture drones or Rs. 10 lakhs, whichever is less. This financial support is aimed at facilitating large-scale demonstrations of drone technology on farmers' fields.

Furthermore, Farmers Producers Organizations (FPOs) can avail grants up to 75% of the agriculture drone cost for demonstrations on farmers' fields. This strategic move is designed to encourage FPOs to integrate drone technology into their agricultural practices.

To cater to implementing agencies that opt for hiring drones for demonstrations rather than purchasing them, a contingency expenditure of Rs. 6000 per hectare is allocated. For agencies that choose to purchase drones for demonstrations, the contingent expenditure is capped at Rs. 3000 per hectare.

In a bid to extend agricultural services through drone applications, existing Custom Hiring Centers (CHCs)

31. https://timesofindia.indiatimes.com/blogs/voices/role-of-data-analytics-and-decision-support-system-in-crop-health-monitoring/

set up by Cooperative Societies of Farmers, FPOs, and Rural entrepreneurs can receive financial assistance equivalent to 40% of the basic cost of drones and their attachments, or Rs. 4 lakhs, whichever is less.

Agriculture graduates establishing Custom Hiring Centers are entitled to a grant covering 50% of the basic cost of drones and their attachments, up to Rs. 5 lakhs. Meanwhile, rural entrepreneurs with a minimum qualification of class tenth examination and a remote pilot license from DGCA or any authorized remote pilot training organization can also benefit from this support.

For individual farmers, financial assistance is provided based on specific criteria. Small and Marginal, Scheduled Caste/Scheduled Tribe, Women, and Northeastern State farmers can receive grants at 50% of the cost, up to Rs. 5.00 lakhs, while other farmers are eligible for a 40% grant, up to a maximum of Rs. 4.00 lakhs.

This comprehensive set of guidelines aims to make agriculture drones more affordable and widely accessible to farmers, CHCs, and Hi-tech Hubs, fostering the adoption of this transformative technology. By incentivizing the use of drones in agriculture, these measures not only enhance farm efficiency but also pave the way for the increased domestic production of drones, aligning with India's broader goal of technological self-sufficiency.

• Automated Machinery and Robotics

Automated machinery and robotics, guided by AI, contribute to precision farming by performing tasks such as planting, harvesting, and weeding with accuracy. This reduces labor requirements, increases efficiency, and ensures that agricultural operations are conducted with minimal waste.

In the realm of precision agriculture, advancements in robotics are revolutionizing key processes in vegetable cultivation, ranging from seed sowing to transplanting and grafting, with the potential to enhance efficiency and reduce labor-intensive tasks.

One pivotal technology gaining traction in India is the use of precision plug tray seeders for nursery seed sowing. F1 hybrid seeds, known for their higher yields and quality produce, are often employed in vegetable cultivation. To maximize germination and produce disease-free seedlings for transplantation, plug trays are utilized. The Indian Agricultural Research Institute (IARI) has designed a precision plug tray seeder using indigenous materials and standard components. This seeder makes indents in plug trays and simultaneously places single seeds in the indented cells. The technology has shown satisfactory performance for capsicum and tomato, achieving more than 90% single seed sowing. The seeder's capacity ranges from 38,000 to 60,000 cells per hour, depending on the tray size.

Addressing the labor-intensive task of seedling transplantation, robotic transplanters offer a potential solution. In greenhouse production systems, seeds are germinated in high-density trays and later transplanted into low-density growing trays. Robotic transplanters can carry out repetitive tasks with precision, reducing labor requirements. Unlike industrial robots, these systems must handle biological seedlings of varying sizes, shapes, colors, positions, and orientations.

Vegetable grafting, originating in Japan and Korea to combat soil-borne diseases, has become a global practice. Grafting robots, such as the GR800 series by Iseki & Co. Ltd., have been commercially available since 1993. These robots, semi- or fully automated, can graft at speeds of 600-800 grafts per hour, equiv-

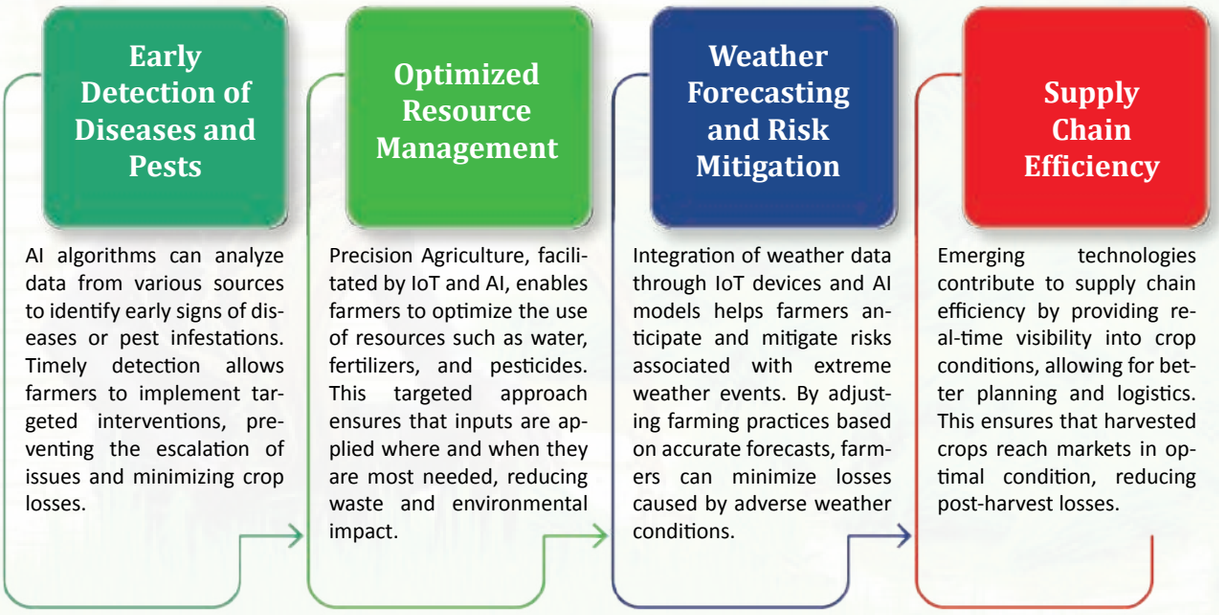
32. https://vikaspedia.in/agriculture/ict-applications-in-agriculture/iot-in-agriculture

alent to the work of skilled manual laborers. While these robots enhance efficiency, they still require human workers for quality inspection.

Weeding management through robotics is another frontier in agricultural technology. Precise methods involve recording the increased leaf area in weedy areas or using shape recognition for accurate identification of weed species. This data is then used to create treatment maps, allowing robots to execute targeted weeding activities. By recognizing unwanted plants during the process, these robots contribute to effective weed removal.

By harnessing the power of data-driven optimization, farmers can minimize losses, enhance productivity, and contribute to the overall sustainability and adaptability of the agricultural sector. The use of these innovative products and services helps farmers for early detection different deficiencies that farm is facing and lead to take preventive measures to increase in the farm production capacity.

Importance of Innovation in Post Harvest Crops Management



Companies operating and offering product related to Precision Agriculture

Name	Headquarter	Service/ Product Offered
Cropin Technology Solutions	Bengaluru	Cloud-based ERP for agriculture utilizes AI for location-agnostic ag-knowledge, offering solutions for farming, agri-input, insurance, seed companies, governments, and advisories, with a farmer-connect app.
Aarav Unmanned Systems Pvt Ltd	Bengaluru	The company Offers high-precision drones and delivers comprehensive drone-based solutions for Urban planning, Industries, Smart Cities, Micro-Irrigation, Watershed, Mining, Power, and Infrastructure applications.
Fruvetech Private Limited	New Delhi	Fruvetch offers a brand-new patented technology that offers safer, user-friendly, and cost-effective storage and transportation for fruits and vegetables.
Aquaconnect	Chennai	Aquaconnect offers Artificial Intelligence, IOT, and Satellite remote sensing to bring transparency and efficiency into the aquaculture value chain. The Aquasat, Aquapartner Store, Aquabazaar, and Aquacred are the different services offered by company that helps them to manage aquaculture ecosystem form seeds to selling of products by farmers.
BharatAgri	Pune	BharatAgri is a farming technology platform that Offers Farming Products, Advisory, to Expert consultancy over Intrenet.
Wolkus Technology Solutions Private Limited		The startup operates under the brand name 'Fasal' and specializes in developing an AI-powered IoT platform for precision agriculture.

In addition to private institutions, the Government of India (GOI) has actively taken steps for the development of advanced products in precision farming and agrotechnology. Notably, NITI Aayog collaborated with IBM in May 2018 to create an AI-powered crop yield prediction model. This initiative aims to provide real-time advisories to farmers in 10 backward districts across Assam, Bihar, Jharkhand, Madhya Pradesh, Maharashtra, Rajasthan, and Uttar Pradesh. Employing climate-aware cognitive farming techniques, advanced AI innovations, and early warning systems for pest outbreaks, the project integrates satellite weather advisories, mobile applications, and IT tools to enhance crop yield and reduce costs through improved farm management.

Furthermore, the Government of India, in conjunction with Microsoft, utilizes AI sensors to empower small-holder farmers. The AI-Sowing App, driven by Cortana Intelligence Suite, delivers sowing advisories without the need for farmers to install sensors. Microsoft's collaboration with Escorts focuses on cloud and AI technology, advancing precision agriculture capabilities.

Another initiative, the "SENSAGRI: Sensor-based Smart Agriculture" project, funded by IT Research Academy, DEITY, and ICAR, employs drones for real-time data collection. This aids in land and crop health assessment, damage severity analysis, and post-event management. The project emphasizes advanced services like yield mapping, tillage change detection, irrigation assessment, and crop maps, providing cost-effective and efficient solutions for the agricultural sector.

Waste Reduction Technologies: From Farm to Fork

In the quest for resilient food systems, waste reduction technologies play a pivotal role in optimizing processes from farm to fork. Implementing efficient technologies along the entire supply chain enhances sustainability, minimizes post-harvest losses, and contributes to a more robust and adaptable food system.

• Best Practices in Storage and Transportation

Efficient storage and transportation practices are crucial components in reducing post-harvest losses. Employing innovative technologies and best practices at these stages ensures that harvested crops reach consumers in optimal condition. Waste reduction technologies, coupled with best practices in storage and transportation, form a dynamic framework for building resilient food systems. Technological advancements along the supply chain empower stakeholders to address challenges proactively, ultimately minimizing post-harvest losses and ensuring a more sustainable and adaptable food future.

• Technological Solutions and Innovations

Cold Chain Technologies

Utilizing advanced cold chain technologies, such as refrigeration and temperature-controlled storage, helps preserve the freshness and quality of perishable goods. Cold storage units, equipped with precise temperature control, extend the shelf life of fruits, vegetables, and other temperature-sensitive products. According to a study on the All-India Cold Chain Infrastructure Capacity conducted by NABARD Consultancy Services Pvt. Ltd. (NABCONS) and commissioned by the National Centre for Cold Chain De-

velopment (NCCD) under the Department of Agriculture, Cooperation, and Farmers Welfare in the Ministry of Agriculture & Farmers Welfare, there is a demand for 35 million MT of cold storage capacity in the country. However, the current available capacity for such storage stands at approximately 32 million MT.

Modified Atmosphere Packaging (MAP)

MAP involves altering the composition of gases surrounding packaged food to slow down the ripening process and inhibit microbial growth. This technology extends the shelf life of fruits and vegetables during storage and transportation, reducing spoilage.

Extended shelf life in Modified Atmosphere Packaging (MAP) provides a range of advantages for various stakeholders in the food supply chain, including food processors, manufacturers, distributors, and retailers.

The prolonged shelf life afforded by MAP enables enhanced control over product quality, availability, and costs for food processors and manufacturers. With products lasting longer on the shelves, there is a reduction in the need for frequent rotation, removal, and restocking of items in grocery stores. This leads to a notable decrease in labor costs and waste disposal expenses for retailers.

Grocers can benefit significantly from longer freshness cycles, as they can streamline operations by eliminating the need for constant product rotation. This efficiency not only results in cost savings but also contributes to a more sustainable approach by minimizing waste in the supply chain.

For distributors, the extended shelf life provided by MAP packages opens up opportunities to expand distribution territories or diversify product lines. With less frequent product replacement requirements, distributors can explore growth in other areas, offering a broader range of products to retailers.

Food manufacturers, leveraging the advantages of extended replacement cycles, can optimize their production processes. Reduced demands for frequent replacements allow manufacturers to use their production capacity more profitably. This, in turn, enables them to focus on innovation and the development of new products without compromising efficiency.

Smart Sensors and Monitoring Systems

Smart sensors and monitoring systems provide real-time data on factors like temperature and humidity, allowing swift actions to prevent spoilage. Agriculture is undergoing a shift towards smart farming, optimizing resources to meet global consumption needs. Smart sensors play a vital role in monitoring and optimizing crops, contributing significantly to livestock and crop management. They aid in animal identification, health monitoring, and efficient crop optimization. Integrated into various equipment, these sensors facilitate data-driven decision-making, promoting efficient resource management and environmental monitoring. Smartphone applications offer accessible alternatives for small-scale farmers, providing cost-effective solutions for precision farming.

Blockchain Technology

Blockchain technology boosts transparency and traceability in the supply chain by maintaining an immutable and decentralized ledger, recording every step in production, storage, and transportation. This transparency aids in swiftly identifying and addressing issues, reducing potential losses. In agriculture, blockchain revolutionizes the sector by tracking plant-related information comprehensively, addressing concerns about illegal practices and enhancing supply chain transparency. With a detailed record of a plant's journey, blockchain ensures traceability, facilitating the identification of contamination sources

during recalls. The core objectives include promoting sustainability and food security, empowering consumers to make informed choices and support ethical farming practices. Integrating IoT devices, blockchain consolidates data on seed quality, crop tracking, and the entire journey from farm to market, enhancing security and deterring unethical practices within the supply chain.

Renewable Energy and Sustainable Infrastructure

Renewable energy and sustainable infrastructure play pivotal roles in fostering resilience within food systems. By integrating environmentally friendly practices and innovative technologies, these solutions contribute to the overall sustainability and adaptability of the food supply chain.

In the pursuit of resilient food systems, proper storage and transportation infrastructure emerge as critical components. Efficient and sustainable facilities enhance the longevity, quality, and safety of harvested produce, ensuring that it reaches consumers in optimal condition.

• Sustainable Infrastructure Practices

Offering a multitude of advantages, an efficient infrastructure for storage and transportation is essential to bolstering the resilience of food systems. It ensures that harvested commodities are transported and stored under ideal circumstances, reducing post-harvest losses brought on by rotting, decomposition, or improper handling. Furthermore, a well-maintained cold chain, made possible by adequate infrastructure, increases the shelf life of perishable goods, resulting in less waste and increased accessibility for customers.

Sustainable infrastructure practices, characterized by stringent quality control measures in storage and transportation, significantly enhance food safety. This commitment to safety is essential for upholding consumer trust and preventing foodborne illnesses. Beyond these critical aspects, investments in sustainable infrastructure translate into long-term cost savings. The adoption of energy-efficient systems and streamlined logistics not only contributes to environmental sustainability but also fosters economic viability for stakeholders across the entire supply chain. In essence, prioritizing proper storage and transportation infrastructure emerges as a cornerstone for building resilient and sustainable food systems.

In the quick commerce sector, companies like Blinkit, Zepto, and others establish decentralized warehouse stores for 10-minute deliveries are good example of resilient food supply system where the use of renewable energy and sustainable infrastructure is at pivotal place. The direct-to-consumer (D2C) model has become a sought-after channel for brands, providing better control over customer experience and preserving margins. This approach doesn't cannibalize other channels but enhances overall demand and product reach, fostering the emergence of niche brands or foods in various categories, including hydroponics, plant-based meats, ice creams, gourmet chocolates, premium milk, and batters. The challenge of building a fulfillment system leads to substantial investments in distributed cold storage assets and fulfillment infrastructure, making it an intriguing market.

The consolidation and progress of Farmer Producer Organizations (FPOs) in agricultural sectors like horticulture, fish, and poultry are gaining traction in the domestic market. Historically, cold chain infrastructure for agricultural products had been primarily focused on export markets. However, due to the rising demand for high-quality food in India, there has been a substantial increase in investments in cold chain

facilities, encompassing hubs, warehouses, and packhouses. Companies are leveraging advanced technologies such as IoT and AI for transportation and supply-demand optimization. In the context of end-user product delivery, these companies predominantly utilize electric vehicles, contributing significantly to carbon reduction in line with sustainability goals. This transformation underscores the resilience of the food system, fostering linkages in the forward market and motivating farmers and FPO groups to actively invest in such facilities.

Policy and Market Reforms: Creating a Level Playing Field

Implementing policy reforms is crucial for fostering resilient food systems. These reforms should focus on promoting sustainable agricultural practices, supporting small-scale farmers, and ensuring equitable access to resources. By creating a regulatory environment that encourages environmentally friendly and socially responsible farming, policies can contribute to the overall resilience of the food system.

Market reforms play a pivotal role in building resilience by establishing a level playing field. This involves reducing barriers to entry, fostering fair competition, and actively supporting local food systems. A fair

Green Logistics Initiatives focus on optimizing transportation routes, reducing fuel consumption, and minimizing emissions by shifting on low emission fuels such solar power vehicle, hydrogen, etc. Additionally, the adoption of Eco-friendly Packaging materials contributes to sustainability by decreasing the environmental impact of packaging waste.

Implementing Smart Warehousing Systems enhances efficiency by optimizing Inventory Management. Technologies like RFID tracking and IoT sensors enable real-time monitoring, reducing the chances of overstocking or understocking, and minimizing food losses.

Improving Cold Chain Efficiency involves upgrading refrigeration systems and ensuring proper insulation during transportation. Advanced technologies, such as phase change materials, contribute to maintaining temperature-controlled environments, preventing spoilage, and extending the shelf life of products.

Shifting Towards Sustainable Transportation Modes, such as electric or hybrid vehicles, powered by renewable energy sources, mitigates the environmental impact of food distribution. Investing in energy-efficient transportation contributes to both cost savings and environmental stewardship.

Integrating Renewable Energy Sources into food processing plants reduces reliance on non-renewable power. Solar, wind, or biomass energy can be harnessed to power processing equipment, making the entire food production process more sustainable.

and competitive market environment enhances the adaptability and responsiveness of the food supply chain to changing conditions. Fair trade practices further reinforce the resilience of food systems. Encouraging fair prices for farmers, promoting sustainable production methods, and upholding social and environmental standards contribute to a more robust and equitable food system.

Supporting small-scale farmers is a key component of resilient food systems. Offering financial and technical assistance, including access to credit, training, and essential infrastructure, can empower small-scale farmers to enhance their productivity and resilience in the face of various challenges.

Strengthening food safety regulations is paramount for ensuring the quality and safety of food throughout the supply chain. Robust regulatory frameworks contribute to building trust in the food system, safeguarding consumer health, and ultimately enhancing the overall resilience of the food supply network.

Incentives for Sustainable Practices: Subsidies and Market Mechanisms

The adoption of sustainable agricultural practices is paramount for developing resilient food systems that can navigate the challenges posed by climate change, resource limitations, and population growth. However, farmers often face economic and knowledge-related hurdles when transitioning to these practices. In this framework, incentives play a pivotal role, serving as catalysts to motivate the adoption of sustainable food production methods and expedite the shift.

Implementing subsidies and market mechanisms is pivotal for promoting sustainable agricultural practices. Direct financial support, such as subsidies, for farmers engaging in sustainable methods like organic farming, cover cropping, and water-efficient irrigation enhances their financial viability, acting as a compelling incentive for adoption. Lowering taxes or providing tax rebates further encourages investment in sustainable technologies. Integration of sustainable agriculture into carbon offset programs offers farmers financial rewards for reducing carbon footprints and sequestering carbon. Moreover, initiatives like green public procurement by government institutions and certification schemes for sustainably produced food create reliable markets, fostering demand and price premiums for farmers embracing these eco-friendly practices.

• India: Policy Framework and Government Initiatives

India has taken several steps towards promoting sustainable agriculture and resilient food systems such as:

Pradhan Mantri Krishi Sinchayee Yojana (National Mission for Sustainable Agriculture (NMSA)):

The National Mission for Sustainable Agriculture (NMSA) has been operational since 2014-15, focusing on enhancing agricultural productivity, sustainability, remuneration, and climate resilience. It promotes integrated farming systems, soil and moisture conservation, comprehensive soil health management, efficient water management, and rainfed technologies. The On Farm Water Management (OFWM) component, initially under NMSA, transitioned to the 'Per Drop More Crop (PDMC)' initiative of Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) in 2015-16, emphasizing water use efficiency through precision and micro-irrigation.

PMKSY-PDMC has successfully brought 30.69 lakh ha under micro irrigation. The Rainfed Area Development Programme, part of NMSA since 2014-15, focuses on Integrated Farming Systems to maximize re-

turns, mitigate climate risks, and enhance livelihood sustainability. With 3.42 lakh ha under this system, it integrates crops with horticulture, livestock, fishery, and more. Soil Health Management (SHM), another NMSA component, promotes Integrated Nutrient Management for improved soil health and productivity. The Soil Health Card Scheme, initiated in 2015, provides farmers with vital information on soil nutrient status and recommendations for enhanced soil fertility., this mission focuses on promoting organic farming, soil health improvement, and water conservation.

Rashtriya Krishi Vikas Yojana (RKVY) cafeteria scheme (Soil Health Card Scheme):

The Soil Health Cards (SHCs) Scheme, initiated in 2014-15, underwent technological enhancements. The revamped Soil Health Card portal integrates with a Geographic Information System (GIS), capturing and mapping all test results. A mobile application facilitates smooth sample collection, linking QR codes to sample and test results on the portal. Launched in April 2023, the system streamlines implementation and monitoring. The scheme's mobile application restricts sample collection regions, automatically selects latitude and longitude, and enhances QR code generation. The scheme, now merged into the Rashtriya Krishi Vikas Yojana (RKVY) cafeteria scheme, operates under the name 'Soil Health & Fertility' since 2022-23.
Guidelines for Village Level Soil Testing Labs (VLSTLs) were issued, allowing individual entrepreneurs, rural youth, and community-based entities like Self Help Groups (SHGs) and Farmers Producers Organization (FPO) to set up VLSTLs. VLSTL enrollment criteria are determined by the District Level Executive Committee (DLEC). Entrepreneurs, after application submission, undergo training organized by manufacturers and state governments on soil sampling, testing, and generating soil health cards. Additionally, detailed soil mapping at a 1:10000 scale is conducted using high-resolution satellite data and field surveys, providing geo-spatial data for Soil Resource Information.

Pradhan Mantri Kisan Sampanna Yojana:

The Ministry of Food Processing Industries (MoFPI) has been executing the Pradhan Mantri Kisan Sampada Yojana (PMKSY) nationwide since 2017-18. As a comprehensive initiative comprising various component schemes, PMKSY aims to establish modern infrastructure with efficient supply chain management from the farm gate to the retail outlet. This initiative significantly boosts the food processing sector's growth, ensures better prices for farmers, generates extensive rural employment, reduces agricultural produce wastage, elevates processing levels, and augments the export of processed foods. The financial support, in the form of grants-in-aid, is extended for food processing projects under different component schemes, including Mega Food Parks, Integrated Cold Chain, Agro Processing Cluster Infrastructure, Food Processing and Preservation Capacities, Backward and Forward Linkages, Operation Greens, Food Safety and Quality Assurance Infrastructure, and Human Resource & Institutions. While specific state-wise fund allocations are not made, Tamil Nadu has received approval for 96 food processing projects under PMKSY, with a total grant-in-aid of Rs. 376.40 crore, and Rs. 206.52 crore has been released for project implementation as of July 19, 2023. This scheme offers financial support for farmers adopting innovative practices like precision agriculture and water-efficient irrigation.

• Existing Policies on Post-harvest Management:

Integrated Cold Chain and Value Addition Infrastructure:

This scheme provides financial assistance of 35% to 50% of admissible cost of projects for setting up cold

storage facilities to reduce post-harvest losses. The goal of the "Integrated Cold Chain and Value Addition Infrastructure" scheme is to establish a seamless integrated cold chain and preservation infrastructure from the farm gate to the consumer. The scheme encompasses the creation of infrastructure facilities across the entire supply chain, including pre-cooling, weighing, sorting, grading, and waxing at the farm level, as well as multi-product/multi-temperature cold storage, CA storage, packing facilities, IQF, blast freezing in distribution hubs, and reefer vans for various products like non-horticulture, horticulture, fish/marine (except shrimp), dairy, meat, and poultry. The scheme allows for project flexibility, with a particular focus on developing cold chain infrastructure at the farm level.

Partnership/Proprietorship Firms, Companies, Corporations, Cooperatives, Self-Help Groups (SHGs), Farmer Producer Organizations (FPOs), NGOs, Central/State PSUs, and other eligible entities can set up the integrated cold chain projects, provided they meet the scheme's guidelines and eligibility conditions.

Operation Greens: Operation Greens is a government scheme aimed at supporting the integrated development of the Tomato, Onion, and Potato (TOP) value chain. Launched in the 2018-2019 Union budget of India, the scheme provides financial assistance, offering grants-in-aid equivalent to 50% of the eligible project cost, capped at a maximum of Rs 50 crores per project. For Farmer Producer Organizations (FPOs), the grant-in-aid is increased to 70% of the eligible project cost.

Additionally, Operation Greens extends a 50% subsidy on various components, including transportation, hiring of storage facilities for TOP crops, and short-term price stabilization measures involving transportation and storage. The eligible crops covered under this initiative span a range of fruits such as mango, banana, guava, and vegetables including bitter gourd, brinjal, onion, potato, and tomato. The scheme aims to enhance the viability and sustainability of the TOP value chain by providing crucial financial support and subsidies.

To enhance post-harvest management, potential policy improvements include fostering public-private partnerships to incentivize private sector investment in cold chain infrastructure through tax benefits and joint ventures with government entities. Strengthening rural infrastructure, particularly improving roads and transportation networks, is essential for facilitating the seamless movement of produce from farms to markets and storage facilities. Additionally, promoting awareness and adoption of improved post-harvest practices among farmers through training and extension services can enhance overall efficiency. Investing in research and development for affordable and energy-efficient post-harvest technologies, such as drying, sorting, and packaging, is crucial for sustainable agricultural practices.

Some of the Successful Government Initiatives on Resilient Food Systems

Saksham Anganwadi and Poshan 2.0: This is an Integrated Nutrition Support program aims to improve nutritional outcomes for children and pregnant women by promoting locally produced and diverse diets, which fosters sustainable agriculture practices. It seeks to address the challenges of malnutrition in children, adolescent girls, pregnant women and lactating mothers through a strategic shift in nutrition content and delivery and by creation of a convergent eco-system to develop and promote practices that nurture health, wellness and immunity.

Paramparagat Krishi Vikas Yojana: The Government of India has actively promoted organic farming through the Paramparagat Krishi Vikas Yojana (PKVY) since 2015-16. This scheme emphasizes comprehensive support for organic farmers, covering production, certification, and marketing, with a focus on post-harvest management, including processing, packing, and marketing, to incentivize organic farming. Under PKVY, farmers receive financial assistance of Rs 50,000 per hectare over three years, with Rs. 31,000

(62%) provided directly through Direct Benefit Transfer (DBT) for inputs like bio-fertilizers, bio-pesticides, organic manure, compost, vermi-compost, and botanical extracts. For Assam, a total of Rs 29.59 crore has been released for 220 clusters, benefiting 11,000 farmers over 4,425 hectares, achieving the target since 2015-16.

The government has introduced the Large Area Certification (LAC) program from 2020-21, certifying large traditional or default organic areas in hills, islands, tribal, or desert regions with no history of GMO or agrochemical use. This program expedites the certification process within 3-6 months, reducing the conversion period from 2-3 years and enabling farmers to market their produce at premium prices. Car Nicobar and Nancowry group of Islands in the Union Territory of Andaman and Nicobar Islands, with 14,491 hectares of cultivable area, became the first Large Contiguous Area declared as certified organic. The Union Territory of Ladakh has received Rs 11.48 lakh for LAC, showcasing the government's commitment to promoting organic farming practices.

Food Parks and Agro Processing Clusters: The scheme is designed to foster the development of contemporary infrastructure and shared facilities, encouraging groups of entrepreneurs to establish food processing units through a cluster approach. It links producers and farmers to processors and markets via a well-equipped supply chain supported by modern infrastructure. Each agro-processing cluster includes two fundamental components: Basic Enabling Infrastructure (such as roads, water supply, power supply, drainage, and ETP) and Core Infrastructure/Common Facilities (including warehouses, cold storage, IQF, tetra pack, sorting, grading, etc.).

Additionally, a minimum of five food processing units with an investment of at least Rs. 25 crore is established concurrently with the creation of common infrastructure. The setup requires a minimum of 10 acres of land to be arranged either through purchase or a minimum 50-year lease for the Agro Processing Cluster. Eligible entities, including government organizations, PSUs, joint ventures, NGOs, cooperatives, SHGs, FPOs, private sectors, and individuals, can receive financial assistance under the scheme guidelines.

The Project Execution Agency (PEA) is responsible for project implementation, encompassing activities like formulating the Detailed Project Report (DPR), land procurement, finance arrangement, infrastructure creation, and ensuring external linkages. While PEAs may sell or lease plots within the agro-processing cluster to other food processing units, common facilities within the cluster cannot be sold or leased out. These initiatives create centralized processing and storage facilities, reducing post-harvest losses and adding value to agricultural produce, while boosting rural economies.

Construction of Silos Under PPP Models: The Food Corporation of India (FCI) has set an ambitious target to construct wheat silos with a total capacity of 3.4 million tonnes across India in the next 18 months, utilizing the Public-Private Partnership (PPP) model. Contracts have been awarded to private entities like Adani Agri Logistics and KCC Infrastructure, aiming to modernize storage infrastructure, streamline grain procurement, and reduce logistical costs. This is part of a larger Rs 11,000-crore project planning to build 11 million tonnes of wheat silos across 250 locations.

The silos follow the Design, Build, Fund, Own, and Transfer (DBFOT) and Design, Build, Fund, Own, and Operate (DBFOO) models. FCI will lease these silos for wheat storage, transitioning from temporary facilities to modern silos to minimize losses and enhance food grain preservation. This initiative aligns with recommendations for modernizing storage infrastructure and securing the food supply chain, reinforcing India's commitment to food security.

Fair Trade Policies: Empowering Farmers and Protecting Workers

Fair trade policies play a crucial role in empowering farmers, protecting workers, and fostering resilient food systems. These policies aim to address challenges related to market access for farmers, ensuring fair compensation and ethical labor practices. Fair-trade practices contribute significantly to reducing post-harvest losses by creating a more equitable and transparent supply chain.

Market Access for Farmers: One of the primary challenges for farmers, especially in developing regions, is gaining fair access to markets. Unfavorable market conditions and exploitative trade practices often disadvantage smallholder farmers. Fair trade policies intervene by establishing transparent and equitable trading relationships, ensuring that farmers receive fair prices for their produce. This empowerment enhances the economic resilience of farmers, allowing them to invest in sustainable practices and technology that can reduce post-harvest losses.

Reducing Post-Harvest Losses: Fair trade practices contribute to the reduction of post-harvest losses through several mechanisms. By guaranteeing fair prices, farmers have the financial capacity to implement better storage, transportation, and processing practices. Additionally, fair trade emphasizes environmental sustainability, encouraging practices that minimize waste and resource use. Strengthening the economic position of farmers also enables them to adopt technologies that improve post-harvest handling, storage, and transportation, ultimately reducing losses.

• Empowering Farmers

Guaranteed Minimum Prices: Fair trade policies guarantee farmers a minimum price for their crops, providing them with a safety net against market fluctuations and exploitative practices. This incentivizes sustainable farming methods and protects livelihoods.

Direct Trade Relationships: By connecting farmers directly with consumers, fair trade eliminates exploitative middlemen and ensures farmers receive a fairer share of the profits. This fosters long-term partnerships and empowers farmers to influence supply chains.

Social and Environmental Premiums: Fair trade premiums provide additional funds to farmer cooperatives, enabling them to invest in community development projects, improve infrastructure, and adopt sustainable practices. This strengthens rural communities and builds resilience to external shocks.

For example: Agribuzz is a complimentary mobile application designed to facilitate connections among farmers, offering a platform for buying, selling, and exchanging agricultural products and services within local communities. Beyond serving as a marketplace, the app provides valuable information on crop production, yield protection, and market trends. With Agribuzz, farmers gain access to a range of features, including the ability to create detailed farm profiles, establish connections with fellow farmers, share updates on their farming activities, and view profiles of available laborers for potential hiring. The app further empowers farmers to streamline their selling processes by enabling them to sell their agricultural produce online.
Additionally, Agribuzz offers insights into best-in-practice farming processes, contributing to the overall knowledge and success of the farming community. In essence, Agribuzz serves as a comprehensive platform that not only facilitates transactions but also fosters collaboration and the exchange of valuable

agricultural insights among farmers.

- ## Protecting Workers

Fair trade standards prioritize safe working conditions, guaranteeing proper safety measures, protection from hazardous substances, and compliance with labor laws. This is particularly crucial in vulnerable sectors like agriculture, safeguarding workers' health. Additionally, fair trade policies advocate for living wages, preventing exploitation and poverty, fostering a stable workforce. Gender equality is promoted, granting women equal access to resources, decision-making, and economic opportunities, empowering them to contribute significantly to resilient food systems.

India has made strides in promoting fair trade practices through initiatives such as the establishment of Fair-Trade India.

This organization plays a pivotal role in certifying and facilitating market access for Indian farmers and producers. Another, FTF-I stands out as a prominent national-level network with a robust membership, impactful program interventions, and global recognition among Fair Trade entities, government bodies, grassroots producers, NGOs, and consumers. Operating as a significant advocate, FTF-I actively lobbies the Indian government for Fair Trade policies. Collaborating with policy lobbying groups, it strives to draw government attention to the challenges faced by artisans and farmers. Engaging in policy formulation consultations, FTF-I contributes to discussions organized by entities like Oxfam, NGO forums on trade policies, and environmental action groups. The organization leverages lobbying activities to influence policymakers by presenting position papers, joint delegations, and appeals to authorities. FTF-I also extends its reach by building networks with stakeholders at local, national, and international levels. The organization submits suggestions for policy improvements, reflecting its commitment to social and environmental concerns, fair wages, gender equity, and the eradication of child labor in various government schemes. The aim is to integrate Fair Trade norms, introduce value chain funds, and streamline coordination between relevant government bodies for the holistic development of artisan communities.

- ## Role of E-commerce and Digital Platforms:

The role of e-commerce and digital platforms in fostering resilient food systems is increasingly vital in the face of today's complex challenges. These platforms contribute to efficiency and transparency within food systems:

E-commerce and digital platforms play a pivotal role in connecting farmers directly to consumers, aligning with fair trade principles. These platforms eliminate the need for intermediaries, enabling farmers to reach a broader consumer base and receive a fair share of the profits. By facilitating direct transactions, digital platforms contribute to transparent and traceable supply chains, reinforcing fair trade values. Consumers, in turn, benefit from access to ethically sourced products and the ability to support farmers directly. This digital connection enhances market access for farmers, strengthens fair trade practices, and promotes resilience within the food system by reducing inefficiencies in traditional supply chains. For example, Mystore and Tinkoko are some ecommerce that empower farmers to list products, manage orders, and receive payments and also connect farmers with a broader audience for diverse agricultural products.

Regulations and Enforcement: Holding Corporations Accountable

Regulations and enforcement mechanisms are pivotal in holding corporations accountable and promoting resilient food systems. Robust regulatory frameworks ensure ethical practices, sustainability, and fair treatment within the food industry. This includes addressing issues such as food safety, environmental impact, and labor conditions. Examining India's policy framework and government initiatives provides insights into efforts aimed at achieving accountability and resilience.

Regulations and Enforcement for Accountability: Implementing stringent regulations ensures that corporations adhere to ethical standards, environmental responsibilities, and fair labor practices. Oversight agencies play a crucial role in monitoring compliance and penalizing violations, creating a deterrent against irresponsible corporate behavior. Transparent labeling and disclosure requirements empower consumers to make informed choices, fostering a market environment that values sustainability and ethical practices.

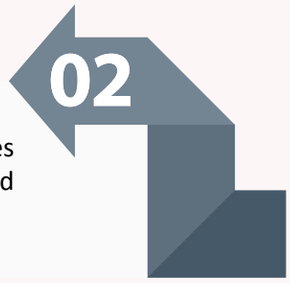
India's Policy Framework and Initiatives: India has taken notable steps to regulate the food industry and promote sustainability:

Food Safety and Standards Authority of India (FSSAI): FSSAI regulates and monitors food safety, ensuring that food products meet specified quality and safety standards. Stringent enforcement contributes to resilient food systems by preventing health hazards and ensuring the quality of food products.

Corporate Social Responsibility (CSR): In 2014, India achieved a significant milestone by becoming the first country to legally mandate corporate social responsibility (CSR). Section 135 of India's Companies Act outlines specific criteria for companies, such as having a net worth of rupees five hundred crore or more, turnover of rupees one thousand crore or more, or a net profit of rupees five crore or more during the immediately preceding financial year. According to this regulation, qualifying companies must allocate 2% of their average net profit over the past three years towards CSR initiatives. This legislative framework underscores the government's commitment to corporate social responsibility, channeling corporate resources into projects and initiatives that contribute to the overall well-being and development of society. The regulatory framework serves as an encouragement for corporations to actively engage in initiatives that enhance the communities in which they operate.

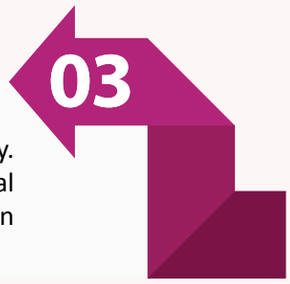
Reduced Wastage and Spoilage

E-commerce platforms such as Imperfect Foods and Misfits Market facilitate direct connections between consumers and farmers, minimizing food waste in traditional supply chains. This not only reduces wastage but also enhances access to fresh, affordable food, especially for vulnerable populations.



Improved Market Access for Small Producers

Online platforms like Etsy and Shopify empower small farmers and local food businesses by enabling them to reach a broader audience, circumventing traditional gatekeepers and creating fairer market conditions.

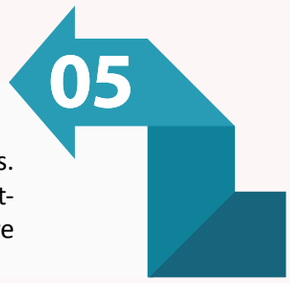


Greater Transparency and Traceability

Utilizing blockchain technology to track food from farm to fork enhances transparency. Consumers gain information about the origin, production methods, and environmental impact of their food choices, promoting sustainable practices and building trust within the food system.

Enhancing Access During Emergencies

E-commerce platforms become crucial during pandemics or natural disasters, providing vital access to food and essential supplies. Services like Instacart and Amazon Fresh played a pivotal role in ensuring food security during the COVID-19 pandemic.

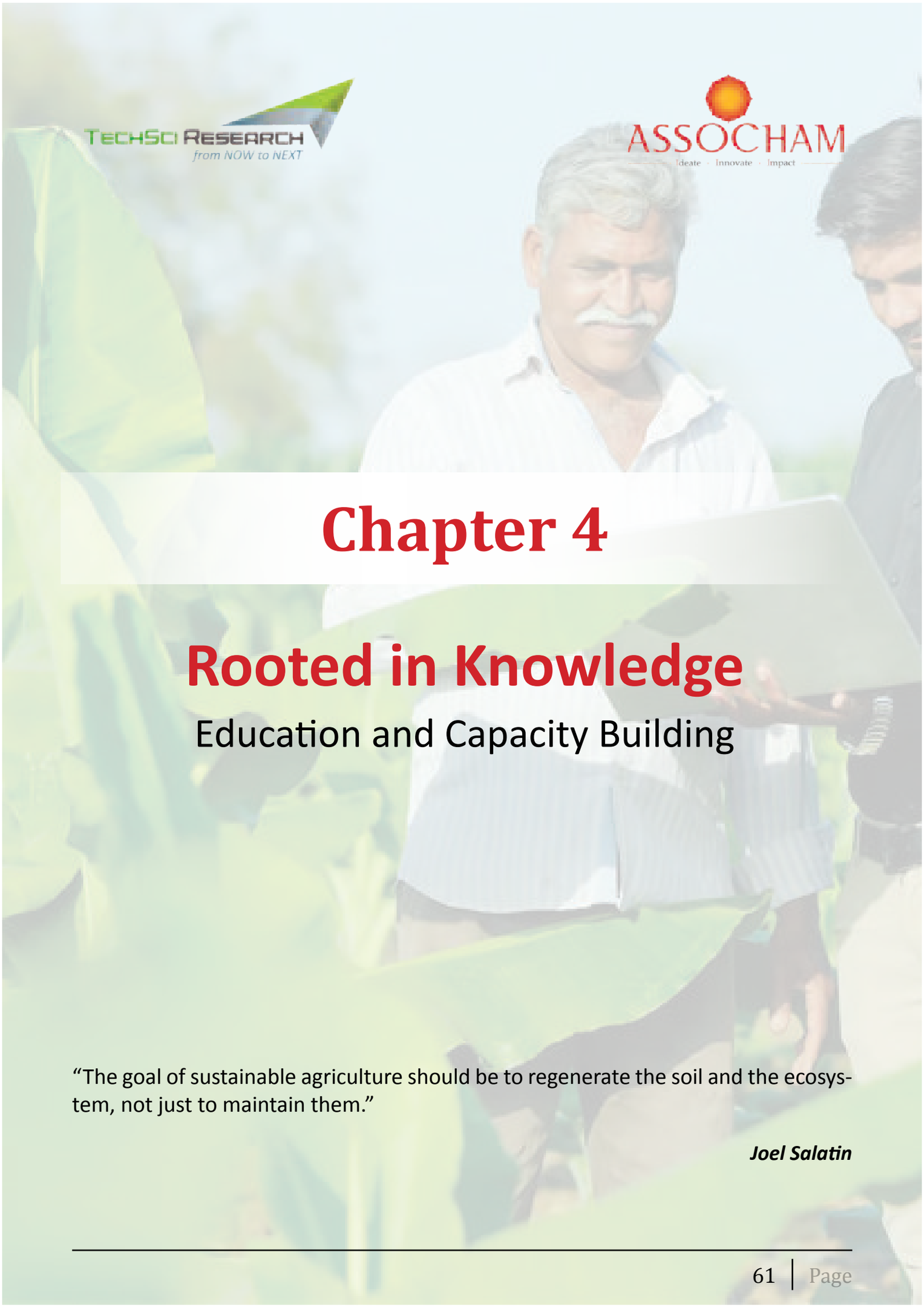


Building Food System Resilience

Digital platforms enable data collection and monitoring of food system vulnerabilities. This information facilitates proactive interventions and risk management strategies, mitigating the impact of future disruptions and contributing to the development of more resilient food systems.

National Action Plan on Climate Change (NAPCC): India's NAPCC outlines strategies for climate change mitigation and adaptation, emphasizing sustainable agriculture practices. The National Action Plan on Climate Change (NAPCC) is designed to enhance the productivity, sustainability, and climate resilience of agriculture. It encompasses various objectives, including the development of climate-resilient crops, the expansion of weather insurance mechanisms, the promotion of water and nitrogen-efficient crops, the establishment of sustainable irrigation systems, and the identification of new varieties of crops resilient to climate challenges. Through these concerted efforts, the NAPCC aims to fortify the agricultural sector against the impacts of climate change, ensuring a more robust and adaptable framework for farming practices in the face of evolving environmental conditions.

Policies on Sustainable Agriculture: Initiatives like the National Mission on Sustainable Agriculture and



Chapter 4

Rooted in Knowledge

Education and Capacity Building

"The goal of sustainable agriculture should be to regenerate the soil and the ecosystem, not just to maintain them."

Joel Salatin

the Paramparagat Krishi Vikas Yojana focus on promoting sustainable agricultural practices, reducing environmental impact, and ensuring the long-term resilience of food systems. The National Mission for Sustainable Agriculture (NMSA) is dedicated to enhancing agricultural productivity, with a particular focus on rainfed regions. The mission incorporates several crucial components, including integrated farming, water use efficiency, soil health management, resource conservation, and rainwater management. These strategic elements collectively aim to promote sustainable agricultural practices and improve overall productivity, especially in areas dependent on rainfall for cultivation.

Rooted in Knowledge: Education and Capacity Building

Empowering Farmers: Knowledge Sharing and Skill Development

Rooted in knowledge, education, and capacity building are foundational pillars for cultivating resilient food systems. By empowering individuals with the necessary skills, information, and understanding, these strategies contribute to sustainable agriculture, climate resilience, and community well-being. One exemplary case illustrating the impact of education and capacity building on resilient food systems is found in India.

India has recognized the pivotal role of education and capacity building in creating resilient food systems, particularly through initiatives such as:

Krishi Vigyan Kendras (KVKs): Kisan Vikas Kendras (KVKs) are agricultural extension centers established by the Indian Council for Agricultural Research (ICAR) and its affiliated institutions. Operating as a crucial link between the National Agricultural Research System (NARS) and farmers, KVKs play a vital role in disseminating agricultural knowledge and technologies. The inaugural KVK was established in 1974 in Puducherry. The Government of India provides complete funding for the KVK scheme, and these centers are sanctioned to agricultural universities, ICAR institutes, relevant government departments, and non-governmental organizations (NGOs) engaged in agriculture. The primary objective of KVKs is to bridge the gap between research and farming practices, facilitating the transfer of advanced agricultural technologies and information to farmers for improved productivity and sustainability, by reducing post-harvest losses and increasing their incomes.

Indian Council of Agricultural Research-Central Institute of Post Harvest Engineering & Technology (ICAR-CIPHET)): The Indian Council of Agricultural Research-Central Institute of Post Harvest Engineering & Technology (ICAR-CIPHET) stands as a pioneering institution dedicated to advancing research in the field of post-harvest engineering and technology. Its focus extends to research and development, aiming to drive technological innovations and interventions in this crucial sector. As a key institute in the post-harvest domain, CIPHET serves as a nodal organization, offering essential support and technical guidance to individuals aspiring to venture into entrepreneurship or processing activities. With a vision set for the year 2025, CIPHET aims to position itself as a highly effective facilitator of technology transfer. To realize this vision, CIPHET has outlined strategic plans, emphasizing the establishment of robust linkages with various entities on both national and international fronts. These include collaborations with research and development institutions, Krishi Vigyan Kendras (KVKs), State Agricultural Universities (SAUs), industries, and non-governmental organizations (NGOs). Through these partnerships, CIPHET seeks to enhance its role as a pivotal hub for disseminating technological advancements, ultimately contributing significantly to the growth and success of stakeholders in the agricultural and post-harvest sectors.

Atmanirbhar Krishi APP: A crucial component of KisanMitr, a national digital platform tailored for farmers, addresses a significant information gap by integrating data from various government ministries and departments, including the Indian Meteorological Department (IMD), Indian Space Research Organization (ISRO), and the National Water Informatics Centre (NWIC). This consolidated data is made accessible to farmers through the Atmanirbhar Krishi app, a pivotal initiative aimed at empowering the agricultural community.

The app, launched in response to the disproportionate impact of the pandemic on farmers and migrant workers, is a collaborative effort with a focus on supporting local manufacturing, market, and supply chain. The Atmanirbhar Krishi app delivers evidence-based information generated by esteemed research organizations such as IMD, ISRO, ICAR, and CGWA. It provides farmers with actionable agricultural insights, early weather alerts, and personalized recommendations based on data related to soil health, moisture, weather conditions, and water Cycle.

Conceived in five stages, from data aggregation to continuous improvement, the app prioritizes simplicity, offering information in 12 languages and ensuring accessibility for users with basic phones. The app is designed to function on minimal bandwidth, addressing connectivity challenges in remote areas for free. The vision behind the app aligns with fostering sustainable farming practices and inclusive decision-making for farmers across the country.

Key Aspects of Education and Capacity Building: Agroecological training plays a pivotal role in shaping resilient agricultural practices by fostering a harmonious relationship between farmers and nature. Through education programs, farmers are encouraged to embrace agroecological principles, including integrated pest management, organic farming, and sustainable soil management. These practices prioritize ecological balance and contribute to the long-term health of agricultural ecosystems.

Capacity building extends to climate-resilient farming techniques, equipping farmers with the knowledge to navigate the challenges posed by a changing climate. Weather-smart agriculture, water conservation, and the cultivation of drought-resistant crop varieties are integral components of this training. By incorporating these practices, farmers enhance their resilience against climatic uncertainties.

Recognizing the transformative potential of technology, digital literacy initiatives are integrated into capacity-building efforts. Farmers are trained to leverage mobile applications for weather forecasting, accessing market information, and utilizing government schemes. This digital literacy empowers farmers with real-time information, facilitating informed decision-making.

Educational initiatives place a significant focus on women's empowerment in agriculture. Capacity-building programs address gender disparities by providing training on crop management, financial literacy, and value addition. Empowering women in agriculture not only enhances their individual livelihoods but also contributes to the overall resilience of farming communities.

Inclusive extension services ensure that educational resources and capacity-building efforts reach farmers across diverse regions. Tailoring programs to specific needs and challenges faced by different communities ensures equitable access to knowledge and skills.

Encouraging youth engagement is a strategic aspect of building resilient food systems. Education and capacity-building programs are designed to attract and involve the younger generation in agriculture. This approach fosters innovation, entrepreneurship, and a renewed interest in sustainable farming practices among the youth.

Community-based learning platforms serve as hubs for knowledge exchange. Farmers actively participate in sharing experiences and best practices, creating a collaborative environment that strengthens local resilience. This communal approach to learning contributes to a collective wisdom that supports the sustainability and adaptability of local agricultural systems.

Farmer-to-Farmer Knowledge Exchange and Peer Learning

Farmer-to-farmer knowledge exchange and peer learning stand out as dynamic solutions for building resilient food systems, fostering a collaborative and community-driven approach to sustainable agriculture. In India, numerous examples showcase the efficacy of these initiatives in enhancing agricultural practices and resilience.

One notable example is the Farmer Field School (FFS) model implemented by organizations like the Indian Council of Agricultural Research (ICAR) and various non-governmental organizations. FFSs serve as platforms for peer learning, where farmers gather to share experiences, insights, and practical knowledge. These schools focus on experiential learning, enabling farmers to collectively experiment with innovative and sustainable agricultural practices.
In the state of Andhra Pradesh, the Zero Budget Natural Farming (ZBNF) movement is another exemplary case. Campaigned by Subhash Palekar, ZBNF relies heavily on farmer-to-farmer knowledge exchange. Farmers who have successfully adopted ZBNF practices share their experiences with their peers, creating a grassroots movement that emphasizes natural farming techniques, reduced input costs, and enhanced sustainability.

Additionally, initiatives like the Digital Green project leverage technology to facilitate peer learning. This project, active in various states across India, employs videos and community-led discussions to disseminate agricultural best practices. Farmers record and share their experiences through digital platforms, creating a rich repository of locally relevant knowledge.
The Farmer Producer Companies (FPCs) in India also exemplify peer learning in action. These organizations, formed by farmers themselves, enable collective decision-making and knowledge sharing. Farmers within FPCs exchange information on sustainable farming methods, market trends, and post-harvest management, contributing to increased resilience at the community level.

Fostering Innovation and Adaptability Through Education

Fostering innovation and adaptability through education emerges as a critical solution for building resilient food systems, empowering farmers with the knowledge and skills needed to navigate challenges. In India, various initiatives exemplify the transformative impact of education in promoting innovation and adaptability within agriculture.
One standout example is the “Kisan Rath” mobile app launched by the Indian government. This app provides farmers with real-time information on market prices, weather forecasts, and best agricultural practices. By leveraging technology and providing accessible education, the app equips farmers to make informed decisions, adapt to market dynamics, and enhance their overall resilience.
The Agri-Udaan program, supported by the Indian government’s Department of Agriculture, Cooperation & Farmers Welfare, is another noteworthy initiative. Agri-Udaan focuses on fostering innovation in

agriculture by providing mentorship, training, and networking opportunities to agri-entrepreneurs. This educational platform encourages the adoption of innovative practices, driving resilience within the agricultural sector.

Furthermore, agricultural universities and research institutions across India play a pivotal role in educating farmers and promoting innovation. For instance, the Tamil Nadu Agricultural University (TNAU) has introduced educational programs that emphasize climate-smart agricultural practices, empowering farmers to adapt to changing environmental conditions.
The National Institute of Agricultural Extension Management (MANAGE) and ICAR-Central Institute of Post-Harvest Engineering and Technology in India also contributes significantly to farmer education. MANAGE conducts training programs, workshops, and capacity-building initiatives aimed at enhancing farmers' skills, knowledge, and adaptability in the face of evolving agricultural landscapes.

Raising Consumer Awareness: Building a Culture of Sustainability

Understanding Food Systems and the Impacts of Choices

Understanding food systems and the impacts of individual choices stands as a foundational solution for fostering resilient food systems. This involves creating awareness among consumers about the implications of their food-related decisions, and it plays a crucial role in building a culture of sustainability. In India, several initiatives highlight the significance of informed choices and consumer awareness.
One notable example is the "Indian Food Sharing Alliance," a grassroots movement that educates consumers about food wastage and the environmental consequences of unsustainable consumption patterns. This initiative emphasizes the importance of responsible food choices in reducing waste and promoting sustainability.

Additionally, the "Anna Daata Sukhi Bhava" campaign, led by the Indian government, focuses on minimizing food wastage. Through public awareness programs and media campaigns, it educates citizens about the impact of food choices on resource utilization, urging them to adopt more sustainable practices.
Consumer education and awareness also extend to certifications like the "Jaivik Bharat" logo for organic products. This labeling system informs consumers about the ecological benefits of choosing organic produce, encouraging them to make environmentally conscious decisions.

Raising awareness about the carbon footprint associated with food consumption is another aspect. Initiatives that highlight the environmental impact of various food choices, such as adopting plant-based diets or supporting local and seasonal produce, contribute to building a culture of sustainability.
Furthermore, educational campaigns by NGOs and environmental organizations emphasize the interconnectedness of food choices, climate change, and biodiversity loss. These efforts aim to empower consumers to make informed decisions aligned with the principles of sustainability.
Therefore, understanding food systems and raising consumer awareness in India, as evidenced by initiatives like the Indian Food Sharing Alliance, the Anna Daata Sukhi Bhava campaign, organic product certifications, and educational campaigns by NGOs, play a vital role in building a culture of sustainability. By making informed choices, consumers contribute to the resilience and sustainability of food systems, fostering a positive impact on the environment and society.

Reducing Food Waste and Promoting Conscious Consumption

Reducing food waste and promoting conscious consumption are integral components of building resilient food systems, and various initiatives in India exemplify the significance of these efforts. One notable example is the "No Food Waste" campaign, which originated in Chennai and has expanded to other cities. This initiative focuses on preventing food wastage at events, restaurants, and households by redistributing surplus food to those in need. By raising awareness about the impact of food waste and encouraging responsible consumption, the campaign contributes to building a culture of sustainability.

Additionally, the "Save Food, Share Food" program, supported by non-profit organizations, educates communities about the consequences of food wastage. Through workshops, awareness drives, and collaborative efforts with local businesses, the program encourages citizens to adopt mindful consumption practices and minimize food waste.

In the context of conscious consumption, the "Zero Waste" movement has gained momentum in various Indian cities. This movement promotes a lifestyle that minimizes waste generation, including food packaging waste. Consumers are educated about sustainable alternatives, reusable packaging, and the environmental impact of single-use plastics, fostering a culture of responsible consumption.

Furthermore, collaborations between government agencies and civil society organizations have led to the development of campaigns such as "Save Food, Fight Hunger." These initiatives emphasize the dual goal of reducing food waste while addressing issues of hunger and food insecurity. By aligning consumer behavior with the principles of sustainability, these efforts contribute to the resilience of food systems.

Supporting Local Markets and Community Supported Agriculture

Supporting local markets and Community Supported Agriculture (CSA) are pivotal solutions for resilient food systems, and notable examples from India underscore the importance of these initiatives. In regions like Maharashtra, the "Farmers' Market" movement has gained prominence. These markets connect consumers directly with local farmers, providing a platform for the sale of fresh produce and fostering community engagement. By eliminating intermediaries, farmers receive fair prices, and consumers gain access to locally sourced, nutritious food.

Community Supported Agriculture (CSA) programs, such as those implemented by organizations like Sahaja Samrudha in Karnataka, exemplify a direct connection between farmers and consumers. CSA members receive a share of the farm's produce, creating a mutually beneficial relationship. These initiatives not only support local agriculture but also contribute to community building and sustainable food systems.

In the perspective of post-harvest management, training programs play a crucial role in educating farmers on modern practices. Organizations like the National Institute of Agricultural Marketing (NIAM) in India conduct training sessions and workshops. These programs cover topics such as proper harvesting techniques, storage methods, and transportation practices. By equipping farmers with knowledge on post-harvest technologies, the programs enhance the quality of produce, reduce losses, and improve market access.

Extension services are instrumental in disseminating knowledge and empowering farmers. The Agricultural Extension Services in India, facilitated by government agencies and non-profit organizations, offer advisory services, training, and information on best practices. These services bridge the gap between scientific advancements and farmers' practical needs, facilitating the adoption of modern post-harvest management techniques. Extension workers act as intermediaries, ensuring that farmers have access to the latest knowledge and technologies, thereby enhancing the resilience of local food systems.

Chapter 5

From Seed to Supper:

Case Studies in Resilience

"We must shift our emphasis from economic efficiency to life efficiency."

Kofi Annan

Urban Agriculture: Cultivating Greener Cities and Sustainable Food Systems

Introduction: Urban agriculture, including terrace farming, has gained significance due to the uncontrolled urbanization and migration of people to urban areas. This has led to the conversion of fertile agricultural land into concrete structures, resulting in a need for sustainable food production within cities. Urban agriculture involves practices such as backyard kitchens, community gardens, and intensive production methods, aiming to meet the daily demand of consumers within urban and peri-urban areas.

Impact & Outcome: The implementation of terrace farming and urban agriculture has shown a significant impact on households in urban areas. For example, households engaged in terrace farming have been able to reduce their monthly expenditure on vegetables and have been able to sell their produce through various channels. This has led to reduced reliance on market vegetables and increased self-sufficiency in horticultural production. Additionally, terrace farming facilitates better time and space management for households, thereby contributing to sustainable urban food systems.

The economic impact of terrace farming in urban areas has been notable. Households have demonstrated an interest in cultivating food for their own requirements and have become more aware of the need for self-sufficiency in horticultural production. Locally produced food requires less transportation and refrigeration and can be supplied in nearby markets at competitive prices. This has resulted in easier access to fresh produce, greater choice, and better prices for consumers. Proper government intervention and awareness campaigns have contributed to the creation of sustainable production systems with a healthy atmosphere.

Recommendations: It is recommended that government interventions focus on creating awareness among the people regarding their responsibility to protect society from the use of harmful pesticides. Reforms in the direction of sustainable urban agriculture and terrace farming need to be encouraged, and support can be provided to initiatives such as the 'Zero Waste and Safe-to-Eat Vegetable' project. Furthermore, efforts should be made to promote the economic and environmental benefits of terrace farming and urban agriculture, emphasizing the importance of self-sufficiency and sustainable food production within urban areas.
At corporate level, existing grocery suppliers can add use this urban agriculture method to optimize their operation and increase profitability. They can motivate people in their operational area to do urban farming and sell those vegetables through their platform. It can also help companies to optimize their supply chain, enhance their emission score, and build their brand reputation.

Permaculture for a Sustainable Future

Introduction: In June 2018, thousands of Indian farmers initiated a 10-day protest, demanding farm loan waivers and higher prices for their products. This protest followed a 40,000-strong march to Mumbai in March of the same year. The crisis in India's farming sector, which employs most of the country's labor force, has been longstanding, marked by a surge in farmer suicides since the 1990s. The roots of this agrarian crisis are multifaceted, with climate change and the transformation of agriculture into large-scale corporate ventures being cited as major contributors.
Amidst this crisis, the permaculture movement has emerged as a concrete and viable alternative. Coined in the 1970s by Australian biologist Bill Mollison, permaculture combines "permanent agriculture" and "permanent culture," promoting three ethics "people care, earth care, and fair share". This approach,

influenced by Japanese natural farmer Masanobu Fukuoka, offers practical guidance to build sustainable alternatives aligning human needs with nature.

Impact & Outcome: Introduced to India by Mollison in 1986, permaculture gained momentum through workshops, with the first demonstration farm established in Andhra Pradesh. The Permaculture Association of India formed in 1989, and organizations like Aranya Agricultural Alternatives played a crucial role in advancing permaculture through events like the National Permaculture Convergence in 2016.
The movement engages diverse actors such as agrarian-focused NGOs offering permaculture training, non-farmers implementing permaculture designs on small farms, traditional farmers transforming lands into permaculture farms, and urbanites practicing permaculture in limited spaces. The transformative potential lies in making small-scale farmers self-sufficient, addressing the deep crisis faced by over 80% of India's agricultural holdings under 2 hectares. Permaculture incorporates elements of traditional farming methods, offering viable solutions for food, soil fertility, input costs, and income. For many, especially young and educated individuals, permaculture has become a life project aligned with ethical values, contributing to a more sustainable and just society.

Recommendation: Considering the manifold benefits of permaculture in environmental conservation, productivity enhancement, and community well-being, it is strongly recommended to embrace permaculture as a sustainable agricultural and lifestyle approach. The implementation of closed-loop systems reduces environmental impact by minimizing waste and decreasing reliance on external inputs. Biodiversity thrives under permaculture practices, promoting essential ecosystem functions such as pollination and pest control, while the adaptable principles contribute to climate change resilience. Notably, permaculture's productivity methods, including vertical gardening and companion planting, yield higher outputs in smaller spaces, diminishing dependence on external inputs and enhancing resilience to environmental shocks. On the social and economic fronts, permaculture fosters community empowerment through local food production and knowledge sharing, fostering robust local economies and healthier living conditions. Choosing a permaculture lifestyle is not only a connection to nature and an encouragement of creativity but also a conscious contribution to a sustainable and fulfilling future for individuals and communities alike.

Andhra Pradesh Community Managed Natural Farming (APCNF) Policy

Introduction: The Andhra Pradesh Community Managed Natural Farming (APCNF) policy is at the forefront of promoting sustainable agricultural practices by advocating the complete elimination of synthetic chemical inputs. This initiative focuses on four key farming practices, including microbial seed coating with cow-dung and urine-based formulations, integration of cow dung and urine to enhance soil microbiome, cover cropping, and mulching. These practices collectively contribute to the enrichment of soil humus (organic matter), improved soil aeration, and enhanced water retention. The program further encourages botanical extracts for pest management, minimal tillage using indigenous seeds, and the promotion of crop diversity.

Impact & Outcome: To ensure the successful implementation of APCNF practices, the government of Andhra Pradesh established Rythu Sadhikara Samstha (RySS). With a mandate to train the six million farmers in the state, RySS has made significant strides, having trained 580,000 farmers in 3011 villages as of December 2020. The training is conducted by community resource persons (CRPs), farmers selected through a rigorous community audit assessing their natural farming knowledge and leadership skills. After

selection, CRPs undergo a year-long training before being deployed in the field. Clusters of approximately 2000 farming households are assigned 2–5 CRPs, who, supported by government remuneration, reside within the cluster to motivate, and assist farmers in adopting APCNF practices. Additionally, CRPs identify master farmers, termed internal community resource persons (iCRPs), some of whom undergo 2–3 years of training to become CRPs for new clusters. Notably, one iCRP is designated for every 100 farmers.
The involvement of non-governmental organizations (NGOs) further strengthens the APCNF initiative. Implementing NGOs plays a vital role in conducting farmer training at the cluster level, while resource NGOs contribute expertise and evaluation support to the program. This collaborative effort, combining government initiatives, community engagement, and NGO support, underscores the comprehensive approach taken by Andhra Pradesh in promoting sustainable and natural farming practices.

Recommendation: Achieving a paradigm shift towards sustainable farming and reducing pesticide reliance mandates a focus on robust training programs. The farmers' demonstrated willingness to adopt alternative techniques underscores the ongoing imperative of continuous education. The pivotal role of frequent farmer-extension worker interactions, crucial in reducing pesticide usage, necessitates the expansion and reinforcement of government-led training initiatives. Ensuring widespread accessibility and active participation in these programs is paramount for their efficacy. Beyond training, a holistic, multi-faceted strategy is recommended, urging policymakers to integrate diverse policy instruments, such as private sector regulations. The proposed ban on 27 hazardous pesticides in India exemplifies a potent regulatory approach that, if rigorously enforced, can significantly contribute to reducing pesticide dependency.

The Rice-Fish Farming System in Kerala

Introduction: The lush paddy fields of Kerala, nestled amidst the emerald hills of India, host a unique and biodiverse agricultural system - the Rice-Fish Farming System (RFFS). This centuries-old practice intertwines rice cultivation with aquaculture, creating a symbiotic relationship that enhances productivity, sustainability, and biodiversity. It is considered as an innovative farming system in which rice is the primary crop and fish fingerlings are used as a secondary source of income. Farmers' poverty is reduced because of rice-fish farming, which improves yield, creates jobs, and increases nutritional consumption, resulting in food security.

Impact & Outcome: The Rice-Fish Farming System (RFFS) presents a transformative approach to agriculture with multifaceted benefits. Through a symbiotic relationship, rice yields witness a substantial increase of 20-30%, driven by the fertilizing effect of fish excrement and enhanced pest control. The integration of fish not only provides farmers with a valuable source of protein but also contributes significantly to income diversification. Beyond the rice field, RFFS brings about positive outcomes for soil health and water quality. Fish waste enriches the soil with organic matter, improving fertility and water retention, while simultaneously acting as a natural filtration system that purifies irrigation water. This dual impact reduces reliance on chemical fertilizers and pesticides, aligning with sustainable agricultural practices.
Moreover, RFFS establishes a harmonious ecosystem within the rice field, fostering increased biodiversity. The presence of diverse life forms, including beneficial insects, birds, and amphibians, facilitates natural pest control and promotes pollination, contributing to the overall health of the agricultural environment. In terms of environmental sustainability, RFFS significantly minimizes the system's carbon footprint by optimizing water usage and relying on natural fertilizers and pest control methods. This reduction in environmental impact aligns with the imperative of sustainable agricultural practices.
In terms of outcomes, RFFS emerges as an empowering force for farmers, providing a resilient and pro-

ductive agricultural system. The consequential increase in food security, income diversification, and overall improved livelihoods highlight the system's positive impact on farming communities. Furthermore, RFFS stands as a beacon of sustainable food production, offering an alternative to conventional rice farming that minimizes environmental degradation and contributes to long-term food security. The conservation of biodiversity, particularly local fish species and aquatic life, enhances the ecological balance of the region. Additionally, RFFS demonstrates its resilience to climate change and extreme weather events through its closed-loop system and efficient water management practices. In essence, the Rice-Fish Farming System encapsulates a holistic and sustainable approach to agriculture, exemplifying the potential for transformative practices in the realm of food production.

Recommendation: To encourage widespread adoption by fostering knowledge-sharing and peer-to-peer learning among farmers is crucial for the successful implementation and adaptation of RFFS across India. Promoting awareness regarding the ecological and economic benefits of RFFS is vital to creating a demand for fish cultivated within these systems. This not only benefits farmers directly but also contribute to the overall sustainability of the practice.

Construction of Silos Under PPP Models: Schemes for Augmentation of Storage Capacity

India faces a significant challenge in its post-harvest infrastructure, particularly concerning the impact of tropical weather on perishable crops. The current inadequacy of storage facilities is evident, with the existing capacity capable of accommodating only 10% of plantation products. Furthermore, the deficiency is pronounced in cold storage, where the country's capacity of 32 million metric tonnes falls short of the required 35 million metric tonnes. Proper packaging materials, climate-controlled storage environments, and efficient cold storage facilities during transportation are imperative, emphasizing the pressing need for substantial investment and improvements in the post-harvest infrastructure to ensure the quality and viability of agricultural products.

Impact & Outcome: To overcome with the storage and Investment problem, Government of India come up with Scheme name "Construction of Silos Under PPP Models". Under this Scheme, The Government of India is actively addressing the need for augmenting and upgrading storage capacity, particularly through the construction of steel silos using various models. One such model is the Railway Siding Model, where the government has sanctioned the construction of 100 LMT (Lakh Metric Tonnes) silos nationwide under the Public-Private Partnership (PPP) mode. Out of this, FCI is set to construct 29 LMT, CWC 2.5 LMT, and State Governments 68.5 LMT. As of September 30, 2023, silos with a total capacity of 14.25 LMT have been completed, and those with a capacity of 9.5 LMT are currently under implementation. Additionally, operational circuit-based silos with a capacity of 5.5 LMT are functioning at six locations.

Another approach to modernizing foodgrain storage in India is the Hub & Spoke model of silos. This model, implemented in Public-Private Partnership (PPP) mode, aims to enhance storage capacity and efficiency. The Hub & Spoke Model involves consolidating transportation assets from standalone locations, known as "Spokes," to a central facility called the "Hub." The Hubs are equipped with dedicated railway siding and container depot facilities, while transportation from Spokes to Hub occurs via road, and from Hub to Hub via rail. This model, operating in Design, Build, Fund, Own & Transfer (DBFOT) and Design, Build, Fund, Own & Operate (DBFOO) modes, capitalizes on railway siding efficiency, promotes cost efficiency through bulk storage and movement, reduces handling and transportation costs and time, and

simplifies operational complexities. This approach also contributes to economic development, infrastructure development, and employment generation in the country.

The construction of 1 MT silos is estimated to cost approximately Rs 1,000 crore as part of a larger Rs 9,000-crore initiative to develop wheat silos with a total capacity of 9.4 MT over the next three to four years under the Public-Private Partnership (PPP) mode. These silos will be strategically distributed across 196 locations in states such as Punjab, Haryana, Madhya Pradesh, Uttar Pradesh, Rajasthan, Gujarat, Maharashtra, Bihar, West Bengal, Jammu, Uttarakhand, and Kerala. Notably, private entities, including Adani Agri Logistics and KCC Infrastructure, have secured contracts for this project.

This initiative marks a significant milestone as it introduces a project specifically dedicated to rice silos, a departure from the existing silos primarily designed for wheat storage. Silos, functioning as sub-mandi yards, offer a valuable infrastructure for farmers to bring in their produce for procurement, thereby reducing transportation costs. This development reflects a pioneering effort to enhance storage infrastructure for rice, contributing to improved agricultural logistics and procurement efficiency. Another, if food grains are stored in silos and transported in bulk, losses due to theft, pilferage, and transportation would be negligible compared to the food grains stored in warehouses.

Chapter 6

Roadmap to Resilience

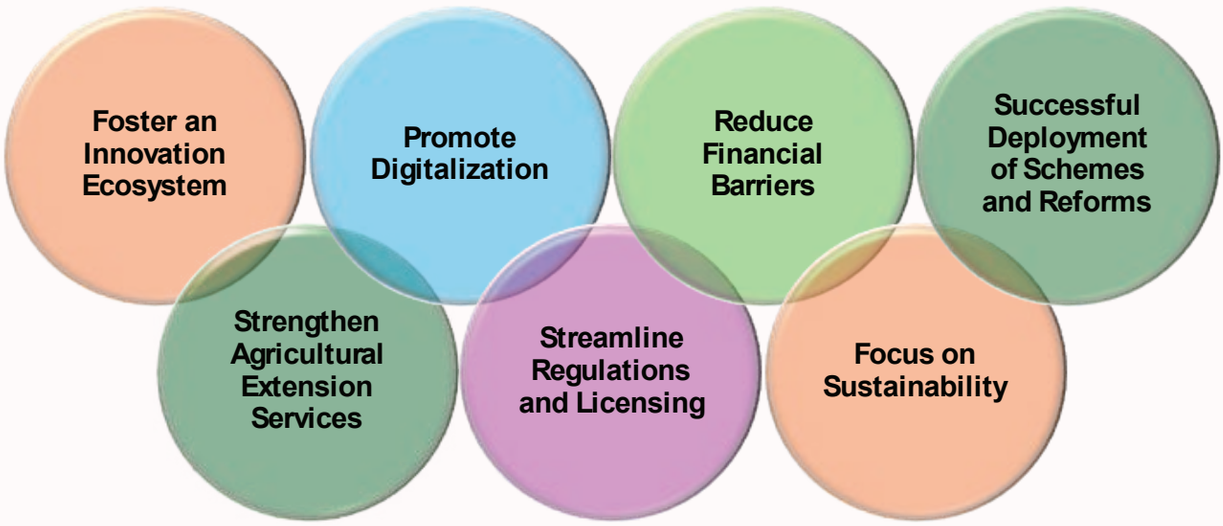
Recommendations for Action

"The greatest threat to our planet is the belief that someone else will save it."

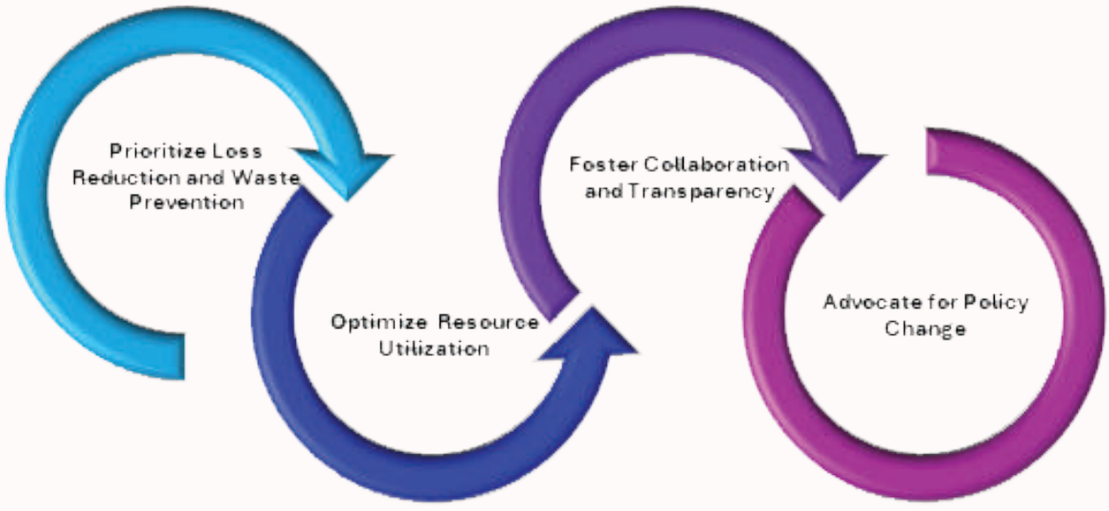
Robert Swan

Roadmap to Resilience: Recommendations for Action

Policymakers: Creating an Enabling Environment for Sustainable Food Systems



Businesses: Integrating Sustainability into Operations and Value Chains



A critical element of building resilient food systems lies in sustainable post-harvest management. By minimizing losses and waste, optimizing resource utilization, and adopting environmentally friendly practices, businesses can not only enhance their own operations but also contribute to a more robust and sustainable food supply chain. For example, Apeel Sciences, a US-based company, developed a plant-based edible coating that extends the shelf life of fruits and vegetables, significantly reducing post-harvest losses.

Civil Society Organizations (CSOs) primarily concentrate on educating farmers about the significance of grading and sorting, effective crop handling methods, and the specific grading standards associated with crops and buyers. Beyond the dissemination of knowledge and training, certain CSOs go a step further by supplying farmers with equipment for these activities. For instance, Harnaut Kishan Producer Company Limited (HKPCL) offers training sessions on grading and sorting techniques for various crops through demonstrations and workshops. CSOs like the Indian Society of Agri-Business Professionals (ISAP) and Agribusiness Systems International (ASI) contribute to farmers' awareness and comfort levels by providing them with grading and sorting equipment, thereby facilitating the adoption of these technologies.

NGOs and Civil Society Organizations: Mobilizing and Educating Communities.

NGOs and CSOs play a vital role in building resilient food systems by empowering communities through education and mobilization.

Community Mobilization and Engagement	Education and Capacity Building	Advocacy and Policy Influence	Monitoring and Evaluation
☐ Facilitate community dialogues	☐ Develop context-specific training programs	☐ Raise awareness about policy issues	☐ Track progress and impact
☐ Empower women and marginalized groups	☐ Utilize diverse learning methods	☐ Build public support for policy change	☐ Adapt and Improve
☐ Build partnerships and networks	☐ Develop and disseminate educational materials	☐ Collaborate with policymakers and decision-makers	☐ Share best practices and lessons learned

The Bangladesh Krishi Andolon (BKAA), a farmer-led organization, successfully advocated for pro-peasant agricultural policies through grassroots campaigns and collaborations with government agencies. Nayakrishi Andolon, the New Agriculture Movement in Bangladesh, advocates for the Shohoj way to Ananda, emphasizing organic farming practices established in the 1990s. With ten simple rules guiding farming practices, the movement embodies the Bangla concept of Ananda, signifying joy, and Shohoj, representing the collective capacity of human faculties to grow naturally in harmony with the shared natural world. Nayakrishi draws inspiration from the rich philosophical traditions embedded in Bengal's oral culture, poetry, songs, and spiritual heritage.

At its core, Nayakrishi Andolon is presently dedicated to the urgent objective of safeguarding the planet Earth from the detrimental effects of greenhouse gas emissions and rising temperatures. The movement

strives to protect the existence and biological integrity of all life forms on our planet. A key focus is maintaining food chains and the web of life free from harmful industrial chemicals like pesticides, herbicides, toxins, biocides, and substances such as arsenic, which can enter food chains through modern industrial food production. Nayakrishi Andolon actively defends farming and rural landscapes, recognizing agriculture and food systems as the biological foundation of civilization. As farmers, they consider farming not just a profe ssion but a way of life.

Monitoring and Evaluation

Track progress and impact: Regularly monitor the effectiveness of programs and interventions through data collection, community feedback, and participatory assessments.

Adapt and improve: Use evaluation findings to identify areas for improvement, adapt strategies based on community needs and changing contexts, and ensure continued progress towards resilient food systems.

Share best practices and lessons learned: Document successes and challenges and disseminate learnings through publications, workshops, and online platforms to inspire and guide other organizations working in similar contexts. The International Institute for Rural Reconstruction (IIRR) in the Philippines uses a participatory monitoring and evaluation approach, involving communities in assessing the impact of their projects on food security and environmental sustainability.

By implementing these recommendations, NGOs and CSOs can effectively mobilize and educate communities, empowering them to build and sustain resilient food systems. The thing that must be in consideration is that long-term success requires ongoing commitment, collaboration, and adaptation to ensure communities are equipped to thrive in a changing world.

Individuals: Making Informed Choices and Contributing to Food System Change

Individuals play a crucial role in shaping a resilient and sustainable food system. By making informed choices about what they eat and how they engage with the food chain, individuals can contribute significantly to positive change.

Support Local farmers and Producers	Choose locally grown and seasonal produce whenever possible. This reduces transportation emissions, supports local economies, and ensures fresher, more flavorful food.
Prioritize Plant-based Proteins	Limit meat consumption and opt for plant-based protein sources like beans, lentils, and tofu. This reduces environmental impact and promotes healthy dietary patterns.
Reduce Food Waste	Plan meals efficiently, store food properly, and compost food scraps. This minimizes waste and conserves valuable resources.
Engage in Informed Conversations	Educate yourself about the challenges and opportunities within the food system and share your knowledge with others. Start discussions and encourage critical thinking about food choices.
Support Organizations and Initiatives	Volunteer your time or donate to NGOs and CSOs working towards sustainable food systems. Participate in campaigns and advocacy efforts to amplify your voice for change.
Spread Awareness through Social Media	Share reliable information, inspiring stories, and actionable tips on your social media platforms to encourage others to make informed choices and contribute to a better food system.
Look for Certification Labels	Choose products certified by organizations like Fairtrade or Rainforest Alliance, FSSAI, and others ensuring fairer prices for farmers and sustainable production practices.
Research Brands and Companies	Support businesses committed to ethical sourcing, responsible labor practices, and environmental sustainability. Ask questions and hold them accountable for their claims.
Request Information from Grocery Store	Request information about the origin and production methods of the products you purchase and encourage them to stock sustainable options.
Learn About Diverse Food Preparation	Develop cooking skills and experiment with diverse cuisines. This reduces reliance on processed foods and empowers you to make healthy and sustainable choices based on your preferences.
Support Community Gardening and Food Initiatives	Participate in or volunteer at community gardens, farmers markets, and food rescue programs. These initiatives not only offer access to fresh food but also foster community engagement and education.
Support Rooftop Urban Gardening or Modern Farming	Urban agriculture, especially rooftop farming, offers resilience to urban food systems, addressing societal, environmental, and economic challenges through controlled growing conditions, enhancing food security and sustainability.

Startup Targeting Post-Harvest Losses Agriculture Market

Company Name	Headquarter	Description
GramHeet Private Limited	Maharashtra	The company offers a comprehensive suite of post-harvest services to farmers through its digital platform, GramHeet Mandi, employing an integrated approach in collaboration with Community Based Organizations (CBOs), Farmer Producer Organizations (FPOs), and Village Entrepreneurs (VEs). This model not only aids farmers in augmenting their income by minimizing post-harvest costs but also ensures improved pricing for their agricultural produce.
[illegible]	[illegible]	[illegible]
Wingrow Agritech Innovations Pvt. Ltd.,	Maharashtra	The company offers Vegetable in Pune both online (website) and offline mode. In offline mode, they organize weekly markets at key locations in Pune, which allows farmers to sell fresh produce directly to the customers, cutting out middlemen in the process.

Recommendation According to Value Chain Stage

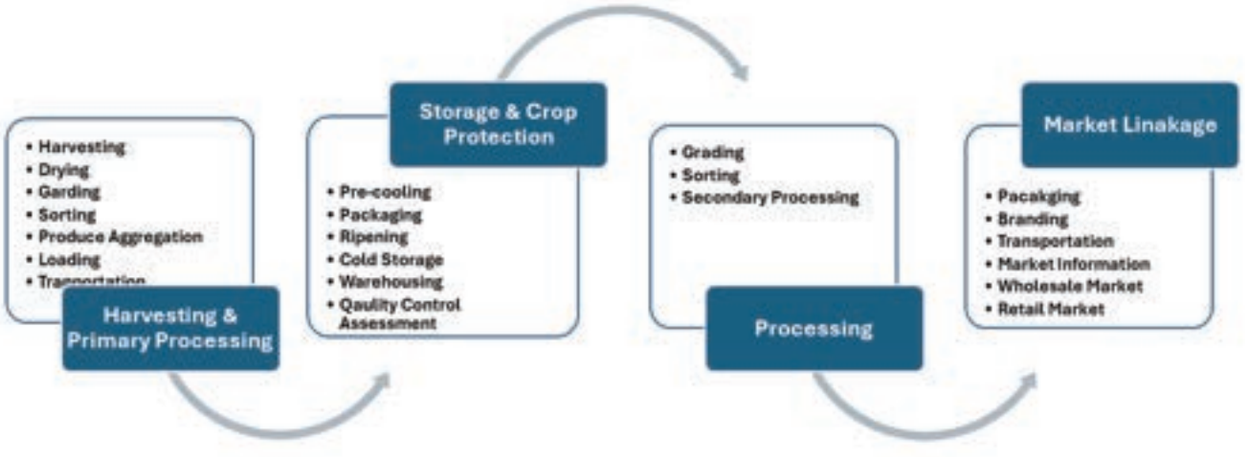
Moreover, the Private business can use opportunity by adding value in Agriculture eco system as the Government of India is focusing on Resilient Food Supply system. Some recommendations for business at different stage of Resilient Food Supply system value chain are:

Individuals play a crucial role in shaping a resilient and sustainable food system. By making informed choices about what they eat and how they engage with the food chain, individuals can contribute significantly to positive change.

At the Harvesting and Primary Processing stage in the agricultural equipment sector, it is recommended that companies explore customization of small-scale agricultural equipment tailored for farmers or farmer communities. Direct distribution to Smallholder Farmers (SHFs) or through Village Level Entrepreneurs (VLEs) and franchisees can enhance accessibility.

For instance, companies can follow the example set by Kamal Kisan, focusing on manufacturing user-friendly farm equipment directly sold to SHFs. The strategic re-engineering of equipment to align with SHFs' affordability and specific requirements, with minimal fuel dependence and ease of maintenance, can be a key consideration.

Moreover, leveraging Information and Communication Technology (ICT) solutions is crucial for streamlining equipment purchase and hiring processes. Establishing online portals, mobile applications, and WhatsApp groups, as demonstrated by FarMart and Agri Hub, can effectively cater to farmers' equipment needs. Exploring innovative models like peer-to-peer equipment renting and facilitating online purchases can enhance efficiency. Incorporating these recommendations can contribute to the development of sustainable and farmer-friendly solutions in the agricultural equipment sector.



At Storage and Crop Protection Stage in the agricultural infrastructure sector, companies can adopt key strategies to enhance on-farm facilities. It is recommended that manufacturing companies explore collective investment models, enabling farmers to pool resources through Farmer Producer Organizations (FPOs) or informal groups. This collaborative approach can overcome the financial barriers that individual Smallholder Farmers (SHFs) face in investing in expensive storage infrastructure and technologies.

For instance, the Association for Social Advancement (ASA) has promoted 54 FPOs, with 33 having warehouses of 500 to1000 ton storage facilities. Additionally, the success of S4S' solar dryers, where 80% of buyers are FPOs or informal groups, exemplifies the potential of collective investment. Another viable approach is local entrepreneurs making the initial investment and renting out facilities or materials to nearby farmers, as seen with ColdHub in Nigeria.

Companies should consider extending this collective investment and rental model to other crop protection infrastructure such as solar dryers and packaging technologies. Reducing access prices through innovative leasing models, like the planned lease models for solar dryers and tomato packaging technologies by S4S, can further enhance Smallholder Farmer uptake.

Furthermore, successful companies like Rinac, Tessol, and S4S have addressed resource constraints by developing technologies such as solar-powered solutions, mobile precooling units, and leasing micro-warehouses. The adaptation of business models to suit SHF resource constraints, as demonstrated by S4S transitioning from outright selling to renting, is a noteworthy approach that other companies should consider. Overall, aligning technology development with suitable business models is essential to address the unique challenges faced by Smallholder Farmers.

Key takeaways that make hub-and-spoke a promising model

Based on the operational efficiency demonstrated At Storage and Crop Protection Stage by companies adopting the centralized hubs and decentralized spokes model, it is recommended that other companies consider integrating this approach into their business strategy. This model, exemplified by companies like Our Food and Mega Food Parks, proves particularly advantageous for company clusters, allowing them to capitalize on economies of scale and achieve optimal capacity utilization by sharing capital-intensive facilities.

For successful implementation, companies can explore collaborative ventures, sharing resources such as cold storage, blast freezers, and warehousing. Joint investments in critical infrastructure like roads, water supply systems, and power backup can further enhance the model's effectiveness.

In this model, emphasizing small-scale processing and temporary storage activities near the farm gate while centralizing large-scale storage and processing facilities at hubs is crucial. Strategic hub locations ensure easy access for both farmers and markets. Companies can take inspiration from initiatives like India Food Park, which encourages small-scale processing by offering facilities and technical assistance to farmer groups.

The nascent near-farm processing sector presents an opportunity for companies to enable farmers to undertake small-scale processing at the village level. Successful examples involve minimal investment products such as kokum juice, jams, jellies, and dried fruit chunks. Companies can advise farmers on equipment and processing practices while handling packaging, branding, and marketing after procuring processed products from them. Although this model is an asset-light for companies, the uptake and sustainability hinge on carefully managing onboarding costs and advertising to end consumers. Companies should leverage available data to assess the viability and potential challenges, ensuring informed decision-making and sustainable implementation.

By integrating these recommendations into their operations and value chains, businesses can play a crucial role in building more resilient food systems. By prioritizing loss reduction, optimizing resource utilization, fostering collaboration, and advocating for supportive policies, businesses can not only contribute to a healthier planet but also secure long-term success in a more sustainable future.
Based on reflecting the potential for a resilient food supply system, it is recommended to implement strategies that facilitate direct engagement between the private sector and Smallholder Farmers (SHFs). This engagement promises to enhance efficiencies throughout the post-harvest value chain. Key recommendations include:

Based on reflecting the potential for a resilient food supply system, it is recommended to implement strategies that facilitate direct engagement between the private sector and Smallholder Farmers (SHFs). This engagement promises to enhance efficiencies throughout the post-harvest value chain. Key recommendations include:

Promoting Direct Engagement

- Encourage and establish platforms that facilitate direct collaboration between private sector entities and farmers. Data indicates that direct engagement leads to streamlined processes and improved coordination within the value chain.

Asset Sharing for SHFs

- Create mechanisms that enable SHFs to share assets, such as farm equipment and logistics costs. This collaborative approach helps in optimizing resource utilization and reducing individual financial burdens, ultimately contributing to a more resilient system.

Encouraging Small-scale Near-farm Processing

- Support SHFs in investing in small-scale near-farm processing. The data suggests that empowering farmers in value addition activities enhances their potential for increased income and sustainability.

Building Business Case for Private Sector Investment

- Strengthen the business case for private sector companies to invest in near-farm storage and processing infrastructure. This can be achieved by bringing together a large number of farmers, ensuring the necessary volumes of produce and creating a conducive environment for private sector participation.

Facilitating Partnerships with Market Actors

- Enable SHFs to form partnerships with market actors, providing them with better access to information. This collaboration helps in reducing Post-Harvest Losses (PHL) by addressing demand and supply imbalances through informed decision-making.

Conclusion: A Future Nourished by Resilience

Call to Action: Collective Responsibility for Building a Sustainable Future

In "A Call to Action: Collective Responsibility for Building a Sustainable Future" underscores the imperative for collaborative efforts in shaping a resilient and sustainable business landscape. The data and insights presented emphasize the need for businesses to go beyond individual interests and embrace a collective responsibility towards environmental, social, and economic sustainability.

In “A Call to Action: Collective Responsibility for Building a Sustainable Future” underscores the imperative for collaborative efforts in shaping a resilient and sustainable business landscape. The data and insights presented emphasize the need for businesses to go beyond individual interests and embrace a collective responsibility towards environmental, social, and economic sustainability. As we navigate the challenges of a rapidly changing global landscape, it becomes evident that the pursuit of sustainability is not merely a choice but a shared obligation. By pooling resources, expertise, and innovative strategies, businesses can play a pivotal role in fostering positive change. The call to action extends beyond mere rhetoric; it is an invitation to actively engage in practices that prioritize long-term viability, ethical conduct, and positive societal impact.

As our world continues to grapple with unprecedented challenges affecting the food supply chain, it is imperative for companies to proactively strengthen their food systems for long-term resilience. We recommend adopting a multi-faceted approach to fortify your supply chain against potential disruptions. They can consider diversifying sourcing strategies by engaging with a broader network of suppliers, both local and international. This not only mitigates risks associated with regional challenges but also fosters agility in response to market fluctuations same as the company like Danone SA, Grupo Bimbo, Unilever, ITC, and others. For that they can create their own supply chain by collaboration, partnership, and acquisition or others business strategies. Apart from these, they can outsource their work to existing companies that manage the supply chain globally like Global eProcure, Ryder System, Inc, UPS Supply Chain Solutions, and other companies.

The company can invest in sustainable agricultural practices, incorporating environmentally conscious initiatives that contribute to both resilience and social responsibility. Embracing technological solutions, such as data analytics for demand forecasting and traceability technologies like blockchain, can enhance transparency and streamline operations. General Mills, a prominent food company, is committed to sourcing 100% of its wheat and oats sustainably by 2020, supporting farmers in developing sustainable production plans. Cargill, a major agricultural player, targets a 30% reduction in greenhouse gas emissions by 2030. Working closely with farmers, Cargill invests in sustainable production plans and research for innovative farming technologies, exemplifying a robust commitment to environmentally responsible agriculture.

Collaborate closely with partners across the supply chain, including farmers, distributors, and retailers, to establish robust communication channels and contingency plans. Regularly assess potential risks and vulnerabilities, enabling your company to implement adaptive strategies promptly. By embracing these measures, your company can play a pivotal role in building a resilient food system that withstands challenges and ensures a stable food supply for the future. Walmart, a global retail giant, aims to source 100% of its produce from sustainable farms by 2025. The company collaborates with farmers, offering financial support for transitioning to sustainable practices. In agriculture sector companies like Cropin Technology Solutions, Fruvetech Private Limited, Aquaconnect, BharatAgri, Wolkus Technology Solutions Private Limited, and others are some companies that actively working in their area of agriculture sector.

In conclusion to business aspect, fostering resilient food systems requires businesses to prioritize sustainable post-harvest management. By focusing on reducing losses and waste, optimizing resource utilization, fostering collaboration, and advocating for supportive policies, businesses can play a pivotal role in building a more robust and sustainable food supply chain. Embracing innovative solutions, engaging with stakeholders, and sharing knowledge will contribute to a collective effort towards a more resilient and environmentally conscious agricultural sector. This holistic approach not only benefits businesses but also positively impacts communities and the overall health of our planet.

There are different government polices and initiatives such as Rashtriya Krishi Vikas Yojana (RKVY) cafeteria scheme (Soil Health Card Scheme), Pradhan Mantri Krishi Sinchayee Yojana (National Mission for Sustainable Agriculture (NMSA)), Pradhan Mantri Kisan Sampanna Yojana, Food Parks and Agro Processing Clusters, Construction of Silos Under PPP Models, and other that outline the efforts of the government to push the sustainable activities in India. Hence, companies can use their policies to increase their profitability directly or indirectly like Adani Agri Logistics and KCC Infrastructure. For governments aiming to fortify their agricultural sectors, a strategic focus on key initiatives is essential.

To enhance the agricultural sector's vitality, governments should prioritize key recommendations. First and foremost, fostering an innovative ecosystem is crucial for promoting technological advancements and efficiency. Additionally, strengthening agricultural extension services ensures that farmers have access to the latest knowledge and best practices. The promotion of digitalization facilitates data-driven decision-making and streamlines operations. Governments should also prioritize streamlining regulations and licensing processes to reduce bureaucratic hurdles. Addressing financial barriers is essential for ensuring that farmers have the capital needed for sustainable practices and innovation. Emphasizing sustainability in policies and practices ensures long-term environmental and economic benefits. Moreover, successful deployment of schemes and reforms requires strategic planning and effective implementation. In conclusion, by focusing on these suggestions, governments can catalyze a resilient and progressive agricultural sector, fostering innovation, sustainability, and economic growth.

NGOs and CSOs play a pivotal role in building resilient food systems through community empowerment. By prioritizing community mobilization, education, advocacy, and monitoring, these organizations contribute to sustainable agriculture and address challenges such as climate change and food insecurity. The examples of successful initiatives, such as those in India and Bangladesh, showcase the transformative impact achievable through collaborative efforts. As these organizations continue to adapt and innovate, their commitment to fostering resilient communities and sustainable food systems remains essential for a flourishing and resilient global agricultural landscape.

In shaping a resilient and sustainable food system, individuals wield significant influence. Through mindful consumption choices, support for local and sustainable products, and adoption of environmentally friendly practices, every person contributes to the broader goal of fostering resilience in the food supply chain. By prioritizing awareness, making informed decisions, and advocating for sustainable practices, individuals become catalysts for positive change. The collective impact of individual actions creates a ripple effect that promotes a more robust and sustainable food system, ensuring the well-being of communities and the planet for generations to come.

In this journey towards a sustainable future, collaboration emerges as the linchpin. From supply chain resilience to environmentally conscious practices, businesses are called upon to unite in their commitment to responsible corporate citizenship. This collective responsibility not only mitigates risks but also unlocks opportunities for growth, innovation, and societal advancement.

In essence, building a sustainable future is a multifaceted endeavor that requires the concerted efforts of businesses, policymakers, and society at large. Embracing this call to action empowers us to contribute meaningfully to a world where economic prosperity, social equity, and environmental stewardship coexist harmoniously. Through collective responsibility, we can pave the way for a future where businesses thrive and the planet flourishes.

Recommendation According to Value Chain Stage

The imperative for business leaders to invest in resilient food systems stands as a strategic and ethical choice with far-reaching benefits for generations to come. The data and insights presented throughout emphasize that beyond immediate returns, such investments contribute to long-term business viability, societal well-being, and environmental sustainability.

For businesses, recognizing the inherent advantages of resilient food systems is not merely a call to altruism but a shrewd business strategy. The interconnected nature of global markets means that disruptions in food supply chains have direct and cascading impacts on businesses. By proactively investing in resilience, businesses can insulate themselves from such shocks, ensuring a stable and secure foundation for operations.

Moreover, the benefits extend beyond risk mitigation. Businesses engaging in the creation of resilient food systems are poised to capitalize on emerging market trends, consumer preferences for sustainable practices, and regulatory shifts towards responsible corporate conduct. This aligns not only with contemporary expectations but positions companies as stewards of positive change, enhancing brand reputation and customer loyalty.

The businesses operating within the agricultural value chain have a pivotal role in shaping a resilient food system, particularly in the post-harvest segment. At the Harvesting and Primary Processing stage, customization of small-scale agricultural equipment, direct distribution to Smallholder Farmers (SHFs), and leveraging Information and Communication Technology (ICT) solutions are key strategies. In the Storage and Crop Protection stage, companies can enhance on-farm facilities through collective investment models, resource-sharing, and adapting technologies to suit Smallholder Farmer constraints. Adopting the centralized hubs and decentralized spokes model at this stage facilitates optimal resource utilization and operational efficiency.

Furthermore, integrating near-farm processing activities presents an opportunity for businesses to empower farmers and enhance sustainability. By incorporating these recommendations, businesses can contribute significantly to building a resilient and sustainable food system, ensuring a healthier planet and long-term success. Some of the example GramHeet Private Limited, headquartered in Maharashtra, stands out as a pivotal solution provider in mitigating post-harvest losses through its digital platform, GramHeet Mandi. Collaborating with Community Based Organizations (CBOs), Farmer Producer Organizations (FPOs), and Village Entrepreneurs (VEs), the company adopts an integrated approach to deliver comprehensive post-harvest services. By minimizing costs and ensuring improved pricing for agricultural produce, GramHeet Mandi empowers farmers to enhance their income. In Delhi, MachPhy addresses diverse post-harvest needs with its extensive line of cold chain technologies, spanning ambient temperature refrigeration, deep freezing, and cryogenic freezing, along with portable refrigerators and freezers. Meanwhile, Wingrow Agritech Innovations Pvt. Ltd. in Maharashtra facilitates direct sales between farmers and consumers through online and offline channels, reducing post-harvest losses by eliminating intermediaries in the process.

In conclusion, as the Government of India focuses on building a resilient food supply system, businesses in the agricultural sector must strategically align with key recommendations at different stages of the value chain, particularly in the post-harvest segment. At the Harvesting and Primary Processing stage, customization of small-scale agricultural equipment and leveraging Information and Communication Technology (ICT) solutions can enhance accessibility and affordability for Smallholder Farmers (SHFs). Moving to the Storage and Crop Protection Stage, adopting collective investment models and innovative leasing approaches for infrastructure can overcome financial barriers, promoting inclusive participation. Additionally, embracing the centralized hubs and decentralized spokes model at this stage enables businesses to capitalize on economies of scale and optimize capacity utilization, further strengthening the overall resilience of the food system. By integrating these recommendations, businesses contribute significantly to reducing post-harvest losses, optimizing resource utilization, and fostering collaboration, thereby playing a pivotal role in building a more resilient and sustainable food supply chain.

As stewards of the economy, business leaders bear a unique responsibility to shape a future where food security is not a fleeting aspiration but a sustainable reality. Investing in resilient food systems is an investment in the well-being of communities, the stability of supply chains, and the overall health of our planet. It is a strategic imperative that transcends immediate profits, offering a legacy of responsible leadership and a prosperous future for generations to come.

About ASSOCHAM

The Associated Chambers of Commerce & Industry of India (ASSOCHAM) is the country's oldest apex chamber. It brings in actionable insights to strengthen the Indian ecosystem, leveraging its network of more than 4,50,000 members, of which MSMEs represent a large segment. With a strong presence in states, and key cities globally, ASSOCHAM also has more than 400 associations, federations, and regional chambers in its fold. Aligned with the vision of creating a New India, ASSOCHAM works as a conduit between the industry and the Government. The Chamber is an agile and forward-looking institution, leading various initiatives to enhance the global competitiveness of the Indian industry, while strengthening the domestic ecosystem.

With more than 100 national and regional sector councils, ASSOCHAM is an impactful representative of the Indian industry. These Councils are led by well-known industry leaders, academicians, economists, and independent professionals. The Chamber focuses on aligning critical needs and interests of the industry with the growth aspirations of the nation.

ASSOCHAM is driving four strategic priorities – Sustainability, Empowerment, Entrepreneurship and Digitisation. The Chamber believes that affirmative action in these areas would help drive an inclusive and sustainable socio-economic growth for the country.

ASSOCHAM is working hand in hand with the government, regulators, and national and international think tanks to contribute to the policy making process and share vital feedback on implementation of decisions of far-reaching consequences. In line with its focus on being future-ready, the Chamber is building a strong network of knowledge architects. Thus, ASSOCHAM is all set to redefine the dynamics of growth and development in the technology-driven 'Knowledge-Based Economy. The Chamber aims to empower stakeholders in the Indian economy by inculcating knowledge that will be the catalyst of growth in the dynamic global environment.

The Chamber also supports civil society through citizenship programmes, to drive inclusive development. ASSOCHAM's member network leads initiatives in various segments such as empowerment, healthcare, education and skilling, hygiene, affirmative action, road safety, livelihood, life skills, sustainability, to name a few.

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