

ASIAN STATE

Climate Resilient Crops: The Next Green Revolution





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Editorial Message

As the world grapples with the escalating threats of climate change, agriculture stands at a critical crossroads. Unpredictable weather patterns, rising temperatures, and dwindling natural resources are directly impacting food production and farmer livelihoods. In this context, climate resilient crops emerge as the cornerstone of a new agricultural revolution—one rooted not in chemical intensification, but in sustainability, innovation, and resilience.

This “Next Green Revolution” is not just about increasing yields—it’s about ensuring food security in a warming world. Climate resilient crops, developed through advanced breeding techniques, biotechnology, and traditional knowledge, can withstand droughts, floods, salinity, and extreme heat. They offer hope to smallholder farmers struggling on the frontlines of climate stress, empowering them with tools to adapt and thrive.

Investing in these crops is investing in our collective future. From national policies and research institutions to grassroots movements, all stakeholders must unite to champion this transformation. By embracing climate smart agriculture, we safeguard not only our food systems, but also the ecosystems and communities they nourish.

Let this be the decade we reimagining agriculture—with science, sustainability, and resilience at its heart. The future of food depends on it.



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Feeding a Warming World through Resilient Agriculture: The Case of Bangladesh

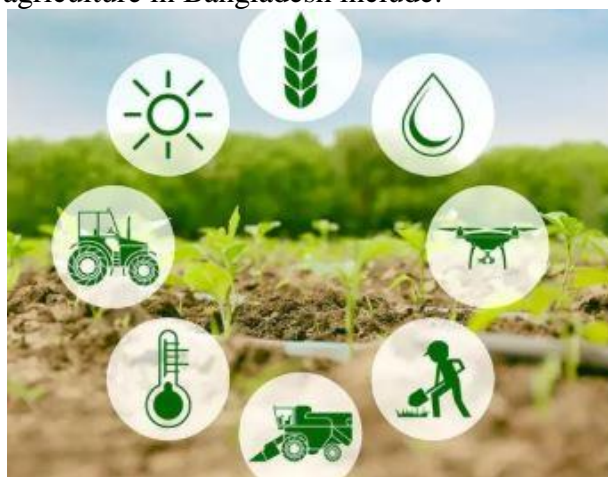
Climate change presents one of the most formidable challenges to global food security. Rising temperatures, erratic rainfall, sea-level rise, and an increase in extreme weather events directly threaten agricultural productivity, especially in climate-vulnerable countries. Among the most affected is **Bangladesh**, a low-lying, densely populated country that relies heavily on agriculture for food, livelihoods, and economic stability. As the country confronts the dual pressures of a growing population and an increasingly hostile climate, the need for **resilient agricultural systems** has never been more critical.

This article explores how Bangladesh is grappling with these challenges and the innovative strategies being deployed to ensure that the country can feed its people in a warming world.

The Climate-Agriculture Nexus in Bangladesh

Bangladesh's geographic location and topography make it uniquely susceptible to climate-related hazards. With 80% of its land comprised of floodplains, and much of it lying

barely above sea level, even minor sea-level rise can have catastrophic consequences. Agriculture, which employs nearly 40% of the population and contributes roughly 13% to GDP, is intricately tied to climatic conditions. The most prominent climate-induced threats to agriculture in Bangladesh include:



1. **Increased Flooding:** Seasonal floods have always been a part of Bangladesh's agrarian cycle, but climate change has increased their frequency and severity, damaging crops and displacing farmers.
2. **Sea-Level Rise and Salinity Intrusion:** Coastal regions are experiencing higher salinity levels, reducing soil fertility and limiting the types of crops that can be grown.
3. **Erratic Rainfall and Drought:** Unpredictable monsoon patterns and prolonged dry spells are disrupting planting and harvesting schedules.
4. **Cyclones and Storm Surges:** These extreme weather events devastate coastal agriculture and fisheries, often destroying entire seasons of crops.

Resilient Agriculture: The Concept and Need

Resilient agriculture refers to farming practices and systems that can withstand and recover from climate-related shocks and stresses while sustainably increasing productivity. In the context of Bangladesh, resilience means:

- Adapting to changing rainfall and temperature patterns.
- Managing water and soil resources efficiently.
- Protecting crops and livestock from extreme events.
- Ensuring food security for a growing population.

Building resilience in agriculture is not merely an environmental or technical challenge; it is a social, economic, and political imperative for Bangladesh.

Strategies and Innovations in Climate-Resilient Agriculture

1. Climate-Resilient Crop Varieties

One of the most transformative developments in Bangladesh's agricultural adaptation strategy has been the **development of climate-resilient crop varieties** by institutions such as the Bangladesh Rice Research Institute (BRRI) and the International Rice Research Institute (IRRI).

- **Flood-Tolerant Rice (e.g., BRRI dhan51, BRRI dhan52):** These varieties can survive being submerged in water for up to two weeks, helping farmers in flood-prone areas retain yields even after heavy rains.
- **Salinity-Tolerant Rice (e.g., BRRI dhan61, BRRI dhan67):** Tailored for coastal regions, these strains can grow in saline conditions, ensuring productivity in areas affected by sea-level rise.
- **Drought-Tolerant Varieties:** In northern districts like Rajshahi and Dinajpur, where rainfall is becoming less reliable, drought-resistant rice and wheat varieties are gaining popularity.

These innovations are critical for ensuring that farmers can maintain food production despite adverse climatic conditions.

2. Floating Agriculture

In areas where seasonal floods make traditional farming nearly impossible, **floating agriculture**—locally known as "**Baira**" or

"**Dhap**" farming—has emerged as a climate-smart solution. This method involves creating floating beds of water hyacinths and other organic materials on which vegetables and spices are grown.

- Common crops include leafy greens, gourds, turmeric, and okra.
- Floating beds are biodegradable and can last through the monsoon season.
- The method requires no arable land and can be a lifeline for displaced or landless farmers.



Floating agriculture has received international attention and is being scaled up with support from NGOs and government agencies.

3. Improved Water Management

Efficient water use is a cornerstone of resilient agriculture. In Bangladesh, multiple initiatives aim to manage both excess and scarcity:

- **Rainwater Harvesting:** Particularly important in saline and drought-prone areas, harvesting rainwater during the monsoon provides a freshwater source for irrigation during dry spells.
- **Solar-Powered Irrigation Pumps:** These are replacing diesel pumps, reducing both emissions and operational costs. Over 2,000 solar pumps have already been installed under public-private partnerships.
- **Drainage and Embankment Rehabilitation:** Improving drainage systems and maintaining embankments helps manage floodwaters and protect agricultural land.

4. Agroforestry and Diversified Farming

Agroforestry—the integration of trees into agricultural landscapes—offers both ecological and economic benefits:

- Trees act as windbreaks and reduce soil erosion.
- Fruit trees like mango, jackfruit, and guava provide additional income and nutrition.
- Multipurpose tree species such as Acacia and Moringa enrich the soil and provide fodder for livestock.

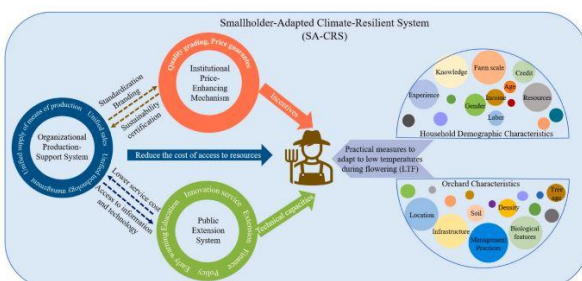
Similarly, **mixed cropping and livestock integration** enhances resilience by spreading risk. If one crop fails due to a climate event, others may still succeed.

5. Digital Agriculture and Early Warning Systems

Digital tools are playing an increasingly vital role in climate adaptation:

- **Mobile Advisory Services:** Apps and SMS services provide farmers with weather forecasts, market prices, and agronomic advice tailored to their location.
- **Early Warning Systems:** Real-time alerts for floods, cyclones, and droughts help farmers take preventive actions to protect crops and livestock.
- **Remote Sensing and GIS Mapping:** These tools are used by government agencies to monitor crop conditions and plan disaster responses.

6. Farmer Education and Community Resilience



Technology and innovation must be paired with **capacity building** to be effective. NGOs, government agencies, and international

organizations are conducting farmer training programs on:

- Climate-smart agricultural techniques.
- Post-harvest management and storage.
- Sustainable pest and nutrient management.

Women, who form a significant part of the rural agricultural workforce, are increasingly being recognized as key stakeholders in building resilient communities. Empowering them through training and microfinance has a multiplier effect on household food security and climate adaptation.



Institutional and Policy Support

Bangladesh has demonstrated strong political will in addressing climate impacts. Key policy frameworks include:

- **Bangladesh Climate Change Strategy and Action Plan (BCCSAP):** A foundational document guiding climate resilience efforts, including agriculture.
- **Delta Plan 2100:** A long-term vision focusing on integrated water management, land use, and food security.
- **National Adaptation Plan (NAP) and Nationally Determined Contributions (NDCs):** Both highlight agriculture as a critical sector for climate adaptation and resilience.

Government agencies such as the Department of Agricultural Extension (DAE) and the Ministry of Environment, Forest and Climate

Change (MoEFCC) coordinate with international donors, NGOs, and the private sector to implement programs at scale.

Challenges to Scaling Resilient Agriculture

Despite notable progress, several barriers remain:

- **Financial Constraints:** Many farmers lack access to credit or insurance to invest in new technologies or recover from climate shocks.
- **Infrastructure Gaps:** Poor roads, storage facilities, and irrigation systems limit the reach of innovations.
- **Policy Fragmentation:** Coordination among ministries and between local and national governments is often lacking.
- **Research and Development Needs:** More localized data and adaptive research are required to tailor solutions to specific regions.
- **Land Tenure and Access:** Marginalized communities, especially in char and haor areas, often lack secure land rights, which hinders long-term investment in resilience.

Toward a Climate-Smart Future

To ensure food security in the face of climate change, Bangladesh must continue to prioritize **climate-smart agriculture (CSA)**—a framework that integrates productivity, adaptation, and mitigation. Key steps include:

1. **Investing in Scalable Innovations:** Promote public-private partnerships for mass dissemination of resilient technologies.
2. **Strengthening Institutional Capacity:** Train extension workers and build integrated data systems for informed decision-making.
3. **Enhancing Market Access:** Improve value chains so farmers can profit from surplus production, encouraging continued investment.

4. **Expanding Risk Management Tools:** Introduce crop insurance schemes and savings products to buffer climate shocks.

5. **Promoting Inclusive Governance:** Engage women, indigenous communities, and youth in planning and implementing adaptation strategies.



As the world warms and the impacts of climate change intensify, the need to transform agriculture from a climate victim to a climate solution becomes urgent. Bangladesh, with its vulnerability and innovation potential, stands at the frontline of this transformation.

Through resilient agriculture, Bangladesh is not only protecting its food supply but also building a model for other developing nations facing similar challenges. With continued investment, collaboration, and innovation, feeding a warming world is not just a challenge—it is an opportunity to build a more sustainable and equitable future for all.



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Reviving Golden Fiber: Climate-Resilient Jute Innovations in Bangladesh

For centuries, **jute** has been synonymous with Bangladesh. Known as the “**Golden Fiber**”, jute once played a central role in the country’s economy, culture, and global trade. Revered for its versatility, biodegradability, and economic value, jute was the lifeblood of rural livelihoods and urban industry. However, over the decades, synthetic alternatives, policy challenges, and outdated production methods diminished its dominance.

Today, amid growing environmental consciousness and the urgent need for **climate-resilient crops**, jute is experiencing a **renaissance**. As Bangladesh faces increasingly erratic weather patterns, soil degradation, and rising salinity, jute is re-emerging not only as an eco-friendly commodity but also as a **strategic crop for climate resilience**.

This article explores the **revival of jute** through innovations, sustainable practices, and climate-smart strategies in Bangladesh. It highlights how modern science, policy

support, and market evolution are breathing new life into the golden fiber, ensuring it remains relevant in a rapidly warming world.

The Historical Significance of Jute in Bangladesh

Bangladesh is historically the **largest producer of high-quality jute**, specifically the *Corchorus capsularis* and *Corchorus olitorius* varieties. During the colonial era and into the mid-20th century, jute was the country’s **most valuable export commodity**, with the bustling jute mills of Narayanganj and Khulna earning Bangladesh global renown.



- In the 1960s and 1970s, jute accounted for **over 70% of export earnings**.
- It provided direct and indirect employment to **millions of farmers and factory workers**.
- The fiber was used in making sacks, ropes, carpets, curtains, upholstery, and even paper.

However, by the late 1980s, **plastic and synthetic fibers** replaced jute products across global markets. Structural challenges, poor innovation, labor unrest, and lack of modernization further contributed to the sector’s decline.

Climate Change and the Return of Jute

The ongoing climate crisis is redefining agricultural priorities worldwide. In Bangladesh, where **climate change affects more than 70% of the population** engaged in farming, jute offers renewed hope:

1. A Natural Climate-Resilient Crop

Jute is inherently **tolerant to floods and heavy rainfall**, making it suitable for Bangladesh's **humid subtropical climate and monsoon ecosystems**.

- Grown during the Kharif season (April to August), jute thrives in **waterlogged or flood-prone areas**.
- It requires minimal chemical inputs and enriches soil by **shedding leaves that decompose into organic matter**.

2. Carbon Sequestration and Sustainability

Jute is a **carbon-negative crop**, absorbing more carbon dioxide than many other crops. One hectare of jute can **absorb up to 15 tons of CO₂** during its growth period.

- Its fibrous stalks regenerate soil structure.
- The plant matures quickly—within 4–5 months—allowing multiple crop rotations.

3. A Boon for Saline and Degraded Lands

With rising sea levels and increasing salinity in southern coastal districts like **Satkira, Khulna, and Bagerhat**, jute varieties tolerant to saline conditions offer an **adaptive livelihood strategy** for affected farmers.



Innovations Driving the Jute Revival

Revitalizing the jute sector requires innovation across the value chain—from seed to fiber to finished product. Recent years have seen a range of technological, genetic, and industrial advances.

1. High-Yield and Climate-Resilient Jute Varieties

The Bangladesh Jute Research Institute (BJRI) has developed **multiple improved jute varieties** to withstand climate variability:

- **BJRI Tossa Jute-8 and 10**: High-yielding, drought and waterlogging tolerant.
- **BJRI Deshi Pat-5**: Short-duration, disease-resistant variety suitable for late sowing.
- **Salinity-Tolerant Varieties**: Being trialed for southern delta regions, ensuring productivity in increasingly brackish soils.

These innovations are backed by participatory field trials and farmer feedback mechanisms to ensure local adaptability.

2. Genome Sequencing and Genetic Engineering

In 2010, Bangladesh made global headlines by becoming the **first country to sequence the jute genome**. This opened up vast opportunities:

- **Gene editing and hybridization** for developing varieties with specific traits—like disease resistance and drought tolerance.
- Enhancing fiber quality through **biotechnological modification**.

The success of genome mapping has positioned Bangladesh as a leader in **fiber crop biotechnology**.

3. Biological Retting Techniques

Retting—the process of extracting fiber from the jute stalk—is traditionally water-intensive and environmentally harmful. However, **microbial and enzyme-based retting methods** are being introduced.

- These methods require **less water**, reduce pollution, and produce **stronger, cleaner fibers**.
- BJRI's **"microbial consortium" retting technology** is being piloted with success in districts like Faridpur and Tangail.

Expanding Applications of Jute in the Green Economy

Reviving jute is not just about restoring old markets—it's about **redefining its utility** in a global green economy.

1. Diversified Jute Products (DJPs)

From household goods to fashion and building materials, DJPs are revolutionizing jute's identity.

- **Eco-friendly shopping bags, sandals, laptop covers, and composites** are being made from jute.
- **Jute geotextiles** are used in erosion control, road construction, and embankment stabilization.
- **Jute-reinforced bioplastics and composites** are gaining international attention as alternatives to petroleum-based materials.

The Bangladesh Jute Research Institute, in collaboration with Dhaka University, has even **developed biodegradable polythene substitutes** from jute cellulose—branded as "Sonali Bag".

2. Automobile and Aviation Applications

International firms are exploring jute composites for **automobile interiors and aircraft panels** due to their strength-to-weight ratio and environmental benefits.

- European car manufacturers like BMW and Mercedes-Benz have tested jute-based materials.
- With proper quality standardization, Bangladesh can enter high-value export markets.

3. Export Market Revitalization

The demand for **sustainable fibers** is growing globally. Countries banning single-use plastics are increasingly turning to jute as an alternative.

- Bangladesh exported **over \$1 billion worth of jute and jute goods in 2022–23**, with key markets in India, Turkey, and the European Union.
- Trade bodies are advocating for **duty-free access and marketing campaigns** to promote DJPs internationally.

Farmer-Centric Approaches to Climate-Ready Jute

To ensure resilience at the grassroots, it's essential to make climate-smart jute innovations **accessible and profitable for smallholder farmers**.



1. Training and Extension Services

The Department of Agricultural Extension (DAE), BJRI, and NGOs provide **farmer field schools** to teach:

- Climate-resilient cultivation techniques.
- Efficient retting and post-harvest handling.
- Integrated pest management (IPM) to reduce chemical use.

2. Input and Market Access

- Access to **certified seeds, fertilizers, retting tanks, and processing tools** is being improved via government subsidies and microfinance.
- Cooperatives and digital platforms like **e-Krishok** are linking farmers with **buyers, exporters, and jute mills**.

3. Women and Youth Engagement

Jute production is labor-intensive, offering employment opportunities, especially for **rural women and youth**.

- Women are engaged in weaving, dyeing, and crafting jute goods for domestic and export markets.
- Startups led by youth are innovating in **jute fashion, packaging, and e-commerce**, reinvigorating the sector with entrepreneurial energy.

Policy and Institutional Support

The Government of Bangladesh has been proactive in repositioning jute as a **strategic crop** for sustainability and economic revival.

Key Policy Measures

- **Mandatory Jute Packaging Act (2010):** Requires 19 essential commodities (like rice and wheat) to be packaged in jute bags.
- **Cash Subsidies and Export Incentives:** The government offers up to **20% subsidies** on jute product exports.
- **Jute Sector Roadmap:** A policy blueprint for increasing jute productivity, enhancing diversification, and improving farmer incomes.

Institutional Players

- **Ministry of Textiles and Jute:** Oversees policy, mill operations, and trade facilitation.
- **BJRI:** Leads research and varietal development.
- **Jute Diversification Promotion Center (JDPC):** Promotes innovative uses and entrepreneurship.
- **Bangladesh Jute Mills Corporation (BJMC):** Though facing financial challenges, it is being restructured to focus on value-added production.

Challenges to Overcome

Despite its potential, the jute sector still faces significant hurdles:

- **Outdated Mill Infrastructure:** Many jute mills are technologically obsolete and financially stressed.
- **Global Market Competition:** Synthetic alternatives are still cheaper in many markets.
- **Inconsistent Raw Material Supply:** Weather variability affects yield and quality.
- **Low Farmer Profitability:** Market price fluctuations, lack of

mechanization, and high labor costs remain concerns.

- **Policy Implementation Gaps:** Delays in enforcement of mandatory jute packaging laws and weak coordination hinder progress.



The Way Forward: A Climate-Resilient Golden Future

To fully unlock the potential of climate-resilient jute, Bangladesh must adopt a **systems approach** that connects innovation, markets, and people.

Strategic Recommendations

1. **Invest in Modernizing Jute Mills:** Through PPPs and foreign direct investment, modernize production lines to meet global standards.
2. **Promote Research-Industry Linkages:** Bridge the gap between scientific innovation and commercial scalability, especially for bioplastics and geotextiles.
3. **Enhance Climate Services for Farmers:** Deploy climate-smart advisories, drought forecasting, and pest surveillance tailored to jute zones.
4. **Foster Green Branding and Certification:** Establish eco-labeling for Bangladeshi jute products to enhance market value and traceability.
5. **Expand Global Diplomacy and Trade Partnerships:** Leverage international forums to promote jute as a flagship sustainable commodity under global green initiatives.

Bangladesh stands at a pivotal moment. Climate change poses existential threats to agriculture, but it also opens new doors for

reimagining how and what we produce. In this context, **jute is more than a fiber—it is a symbol of resilience, innovation, and sustainability.**



Reviving the golden fiber is not a nostalgic project; it is a forward-looking strategy to **build a green economy**, ensure **rural livelihoods**, and contribute to **global climate goals**. Through science, policy, and inclusive growth, Bangladesh can once again make jute a pillar of national pride—and a beacon for a climate-resilient future.



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Dr. Md. Harunur Rashid
Director
SAARC Agricultural Centre (SAC)

“Climate Change and Agriculture in Bangladesh: Prospects and Challenges of Climate-Resilient Crops”

**Interview with the Director,
 SAARC Agricultural Centre (SAC)**



□ Introductory Questions:

Country Editor: How do you think climate change is affecting Bangladesh’s agricultural system?

Dr. Md. Harunur Rashid: Bangladesh’s agriculture is highly vulnerable to climate change. Rising temperatures, erratic rainfall,

increased salinity in coastal areas, and frequent floods and droughts are directly affecting crop production. These impacts reduce yield, damage arable land, and destabilize the food security of millions of smallholder farmers.

Country Editor: What types of initiatives is the SAARC Agricultural Centre undertaking to promote climate-resilient agriculture in Bangladesh?

Dr. Md. Harunur Rashid: SAARC Agricultural Centre has been promoting Climate Smart Agriculture (CSA) across the South Asian region, including Bangladesh. We are working on developing climate-resilient crop technologies, conducting regional training, and supporting national agricultural research institutions with resources, modules, and expertise. Our goal is to build farmers' resilience while ensuring sustainable productivity.



□ Crop & Technology-Related Questions:

Country Editor: Which crops do you consider to be the most promising as climate-resilient crops for Bangladesh?

Dr. Md. Harunur Rashid: Some of the most promising climate-resilient crops for Bangladesh include saline-tolerant rice varieties like BRRI dhan67, drought-tolerant wheat, submergence-tolerant rice like BRRI dhan51 and 52, flood-resistant maize, and short-duration pulses such as mung bean and lentil.

Country Editor: Are these crops only drought-tolerant, or do they also resist salinity and flooding?

Dr. Md. Harunur Rashid: These crops have been specifically developed to cope with multiple climatic stresses. Some varieties are tolerant to salinity and waterlogging, while others can survive prolonged drought or flash floods. Multi-stress tolerance is crucial for Bangladesh due to its geographic and climatic diversity.

Country Editor: How is the SAARC Agricultural Centre contributing to the research and expansion of such crops?

Dr. Md. Harunur Rashid: We provide funding and technical support to national research bodies like BARI and BRRI. We also collaborate with international organizations such as IRRI and IFPRI. SAC conducts research on adaptive crop technologies and shares validated CSA modules across SAARC countries. Our platform enables knowledge exchange and policy dialogue.

Country Editor: In which regions of Bangladesh are these resilient crops currently being cultivated?



Dr. Md. Harunur Rashid: Saline-tolerant rice is being cultivated in the coastal belt including Satkhira, Khulna, and Barisal. Drought-tolerant varieties are used in the north-western regions like Rajshahi and

Rangpur. Submergence-tolerant rice is grown in flood-prone areas of central Bangladesh like Faridpur and Jamalpur.

□ **Research and Innovation:**

Country Editor: Is the SAARC Agricultural Centre collaborating with institutions like BARI, BRRI, or DAE?

Dr. Md. Harunur Rashid: Yes, we actively collaborate with BARI, BRRI, DAE, and other institutions. These partnerships are essential for field trials, farmer training, and scaling up technologies. We also support capacity building through joint research, policy dialogue, and regional workshops.

Country Editor: Has SAC arranged any training or knowledge-sharing programs on Climate Smart Agriculture (CSA) in Bangladesh?

Dr. Md. Harunur Rashid: Absolutely. In recent years, SAC has organized several regional and national workshops on CSA. One of our notable initiatives includes the training and validation of ten CSA modules tailored for South Asian conditions, which were piloted in Bangladesh in collaboration with local stakeholders.

Country Editor: What technologies are farmers using in the cultivation of these crops—such as zero tillage, smart irrigation, or drone-assisted farming?

Dr. Md. Harunur Rashid: While large-scale adoption is still in progress, we've seen promising use of zero tillage, drip irrigation, and alternate wetting and drying (AWD) for rice. Precision agriculture technologies such as mobile-based advisory systems and, in some pilot areas, drones for pest detection and crop monitoring are being tested.

□ Challenges and Solutions:

Country Editor: What are the major challenges facing the cultivation of climate-resilient crops in Bangladesh?

Dr. Md. Harunur Rashid: Challenges include limited access to quality seeds, insufficient extension services, low awareness among farmers, and poor market linkage. Moreover, climate-resilient crops sometimes have lower yields than traditional ones, discouraging adoption without proper incentive mechanisms.

Country Editor: What types of support—such as seed availability or access to technology—should SAC or other international agencies provide?

Dr. Md. Harunur Rashid: We need to ensure timely availability of certified resilient seeds, affordable farm technologies, and customized training. SAC and international partners should also support digital tools for climate forecasting and invest in rural infrastructure like storage and irrigation facilities.

Country Editor: Do you believe the government and policymakers need to be more proactive in this area?

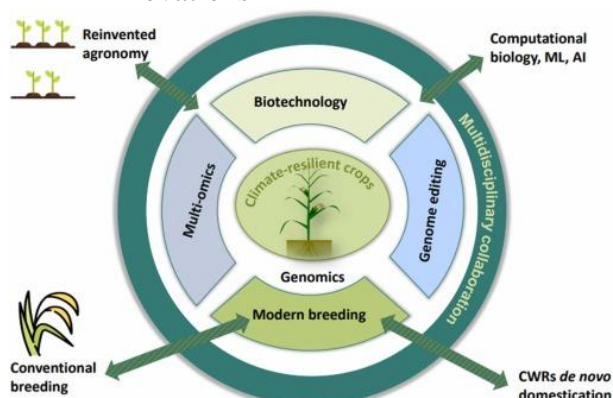
Dr. Md. Harunur Rashid: Yes, proactive policy support is essential. We need climate-smart subsidies, targeted R&D funding, crop insurance schemes, and support for public-private partnerships that promote CSA technologies. Policymakers must prioritize resilience in agricultural planning and budget allocations.

□ Future Plans and Recommendations:

Country Editor: What are SAC's goals or strategic plans for the development of climate-resilient crops in Bangladesh over the next five years?

Dr. Md. Harunur Rashid: Our strategic goals include:

- Expanding the adoption of CSA technologies at grassroots level
- Supporting the development of multi-stress-tolerant crops
- Facilitating policy harmonization across SAARC countries
- Enhancing gender-sensitive approaches in climate adaptation
- Promoting digital agriculture innovations



Country Editor: What advice would you give to a general farmer trying to adapt to changing climate conditions?

Dr. Md. Harunur Rashid: I would urge farmers to remain informed, embrace new crop varieties, adopt water-saving techniques, and work with local agricultural extension offices. Participating in training and trying small-scale trials of new technologies can help reduce risks.

Country Editor: Do you have any message for young agricultural researchers and agripreneurs in Bangladesh?

Dr. Md. Harunur Rashid: Yes—Bangladesh's future food security depends on innovation. I encourage young minds to focus on sustainable, tech-driven, climate-smart solutions. Agripreneurship, smart farming, and agri-startups hold great promise. SAC is ready to support capacity-building initiatives and welcomes youth participation in regional programs.



Malik Khosru PPM
Former AIG

Bangladesh Police

Battling Drought, Heat, and Floods with Science-Driven Solutions: The Case of Bangladesh

Bangladesh, a deltaic nation crisscrossed by hundreds of rivers, is uniquely vulnerable to the accelerating impacts of climate change. Despite contributing minimally to global carbon emissions, Bangladesh finds itself on the front lines of climate-induced disasters such as droughts, heatwaves, and devastating floods. The country's dense population, geographic location, and dependence on agriculture make it especially susceptible. However, science-driven solutions are increasingly becoming the cornerstone of Bangladesh's climate resilience strategy. From early warning systems and climate-smart agriculture to green infrastructure and policy innovation, the country is embracing data, technology, and scientific research to adapt and survive.

A Climate Hotspot Under Pressure

Bangladesh's climate is tropical and monsoonal, with distinct wet and dry seasons. However, shifting weather patterns are disrupting this balance. Droughts are

becoming more frequent in the northwestern region, known as the "Barind Tract," while heatwaves are scorching urban areas with increasing regularity. On the other end of the spectrum, prolonged monsoons and heavy rainfall are causing devastating floods, especially in the low-lying southern coastal areas. These hazards threaten food security, public health, and livelihoods for millions.

In 2023, Bangladesh faced one of its longest and most intense heatwaves in recent memory, with temperatures in some regions crossing 40°C. Simultaneously, erratic rainfall patterns left large areas parched, while others were submerged. Such extreme variability highlights the need for robust, science-led climate adaptation strategies.



Science as the Foundation for Solutions

Bangladesh's vulnerability is undeniable, but so is its commitment to science-led adaptation. Several homegrown and internationally supported initiatives are setting global examples of resilience and innovation.

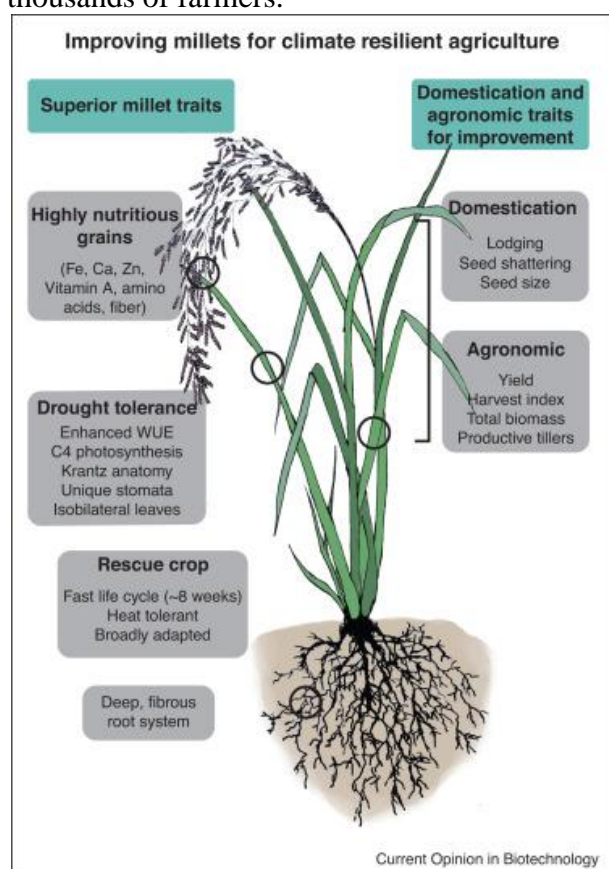
1. Climate-Resilient Agriculture

Agriculture remains the backbone of Bangladesh's economy, employing nearly 40% of the workforce. But climate change has disrupted traditional farming patterns. In response, Bangladesh is investing in climate-resilient agriculture.

The Bangladesh Rice Research Institute (BRRI) has developed several drought- and flood-tolerant rice varieties such as BRRI

Dhan-56 and BRRI Dhan-72. These can survive prolonged dry spells and yield significantly more under stress. Similarly, saline-resistant rice like BRRI Dhan-67 is helping farmers in coastal areas affected by saltwater intrusion due to rising sea levels.

Precision agriculture, supported by satellite data and weather forecasting tools, allows farmers to make better decisions on when to plant, irrigate, and harvest. Initiatives like the *Digital Climate Advisory Services* (DCAS) provide real-time advice via mobile phones to thousands of farmers.



2. Early Warning Systems and Forecasting Models

Bangladesh has made significant progress in developing meteorological infrastructure and early warning systems. The Flood Forecasting and Warning Centre (FFWC), under the Bangladesh Water Development Board, uses remote sensing and hydrological models to provide flood forecasts several days in advance.

The Bangladesh Meteorological Department (BMD), in partnership with global agencies like the Japan Meteorological Agency and the UK Met Office, has enhanced heatwave and cyclone forecasting capabilities. These systems allow the government and humanitarian agencies to prepare better and minimize human and economic losses.

3. Urban Heat Mitigation through Green Infrastructure

Cities like Dhaka and Chattogram are experiencing the urban heat island effect due to unplanned development and loss of greenery. Scientists and urban planners are promoting nature-based solutions, such as rooftop gardens, urban tree planting, and permeable pavements, to counter heat stress. Projects like the “Dhaka Green Belt” aim to restore wetlands and plant thousands of trees around the capital. This not only mitigates heat but also improves air quality and reduces flood risk by enhancing water absorption.

4. Rainwater Harvesting and Drought Resilience

In drought-prone areas, science-driven water conservation techniques are gaining popularity. Rainwater harvesting systems, both at household and community levels, are being promoted by NGOs like BRAC and government agencies.

The Barind Multipurpose Development Authority (BMDA) has introduced solar-powered deep tube wells and drip irrigation systems to optimize water use. Scientific soil mapping and crop rotation models are also helping farmers adapt to declining water tables and changing rainfall patterns.

5. Flood Protection with Smart Infrastructure

While floods are a natural part of life in Bangladesh, climate change has made them more unpredictable and destructive. To address this, the country is investing in smarter flood protection systems.

The Bangladesh Delta Plan 2100, a visionary long-term strategy, integrates scientific

modeling, engineering, and socio-economic planning to manage water resources and build resilience. It emphasizes building embankments, polders, and tidal river management systems that work *with* nature rather than against it.

For instance, in coastal Khulna, a hybrid solution known as “Tidal River Management” (TRM) uses the natural flow of tides to reduce waterlogging and improve soil fertility. This approach has been developed and refined through extensive field studies and local community participation.



6. Community-Based Research and Local Knowledge

Science doesn't operate in isolation. Local knowledge systems and participatory research are integral to sustainable solutions. Organizations like the International Centre for Climate Change and Development (ICCCAD) and the Bangladesh Centre for Advanced Studies (BCAS) conduct action research with rural communities to co-create solutions.

This includes training locals in data collection, piloting solar-based irrigation systems, and testing biodegradable materials for flood-resilient housing. Such initiatives not only enhance adaptation but also empower communities.

Bridging Policy, Science, and Action

The government of Bangladesh recognizes that evidence-based policymaking is key to effective climate action. The country's Climate Change Strategy and Action Plan (BCCSAP) and the National Adaptation Plan (NAP) are rooted in scientific assessment and stakeholder consultation.

Bangladesh is also leveraging international partnerships to access climate finance and technical expertise. Projects funded by the Green Climate Fund (GCF) and Global Environment Facility (GEF) are supporting ecosystem restoration, resilient housing, and capacity building for scientists and local institutions.

Looking Ahead: Challenges and Opportunities

While science-driven solutions offer immense promise, several challenges remain. There is a need for greater investment in research infrastructure, improved data-sharing mechanisms, and better integration of scientific findings into local governance.

Moreover, engaging youth, promoting science education, and building a new generation of climate scientists is critical for sustained resilience. With the right policies, funding, and public support, Bangladesh has the potential to be a global leader in climate adaptation science.

Conclusion

As Bangladesh faces an uncertain climate future, the country's strategy is clear: turn to science, innovation, and community wisdom. The battle against drought, heat, and floods is far from over, but with science-driven solutions leading the way, Bangladesh offers a blueprint for resilience in the face of adversity. Through a fusion of traditional knowledge, cutting-edge research, and policy action, the country is not just surviving—but shaping a sustainable, climate-resilient future.



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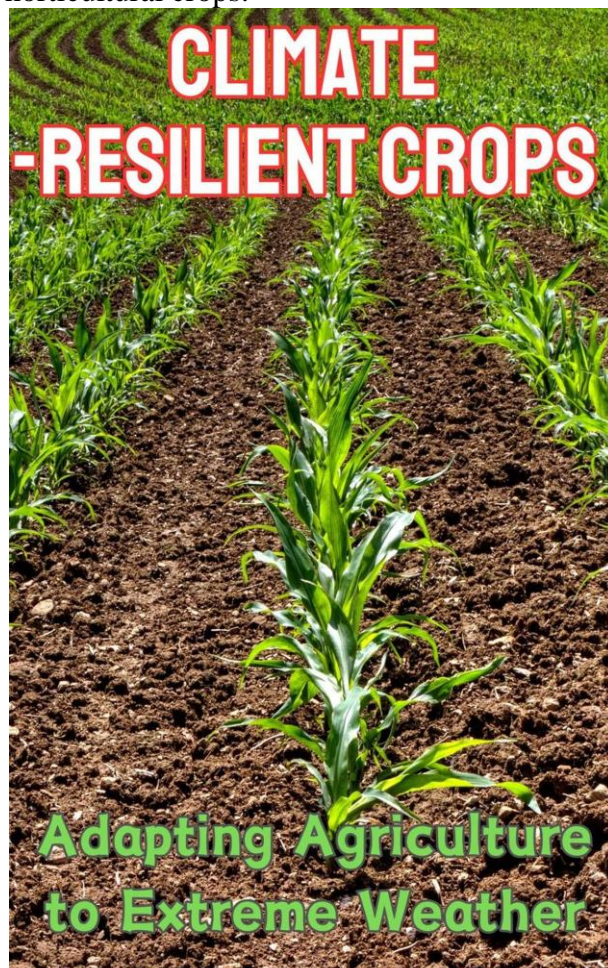
Building a Climate-Ready Horticulture Sector for Bangladesh's Future

Climate change is rapidly altering the agricultural landscape worldwide, and Bangladesh—due to its geographical location, dense population, and heavy dependence on agriculture—is especially vulnerable. While much attention has been given to staple crops like rice and wheat, **horticulture**, which includes the cultivation of fruits, vegetables, flowers, and spices, is an equally vital sector for ensuring **nutritional security, income diversification, and climate resilience**. In the face of increasing temperature fluctuations, erratic rainfall, rising salinity, and frequent extreme weather events, **building a climate-ready horticulture sector** is no longer a choice—it is an urgent necessity for Bangladesh's future.

This article explores the critical role of horticulture in the national food system, the climate-related challenges it faces, and the innovations, strategies, and policy pathways that can drive the transformation toward a more resilient, productive, and sustainable horticulture sector in Bangladesh.

The Importance of Horticulture in Bangladesh

Horticulture is a cornerstone of Bangladesh's rural economy and nutritional well-being. The country produces a wide variety of horticultural crops:



- **Fruits:** Mango, banana, guava, litchi, papaya, jackfruit (the national fruit), pineapple, and citrus.
- **Vegetables:** Brinjal (eggplant), tomato, okra, spinach, bottle gourd, chili, cabbage, cauliflower, and more.
- **Spices:** Garlic, onion, turmeric, ginger, and coriander.
- **Flowers and Medicinal Plants:** Grown mostly in areas like Jashore and Savar, supporting local economies.

Contribution to Economy and Health

- Horticulture contributes significantly to GDP, employment, and export earnings.
- It plays a critical role in **diversifying farm income** and increasing profitability per hectare.
- Fruits and vegetables are essential for **nutrition and food diversity**, helping to combat malnutrition and hidden hunger.
- Many horticultural crops are **high-value and quick-return**, offering livelihood opportunities, especially for women and smallholders.



Climate Change: A Direct Threat to Horticultural Productivity

Horticultural crops are **highly sensitive** to climatic variables such as temperature, rainfall, humidity, and sunlight. These crops often lack the physiological robustness of cereals and are particularly prone to pests and diseases, which are exacerbated by changing climate patterns.

Key Climate-Related Threats to Horticulture in Bangladesh

1. Temperature Extremes:

- Unseasonal heatwaves or cold spells affect flowering, fruit set, and overall yield.
- For example, mango and litchi require specific chilling hours and dry spells to flower, which are being disrupted.

2. Irregular Rainfall and Drought:

- Inconsistent rainfall affects water availability during critical growth stages.
- Water stress during flowering or fruiting significantly reduces yield and quality.

3. Floods and Waterlogging:

- Seasonal floods and sudden flash floods damage root systems and reduce oxygen availability in the soil.
- Vegetables like tomato and chili are particularly vulnerable to prolonged waterlogging.

4. Cyclones and Salinity Intrusion:

- Coastal areas, particularly in Khulna, Satkhira, and Barisal, are facing increasing soil salinity, limiting the scope of horticulture.
- Cyclones also destroy nursery infrastructure and mature orchards.

5. Pests and Diseases:

- Rising temperatures and humidity create favorable conditions for new pests and faster disease cycles.
- Crops like brinjal are under constant attack from fruit and shoot borers, while climate variability is enabling the spread of fungal diseases in cucurbits.



Toward Climate-Ready Horticulture: Strategies and Innovations

To build a climate-ready horticulture sector, Bangladesh must adopt a **multi-dimensional approach** that encompasses technological innovation, ecological farming practices, market development, and institutional support.

1. Climate-Resilient Varieties and Crop Selection



Developing and promoting climate-resilient varieties is a crucial first step.

- **Heat-tolerant tomatoes, cold-tolerant beans, and salt-tolerant spinach** are being developed by research institutes such as BARI (Bangladesh Agricultural Research Institute).
- Crop calendars are being adjusted to align with changing climate windows.
- Indigenous and underutilized crops like drumstick (moringa), amaranth, and local gourds are being reintroduced due to their natural resilience.

2. Protected Cultivation and Controlled Environments

Greenhouses, polyhouses, and net houses offer protection against wind, pests, and excessive rain.

- Low-cost tunnel farming is gaining traction in areas like Bogura and Cumilla.
- These structures also enable **off-season production**, increasing market value and income.
- Drip irrigation and fertigation systems within greenhouses optimize water and nutrient use.

3. Improved Irrigation and Water Management

Water-efficient irrigation techniques are essential in both saline and drought-prone zones.

- **Drip and sprinkler systems** are being promoted through government subsidies.
- **Mulching** (using plastic sheets or organic matter) helps retain soil moisture and suppress weeds.
- **Rainwater harvesting** and pond rehabilitation projects are improving water access during dry months.

4. Vertical and Urban Horticulture

Urban agriculture initiatives using **rooftop gardens, hydroponics, and vertical farms** are gaining popularity in Dhaka and Chattogram.

- These methods reduce pressure on rural land, promote household nutrition, and insulate crops from rural climate impacts.
- NGOs and startups are providing kits, training, and marketing assistance for home-based horticulture.

5. Integrated Pest Management (IPM) and Bio-Control



Chemical pesticide dependency is risky for climate-vulnerable crops.

- **IPM practices** using pheromone traps, neem oil, biopesticides, and resistant crop varieties are being scaled up.
- BARI and the Department of Agricultural Extension (DAE) are providing training on pest surveillance and eco-friendly alternatives.

- Bio-control labs are producing natural enemies like Trichogramma to combat pests organically.

6. Post-Harvest Management and Cold Chains

Climate-induced delays and damages often lead to post-harvest losses of up to 30-40% in vegetables and fruits.

- **Solar-powered cold storage units**, mobile coolers, and improved packaging materials are being piloted.
- Investment in **rural aggregation centers** and collection points helps consolidate produce and reduce spoilage.
- Digital platforms are linking farmers to retailers and consumers directly, reducing market volatility.



Empowering Farmers and Building Capacity

A climate-ready horticulture sector must place **farmers at the center** of the transformation.

1. Training and Extension Services

- DAE field officers and NGOs provide hands-on training in climate-smart horticultural practices.
- Farmer Field Schools and Participatory Learning Approaches enhance peer-to-peer knowledge sharing.

2. Women and Youth Inclusion

- Women are key actors in home gardening and seed preservation.
- Youth-led agribusinesses in nurseries, flower farming, and digital agriculture are emerging across rural Bangladesh.
- Climate-resilient horticulture offers entrepreneurship pathways for marginalized communities.

3. Access to Finance and Insurance

- Crop insurance tailored for high-value horticultural crops is limited but urgently needed.
- Microfinance institutions and banks are piloting **climate-linked credit products**.
- Risk-sharing and subsidy models for technologies like polyhouses or solar pumps can catalyze adoption.

Policy and Institutional Frameworks

The Government of Bangladesh has taken several policy initiatives that support climate-smart horticulture:

Key Policy Instruments

- **Bangladesh Delta Plan 2100:** Integrates climate, water, and agricultural planning with a long-term vision.
- **Seventh and Eighth Five-Year Plans:** Emphasize horticulture diversification and export development.
- **National Agricultural Policy (2018) and NAP:** Support adaptive agricultural practices, including in horticulture.

Institutional Support

- **Hortex Foundation** under the Ministry of Agriculture promotes high-value horticulture for domestic and export markets.
- **BARI Horticulture Wing**, NGOs like BRAC and iDE, and international partners (FAO, IFAD) are working collaboratively to expand outreach and capacity.



Opportunities and Future Directions

Bangladesh stands at a critical crossroads. The future of its horticulture sector depends on **embracing innovation, building climate resilience, and creating enabling ecosystems** for smallholders and entrepreneurs.

1. Digital and Smart Agriculture

- Satellite monitoring, AI-powered pest forecasting, and remote sensing tools can provide real-time guidance to farmers.
- Mobile apps for weather alerts, disease detection, and market linkages (e.g., eKrishi, Krishoker Janala) are proving effective.

2. Export and Value Chain Development

- Export potential for mangoes, pineapples, and flowers can be unlocked through certification, branding, and cold chain improvements.
- Value addition through **processing (e.g., dried mango, spice powder, pickles)** can stabilize prices and reduce waste.

3. Climate Risk Mapping and Zoning

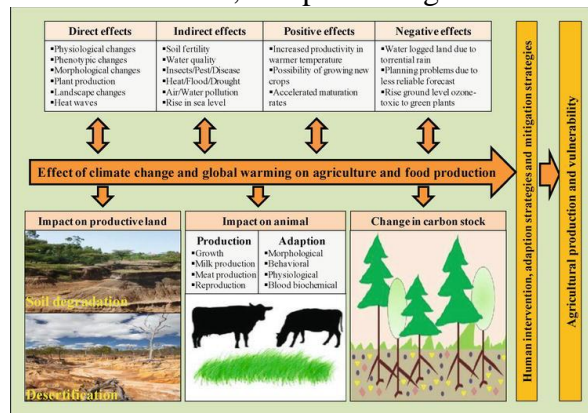
- Agro-ecological zoning maps need to be updated to reflect new climate realities.
- Climate risk assessments can guide localized interventions for different crops and regions.

4. Research and Innovation Hubs

- Investment in **horticultural research hubs** focused on climate adaptation

will accelerate the development of suitable technologies.

- Public-private partnerships (PPPs) can fund innovations in seeds, protected cultivation, and processing.



In an era of unprecedented climate uncertainty, Bangladesh's **horticulture sector holds immense promise**—not only as a source of food and nutrition but also as a pathway to economic resilience and environmental sustainability. However, realizing this promise requires a **paradigm shift** in how we grow, manage, and value horticultural crops.

From salt-tolerant spinach in the coastal belts to rooftop tomatoes in Dhaka, the country is already experimenting with new models of adaptation. The future lies in **scaling these innovations, supporting farmers, and building an inclusive, climate-smart horticulture ecosystem** that can thrive in the face of climate challenges.

With strategic investments, strong institutions, and community-driven action, Bangladesh can not only build a climate-ready horticulture sector but also become a model for other climate-vulnerable nations navigating the path toward agricultural resilience.

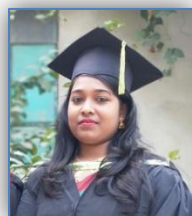


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Safeguarding Bangladesh's Fruits and Vegetables in a Changing Climate

Bangladesh, a fertile land crisscrossed by more than 700 rivers, has long enjoyed a thriving tradition of fruit and vegetable cultivation. The nation's favorable climatic conditions, rich soils, and diverse agro-ecological zones have made it one of the most productive countries for horticulture in South Asia. From the luscious mango orchards of Rajshahi to the expansive fields of winter vegetables in the north and the bountiful guava plantations in Barisal, horticulture plays an indispensable role in the country's food security, nutrition, and rural economy.

However, the idyllic narrative is increasingly being rewritten by the global climate crisis. Bangladesh's geographical location and dense population render it especially vulnerable to the impacts of climate change. Rising temperatures, erratic rainfall, prolonged droughts, intensified floods, saline intrusion, and shifting seasons are now recurring threats that jeopardize fruit and vegetable production. In the face of these adversities, Bangladesh must turn to innovation, technology, and

science-driven strategies to protect and promote this crucial agricultural sector.

This article explores the multifaceted impact of climate change on Bangladesh's horticulture, the emerging science-based solutions, policy responses, and the road ahead to ensure a resilient and sustainable future for the country's fruits and vegetables.

1. The Role of Horticulture in Bangladesh

1.1 Economic Significance

Horticulture contributes approximately 16% to Bangladesh's agricultural GDP and engages millions in direct and indirect employment.

Popular crops include:

- **Fruits:** Mangoes, jackfruits, bananas, guavas, lychees, coconuts, watermelons.
- **Vegetables:** Brinjal (eggplant), tomatoes, spinach, gourds, cucumbers, beans, radish, and chili.



The increasing demand for fresh produce in both domestic and export markets highlights the sector's growing economic potential. Moreover, the sector supports women's employment, smallholder livelihoods, and nutrition-sensitive farming.

1.2 Nutritional Importance

Fruits and vegetables are essential components of a balanced diet. In a country where malnutrition and micronutrient deficiencies are still prevalent, the promotion of horticulture offers a vital strategy for improving public health. However, access to affordable, high-quality produce is threatened by climate shocks and supply disruptions.

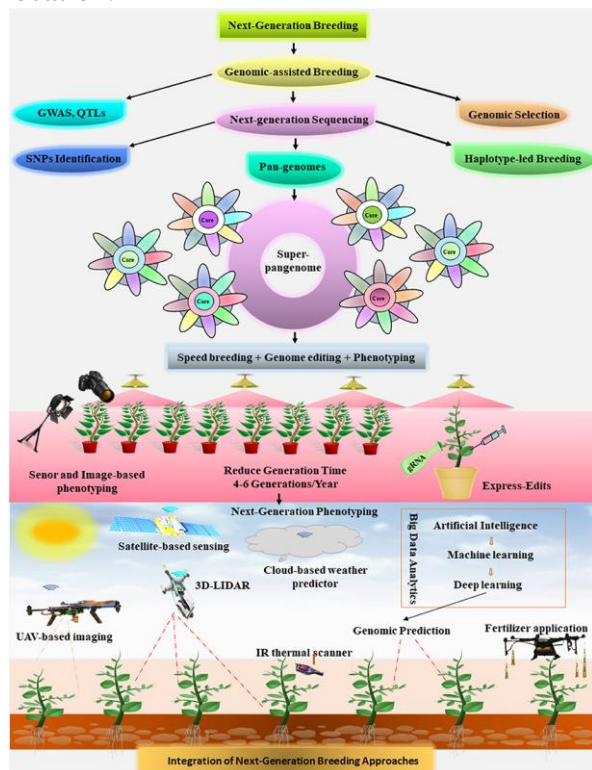
2. How Climate Change Threatens Horticulture

2.1 Rising Temperatures and Heat Stress

Bangladesh has witnessed a steady increase in average temperatures, especially during the pre-monsoon and summer seasons. This is particularly damaging to temperature-sensitive crops:

- Mango and litchi flowering and fruit setting are disturbed by early-season heat.
- Leafy vegetables like spinach and coriander wilt or become bitter in extreme heat.
- Tomato, cauliflower, and capsicum yields drop when exposed to prolonged high temperatures.

A 1–2°C rise can reduce vegetable yields by up to 10–25%, depending on the crop and location.



2.2 Erratic Rainfall and Droughts

Rainfall in Bangladesh has become increasingly unpredictable. Prolonged dry spells during critical growing periods cause:

- Wilting and stunted growth in vegetables.

- Fruit cracking due to sudden hydration after drought.
- Soil moisture depletion, reducing nutrient uptake.

The northwest region, especially Rajshahi and Dinajpur, faces recurrent droughts that disrupt planting schedules and harvests.

2.3 Intensified Flooding and Waterlogging

Bangladesh is known for seasonal floods, but climate change has exacerbated both their frequency and intensity. Horticultural impacts include:

- Rotting of root vegetables like onions, carrots, and potatoes.
- Disruption of planting cycles.
- Infrastructure damage (seedbeds, irrigation systems, storage units).

Flash floods in northeastern haor areas (e.g., Sunamganj) often destroy standing crops within hours.

2.4 Salinity Intrusion in Coastal Areas

Sea-level rise and cyclonic storm surges are leading to higher salinity in coastal districts like Khulna, Satkhira, and Bagerhat.

- Many common vegetables and fruits are sensitive to salinity.
- Soil degradation and saline groundwater limit cultivation options.
- Coconut, banana, and watermelon face reduced productivity in salinized zones.

2.5 Shifting Growing Seasons

Climate variability is leading to unpredictable seasonal changes, making traditional planting calendars less reliable. This affects crop phenology (e.g., flowering, fruiting, and harvesting times) and poses challenges for planning, pest control, and market supply.

3. Science-Driven Solutions to Safeguard Horticulture

Bangladesh is embracing a suite of scientific interventions and technologies to mitigate these challenges and build climate resilience in horticulture.

3.1 Development of Climate-Resilient Crop Varieties

The Bangladesh Agricultural Research Institute (BARI), Bangladesh Rice Research Institute (BRRI), and various universities are at the forefront of developing improved cultivars.



Key innovations include:

- **Heat-tolerant tomato and cauliflower varieties.**
- **Drought-tolerant pumpkin and brinjal strains** for the northwest.
- **Salinity-tolerant watermelon, spinach, and okra** for the southwest.
- **Short-duration fruit varieties** like early-bearing guava and papaya that mature before monsoon or flooding.

Biotechnology and traditional breeding techniques are being combined to ensure that new varieties remain accessible to smallholders.

3.2 Improved Irrigation and Water Management

Efficient water use is critical in drought-prone and water-scarce areas.

- **Drip and sprinkler irrigation systems** minimize water loss and maintain consistent soil moisture.
- **Rainwater harvesting** structures allow off-season vegetable production in dry zones.

- **Raised beds and furrow systems** prevent waterlogging during floods.

Solar-powered pumps, promoted through public-private partnerships, provide sustainable and cost-effective irrigation solutions.

3.3 Protected and Controlled Environment Agriculture

Technologies like greenhouses, low tunnels, and shade nets are gaining popularity for off-season and high-value vegetable farming.

Benefits include:

- Reduced exposure to heat, pests, and excessive rainfall.
- Stable microclimates for sensitive crops.
- Enhanced productivity and year-round cultivation potential.

Farmers in peri-urban Dhaka and Chattogram have adopted these methods to supply high-demand produce to city markets.

3.4 Integrated Pest and Disease Management (IPM)

Climate change has intensified pest attacks and disease outbreaks. Warmer temperatures favor the rapid reproduction of pests like whiteflies, aphids, and fruit borers.

IPM techniques include:

- Use of pheromone traps and biological control agents.
- Organic pesticides made from neem and garlic extracts.
- Rotational cropping and intercropping with pest-repellent species.

The Department of Agricultural Extension (DAE) offers training and field demonstrations to promote IPM at the grassroots level.

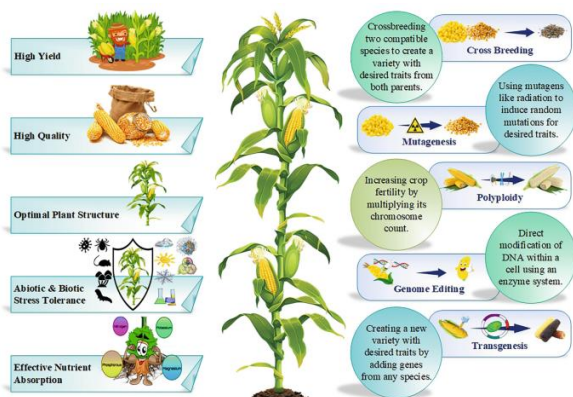
3.5 Digital Agriculture and Climate Advisory Services

Access to real-time climate information is vital for decision-making.

- **Mobile apps and SMS alerts** deliver localized weather forecasts and planting tips.

- **Agri-call centers** offer expert advice on pest outbreaks and irrigation management.
- Farmers are using remote sensing and GIS maps to monitor soil conditions and rainfall trends.

Projects like **Digital Climate Services for Farmers (DCSF)** and **Krishi Bot** are bringing AI-based assistance to rural users.



4. Post-Harvest Innovations and Supply Chain Resilience

Climate shocks frequently disrupt supply chains and cause post-harvest losses.

4.1 Cold Storage and Transportation

Lack of refrigeration leads to spoilage of perishable items like tomatoes, bananas, and leafy greens. The government and private sector are investing in:

- **Rural cold storage facilities** for vegetables and fruits.
- **Refrigerated transport systems** to connect remote growers to urban markets.
- Mobile cooling units that serve multiple villages.

4.2 Value Addition and Agro-Processing

Processing extends shelf life and opens up new income streams for farmers.

- Mango pulp, chili powder, dried jackfruit, and pickled vegetables are being packaged for domestic and export markets.
- Cottage industries, often run by women, are adding value through solar drying and home-based processing.

4.3 Market Information Systems

Digital platforms that provide real-time market prices and buyer-seller linkages help farmers make better decisions and avoid distress sales.



5. Policy Framework and Institutional Support

Bangladesh has formulated several policies and programs to address climate risks in agriculture.

5.1 National Policies

- **Bangladesh Climate Change Strategy and Action Plan (BCCSAP)**: Emphasizes climate-resilient agriculture, research, and capacity-building.
- **National Agricultural Policy 2018**: Promotes diversification and sustainable horticulture.
- **Delta Plan 2100**: Long-term vision incorporating climate adaptation, water management, and land use planning.

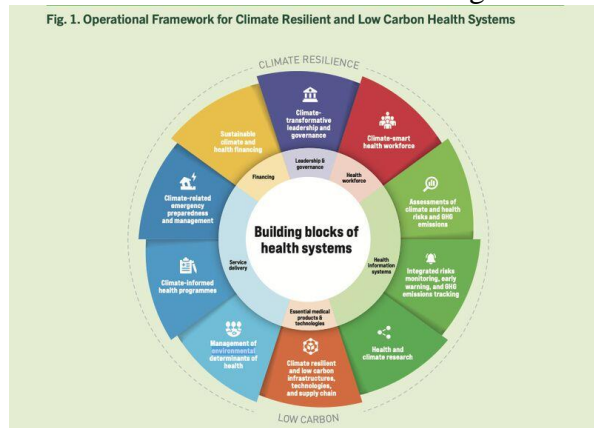
5.2 Investment in Research and Extension

- **Bangladesh Agricultural Development Corporation (BADC)** and **DAE** are strengthening seed distribution, irrigation support, and farmer training.
- **Research collaborations** with international institutes like IRRI, CIMMYT, and World Vegetable Center are fostering innovation.

5.3 Climate Financing and Insurance

- The **Bangladesh Climate Change Trust Fund (BCCTF)** has financed over 700 adaptation projects.

- **Index-based crop insurance schemes** are being piloted to cover horticultural losses due to floods and droughts.



6. Community-Based Adaptation and Gender Inclusion

Climate resilience cannot be achieved without community ownership and inclusive strategies.

6.1 Participatory Approaches

- Farmer Field Schools (FFS) and participatory varietal selection (PVS) empower communities to test and choose suitable innovations.
- Community seed banks and collective marketing groups enhance resilience.

6.2 Women in Climate-Smart Horticulture

Women play a critical role in vegetable gardening, seed preservation, and post-harvest activities. Gender-focused training and microcredit are enabling women to adopt improved practices and lead local adaptation efforts.

7. Challenges and the Way Forward

7.1 Persistent Barriers

- Limited access to credit and inputs among smallholders.
- Inadequate extension coverage in remote regions.
- Weak coordination among ministries, research centers, and the private sector.
- Infrastructure gaps (storage, transport, market facilities).

7.2 Future Strategies

To secure the future of horticulture in a warming world, Bangladesh should:

- Scale up climate-smart agriculture hubs in key regions.
- Expand public-private partnerships for technology dissemination.
- Strengthen climate education in agricultural universities.
- Promote youth entrepreneurship in horticulture and agri-tech.
- Enhance monitoring and early warning systems for extreme weather events.



Bangladesh's fruits and vegetables are more than just produce—they are a vital lifeline for nutrition, livelihoods, and cultural identity. As climate change reshapes the landscape of agriculture, the country stands at a critical juncture. The path forward lies in embracing science-driven solutions, empowering communities, and integrating resilience into every step of the horticultural value chain.

With sustained investment, visionary policy, and inclusive innovation, Bangladesh can not only safeguard its fruits and vegetables but turn its climate challenges into a catalyst for transformation—ensuring food security, economic prosperity, and environmental sustainability for generations to come.



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From Vulnerable Fields to Climate-Ready Farms

Reimagining Agriculture in the Age of Climate Crisis

Across the globe, climate change is redrawing the boundaries of possibility in agriculture. For millions of farmers, especially in developing nations like Bangladesh, the once predictable rhythm of the seasons has given way to a troubling uncertainty. Unseasonal rains, longer droughts, rising temperatures, and saline intrusions now threaten not just crops—but entire communities. Fields once fertile and abundant are becoming barren, vulnerable, and increasingly risky to cultivate. But amid this looming crisis lies a powerful opportunity—to transform agriculture into a climate-resilient, adaptive, and sustainable force for food security and environmental stewardship. This transformation, from vulnerable fields to climate-ready farms, is not just desirable—it is essential. It demands innovation in science, rethinking in policy, and empowerment at the grassroots.

This article dives deep into this critical transition, examining the risks faced by today's farmers, the science behind climate-

resilient agriculture, and the systemic changes needed to secure a food-secure future for all.

Chapter 1: Understanding Vulnerability in Agriculture

1.1 The Fragility of Traditional Farming Systems

Traditional farming systems, especially those in developing countries, have long depended on the consistency of climatic patterns. Monsoons were expected to arrive on time, floods came and went in familiar cycles, and soil fertility remained stable with predictable cropping. But with global temperatures rising and weather patterns becoming erratic, this balance has been shattered.

For instance, a farmer in northern Bangladesh now faces both early-season drought and late-season flash floods—an almost impossible combination for rice cultivation. Crop calendars have been upended, pest patterns have changed, and irrigation sources are drying up. This has left fields more fragile and farmers more exposed.



1.2 Economic and Social Risks

Beyond environmental vulnerability, there are socio-economic consequences. Crop failure

means financial loss, hunger, and sometimes forced migration. Women and smallholder farmers are often the hardest hit. According to FAO, more than 80% of the world's food is produced by small-scale farmers, many of whom lack access to crop insurance, modern technology, or extension services.

In many regions, the rising cost of inputs like fertilizers and water, coupled with declining yields, is driving farmers into debt. Mental health issues, suicides, and rural displacement are emerging as secondary crises rooted in agricultural vulnerability.

Chapter 2: What Makes a Farm Climate-Ready?

2.1 Climate Resilient Crops

At the heart of climate-ready farming lies innovation in crop science. Researchers are developing crop varieties that can withstand abiotic stresses like drought, salinity, heat, and flood. These are not just genetically modified organisms (GMOs), but also traditionally bred varieties strengthened through advanced selection techniques.

Examples include:

- **Drought-tolerant maize** in sub-Saharan Africa.
- **Flood-resistant “scuba rice”** in South Asia, which survives submersion for up to two weeks.
- **Salt-tolerant wheat and rice** strains being tested in coastal regions.

Such crops enable farmers to maintain productivity even under extreme conditions.

2.2 Soil and Water Management

Climate-ready farms emphasize the health of the soil. Techniques like conservation agriculture, minimal tillage, crop rotation, and composting help maintain organic matter and water retention capacity in soil. Mulching and cover cropping reduce erosion and protect against heat.

Water-smart farming is also key. Drip irrigation, rainwater harvesting, and solar-powered pumps are helping reduce

dependency on unreliable rainfall while using water more efficiently.

2.3 Precision and Digital Farming

Technology is also bringing precision to the field. With mobile apps, satellite monitoring, and AI-driven forecasting, farmers can now access real-time information about weather, soil conditions, pest outbreaks, and best planting practices.

Digital climate advisory systems are already supporting millions of farmers in India, Kenya, and Bangladesh, helping them make informed decisions based on hyper-local data.

Chapter 3: Building a System That Supports Transformation



3.1 Policy Shifts and Institutional Support

Government policies must be realigned to incentivize climate resilience over short-term yield maximization. This includes:

- Providing subsidies for climate-resilient seeds, solar irrigation, and organic inputs.
- Establishing minimum support prices for risk-prone but ecologically sound crops.
- Expanding crop insurance schemes that include climate-induced disasters.

Institutions like agricultural universities and extension services must be re-equipped to deliver climate education, not just traditional agronomy.

3.2 Finance and Investment

Financing the transition is crucial. Climate-resilient agriculture requires initial investments—in new seeds, technologies, and infrastructure. Microfinance institutions, banks, and governments must create farmer-friendly credit instruments.

Global climate funds, such as the Green Climate Fund (GCF), can be directed toward national adaptation programs in agriculture. Involving the private sector through public-private partnerships (PPPs) can also accelerate adoption.



3.3 Empowering Women and Marginalized Farmers

Resilience cannot be achieved without inclusivity. Women make up nearly half the agricultural workforce in developing countries, yet they have less access to land, credit, and training. Empowering them with decision-making roles and technical support can double the impact of climate-ready strategies.

Similarly, landless laborers and indigenous communities—often the first victims of climate disasters—must be integrated into policy responses.

Chapter 4: Case Studies of Transformation

4.1 Bangladesh's Climate-Smart Villages

In the coastal belt of Bangladesh, where saltwater intrusion is a growing threat, climate-smart villages are demonstrating integrated solutions. Farmers are growing salt-tolerant rice alongside fish in polders (embanked fields), combining aquaculture and agriculture.

With solar pumps, floating gardens, and real-time weather alerts via mobile, these villages are turning adversity into opportunity.

4.2 Ethiopia's Regreening Movement

Ethiopia, once facing desertification and famine, is restoring degraded lands through agroforestry. Farmers are intercropping trees with crops to improve soil fertility, prevent erosion, and capture carbon. The result: higher yields, better income, and restored biodiversity.

4.3 India's Water-Positive Farming in Maharashtra

In Maharashtra, India, community-led watershed management has turned drought-prone districts into water-positive zones. With check dams, recharge wells, and community farming collectives, farmers are reducing their reliance on erratic monsoons.

Chapter 5: Climate-Ready Farms as Agents of Environmental Restoration

5.1 Carbon Sequestration and Biodiversity

Climate-ready farms are not just passive victims of climate change—they can actively combat it. Practices like agroforestry, organic farming, and conservation agriculture can turn farms into carbon sinks. Healthier soil stores more carbon. More trees increase biodiversity and protect pollinators.

This approach aligns agriculture with global climate goals, including the Paris Agreement and the UN's Sustainable Development Goals (SDGs).

5.2 Reducing Emissions from Agriculture

Methane from rice paddies and livestock, nitrous oxide from fertilizers, and CO₂ from tillage are major contributors to greenhouse gas emissions. Climate-ready farms use techniques like alternate wetting and drying in rice fields, integrated pest management (IPM), and organic manures to lower emissions.

Reducing food loss through better storage and logistics further strengthens resilience while lowering environmental impact.

Chapter 6: Youth, Innovation, and the Future of Farming

6.1 Engaging the Next Generation

A sustainable agricultural future hinges on young people. But many rural youth see farming as a livelihood of last resort. By integrating climate resilience, technology, and entrepreneurship into agriculture, we can make it a sector of innovation and pride.

Programs like hackathons for agri-tech solutions, climate fellowships, and youth cooperatives can mobilize energy and ideas to solve local climate challenges.

6.2 Role of Education and Research

Agricultural education must evolve. Climate science, sustainability, regenerative agriculture, and digital tools must become core subjects in agri-institutes. Research centers must prioritize local adaptation needs, and collaborate with global institutions to fast-track innovations.



Conclusion: The Path Forward

The journey from vulnerable fields to climate-ready farms is one of the most critical transformations of our time. It is about more than food security—it is about dignity, survival, and planetary health. While the challenges are immense, the tools, knowledge, and will to act are within reach.

Governments must lead with bold policy. Scientists must innovate with local relevance. Farmers must be empowered with rights, resources, and respect. And society must recognize the farmer—not as a passive recipient of aid, but as a frontline warrior in the battle against climate change.

From the fields of Bangladesh to the plains of Africa, from mountain farms in Nepal to drought zones in California, this transformation is underway. The seeds of

resilience have been planted. It is now time to nurture them into a new harvest—one of hope, security, and a climate-ready future for all.



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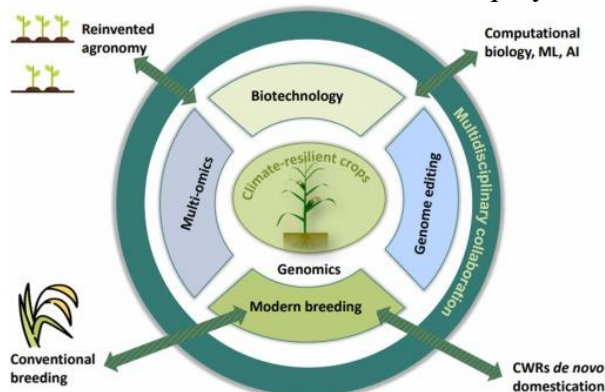
Redesigning Agriculture for an Unpredictable Planet

A Blueprint for Resilient, Regenerative, and Inclusive Food Systems

The agricultural landscape of the 21st century is being shaped by one of the greatest challenges of our time: an increasingly unpredictable planet. Climate change, resource scarcity, population growth, and geopolitical shocks are disrupting global food systems and forcing a fundamental rethinking of how we produce, distribute, and consume food. The traditional agricultural model—linear, extractive, and reliant on stable environmental conditions—is no longer sufficient. We are now living in a time when a single flood, drought, or pest outbreak can devastate an entire season's harvest.

Against this backdrop, redesigning agriculture is not merely an option—it is a necessity. The future of farming must be climate-smart, technologically empowered, environmentally sustainable, socially inclusive, and economically viable. This article explores how we can transform agriculture to meet the

demands of an unpredictable planet, with a focus on resilience, innovation, and equity.



Chapter 1: The New Normal—Why Change Is Urgent

1.1 A Planet Out of Balance

Our planet is entering a phase of extreme ecological volatility. Rising temperatures are altering precipitation patterns, disrupting pollination cycles, and increasing the frequency of extreme weather events such as heatwaves, storms, and wildfires. The Intergovernmental Panel on Climate Change (IPCC) warns that unless global emissions are drastically reduced, food production could fall by up to 30% in some regions by 2050.

1.2 The Limits of Traditional Agriculture

Traditional farming practices—monoculture cropping, excessive chemical use, over-reliance on groundwater, and deforestation—have contributed significantly to environmental degradation. These systems, while once productive, are ill-equipped to handle modern stresses. They are vulnerable to soil degradation, water stress, pest infestations, and changing climate patterns.

In regions like Sub-Saharan Africa, South Asia, and Latin America, farmers are already witnessing crop failures, livestock deaths, and land loss. Food insecurity is on the rise. This crisis calls for a total redesign of the agricultural paradigm.

Chapter 2: Principles of Climate-Resilient Agriculture

2.1 Diversification: The First Line of Defense

Resilience begins with diversity. Monocultures may offer short-term efficiency, but they collapse in the face of climatic shocks. Diversifying crops, livestock, and income sources makes farms more adaptable. Intercropping, agroforestry, and polyculture systems mimic natural ecosystems and enhance ecological balance.

In India's Deccan Plateau, traditional millet farming—a highly diversified and drought-tolerant system—is being revived with impressive results. Yields are stable, nutritional value is high, and soil health is improving.

2.2 Soil as a Living System

Healthy soils are the foundation of sustainable agriculture. Practices like no-till farming, composting, green manure, and cover cropping regenerate the soil's biological activity. Healthy soil retains more water, stores more carbon, and requires fewer chemical inputs.

Soil organic matter is a buffer against drought and flood—making it a key tool in climate adaptation. Redesigning agriculture means treating soil as a living ecosystem, not a production surface.

2.3 Water Intelligence

Water scarcity is now a global concern. Agriculture consumes 70% of freshwater resources worldwide. In many areas, unsustainable irrigation practices are depleting aquifers and drying rivers.

Climate-smart water solutions include:

- **Drip and sprinkler irrigation** to minimize waste.
- **Rainwater harvesting and micro-dams** to store seasonal rains.
- **Moisture sensors and AI tools** to optimize irrigation.

In arid regions of Israel and Australia, digital water management is enabling farmers to maintain productivity with minimal water.

Chapter 3: Leveraging Technology for Resilient Farming

3.1 Digital Agriculture

From AI to IoT, technology is revolutionizing farming. Drones can monitor crop health, satellites can predict pest outbreaks, and mobile apps can deliver weather updates and market prices directly to farmers. This real-time data allows farmers to make smart decisions, reduce losses, and increase efficiency.

In Kenya, the platform "Digital Green" connects farmers with extension workers through video tutorials in local languages. The result: improved practices and increased resilience.



3.2 Climate-Resilient Seeds and Biotech

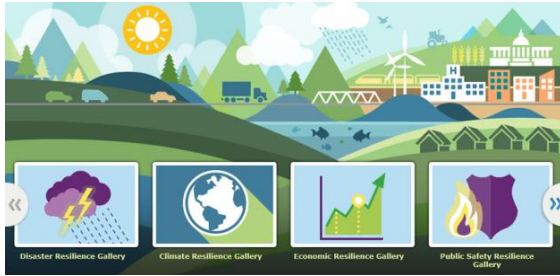
The development of heat-tolerant, drought-resistant, and pest-resistant seeds is accelerating. CRISPR gene-editing and marker-assisted breeding are enabling faster, more precise improvements in crop genetics. These innovations are critical in regions where climate variability is extreme.

In Bangladesh, flood-tolerant rice varieties like **BRRI Dhan 51 and 52** are allowing farmers to recover harvests after submergence. In Africa, drought-resistant maize is reducing yield losses during dry spells.

3.3 Renewable Energy for Agro-Processing

Farms of the future will need to be energy-smart. Solar-powered pumps, biogas digesters, and wind-powered cold storage units are already helping farmers reduce their reliance on fossil fuels. These technologies cut costs and reduce greenhouse gas emissions—an

essential step in making agriculture part of the climate solution.



Chapter 4: Rethinking Supply Chains and Food Systems

4.1 Localized Food Systems

Globalized food supply chains are vulnerable to disruption—from pandemics to geopolitical tensions. Resilient agriculture must be supported by more localized, circular food systems that prioritize local production, processing, and consumption.

Community-supported agriculture (CSA), urban farming, and farm-to-table networks reduce the distance between farmers and consumers, lower carbon footprints, and strengthen food security.

4.2 Reducing Food Waste

Nearly one-third of all food produced globally is wasted. In an unpredictable world, we cannot afford this inefficiency. Redesigning agriculture must involve better storage, transportation, and logistics.

Low-cost cold storage units, mobile markets, and improved packaging can dramatically reduce post-harvest losses—especially in perishable crops like fruits and vegetables.

4.3 Sustainable Agribusiness and Market Access

Farmers need fair, reliable markets. Digital platforms are opening up new marketing channels, while traceability systems ensure food safety and quality. Policies that link smallholder farmers to institutional buyers—like schools, hospitals, and government programs—can stabilize incomes and encourage sustainable practices.

Chapter 5: Regenerative Agriculture—Healing the Planet While Feeding It

5.1 Beyond Sustainability

Sustainability aims to do no harm. Regeneration goes further—it seeks to heal. Regenerative agriculture focuses on rebuilding soil, increasing biodiversity, enhancing ecosystem services, and restoring degraded lands.

Practices include:

- Integrating livestock and crops.
- Rotational grazing to restore grasslands.
- Reforesting farmlands with native species.
- Eliminating synthetic chemicals.

Regenerative farms store more carbon, resist climate extremes better, and often produce healthier food. Companies like Patagonia and Nestlé are now investing in regenerative supply chains, signaling a shift in global food business.

5.2 Carbon Farming and Ecosystem Services

Farmers can become stewards of the planet by participating in carbon markets and ecosystem service programs. Paying farmers for storing carbon, preserving wetlands, or enhancing pollination could be the next big frontier in agricultural economics.

Pilot projects in Australia and the U.S. are already showing that this model can support both climate goals and rural livelihoods.



Chapter 6: Equity, Inclusion, and the Human Face of Farming

6.1 The Role of Women in Climate-Resilient Agriculture

Women are central to global agriculture, yet they face systemic barriers to land, credit,

education, and decision-making. Empowering women farmers leads to better outcomes for nutrition, income, and resilience.

Programs offering climate-smart tools, leadership training, and access to finance for women are closing the gender gap in farming.

6.2 Supporting Indigenous Knowledge and Agroecology

Indigenous communities have practiced resilient agriculture for centuries. Their knowledge—of seed saving, water harvesting, and soil regeneration—must be recognized, preserved, and scaled. Agroecology, the science of applying ecological principles to agriculture, often aligns with these traditional systems.

Collaborative models that bridge science and tradition are proving especially effective in Latin America, Southeast Asia, and parts of Africa.

6.3 Youth and the Future of Farming

The average age of farmers is rising. To redesign agriculture, we must attract young people to the sector. This means:

- Making agriculture profitable.
- Promoting agri-tech startups and innovation hubs.
- Integrating agriculture into climate and digital education.

Youth-led climate action in agriculture is already emerging, with social enterprises, vertical farms, and AI-powered advisory services gaining momentum.

Chapter 7: Policy, Investment, and Global Cooperation

7.1 Rethinking Agricultural Subsidies

Globally, more than \$700 billion is spent annually on agricultural subsidies. Much of this supports carbon-intensive practices. Redirecting subsidies toward climate-resilient and regenerative practices can trigger large-scale transformation.

Countries must reform agricultural policies to support climate adaptation, risk insurance,

biodiversity protection, and smallholder inclusion.

7.2 Public and Private Investment

Climate-smart agriculture needs funding. This includes investment in R&D, infrastructure, training, and credit. Governments, donors, and private companies must collaborate to de-risk innovation and scale successful models.

Impact investing and blended finance tools are already mobilizing billions of dollars into sustainable agriculture.

7.3 International Frameworks

Agriculture must be central to climate negotiations. Frameworks like the Koronivia Joint Work on Agriculture (UNFCCC) and the Sustainable Development Goals (SDGs) provide platforms for international cooperation.

Global food systems summits and regional climate platforms must prioritize agriculture as both a contributor to and solution for climate change.



Conclusion: A Blueprint for the Future

Redesigning agriculture for an unpredictable planet is one of humanity's greatest challenges—and greatest opportunities. It is not just about growing more food; it is about growing food differently—resiliently, regeneratively, inclusively, and intelligently.

It means embracing diversity in crops and people. It means honoring tradition while harnessing innovation. It means empowering farmers as climate heroes, not as victims of a broken system.

This transformation is already underway—from climate-smart villages in Bangladesh to regenerative ranches in the U.S., from youth-led agri-tech labs in Kenya to agroecology schools in Brazil. The blueprint is clear. What's needed now is bold leadership, inclusive policymaking, and shared global vision.

The future of food lies not in the past, nor in business-as-usual, but in courageous redesign. Let us sow the seeds of a new agricultural revolution—one that can nourish both people and planet for generations to come.

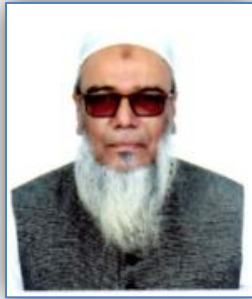


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**From Crisis to Cultivation: Building
 Climate-Ready Agriculture
 Rethinking Food Systems for a Resilient
 Future**



We are living in an era marked by the overlapping crises of climate change, environmental degradation, population growth, and global food insecurity. Nowhere is this convergence more visible—and more

urgent—than in agriculture. Once the backbone of civilization, agriculture is now increasingly a frontline victim of a rapidly warming planet. But it also holds the key to global survival.

Farming systems around the world are struggling. Erratic rainfall, rising temperatures, prolonged droughts, flooding, and salinity intrusion are destroying crops, disrupting food supply chains, and threatening the livelihoods of over 570 million smallholder farmers worldwide. Yet in the heart of this crisis lies a unique opportunity: to reimagine and rebuild agriculture to be climate-resilient, regenerative, and future-proof.

This article explores the urgent journey from crisis to cultivation—detailing how the global community can transform agriculture into a resilient force that not only feeds humanity but also heals the planet.

**Chapter 1: Understanding the Crisis—
 Climate and Agriculture at a Crossroads**
**1.1 Agriculture’s Fragility in a Changing
 Climate**

Climate change is destabilizing the foundational pillars of agriculture. Rising global temperatures have extended drought periods in Africa, increased salinity in coastal Asia, and escalated unpredictable rainfall in Latin America. In many regions, traditional crop calendars no longer align with the changing seasons. Floods drown rice paddies, heat waves shrivel maize, and unseasonal frosts wipe out fruit harvests.

These changes are not distant projections—they are happening now. In Bangladesh’s coastal regions, farmers face both saline water intrusion and stronger cyclones. In California, mega-droughts have rendered large swathes of farmland unproductive. And in East Africa, back-to-back droughts are creating food crises that displace communities and destabilize economies.

1.2 The Vicious Feedback Loop

Ironically, agriculture is both a victim and a contributor to climate change. It accounts for about 25% of global greenhouse gas emissions—largely through methane from livestock, nitrous oxide from fertilizers, and carbon from land-use change. Unsustainable practices such as deforestation, overgrazing, monocropping, and excessive use of chemical inputs degrade the land and exacerbate climate vulnerabilities.

Breaking this vicious cycle requires bold, transformative action—shifting from carbon-intensive food systems to climate-smart, regenerative models of production.



Chapter 2: Principles of Climate-Ready Agriculture

2.1 Resilience through Diversification

Diversity in crops, income streams, and ecosystem services is the foundation of agricultural resilience. Monocultures may be economically appealing in the short term, but they are ecologically fragile. A single pest or weather anomaly can wipe out an entire yield. Agro-biodiversity—growing multiple crop species, integrating livestock, and using agroforestry systems—ensures that farms can adapt to shocks. Intercropping legumes with cereals, for example, improves soil fertility while reducing pest risks. Diversification also enhances dietary nutrition and income stability for farming families.

2.2 Climate-Resilient Seeds

Adaptation starts at the seed level. Crop breeders worldwide are developing varieties that can withstand the stresses of a changing climate—drought-tolerant maize, salt-resistant rice, heat-resilient wheat, and flood-tolerant pulses.

In Bangladesh, the release of flood-resistant rice varieties like BRRI dhan51 and 52 has helped farmers recover yields in submerged conditions. In Sub-Saharan Africa, drought-resistant sorghum and pearl millet are being reintroduced in drylands. These climate-smart seeds give farmers a vital tool to secure their harvests against erratic weather.

2.3 Soil Health and Water Management

Healthy soils retain water, store carbon, and support productive crops. Yet modern agriculture has often treated soil as a dead substrate for inputs. Regenerative practices such as composting, minimal tillage, cover cropping, mulching, and integrating organic matter restore the soil's biological vitality.

Water-smart solutions such as drip irrigation, rainwater harvesting, check dams, and soil moisture sensors help optimize water usage—critical in both drought-prone and flood-prone regions.

Chapter 3: Technological Transformation of Agriculture

3.1 Precision Agriculture and Big Data

Digital technologies are revolutionizing agriculture. Precision agriculture uses GPS, sensors, and data analytics to tailor decisions on planting, watering, and input application—minimizing waste and maximizing efficiency. AI-powered weather forecasts, pest detection apps, and disease early warning systems are helping farmers anticipate threats before they become disasters. In India, the e-Choupal platform provides real-time market and weather data to rural farmers. In Kenya, “PlantVillage Nuru” uses AI and smartphone cameras to diagnose crop diseases instantly.

3.2 Internet of Things (IoT) and Drones

Connected devices—IoT sensors—can monitor soil moisture, weather patterns, and plant health in real-time. These are being adopted in both large commercial farms and small-scale pilot projects. Drones are being used to map fields, identify water stress, and apply fertilizers precisely—saving time, money, and environmental cost.

Such innovations not only improve productivity but also enable adaptation to fast-changing environmental conditions.

3.3 Blockchain and Market Access

Climate-ready agriculture also needs reliable, transparent, and fair market systems. Blockchain technology is offering solutions in traceability and certification—ensuring that farmers who grow sustainably can prove it and access premium markets. Platforms like AgUnity are helping smallholders track and sell their produce securely while building digital identities.



Chapter 4: Regeneration—Restoring Ecosystems through Farming

4.1 Regenerative Agriculture: Going Beyond Sustainability

While sustainable agriculture seeks to reduce harm, regenerative agriculture aims to restore ecosystems. It focuses on practices that rebuild soil health, sequester carbon, increase biodiversity, and improve water cycles.

Key practices include:

- Integrating trees (agroforestry)
- Rotational grazing of livestock
- Natural pest control using companion planting
- Composting and organic inputs

These practices not only make farms more climate-resilient but also turn them into carbon sinks that help mitigate climate change.

4.2 Ecosystem Services and Payments for Farmers

Climate-ready agriculture is also about recognizing the environmental services that farmers provide. Farms that preserve wetlands, protect pollinators, or prevent erosion offer public goods. Payment for Ecosystem Services (PES) programs are emerging across Latin America and Africa to compensate farmers for these benefits.

In Costa Rica, farmers are paid for preserving forest cover on their land. Similar models are being tested in Kenya, where communities receive incentives for protecting watersheds and conserving biodiversity.

Chapter 5: Climate-Ready Livelihoods—Putting Farmers First

5.1 Empowering Women and Marginalized Farmers

Climate vulnerability is not evenly distributed. Women, indigenous communities, and landless laborers are disproportionately affected. Yet they are also essential to the solution.

Women comprise up to 50% of the agricultural workforce in many developing countries, but have limited access to land, finance, and training. Gender-sensitive climate adaptation programs that provide credit, technology, and leadership opportunities are key to inclusive resilience.

5.2 Farmer-Led Innovation and Indigenous Knowledge

Farmers are not passive recipients of technology—they are innovators in their own right. Across the world, communities are combining ancestral knowledge with modern tools to develop locally adapted solutions.

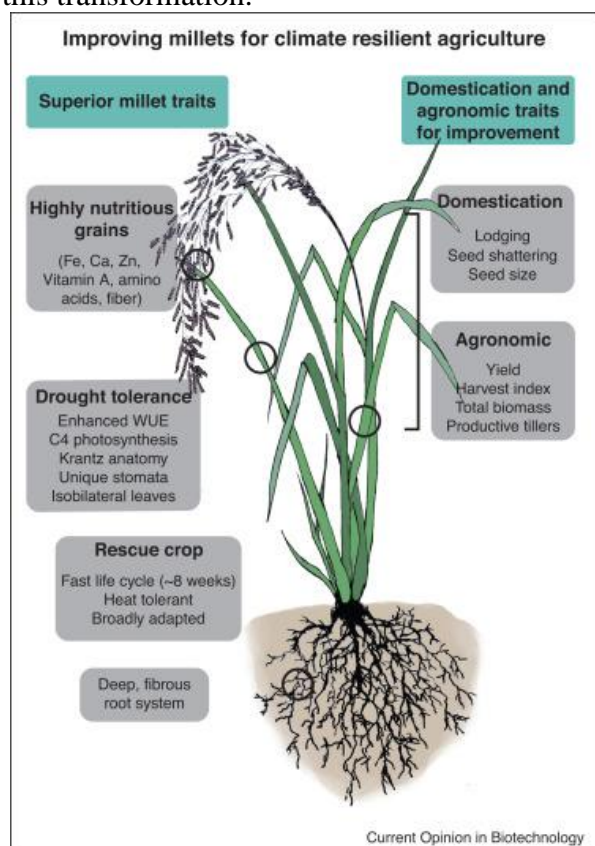
In Peru's Andes, farmers are reviving ancient terraces and irrigation systems to cope with erratic rainfall. In West Africa, farmer-

managed natural regeneration (FMNR) is bringing back forests without planting a single tree.

5.3 Education, Youth, and the Future of Farming

Young people are the future of agriculture—but too often, they see it as a last resort. Building climate-ready agriculture means making farming aspirational through agri-tech, entrepreneurship, and climate education.

Programs that support youth in agribusiness, innovation labs, and green startups are transforming rural economies. Digital training platforms, hackathons, and climate fellowships are giving youth the tools to lead this transformation.



Chapter 6: Policies, Investment, and International Cooperation

6.1 Policy Realignment for Climate-Smart Agriculture

Governments play a critical role in enabling the shift to climate-ready agriculture. This involves:

- Reforming input subsidies that favor water- and chemical-intensive crops
- Supporting research in climate-resilient crops and agroecology
- Integrating agriculture into National Adaptation Plans (NAPs) and climate strategies
- Developing early warning systems and climate insurance

Policies must also protect farmers' land rights and biodiversity against commercial exploitation.

6.2 Climate Finance and Green Investment

Climate-ready agriculture requires upfront investment. Public-private partnerships, green bonds, climate funds, and concessional loans can finance this transition. The Green Climate Fund (GCF), Adaptation Fund, and IFAD's ASAP program are already supporting such efforts.

Blended finance models—combining grants, equity, and insurance—are enabling smallholders to adopt solar pumps, smart seeds, and digital tools.

6.3 Global Solidarity and Knowledge Exchange

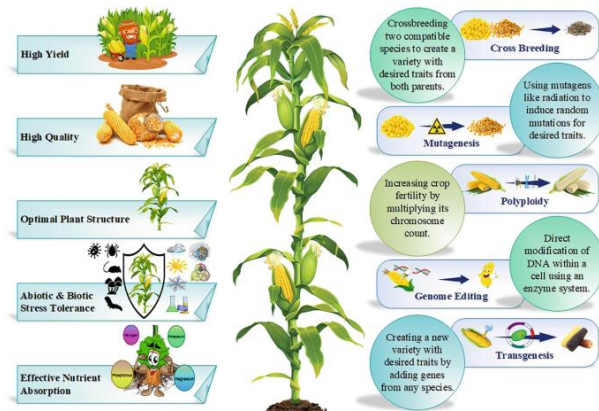
Agricultural challenges are global—but so are the solutions. Climate-resilient agriculture must be fostered through international research cooperation, south-south learning exchanges, and regional platforms.

Institutions like CGIAR, the UN Food Systems Summit, and regional climate-smart agriculture alliances are vital for scaling best practices, sharing innovations, and coordinating action.

Conclusion: Cultivating Hope from Crisis

The agricultural crisis brought on by climate change is profound—but it is not insurmountable. The solutions exist, the science is available, and the innovations are multiplying. What's needed now is bold leadership, strategic investment, and inclusive action.

From crisis must come cultivation—not just of crops, but of a new mindset. A mindset that sees the farmer not as a victim of the climate crisis, but as a frontline responder. A mindset that values soil not as dirt but as a living system. A mindset that invests in youth, women, and indigenous wisdom alongside cutting-edge technology.



Climate-ready agriculture is not a destination—it's an evolving journey. But each climate-resilient seed planted, each regenerative acre cultivated, each farmer empowered, takes us closer to a secure, sustainable future.

We can turn the greatest challenge of our time into an unprecedented opportunity—for food, for livelihoods, and for the planet. From the ashes of crisis, let us cultivate resilience. Let us build the agriculture of tomorrow—today.



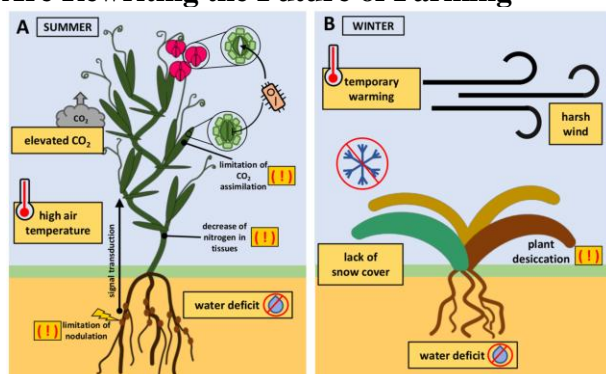
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Innovating for Survival in the Age of Agricultural Uncertainty

How Disruption, Climate, and Innovation Are Rewriting the Future of Farming



We have entered a new age—one where traditional farming methods are being outpaced by climate volatility, unpredictable markets, shifting consumer patterns, and emerging pests and diseases. Farmers across the globe, from rice cultivators in Bangladesh to corn producers in the American Midwest, are navigating an increasingly uncertain agricultural future.

The unpredictable nature of agriculture today is not just about erratic weather patterns; it's

about economic shocks, fragile supply chains, water scarcity, land degradation, technological disruption, and rapidly changing socio-political dynamics. The security of food, income, and ecological balance is under threat. Yet amid this chaos, a quiet revolution is taking place: innovation is emerging as the most potent survival tool.

“Innovating for survival” is more than a slogan—it’s the guiding principle for agriculture in the 21st century. Farmers, researchers, entrepreneurs, and policymakers are designing bold new approaches to withstand and adapt to shocks. From climate-resilient seeds to AI-powered precision farming, from regenerative agriculture to digital marketplaces, innovation is making agriculture not just survivable—but sustainable and even profitable.

This article explores how innovation—technological, ecological, institutional, and social—is becoming the driving force behind agricultural resilience in an uncertain world.

Chapter 1: Mapping the Terrain of Agricultural Uncertainty

1.1 Climate Change as a Core Disruptor

Agriculture is one of the sectors most sensitive to climate change. Increased temperatures, erratic rainfall, prolonged droughts, floods, and unseasonal frosts are making crop cycles unreliable and farming decisions riskier than ever. According to the UN FAO, over 500 million smallholder farmers are directly exposed to climate shocks that threaten their livelihoods.

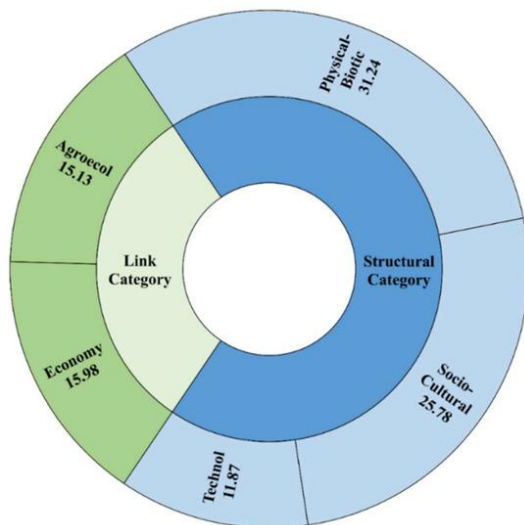
In Bangladesh’s delta region, once fertile lands are being affected by salinity due to sea-level rise. In the Horn of Africa, back-to-back droughts are leaving livestock dead and millions in hunger. Climate change is turning once-reliable farming systems into unpredictable ventures.

1.2 Beyond Climate: A Web of Risks

Other forces intensify this uncertainty:

- **Market Volatility:** Prices for inputs and produce fluctuate wildly due to geopolitical tensions, pandemics, and global supply chain issues.
- **Soil and Water Degradation:** Intensive monoculture and chemical use are degrading vital ecosystems.
- **Labor Migration:** Youth are leaving agriculture, leaving behind an aging workforce with reduced capacity to adopt innovations.
- **Technological Gaps:** In many developing nations, farmers lack access to innovations that could help them adapt.

Uncertainty is no longer a seasonal issue—it is structural and chronic.



Chapter 2: Seed of Survival—Biological Innovation

2.1 Climate-Resilient Crops

One of the most profound innovations in agriculture is in the seed itself. Scientists are now developing crops that can resist drought, tolerate floods, grow in saline soils, and withstand extreme temperatures.

Examples include:

- **Scuba Rice:** Developed for flood-prone areas in South Asia, it can survive underwater for up to two weeks.

- **Drought-Tolerant Maize:** Used across Sub-Saharan Africa, this variety reduces yield loss during dry spells.
- **Salt-Tolerant Quinoa and Wheat:** Now being tested in coastal and saline-prone areas.

These seeds are a lifeline for millions of farmers working on marginal or degraded land.

2.2 Gene Editing and Biotechnology

Modern biotechnology, particularly CRISPR and marker-assisted breeding, is allowing scientists to speed up crop improvement in targeted, precise ways. These techniques are safer, faster, and more publicly accepted than previous GMO models.

Biotech is also helping fight crop diseases like wheat rust, banana wilt, and fall armyworm, which are becoming more widespread due to shifting climates.

Chapter 3: Digital Agriculture—Precision in Uncertain Times

3.1 The Rise of Smart Farming

Digital agriculture uses technology—drones, satellites, sensors, mobile apps, AI—to make farming more data-driven and efficient. In a volatile world, information is power.

For example:

- **Weather Forecasting Apps:** Allow farmers to adjust sowing and harvesting schedules.
- **Remote Sensing:** Detects pest outbreaks before they spread.
- **Soil Sensors:** Help optimize irrigation and fertilizer use, saving resources and protecting the environment.

These tools are reducing guesswork and helping farmers adapt in real time.

3.2 Big Data and Artificial Intelligence

AI is helping predict everything from rainfall to market prices. By analyzing massive datasets, AI systems can give early warnings about drought, suggest climate-smart cropping plans, and even automate pest detection.

Platforms like IBM's Watson Decision Platform for Agriculture, and tools developed

by CGIAR and local startups, are already serving thousands of farmers globally.



Chapter 4: Water, Soil, and Land—Ecological Innovations

4.1 Water-Smart Agriculture

Water scarcity is a growing crisis. Traditional irrigation wastes water and energy. New innovations are offering alternatives:

- **Drip and Micro-Irrigation:** Delivers water precisely at the root zone.
- **Solar-Powered Pumps:** Provide off-grid access to irrigation.
- **Rainwater Harvesting Systems:** Enhance water security during dry spells.

In Maharashtra, India, water budgeting initiatives and community water planning have turned drought-prone villages into water-resilient communities.

4.2 Soil Regeneration and Conservation Agriculture

Innovations are also reviving the soil—our most critical natural asset:

- **Minimum Tillage:** Reduces soil erosion and fuel use.
- **Cover Cropping and Mulching:** Keeps soil fertile and moist.
- **Biochar and Composting:** Restore organic matter to the soil.

In Malawi and Kenya, Farmer Field Schools are teaching these techniques to tens of thousands of smallholders.

4.3 Agroecology and Permaculture

Agroecological approaches integrate ecological science with traditional farming knowledge. They emphasize biodiversity, closed nutrient loops, and natural pest control. Permaculture designs create self-sustaining farms that mimic ecosystems. They are increasingly used in regions vulnerable to climate extremes.

Chapter 5: Market Innovation—Stability in a Chaotic Economy

5.1 Digital Marketplaces

Innovation is helping farmers access better markets with fewer intermediaries. Platforms like **Farmers Fresh Zone** in India and **Twiga Foods** in Kenya connect producers directly with consumers, retailers, and institutions using mobile apps.

This not only improves income stability but also reduces food waste and logistical emissions.

5.2 Blockchain and Traceability

Blockchain technology is bringing transparency and trust to supply chains. With tamper-proof records of origin, quality, and handling, farmers can earn premiums for sustainable or organic produce.

These systems are also helping smallholders access international markets that demand traceability.

5.3 Risk Insurance and Financial Tools

Index-based crop insurance, bundled with mobile technology, is helping protect farmers from climate-related losses. Startups are also developing credit scoring models based on farming behavior, allowing previously excluded farmers to access loans.

Companies like Pula and MicroEnsure are leading innovations in this space, especially in Africa and Asia.

Chapter 6: Institutional and Social Innovation

6.1 Rethinking Agricultural Extension

Traditional extension systems are often under-resourced and outdated. Digital extension—via SMS, IVR calls, and YouTube—reaches more farmers at lower cost.

Innovative models include:

- **Farmer-to-Farmer Learning Platforms**
- **Video-Based Training in Local Languages**
- **Interactive Radio Shows on Agricultural Issues**

These help democratize access to knowledge.

6.2 Youth Innovation in Agri-Tech

Across the Global South, young entrepreneurs are building climate-smart agri-tech startups. From soil-testing kits to AI-powered crop disease detectors, they are redesigning farming for the next generation.

Agripreneurship is being nurtured through incubators, innovation challenges, and climate finance platforms.

6.3 Women at the Forefront of Innovation

Women farmers are innovating with kitchen gardens, seed-saving groups, and micro-irrigation. Yet they are often invisible in formal innovation systems. Inclusive policies must ensure women have access to land, finance, education, and decision-making roles.

Chapter 7: Policy, Governance, and International Collaboration

7.1 Aligning Policy with Innovation

Policies must shift from promoting input-heavy monocultures to supporting diversified, regenerative, and technologically empowered systems. This includes:

- Incentivizing climate-resilient crops.
- Subsidizing smart irrigation and renewable energy.
- Scaling up research on local adaptation.

Laws must also protect smallholder land rights and biodiversity.

7.2 Investing in Innovation Ecosystems

Public and private investment must fund innovation labs, rural tech hubs, and agricultural R&D. Platforms like **AGRA**, **CGIAR**, and the **Global Innovation Lab for Climate Finance** are already doing this, but more scale and support are needed.

7.3 Regional and Global Cooperation

Climate-resilient agriculture requires cross-border learning. Countries can share climate models, seed banks, and market intelligence. Global forums must place agriculture at the center of climate, trade, and development talks.



Conclusion: Cultivating Hope Through Innovation

In the face of agricultural uncertainty, one truth becomes clear: survival depends on innovation. But innovation in this context is not just about gadgets or apps—it is about resilience, creativity, and collaboration at every level.

It's the farmer in Ethiopia using solar pumps to irrigate teff. It's the youth entrepreneur in Dhaka designing flood prediction software. It's the woman in Uganda saving seeds for her community.

It's the policymaker in Peru funding agroecological research. It's the scientist editing a crop to survive the next drought.

“Innovating for survival” is a collective mission. It asks us to reimagine agriculture not as a fragile industry threatened by crisis, but as a dynamic ecosystem capable of adapting, evolving, and thriving.

By investing in innovation today, we plant the seeds of a food-secure, climate-resilient tomorrow. In a world that is increasingly unpredictable, this is how we restore certainty—not by resisting change, but by cultivating it.



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A Green Revolution Rooted in Resilience, Not Abundance

Reimagining Agriculture for a Climate-Conscious World

The Need for a New Revolution

The original Green Revolution of the mid-20th century is credited with transforming global food production. Through the introduction of high-yielding varieties, synthetic fertilizers, pesticides, and irrigation systems, it dramatically increased crop output and averted famine in many parts of the world. But its legacy is mixed. While it ushered in a new era of agricultural abundance, it also led to widespread environmental degradation, soil depletion, water stress, and socio-economic inequalities.

Today, we stand at a critical juncture. Climate change, resource scarcity, soil degradation, water crises, biodiversity loss, and socio-political instability have made the old paradigm of abundance-through-inputs unsustainable. We need a new agricultural revolution—one not rooted in maximizing yield at any cost, but in building resilience. This revolution must prioritize ecological

balance, long-term sustainability, and the ability of farming systems to withstand shocks.

“A Green Revolution Rooted in Resilience” is about transforming food systems to thrive amid adversity. This article explores how this new vision can be achieved—through technology, tradition, community engagement, ecological restoration, and policy reform.



Chapter 1: The Limits of Abundance

1.1 The High Cost of High Yields

The original Green Revolution's gains came at significant environmental and human costs. Over-farming depleted soils, heavy irrigation drained aquifers, and pesticide use contaminated ecosystems. Monoculture—growing a single crop over vast areas—led to biodiversity collapse and made crops more vulnerable to disease and pests.

In Punjab, India—once the crown jewel of the Green Revolution—overextraction of groundwater is leading to desertification. In the U.S. Midwest, decades of monocropping and fertilizer use have created a “dead zone” in the Gulf of Mexico due to agricultural runoff.

The focus on abundance led to fragility. Resilience was not part of the equation.

1.2 A New Reality: A Planet in Peril

Today's farmers face unprecedented uncertainty. Weather patterns have become erratic; droughts last longer; floods arrive more violently; pests and diseases spread into new territories. Agricultural success now depends less on how much we grow, and more on how well we adapt.

To secure food systems in the 21st century, we must shift from input-intensive farming to knowledge-intensive, context-specific, and ecology-driven systems. The goal is not to overproduce, but to produce well—sustainably and equitably.



Chapter 2: Defining Resilience in Agriculture

2.1 What Is Agricultural Resilience?

Resilience is the ability of a system to absorb shocks, adapt to stress, and transform in the face of challenges without collapsing. In agriculture, it means the capacity to maintain productivity, protect the environment, support livelihoods, and ensure food security under variable conditions.

It is measured not just by yields, but by:

- Soil health and biodiversity
- Water use efficiency
- Energy independence
- Social equity
- Economic viability
- Nutritional value

Resilient agriculture sees nature as an ally, not an obstacle.

2.2 The Dimensions of Resilient Farming Systems

- **Ecological Resilience:** Healthy ecosystems provide natural pest control, pollination, and water regulation.
- **Economic Resilience:** Diversified incomes and local markets help buffer price shocks.
- **Social Resilience:** Empowered communities, particularly women and youth, drive innovation and adaptation.
- **Technological Resilience:** Smart tools and data help respond to climatic shifts.

This holistic approach acknowledges that farming systems are not isolated plots—they are part of a larger socio-ecological web.

Chapter 3: Building Resilience from the Ground Up

3.1 Regenerative Agriculture and Soil Health

Soil is a living system. Its ability to retain moisture, cycle nutrients, and support microbial life is critical to resilience. Yet modern agriculture has often treated soil as inert.

Regenerative agriculture practices such as cover cropping, crop rotation, minimal tillage, and compost application restore the biological health of soil. These practices improve water retention, reduce erosion, and sequester carbon—making farms both more productive and climate-friendly.

3.2 Agroecology and Biodiversity

Agroecology applies ecological principles to farming. It emphasizes crop diversity, polycultures, agroforestry, and the integration of animals and plants into mutually beneficial systems.

In Latin America, “milpa” farming combines maize, beans, and squash to optimize land use and resist pests. In parts of Africa,

intercropping cassava with legumes enhances soil fertility and ensures multiple harvests. Biodiversity reduces the risk of total crop failure and enhances resilience to climate variability.

3.3 Water Resilience and Climate-Smart Irrigation

With water becoming scarcer, climate-ready agriculture must adopt efficient irrigation. Innovations include:

- Drip and sprinkler systems
- Rainwater harvesting
- Solar-powered pumps
- Moisture sensors and AI-powered irrigation scheduling

In Rajasthan, India, community-led watershed management has revived rivers and boosted agricultural productivity even during dry spells.



Chapter 4: Rethinking Productivity and Profitability

4.1 Beyond Yield Per Acre

Traditional agricultural metrics prioritize yield per acre. But resilience requires broader indicators: energy input per unit of food, nutritional density, long-term soil fertility, carbon sequestration, and farmer well-being.

For example, diversified farms may produce less wheat per acre than monoculture, but they yield more total food, reduce dependency on chemicals, and support household nutrition and income security.

4.2 True Cost Accounting

Cheap food often hides high environmental and social costs. The depletion of groundwater, pollution of rivers, loss of pollinators, and displacement of communities are not reflected in market prices.

True cost accounting incorporates these externalities into food economics—revealing the real price of industrial agriculture and the long-term savings of resilient farming systems.



Chapter 5: Innovating for Resilience

5.1 Technological Innovation with Ecological Intelligence

Technology can serve resilience—if guided by ecological wisdom. Examples include:

- Drones and satellites for monitoring crops and predicting weather
- Mobile apps for market and climate information
- Biodegradable mulches and biofertilizers
- Seed banks with climate-resilient varieties

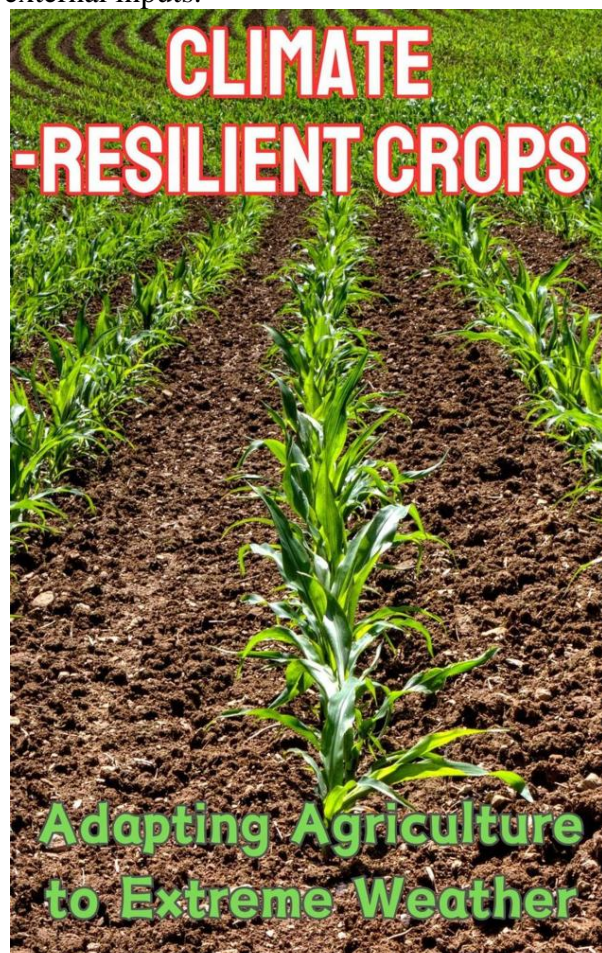
Digital platforms like Digital Green and FarmStack are helping smallholders in Asia and Africa access localized, timely, and actionable data.

5.2 Breeding Climate-Resilient Crops

Breeders are developing crop varieties that resist drought, heat, salinity, and pests. In Bangladesh, flood-tolerant rice (“scuba rice”) allows farmers to recover crops after inundation. In Africa, drought-tolerant maize

and disease-resistant cassava are gaining ground.

Seed innovation, combined with community-based seed systems, strengthens food sovereignty and reduces dependency on external inputs.



Chapter 6: Social Innovation and Equity

6.1 Women as Agents of Resilience

Women play a central role in food production and nutrition, yet often lack land rights, credit access, and training. Resilient agriculture must empower women—ensuring equal access to technology, leadership roles, and decision-making power.

Programs that train women in agroecology, financial literacy, and climate adaptation create ripple effects across entire communities.

6.2 Youth Engagement and Future Farming

Farming must become attractive to youth. This requires investment in agri-entrepreneurship, digital literacy, and green innovation hubs. In countries like Kenya and Nigeria, youth-led startups are transforming waste into compost, building drone services for farmers, and launching climate-smart agri-platforms.

Educating the next generation of farmers, scientists, and policymakers is vital for sustaining a resilient food future.

Chapter 7: Policy, Investment, and Governance

7.1 Enabling Environments for Resilient Agriculture

Policy reform is critical. Governments must shift from input-heavy subsidies to incentives for agroecology, conservation, and risk management. Key priorities include:

- Investing in rural infrastructure
- Supporting farmer cooperatives
- Integrating agriculture into national climate strategies
- Scaling up climate insurance

Success stories in Brazil, Rwanda, and Ethiopia show that political will can rapidly transform degraded lands into productive, climate-smart zones.

7.2 Climate Finance and Risk Reduction

Transitioning to resilience requires investment. Blended finance—combining public, private, and philanthropic capital—can de-risk green investments. Climate funds like the Green Climate Fund (GCF) and the Adaptation Fund should prioritize regenerative, community-led models.

Risk reduction strategies such as index-based crop insurance, early warning systems, and disaster preparedness also protect farmers from losing everything during a climate event.

Chapter 8: Global Solidarity and Knowledge Sharing

8.1 International Cooperation

Climate-resilient agriculture is a global necessity. Knowledge-sharing platforms,

global seed networks, and climate adaptation alliances help countries learn from one another.

South-South cooperation and inclusive research systems (e.g., CGIAR) are critical in tailoring solutions to local contexts while avoiding the imposition of one-size-fits-all models.

8.2 A Shared Ethical Framework

Finally, resilience requires rethinking our values. Food is not merely a commodity—it is a right, a relationship with the earth, and a pillar of cultural identity. A resilient green revolution must be rooted in equity, justice, and stewardship.



Conclusion: Sowing the Seeds of a Resilient Future

The age of agriculture as an engine of unchecked abundance is over. In its place, we must plant the seeds of a new era—an era where food is grown with respect for the land, where communities are empowered, where diversity thrives, and where resilience replaces fragility.

This new green revolution is not a replication of the past—it is a transformation. It draws strength from innovation and ancient wisdom, from ecological integrity and human dignity.

From rooftop gardens in urban slums to permaculture in drought zones, from digital

tools in rice fields to the revival of forgotten seeds, the movement is already underway.

The question is not whether we can build climate-ready agriculture. The question is: Will we act fast enough—and boldly enough—to ensure food, justice, and survival on a warming planet?

The time for abundance without accountability is past. The time for resilience—deep, diverse, and regenerative—has come.



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