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The Agricultural ECONOMIST

Pakistan's Premier Magazine on Agriculture and Economics

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The Agricultural Economist is dedicated to advancing knowledge of Agricultural Economics and related disciplines.

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- Comprehensive coverage of pressing agricultural, rural and national economic issues.
- Insightful analyses on economic and business trends shaping the agricultural sector and the economy.
- Interdisciplinary perspectives bridging agriculture, finance, management & public health.

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EDITORIAL

June 2026: Cultivating Resilience in Agriculture and Health

Explore the vital connections between agriculture, human health, social justice, and ecological sustainability. Discover how recent climate disruptions and geopolitical changes are reshaping food systems and the importance of resilience in these critical areas.

Muhammad Khalid Bashir

6/1/2026

As we enter June 2026, *The Agricultural Economist* turns its focus to a world that has changed markedly since our 2024 editorial. The past two years have seen cascading climate disruptions from the record-breaking heatwaves of 2025 that decimated wheat yields across South Asia to the persistent El Niño-driven drought in the Amazon basin. Meanwhile, ongoing geopolitical realignments have reshaped fertilizer and grain trade routes, and a renewed global push for pandemic preparedness has placed agricultural health systems at the center of policy debates. This June, our theme, **Cultivating Resilience: Health, Equity, and Sustainability in Agriculture**, is no longer an aspiration, it is an operational imperative.

June 2026 arrives with a fresh tapestry of global observances that have gained new urgency. World Bicycle Day (June 3) now coincides with the final year of the UN Decade of Family Farming (2019–2028). World Environment Day (June 5) falls just months after the 2025 UN Biodiversity Conference (COP16) outcome, which mandated that 30% of degraded agricultural land must be under restoration by 2030. World Oceans Day (June 8) follows the 2025 High Seas Treaty ratification, opening new frameworks for blue carbon and sustainable aquaculture. The World Day Against Child Labor (June 12) will be observed against the backdrop of the 2025 Global Child Labor Report, which showed a troubling 5% increase in agriculture-related child labor due to cost-of-living shocks. MSME Day (June 27) arrives as digital agricultural enterprises have become the fastest-growing employment sector in low-income nations, fueled by AI-driven extension services and drone-based crop monitoring.

This month, we explore how agricultural systems can absorb, adapt, and transform in the face of compounding crises. Resilience in 2026 means moving beyond climate-smart agriculture to **regenerative and anticipatory systems**, farming that restores soil organic carbon, pre-positions drought-tolerant seed banks, and integrates zoonotic disease surveillance into livestock management. It also means confronting the social fractures exposed by recent food price inflation, which hit a decade-high in mid-2025 before moderation.

Week 1: Mobility, Ecosystems, and the Post-COP16 Landscape

On World Bicycle Day, we feature new research from rural Kenya and Uttar Pradesh, where last-mile delivery e-bike cooperatives, subsidized by the 2025 Green Climate Fund's micro-mobility window, have cut post-harvest losses by 40% for smallholders. For World Environment Day, we showcase a special report on agroecology from the 2025 UN Food Systems Summit +2 stocktake, highlighting how Colombia's campesino-led restoration of the Orinoco savanna has become a model for biodiversity credits.

Week 2: Blue Frontiers and the Fight Against Child Labor

On World Oceans Day, we examine the tension between rapid aquaculture expansion (projected to supply 60% of human seafood consumption by 2026) and the rights of coastal communities in West Africa. Our lead article features a new blockchain traceability tool, mandated by the 2025 EU Deforestation Regulation extension to marine products, which is helping eliminate forced labor in shrimp supply chains. Then, on the World Day Against Child Labor, we confront the reality of 2026: despite pledges, agriculture remains responsible for 70% of child labor cases globally. We profile a successful cash-plus-care intervention in Côte d'Ivoire's cocoa sector, linking household livelihood transfers to mobile schooling, an approach that cut child labor by 55% in a 2025 randomized trial.

Week 3: Desertification, Displacement, and the Land–Conflict Nexus

As we mark the World Day to Combat Desertification and Drought (June 17), we analyze the latest data from the UN Convention to Combat Desertification (UNCCD), which reports that 1.5 billion people now live on degrading land. Our focus is on the Great Green Wall 2.0, an accelerated effort that, by early 2026, has restored over 400 million hectares across the Sahel, but faces sustainability challenges from armed conflict. On World Refugee Day (June 20), we travel to eastern Uganda, where refugees from South Sudan and Somalia have been integrated into the national agricultural extension system under the 2025 Kampala Declaration. New evidence shows that refugee-led farming households are 30% more likely to adopt drought-resistant cassava than host communities, turning a humanitarian crisis into a source of agroecological innovation.

Week 4: MSMEs and the Digital–Agri Revolution

Our final week leads up to MSME Day (June 27) with a deep dive into the 2026 landscape for micro, small, and medium-sized agribusinesses. Since 2024, AI-powered market aggregation platforms have exploded, from Pakistan's "Dukkan-e-Digital" to Nigeria's "FarmPass." However, our investigative series reveals a digital divide: women-owned agri-SMEs still receive only 12% of agri-fintech lending. We feature a policy brief on the newly launched African Agri-MSME Resilience Fund (backed by the AfDB and Green Climate Fund), which combines solar cold storage leasing with parametric insurance against extreme weather. In a concluding interview, the Fund's director notes: "The next five years will determine whether agri-MSMEs become the shock absorbers or the weak links in global food systems."

A 2026 Reflection: Resilience as Political Choice

As June draws to a close, we step back to ask: What has changed since our 2024 editorial? The answer is both sobering and hopeful. The sobering part: climate volatility has worsened, conflict has expanded, and child labor has not retreated. The hopeful part: the toolbox has deepened. We now have proven, scalable solutions, from ecosystem-based adaptation to digital last-mile logistics, and a policy

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architecture (COP16, the High Seas Treaty, the post-2025 UN Food Systems roadmap) that can finally align incentives.

But tools and treaties are not enough. Resilience in 2026 requires confronting the structural asymmetries that our June observances lay bare. Who owns the bicycles? Who holds the ocean permits? Who bears the debt when drought strikes? Whose land is restored, and whose is fenced off for conservation?

We call on policymakers, researchers, agribusiness leaders, and citizens to move beyond resilience-as-bouncing-back. True resilience, in this decade of cascading risks, means bouncing forward into systems that are redistributive, restorative, and radically participatory. It means treating agriculture not as a sector to be optimized, but as a living fabric that connects soil microbes to school lunches, farmworker wages to wetland health, and refugee seed banks to national food security.

This June let us cultivate that deeper resilience, not with nostalgia for a stable past, but with clear eyes on the turbulent, yet still winnable, future.

Warm regards,

Muhammad Khalid Bashir
Managing Editor
The Agricultural Economist
www.agrieconomist.com
June 2026

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SPOTLIGHT

Pakistan's Agricultural Waste Crisis

Pakistan faces a significant agricultural challenge 'waste crisis' as it burns what it grows and discards valuable nutrients, leading to costly imports of chemical fertilizers. By reconnecting cities and fields, waste can re-enter circulation instead of remaining outside the system forever.

Nadeem Riyaz

6/3/2026

On a cold winter morning in Punjab's wheat belt, you can watch a farmer commit an act that seems perfectly logical to him and perfectly insane to anyone who understands the soil. He gathers the dry straw left over from his harvest. He touches a match to it. Within minutes, the residue that once held the promise of next year's crop vanishes into black smoke drifting across the horizon. The field looks clean. His work looks done.

But here's the catch: he has just burned fertilizer. A few days later, that same farmer will drive to the local market and spend precious rupees on sacks of chemical fertilizer, nitrogen, phosphorus, potash, imported at great national cost. He doesn't see the irony. And why would he? No one has ever shown him the connection between the smoke in his field and the expense in his pocket.

Pakistan burns fertilizer twice: first in its fields, then in its cities. In Lahore, Karachi, and Multan, the story repeats itself in reverse. Food scraps, vegetable peels, and organic waste from millions of kitchens are dumped into landfills, buried under mountains of trash, or burned as garbage. What could have fed the soil is treated as a nuisance. What could have saved farmers money is treated as a problem to be eliminated. The truth is uncomfortable but simple: Pakistan is not short of nutrients. It is short of connection.

The Broken Loop

Behind this contradiction lie two systems that never talk to each other. The first is agriculture. Year after year, Pakistani farmers extract nutrients from their soil to grow wheat, rice, and sugarcane. When the land grows tired, they reach for industrial fertilizers, expensive, imported, and increasingly unaffordable for small landowners.

The second system is waste. Every season, millions of tons of crop residue, animal manure, and urban food waste are generated across the country. And almost all of it is either burned or dumped. What should be a cycle, soil grows food, food creates waste, waste feeds soil, has become a straight line to destruction.

Nothing about fixing this is mysterious. Composting crop residue is not a rocket science. Turning animal manure into organic fertilizer has been done for centuries. Converting city food waste into biogas slurry is common practice across Europe and parts of Asia. These are not experimental ideas. They are proven technologies. So why doesn't Pakistan do it? Because no single institution is responsible for making it happen.

No One's Job, Everyone's Problem

Here is how the system currently works: waste authorities are judged by how quickly they make garbage disappear. Burn it, bury it, haul it away, just get it out of sight. Agricultural departments are measured by crop yields and how many bags of chemical fertilizer they distribute. Long-term soil health? Not their metric. Nutrient recycling? Not their budget line.

Between waste generation and farm application lies a gaping hole where ownership goes to die.

Into that gap steps the chemical fertilizer industry. And it fits beautifully. Urea and DAP are standardized, predictable, and backed by strong supply chains. A farmer can walk into any market and buy a bag with a guaranteed nutrient content. When you are already fighting unpredictable weather, unstable prices, and rising debt, certainty matters more than sustainability. In that sense, Pakistan's dependence on imported fertilizer is not irrational. It is the logical result of a broken system. But the cost of that logic adds up quietly.

Every burned field means nitrogen, phosphorus, and potassium lost to the air. Every landfill filled with rotting vegetables represents a missed opportunity to feed the soil. Over time, soils that rely only on industrial chemicals lose their organic matter and microbial health. Yields might stay steady for a while but resilience crumbles. The land becomes a drug addict, needing ever larger doses of external inputs just to stay productive.

The Raw Material Is Already Here

Here is the good news: Pakistan already generates almost everything it needs for a partial organic fertilizer economy. Crop residue from rice and wheat. Livestock manures from millions of buffalo and cattle. Urban food is wasted from every kitchen, restaurant, and market. The raw material is not missing. The system that connects waste back to farms is what is missing. So what would it take to build that system?

First, visibility. Right now, waste streams are invisible to planners. No one maps where crop residue is concentrated, where livestock manure accumulates, or where city organic waste is generated. Once you map it, you stop seeing "garbage" and start seeing "input."

Second, coordination. Municipal authorities need to start treating waste recovery as agricultural infrastructure, not just urban sanitation. Agricultural departments need to start caring about where nutrients come from, not just how much urea they sell.

Third, incentives. Pay waste collectors only for dumping garbage? They will dump garbage. Pay them for converting waste into compost or biogas? They will build conversion facilities. Right now, the reward structure is backwards. We pay for disappearance. We should pay for return.

Fourth, private sector engagement. The government does not need to run composting plants or biogas units. But it can enable them through land access, regulatory reform, and initial subsidies to get the market moving. Let entrepreneurs build the facilities. Let farmers buy the products. The state's job is to unlock the loop, not operate every piece of it.

What the World Already Knows

Across much of Europe, organic waste is no longer seen as a disposal problem. It is a resource. Cities invest in anaerobic digestion plants that turn food scraps into energy and nutrient-rich slurry for farms. The result is less landfill pressure, lower emissions, and healthier soils.

Closer to home, India has begun wrestling with the same crop-burning crisis that plagues Pakistan's Punjab. In response, states like Haryana and Punjab have experimented with decentralized composting, bioenergy generation, and residue-utilization systems. The transition is messy and incomplete, but the direction is clear: agricultural waste can become productive input instead of environmental liability.

Pakistan does not need to copy these models exactly. Its landholdings are smaller. Its institutional capacity is different. But the underlying principle is universal: waste must circulate economically before it is discarded physically.

No Overnight Miracles and That's Fine

Let's be realistic. Organic compost is not going to replace chemical fertilizer next season. Nor should it. A sudden shift would crash yields and ruin livelihoods. The smarter path is blended systems. A farmer might apply 80 percent of his usual chemical fertilizer plus organic compost. Yields stay stable. Soil structure slowly improves. Dependency gradually declines. Trust is built over seasons, not policy cycles.

And here is where it gets interesting: reducing crop burning also lowers emissions and air pollution. That opens the door to carbon credits and environmental financing. What starts as an ecological fix can become an economically self-sustaining transition, not a permanent government subsidy. Pakistan's agricultural debates are usually about small landholdings, rising fertilizer prices, import bills, and declining soil fertility. All of those are real problems. But beneath them lies a quieter, more structural failure.

Pakistan burns what it grows. It dumps what it consumes. And then it buys back, at great expense, what it already threw away. Think about the absurdity. A farmer in Punjab sets fire to straw that contains nitrogen. A family in Karachi throws vegetable peels into a landfill where they rot into methane. Then Pakistan spends billions of dollars importing chemical fertilizer from other countries. We are paying twice: once to waste our own nutrients, and again to import someone else's.

None of this requires a revolution. It requires reconnection. Cities can return nutrients instead of discarding them. Fields can receive input from multiple sources instead of relying on a single industrial pipeline. Waste can re-enter circulation instead of remaining outside the system forever.

Pakistan does not lack fertilizer.

It simply throws it away first.

Please note that the views expressed in this article are of the author and do not necessarily reflect the views or policies of any organization.

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Transforming Pakistan's Indus Delta with Halophytes

Explore how halophytes can restore Pakistan's Indus Delta, addressing ecological stress caused by salinity and waterlogging. Discover the potential of bio-saline agriculture to enhance rural livelihoods while rehabilitating degraded landscapes through sustainable practices.

Nazar Gul

6/17/2026

The Indus Delta, recognized among the world's most ecologically important regions, is facing a slow but devastating environmental decline. Rising salinity, seawater intrusion, waterlogging, and diminishing freshwater flows are transforming once-productive agricultural lands into barren landscapes. Across large parts of Sindh, fertile soils are increasingly covered with salt deposits, groundwater tables continue to rise, and the advancing Arabian Sea is encroaching further inland. These interconnected challenges threaten agricultural productivity, biodiversity, rural livelihoods, and the long-term sustainability of the delta ecosystem. Yet amid this growing crisis, nature may already have provided an effective and affordable solution in the form of halophytes, specialized plants that naturally thrive in saline environments.

Halophytes possess a remarkable ability to survive and grow under conditions that would be lethal to most conventional crops. More importantly, many of these species actively contribute to the rehabilitation of degraded lands. Pakistan is exceptionally rich in this biological resource. Of the approximately 2,200 halophyte species identified worldwide, around 410 occur in Pakistan, making the country one of the most important centers of halophytic biodiversity. Even more significant is the fact that nearly 178 of these species were first documented within Pakistan, highlighting the country's unique ecological wealth. Research indicates that approximately 274 of these species possess economic value, offering opportunities for food production, livestock fodder, medicinal products, fuelwood, industrial raw materials, and environmental restoration.

The environmental benefits of halophytes are equally impressive. Certain deep-rooted tree species can consume up to 2,300 millimeters of water annually, helping to lower shallow groundwater tables and reduce waterlogging in affected areas. Other species absorb and accumulate salts from the soil through a natural process known as phytoremediation. When these plants are harvested, a portion of the accumulated salt is removed from the ecosystem, gradually improving soil quality and creating conditions more favorable for conventional agriculture. Unlike expensive engineering interventions or chemical reclamation methods, halophyte-based restoration works with natural ecological processes, offering a low-cost, sustainable, and climate-resilient strategy for reclaiming Pakistan's salt-affected lands while generating new economic opportunities for rural communities.

From Environmental Crisis to Ecological Opportunity

The Indus Delta, once one of South Asia's most productive coastal ecosystems, is now at the frontline of Pakistan's environmental challenges. Decades of reduced freshwater flows, climate change, upstream water diversions, and inadequate environmental management have fundamentally altered the delta's ecological balance. Rising sea levels have accelerated seawater intrusion, allowing saline water to penetrate deeper inland and contaminate both agricultural land and freshwater resources. At the same time, shrinking river flows have weakened the natural ability of the delta to flush salts from the soil and

sustain its wetlands, mangrove forests, and fisheries.

The consequences are visible across the region. Large areas of agricultural land have become increasingly saline and waterlogged, reducing crop productivity and rendering many fields unsuitable for conventional farming. Groundwater in numerous communities has become brackish, limiting access to safe drinking water and increasing health risks for local populations. The decline of mangrove ecosystems and coastal fisheries has further undermined livelihoods, leaving many households with fewer economic opportunities. As a result, thousands of families have been forced to abandon traditional farming and fishing activities and migrate to urban centers in search of alternative sources of income.

Despite these challenges, the Indus Delta also presents an opportunity to rethink agricultural development in salt-affected environments. Community-led mangrove restoration projects have already demonstrated that degraded ecosystems can recover when appropriate species and management practices are introduced. Building on this success, bio-saline agriculture offers a promising pathway forward. Rather than attempting to eliminate salinity through costly engineering interventions, bio-saline agriculture embraces saline conditions by cultivating halophytes and other salt-tolerant species that can grow productively where conventional crops fail.

These plants not only provide fodder, fuel, food, and industrial raw materials but also contribute to soil rehabilitation by lowering water tables and removing excess salts. Over time, such ecological restoration can improve land productivity, enhance environmental resilience, and create new livelihood opportunities for local communities. In this way, the Indus Delta's salinity crisis can be transformed into an opportunity for sustainable development, climate adaptation, and rural economic renewal.

Harnessing the Potential of Pakistan's Salt-Tolerant Plant Resources

Pakistan possesses a remarkable diversity of halophytes that offer practical solutions for restoring degraded lands while generating economic benefits for local communities. Among these salt-tolerant species, several stand out because of their adaptability, commercial value, and potential role in rehabilitating the Indus Delta and other salt-affected regions.

One of the most promising species is *Eucalyptus camaldulensis* (Suphaida), a fast-growing tree capable of thriving under saline and waterlogged conditions. It is widely valued for timber production, fuelwood, and various medicinal uses. Due to its rapid growth and high water consumption, it is particularly suitable for reclaiming degraded lands and lowering shallow groundwater tables. However, its cultivation is most appropriate on marginal and salt-affected lands rather than productive agricultural fields.

Another important species is *Atriplex* (saltbush), which is highly tolerant of salinity, drought, and poor soil conditions. It is easy to establish and produces nutritious forage for livestock, making it especially valuable in areas where conventional fodder crops struggle to survive. By providing a reliable feed source, saltbush can support livestock production in environmentally stressed regions.

Perhaps the most versatile halophyte is *Salicornia virginica* (glasswort). This unique plant thrives in highly saline and waterlogged environments and can be used as animal feed, human food, and a source of bio-oil extracted from its seeds. In addition, it plays a significant role in phytoremediation by absorbing excess salts from the soil, helping restore degraded land over time.

Other notable species include *Salvadora persica* (Chota Pilu), famous for its traditional use as Miswak and its medicinal properties, and *Salix babylonica* (willow), which provides timber and raw material for the furniture industry. Together, these species demonstrate how halophytes can simultaneously support environmental restoration, rural livelihoods, and sustainable economic development in Pakistan's salt-affected landscapes.

Building a Halophyte-Based Future for the Indus Delta

The growing body of research on halophytes offers valuable lessons for addressing the environmental challenges facing the Indus Delta and other salt-affected regions of Pakistan. However, realizing the full potential of these species will require a coordinated approach that combines scientific research, community participation, and supportive public policies. The first and perhaps most important lesson is that successful conservation and utilization of halophytes cannot be achieved through top-down interventions alone. Local communities must be placed at the center of planning and implementation efforts because their livelihoods are directly linked to the health of the surrounding ecosystem. Empowering local residents through participatory management programs, training initiatives, and incentive-based conservation schemes can significantly improve the long-term sustainability of restoration efforts.

Equally important is recognizing that halophytes should complement rather than replace conventional agriculture. Their primary role should be the productive utilization and rehabilitation of lands already degraded by salinity, waterlogging, and seawater intrusion. By converting otherwise unproductive areas into sources of fodder, fuelwood, medicinal products, and industrial raw materials, halophytes can generate economic value while gradually improving soil conditions. Productive agricultural lands, meanwhile, should continue to support conventional crop cultivation.

Research remains another critical priority. Despite Pakistan's extraordinary diversity of halophyte species, scientific understanding of many native plants remains limited. More laboratory studies, field trials, and ecological assessments are needed to identify species with the greatest economic and environmental potential while ensuring that large-scale cultivation does not create unintended ecological impacts.

Perhaps the most important change required is a shift in perspective. Saline lands should no longer be viewed as wastelands destined for abandonment. Instead, they should be recognized as specialized ecosystems capable of supporting productive and climate-resilient agricultural systems. With strategic investment, community engagement, and continued research, Pakistan can transform its salt-affected landscapes into engines of environmental restoration and rural development, positioning itself as a global leader in bio-saline agriculture and sustainable land management.

Conclusion

Pakistan's Indus Delta is undergoing severe ecological stress driven by salinity, waterlogging, seawater intrusion, and declining freshwater flows, yet halophytes offer a viable pathway to transform degradation into restoration. These salt-tolerant plants not only survive harsh conditions but actively rehabilitate soils through phytoremediation, groundwater regulation, and biomass production. With Pakistan's rich halophytic biodiversity, there is strong potential to develop bio-saline agriculture that generates fodder, fuel, timber, medicinal products, and industrial raw materials while restoring degraded landscapes. Species such as Atriplex, Salicornia, Eucalyptus camaldulensis, and Salvadora persica demonstrate how ecological resilience and rural livelihoods can be jointly strengthened. However, success depends on participatory governance, targeted research, and policy support that integrates halophytes into marginal land use strategies without displacing

conventional agriculture. Reframing saline lands as productive ecosystems can turn environmental risk into opportunity. The Indus Delta can emerge as a model for climate-resilient ecological restoration and sustainable rural development in Pakistan.

Please note that the views expressed in this article are of the author and do not necessarily reflect the views or policies of any organization.

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Shaping the Future of Agriculture Sustainably

Discover how the future of agriculture is being transformed by sustainable practices, artificial intelligence, and innovative technologies. Learn about the importance of ethical governance, environmental stewardship, and inclusive access that ensures smallholder farmers are not left behind.

Mithat Direk

6/26/2026

As humanity moves deeper into the twenty-first century, agriculture stands at one of the most critical turning points in its ten-thousand-year history. Never has the world's food production system faced such a complex combination of challenges, yet never has it possessed such extraordinary opportunities for innovation and transformation. The global agricultural sector must now achieve what once seemed impossible: produce significantly more food while using fewer natural resources, reducing environmental impacts, and adapting to a rapidly changing climate. This delicate balancing act has become one of the defining challenges of sustainable development.

The scale of the challenge is immense. According to projections by the United Nations, the global population is expected to reach approximately 9.7 billion by 2050. Feeding this growing population will require an estimated 60–70 percent increase in agricultural production, while some studies suggest that overall food availability may need to nearly double to meet rising demand. Increasing incomes in many developing countries are also changing dietary preferences, leading to greater consumption of meat, dairy products, fruits, and vegetables, all of which place additional pressure on agricultural systems.

At the same time, the natural resource base that supports agriculture is under unprecedented strain. Freshwater resources are becoming increasingly scarce due to overuse, pollution, and prolonged droughts. Climate change is altering rainfall patterns, increasing temperatures, and intensifying extreme weather events such as floods, heatwaves, storms, and prolonged dry spells, making agricultural production more uncertain and vulnerable. Productive farmland is steadily shrinking because of rapid urbanization, industrial expansion, soil degradation, salinization, and desertification. Biodiversity loss, declining soil fertility, and increasing pest and disease outbreaks further threaten crop productivity and livestock production.

These interconnected pressures have fundamentally changed the role of agriculture. It is no longer viewed simply as an economic sector responsible for producing food and raw materials. Today, agriculture lies at the heart of global food security, poverty reduction, public health, environmental sustainability, climate resilience, and geopolitical stability. Countries increasingly recognize that maintaining reliable food production is closely linked to national security, economic competitiveness, and social stability. Consequently, agricultural transformation has become a strategic priority for governments, researchers, and international organizations worldwide.

Meeting these challenges will require more than incremental improvements in conventional farming practices. Future agriculture must become smarter, more efficient, and more resilient by embracing technological innovation, digital agriculture, climate-smart farming, precision agriculture, biotechnology, sustainable water management, and resource-efficient production systems. The question facing the global community is therefore no longer whether agriculture must transform, but how quickly can it adopt innovative solutions capable of producing more food while protecting the planet for future generations.

The Technological Revolution Reshaping Agriculture

Agriculture is undergoing one of the most profound technological transformations in human history. The Fourth Industrial Revolution, a concept introduced by Klaus Schwab, describes the fusion of physical, digital, and biological technologies that are redefining industries across the world. Agriculture is at the forefront of this transformation, as innovations once considered futuristic are rapidly becoming part of everyday farming. The integration of digital technologies into agriculture is creating smarter, more efficient, and more sustainable production systems capable of meeting the growing global demand for food while conserving natural resources.

Artificial intelligence (AI), big data analytics, the Internet of Things (IoT), robotics, autonomous machinery, cloud computing, blockchain, and advanced biotechnology are collectively revolutionizing how crops and livestock are produced, managed, and marketed. Traditional farming, which largely depended on manual labor, accumulated experience, and unpredictable weather conditions, is increasingly evolving into a knowledge-intensive, data-driven enterprise where timely information has become as valuable as land, water, or machinery.

One of the most significant developments is precision agriculture. Using satellite imagery, drones, GPS-guided equipment, remote sensors, and IoT-enabled monitoring devices, farmers can collect real-time information on soil moisture, nutrient levels, crop health, weather conditions, and pest infestations. Artificial intelligence processes these large datasets to recommend the optimal timing and quantity of irrigation, fertilization, pesticide application, and harvesting. This precision not only increases crop yields but also reduces production costs, minimizes environmental pollution, conserves water, and improves input-use efficiency.

The technological revolution extends well beyond precision farming. Autonomous tractors and robotic harvesters are reducing labor shortages while improving operational efficiency. Vertical farming and controlled-environment agriculture allow crops to be grown year-round using significantly less land and water. Advances in gene-editing technologies, such as CRISPR, are enabling the development of crop varieties that are more

resistant to drought, pests, and diseases while offering improved nutritional value. Meanwhile, digital twin technology creates virtual models of farms, allowing producers to simulate different management strategies, predict outcomes, and optimize production before making real-world decisions. Together, these innovations are reshaping agriculture into a highly connected, intelligent, and resilient sector capable of addressing the food security challenges of the twenty-first century.

Agriculture 5.0: The Human-Robot Symbiosis

The evolution of agriculture has progressed through several transformative stages, each driven by technological innovation. Agriculture 1.0 relied almost entirely on human labor and animal power. Agriculture 2.0 introduced mechanization through tractors and modern machinery, dramatically increasing productivity. Agriculture 3.0 brought computers, Global Positioning Systems (GPS), and precision farming technologies into agricultural operations, while Agriculture 4.0 integrated digital technologies, artificial intelligence, sensors, drones, and the Internet of Things to create data-driven farming systems. Today, the world is entering Agriculture 5.0, a new era that emphasizes collaboration between humans and intelligent machines rather than simple automation.

Agriculture 5.0 envisions farms where farmers, robots, and artificial intelligence complement one another's strengths. While machines excel at repetitive, labor-intensive, and highly precise tasks such as planting, spraying, harvesting, and monitoring crop health, human farmers continue to provide strategic planning, ethical judgment, creativity, and experience-based decision-making. This partnership creates more efficient, productive, and sustainable farming systems capable of responding rapidly to changing environmental conditions.

One of the most advanced concepts emerging from Agriculture 5.0 is autonomous or "lights-out" farming, where interconnected machines, sensors, and AI systems manage entire production cycles with minimal human intervention. These systems can operate around the clock, optimize resource use, reduce production costs, minimize waste, and improve yields. Nevertheless, the transition also raises important questions regarding employment, rural livelihoods, digital inclusion, and equitable access to technology. Ensuring that technological progress benefits smallholder farmers alongside large commercial enterprises will be essential if Agriculture 5.0 is to support both agricultural productivity and inclusive rural development.

The Geopolitics and Ethics of Agricultural Technology

The rapid digital transformation of agriculture is reshaping not only how food is produced but also how economic and political power is distributed across the world. Agricultural technology has become a strategic asset, placing food production at the center of international competition. In the twenty-first century, agricultural data are increasingly viewed as the "new oil" of the global food system. Countries and companies that possess accurate, timely, and comprehensive data on weather, soil, crop performance, water resources, markets, and consumer demand gain significant advantages in improving productivity, forecasting food supplies, influencing commodity markets, and strengthening national food security. As a result, control over agricultural data is becoming as important as control over traditional natural resources.

This transformation has important geopolitical implications. Seed patents, biotechnology, artificial intelligence, and digital farming platforms are increasingly concentrated in a relatively small number of multinational corporations and technologically advanced countries. Dependence on imported seeds, agricultural software, precision equipment, cloud-based platforms, and satellite services creates new forms of technological dependence, particularly for developing nations. At the same time, concerns over cross-border data flows, cybersecurity, digital surveillance, and ownership of farm-generated data have elevated agriculture from a purely economic activity to a matter of national security. Autonomous machinery and AI-powered decision systems also raise new legal and regulatory questions concerning liability, data ownership, privacy, and intellectual property rights. Nations that fail to build domestic research capacity and technological capabilities risk losing control over critical components of their food systems, making agricultural innovation an increasingly important dimension of economic sovereignty.

Yet technological advancement alone cannot guarantee a sustainable agricultural future. The transition toward Agriculture 5.0 must be guided by ethical principles that place people, equity, and environmental stewardship at its core. The vision of a highly automated, carbon-negative, climate-resilient agricultural system by 2050 should not be measured solely by productivity gains but also by its ability to improve livelihoods, reduce inequality, and protect natural ecosystems. Smallholder farmers, who produce a significant share of the world's food, must have equitable access to digital technologies, financial resources, extension services, and agricultural innovations. Protecting data sovereignty alongside food sovereignty will be essential to ensure that farmers retain control over information generated on their farms. Likewise, international cooperation should complement healthy technological competition, encouraging knowledge sharing, responsible innovation, and collaborative responses to global food challenges.

Emerging frontiers such as synthetic foods, cellular agriculture, gene editing, vertical farming, and even space agriculture offer exciting possibilities for the future of food production. However, these innovations should complement rather than replace sustainable farming systems rooted in ecological principles. Regenerative agriculture, agroforestry, conservation tillage, precision resource management, and soil carbon sequestration demonstrate that food production and environmental restoration can progress together. Ultimately, the future of agriculture will depend not only on the sophistication of its technologies but also on humanity's ability to ensure that innovation remains inclusive, ethical, resilient, and aligned with the long-term goals of food security, environmental sustainability, and shared global prosperity.

Conclusion

The future of agriculture will be shaped not only by how much food we produce but by how intelligently, sustainably, and equitably we produce it. Emerging technologies such as artificial intelligence, robotics, biotechnology, and digital agriculture offer unprecedented opportunities to improve productivity, conserve natural resources, and strengthen global food security. However, technological progress must be accompanied by sound policies, ethical governance, environmental stewardship, and inclusive access that ensures smallholder farmers are not left behind. As climate change, resource scarcity, and population growth continue to reshape global agriculture, innovation must serve both people and the planet. By combining scientific advancement with sustainable farming practices and international cooperation, agriculture can evolve into a resilient, climate-smart system capable of feeding future generations while protecting the natural resources upon which humanity depends.

Please note that the views expressed in this article are of the author and do not necessarily reflect the views or policies of any organization.

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Climate Change Impact on Pakistan's Agriculture

Explore how climate change is reshaping Pakistan's agricultural economy, affecting water availability, crop productivity, and rural livelihoods. Learn about the rising temperatures, shifting rainfall patterns, and the need for climate-smart agriculture to ensure food security.

Nazar Gul

6/10/2026

Climate change is no longer a distant environmental issue discussed only in scientific reports and international conferences. It has become a present-day reality that is already reshaping agricultural production systems across the world. While variations in climate have occurred throughout Earth's history, an overwhelming body of scientific evidence confirms that human activities particularly the burning of fossil fuels, deforestation, industrialization, and the rapid increase in greenhouse gas emissions since the Industrial Revolution, have significantly accelerated global warming. These changes are altering temperature patterns, rainfall distribution, and the frequency of extreme weather events, creating unprecedented challenges for food production and rural livelihoods.

Developing countries are especially vulnerable because their economies depend heavily on climate-sensitive sectors such as agriculture. Among these nations, Pakistan stands out as one of the countries most exposed to climate-related risks. Despite contributing, only a small share of global greenhouse gas emissions, Pakistan consistently ranks among the countries most affected by climate variability and extreme weather events. Rising temperatures, erratic rainfall patterns, glacier melt, prolonged droughts, and devastating floods are becoming increasingly common, placing immense pressure on natural resources and agricultural systems.

Climate projections paint a concerning picture for the country. Under moderate emission scenarios, Pakistan's average annual temperature is expected to rise by approximately 3-5°C by the end of the century. Under high-emission pathways, temperature increases could reach 4-6°C or even higher in some regions. Such warming is expected to intensify heatwaves, accelerate evapotranspiration, reduce soil moisture, and increase crop water requirements. At the same time, changes in precipitation patterns may lead to more frequent and severe droughts in some areas while increasing the risk of flash floods and riverine flooding in others.

These climatic changes have serious implications for water availability. Pakistan's agriculture relies heavily on the Indus Basin Irrigation System, one of the largest irrigation networks in the world. However, rising temperatures, changing river flows, declining groundwater reserves, and increased competition for water resources threaten the long-term sustainability of agricultural production. Water scarcity is likely to become one of the most significant constraints on future food security.

The implications extend far beyond crop production. Agriculture remains a cornerstone of Pakistan's economy, supporting millions of rural households and providing livelihoods for a substantial share of the population. Even modest declines in agricultural productivity can reduce farm incomes, increase rural poverty, worsen food insecurity, and undermine national economic growth. Consequently, climate change represents not only an environmental challenge but also a major socioeconomic threat that demands urgent adaptation measures, resilient agricultural practices, and long-term policy planning to safeguard Pakistan's food security and rural development.

Changing Agro-Climatic Conditions: Evidence from Pakistan

Long-term meteorological records provide clear evidence that Pakistan is already experiencing significant climatic changes. Rather than being a future possibility, climate change is now observable in the country's weather patterns, particularly in agricultural regions that depend heavily on predictable temperature and rainfall conditions. An analysis of 34 years of climatic data (1987-2020) from the Tando Jam research station in Sindh reveals notable shifts in several key weather indicators that directly influence crop production and water management.

The data show that average annual temperatures increased from 26.38°C during 1987-2003 to 26.83°C during 2004-2020, reflecting a rise of 0.45°C. Although this increase may appear modest, even small temperature changes can have substantial impacts on crop growth, water requirements, pest populations, and overall agricultural productivity. At the same time, average annual rainfall increased by approximately 75.5 mm, indicating growing variability in precipitation patterns. While additional rainfall may seem beneficial, irregular and intense rainfall events often create challenges such as waterlogging, soil erosion, and flooding rather than improving agricultural productivity.

Other climatic variables also demonstrate important changes. Average wind speed declined by 1.20 knots, while relative humidity decreased by nearly 3 percentage points. Sunshine duration increased by approximately 0.82 hours per day, exposing crops to longer periods of solar radiation and higher heat stress. Meanwhile, reductions in reference evapotranspiration and pan evaporation suggest alterations in the regional water balance and atmospheric conditions.

These observed trends are consistent with findings reported by the Intergovernmental Panel on Climate Change (IPCC) and other international climate assessments. Rising temperatures accelerate crop development, often shortening growing seasons and reducing grain-filling periods, which can lower yields. Changes in rainfall patterns affect irrigation scheduling, groundwater recharge, and drainage management, creating additional uncertainty for farmers. Collectively, these climatic shifts indicate that Pakistan's agricultural sector is operating under increasingly different environmental conditions than those experienced by previous generations, highlighting the urgent need for climate-smart farming practices and adaptive agricultural policies.

Climate Change and the Need for Adaptive Irrigation Management

Water availability is one of the most important pathways through which climate change influences agricultural productivity. In a country like Pakistan, where agriculture depends heavily on irrigation, even small changes in temperature, rainfall, humidity,

sunshine duration, and wind speed can significantly alter crop water requirements. Crop evapotranspiration (ET), which represents the combined loss of water through soil evaporation and plant transpiration, is particularly sensitive to these climatic factors and serves as a key indicator for determining irrigation needs. Traditionally, irrigation allocations in Pakistan have been based on historical estimates of crop water requirements. However, ongoing climatic changes suggest that many of these long-established benchmarks may no longer accurately reflect current field conditions.

Evidence from lysimeter-based studies conducted at Tando Jam provides valuable insights into how climate change is affecting major crops differently. Comparisons between data collected during 1986-1987 and more recent observations from 2017-2021 indicate that wheat evapotranspiration has increased noticeably. Rising maximum temperatures and longer sunshine hours during the critical growth period from December to March have intensified crop water demand. Higher temperatures increase transpiration rates and accelerate crop development, requiring additional irrigation to prevent moisture stress and yield losses.

In contrast, cotton has exhibited a decline in evapotranspiration requirements. Reduced wind speeds, lower reference evapotranspiration rates, and changing rainfall patterns have collectively decreased the crop's overall water demand. Increased seasonal rainfall also contributes more moisture to the soil profile, reducing dependence on irrigation water and lowering groundwater contributions, which previously supplied an estimated 6% to 32% of cotton's water requirements.

These findings highlight the urgent need to modernize irrigation management policies. Water allocations for wheat may need to be increased to accommodate higher evapotranspiration demands, while allocations for cotton could be optimized, particularly in areas with shallow groundwater tables. More importantly, irrigation planning should move away from static historical schedules and adopt dynamic, climate-responsive approaches based on real-time weather data, crop monitoring, and seasonal forecasts. Such adaptive water management strategies will be essential for maintaining agricultural productivity and ensuring sustainable use of Pakistan's increasingly scarce water resources under a changing climate.

Climate Change and Its Impact on Crop Productivity

Climate change is increasingly influencing crop productivity by altering growing conditions, shortening crop growth cycles, and affecting yields across Pakistan's major agricultural systems. Changes in temperature, rainfall patterns, humidity, and solar radiation directly influence plant development, making it essential for farmers and policymakers to understand how these shifts affect agricultural production. Both field observations and simulation studies indicate that climate change is modifying the phenological behavior of crops, often accelerating growth stages and reducing the time available for biomass accumulation and yield formation.

Research using the Agricultural Production Systems Simulator (APSIM) model has shown that rising temperatures are significantly shortening the cotton growth cycle. The duration from sowing to physiological maturity has declined by approximately 2.30 to 5.66 days per decade, while the overall phenological period has contracted by around 4.23 days per decade. Shorter growth periods limit the crop's ability to utilize sunlight, water, and nutrients effectively, ultimately reducing productivity. Over the period from 1961 to 2015, changing climatic conditions were estimated to have reduced cotton yields by approximately 18.2%, highlighting the vulnerability of this important cash crop to warming temperatures.

The impact on wheat is more complex. Some studies suggest that moderate increases in temperature and humidity may enhance wheat growth under favorable conditions. However, excessive rainfall can damage crops, increase disease incidence, and reduce yields. More importantly, rising temperatures during critical reproductive stages increase the likelihood of heat stress, which can shorten grain-filling periods and reduce grain quality and yield.

In Sindh, climate change interacts closely with water management challenges. Increased rainfall combined with inadequate drainage systems heightens the risks of waterlogging and soil salinity, particularly in areas where groundwater tables are already shallow. These conditions can significantly degrade agricultural land and reduce long-term productivity. To adapt to changing climatic conditions, researchers recommend adjusting planting schedules. For cotton, sowing during the first week of April allows farmers to complete the most productive harvesting stages before the arrival of monsoon rains, thereby reducing weather-related production risks and improving overall crop performance.

Socio-Economic Impacts and Policy Imperatives for Climate-Resilient Agriculture

Climate change is far more than an environmental challenge; it is a profound socio-economic threat that affects livelihoods, incomes, employment opportunities, and overall rural welfare. While declining crop yields often receive the greatest attention, the consequences extend throughout the rural economy, influencing labor markets, household consumption, investment decisions, and poverty levels. As temperatures rise and weather patterns become increasingly unpredictable, rural households face growing uncertainty regarding both agricultural production and income generation.

Recent empirical research based on data from 156,441 households across 126 districts of Pakistan, combined with climatic records covering the period 1960-2020, provides compelling evidence of the economic costs of climate change. The study found that a 1°C increase in average temperature reduces agricultural household income by approximately 3.3%, while non-agricultural household income declines by 0.4%. Furthermore, a 1°C increase in temperature variability lowers incomes by nearly 4% across both agricultural and non-agricultural sectors. Although increases in average precipitation can generate modest income gains, greater rainfall variability often produces the opposite effect by increasing production risks, damaging infrastructure, and disrupting economic activities.

These findings highlight the interconnected nature of climate vulnerability. Rural economies are not solely dependent on farming. Agricultural production supports transport services, input suppliers, traders, processors, and rural labor markets. Consequently, climate-induced shocks in agriculture create ripple effects throughout local economies, reducing employment opportunities and weakening household resilience.

Addressing these challenges requires a comprehensive and evidence-based policy response. Strengthening climate information services can help farmers make informed decisions regarding planting dates, irrigation schedules, and crop management practices. Expanding access to localized weather forecasts and digital advisory systems will improve adaptive capacity at the farm level. Water management policies must also be revised to reflect changing crop water requirements, supported by investments in efficient irrigation technologies and improved drainage systems.

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Promoting climate-smart agriculture through heat-tolerant crop varieties, conservation agriculture, precision farming, and sustainable water management practices will be essential for maintaining productivity under changing climatic conditions. At the same time, targeted credit programs and climate adaptation financing can enable farmers to invest in resilient technologies. Investments in disaster preparedness, flood protection infrastructure, early warning systems, and rural emergency response mechanisms will further reduce economic losses. Ultimately, climate resilience must become a central pillar of Pakistan's development strategy, integrating agriculture, water resources, renewable energy, environmental conservation, and rural development into a unified framework capable of safeguarding livelihoods and food security in an increasingly uncertain climate.

Conclusion

Climate change has emerged as a defining challenge for Pakistan's agricultural economy, reshaping water availability, crop productivity, and rural livelihoods. Evidence from long-term climatic records and field-based studies confirms rising temperatures, shifting rainfall patterns, and increasing variability in key weather variables that directly affect evapotranspiration and crop growth cycles. These changes are already reducing yields of major crops like cotton, altering wheat responses, and increasing risks of waterlogging, salinity, and irrigation inefficiencies across Sindh and other irrigated regions. The socio-economic impacts are equally severe, with rural households experiencing income losses, higher vulnerability, and reduced resilience due to climate-induced shocks that extend beyond agriculture into wider rural economies. Addressing these challenges requires climate-smart agriculture, improved water management, strengthened climate information systems, and supportive policies that promote adaptation, investment, and rural resilience. Ultimately integrating climate resilience into Pakistan's agricultural planning is essential for food security.

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Intercropping in Sugarcane Farming for Smallholders

Discover how intercropping in sugarcane-based systems can enhance smallholder agriculture across Pakistan. This approach optimizes land use, boosts productivity, and provides economic stability for farmers in Sindh, Punjab, and other regions.

Nazar Gul

6/2/2026

In the sugarcane fields of Sindh and Punjab, a quiet transformation is emerging that challenges the conventional logic of farming systems in Pakistan. It does not depend on expensive machinery, imported seed packages, or large-scale land consolidation. Instead, it relies on rethinking how a single piece of land can be used more intelligently by the same farmer who has worked it for decades. The approach is intercropping, and it represents one of the most accessible pathways toward climate-resilient and income-stabilizing agriculture for smallholders.

At its core, intercropping involves cultivating two or more crops simultaneously on the same field. Rather than dedicating an entire season to a single crop, farmers integrate compatible crops such as legumes between sugarcane rows or vegetables like onions and tomatoes in mixed spatial arrangements. This system allows the land to produce multiple outputs within the same growing cycle, effectively multiplying productivity without expanding cultivated areas.

The urgency for such practices is increasing as Pakistan faces severe water stress and climatic volatility. In regions such as southern Punjab and Sindh, declining canal supplies, falling groundwater tables, and erratic rainfall patterns are making traditional mono-cropping systems increasingly risky. A single crop failure can wipe out an entire season's income, leaving households financially exposed and food insecure.

Intercropping helps mitigate these risks by diversifying production and stabilizing farm returns. Agronomic evidence suggests that mixed cropping systems improve water-use efficiency and nutrient uptake, while also reducing pest pressure through greater ecological diversity. For instance, nitrogen-fixing legumes can enhance soil fertility, reducing dependence on costly chemical fertilizers. Similarly, diversified crop canopies can reduce evaporation losses and improve soil moisture retention.

For smallholders operating on two to five acres, these gains are not abstract technical improvements but tangible livelihood safeguards. Additional harvests provide supplementary income streams that can cover school fees, healthcare costs, and debt repayment. In many rural households, this diversification can mean the difference between seasonal survival and long-term economic mobility.

Beyond household benefits, intercropping also contributes to national agricultural resilience. It reduces pressure on water resources, enhances productivity, and supports more stable food supply systems. In a country where agriculture remains highly vulnerable to climate shocks, such adaptive practices are not optional innovations but necessary components of future food security strategies. Ultimately, intercropping represents a shift from extractive to regenerative thinking in Pakistani agriculture where land is no longer seen as a single-output resource but as a dynamic system capable of sustaining multiple livelihoods at once.

The Hidden Wealth Between the Rows

Sugarcane remains one of Pakistan's most important cash crops, underpinning the sugar industry and sustaining millions of rural livelihoods. Yet beneath its apparent economic strength lies an underutilized spatial opportunity. For nearly three to four months after planting, sugarcane occupies the land only partially, leaving wide inter-row spaces exposed to sunlight, moisture, and fertile soil that often go unused. In a resource-constrained agricultural economy, this "empty space" represents a missed production opportunity.

Intercropping transforms this inefficiency into additional income. Farmers strategically introduce short-duration crops into the gaps between sugarcane rows during its early growth phase. A wide range of crops can be integrated depending on season and locality, including potatoes, onions, tomatoes, garlic, peas, lentils, wheat, mustard, sunflower, coriander, mung beans, and even tobacco. These crops mature quickly and are harvested before the sugarcane canopy closes, ensuring minimal competition for light and nutrients if managed properly.

Field evidence from Pakistan strongly supports this approach. In sugar beet–wheat systems, intercropping reduces sugar beet yield only marginally from about 76 to 70 tonnes per hectare while adding a full wheat harvest. This dual output significantly increases profitability, raising net income from around 70,000 rupees per hectare to over 86,000 rupees. Similarly, in Muzaffargarh, onion-tomato intercropping systems have shown benefit-cost ratios of 1.59, outperforming sole cropping systems. The land equivalent ratio of 1.31 indicates that intercropping produces 31 percent more value from the same land area.

For smallholders facing rising input costs, shrinking landholdings, and climate variability, these gains are economically transformative. Intercropping does not demand additional land or expensive technology; it simply requires better spatial planning and agronomic timing. In doing so, it converts idle field space into productive capital, strengthening household income, improving food availability, and enhancing resilience in Pakistan's fragile rural economy.

The Best Combinations for Pakistani Farmers

Field research conducted at the University of Agriculture, Faisalabad has provided strong empirical evidence on the most profitable intercropping combinations within sugarcane-based systems in Pakistan. These trials demonstrate that careful crop pairing can significantly enhance farm profitability without requiring additional land or major capital investment.

Among all tested combinations, sugarcane intercropped with lentil delivered the highest benefit-cost ratio of 2.78. Lentils mature early, allowing timely harvest before sugarcane canopy closure while also improving soil fertility through nitrogen fixation. Sugarcane with garlic closely followed at 2.72, reflecting strong market demand and compatibility with winter cropping windows. Sugarcane–peas (2.63) and sugarcane–sunflower (2.58) also showed robust economic performance, combining stable yields with diversified income

streams. Even more traditional combinations such as sugarcane–wheat (2.04) and sugarcane–mustard (2.20) remained economically viable, particularly for risk-averse farmers.

The recommended agronomic package for these systems includes 90-centimeter row spacing for sugarcane, intercrop sowing during October–November, and balanced fertilization of approximately 150–100–100 kg/ha of NPK. With around 18 light irrigations across the growing season, researchers observed stable crop interactions and efficient resource utilization.

A particularly important finding is that sugarcane yield reduction remains relatively minor, typically only 5 to 10 percent under intercropping conditions. However, the additional income from the intercrop more than compensates for this marginal decline, resulting in a clear net economic gain for farmers. In essence, farmers sacrifice a small portion of a single crop to secure a second full harvest.

Despite these advantages, adoption remains limited across Pakistan's rural landscape. One major constraint is lack of awareness, particularly in districts of Sindh and Balochistan where extension outreach is weak and demonstration plots are scarce. Farmers often remain unaware of successful models operating in other regions.

Secondly, intercropping demands careful agronomic planning. Precise timing of sowing, irrigation scheduling, and fertilizer application are essential to avoid competition between crops. For many smallholders accustomed to simpler mono-cropping systems, this added complexity can be discouraging.

Finally, input and mechanization constraints persist. High-quality seed for intercrops is often costly and not readily accessible, while existing farm machinery is typically designed for single-crop systems. Without affordable inputs and suitable equipment, scaling intercropping remains a structural challenge despite its proven economic benefits.

Practical Advice for Farmers Who Want to Start

For farmers considering intercropping in sugarcane systems, the key message from agronomists is simple: start cautiously, manage precisely, and treat the intercrop as an opportunity for additional income rather than a substitute for the main crop. Sugarcane remains the backbone of the system, while the intercrop functions as a strategic supplement that improves land productivity and cash flow.

Proper field layout is essential. Maintaining row spacing of 3 to 4 feet between sugarcane lines creates enough light penetration and physical space for intercrops to establish without excessive competition. Narrow spacing increases yield risk for both crops, while wider spacing improves air circulation and reduces disease pressure.

Crop selection is equally important. Farmers are advised to choose short-duration and short-stature varieties such as lentils, peas, garlic, onions, or certain leafy vegetables. Long-duration or tall crops, particularly late-maturing sunflowers or aggressive cereals, can overshadow sugarcane and reduce overall system performance. Timing should align with the early growth stage of sugarcane, typically within the first 90-120 days after planting.

Soil fertility management plays a critical role in success. Application of organic manure improves soil structure, moisture retention, and nutrient availability, making the system more resilient. Importantly, intercrops should receive their own targeted fertilizer doses rather than relying solely on inputs applied to sugarcane. This ensures balanced growth and avoids nutrient competition.

Weed management must also be carefully monitored. While intercropping naturally suppresses weed growth due to better ground cover, farmers may still need manual weeding or selective herbicide application to protect yields. Neglecting weed control can quickly offset the economic benefits of the system.

Finally, post-harvest management is crucial. Once the intercrop is harvested, farmers must immediately refocus attention on sugarcane. Earthing up, irrigation scheduling, and supplemental fertilization at this stage ensure that the main crop recovers fully and continues its growth trajectory without stress.

Conclusion

Intercropping in sugarcane-based systems is emerging as one of the most practical and inclusive pathways for strengthening Pakistan's smallholder agriculture. Across Sindh, Punjab, and other agro-ecological zones, it demonstrates how better use of existing lands (not the expansion of land) can significantly improve productivity, income stability, and resilience to climate stress. By integrating short-duration crops within sugarcane fields, farmers can convert previously underutilized inter-row spaces into productive economic assets, effectively generating two streams of output from a single growing season.

The evidence from field trials is compelling. Whether through lentils, garlic, peas, or wheat, intercropping consistently improves benefit-cost ratios and land-use efficiency while only marginally reducing sugarcane yields. More importantly, these gains are not confined to experimental plots; they translate directly into improved household cash flow, better food security, and reduced vulnerability to market and climate shocks. For smallholders, the ability to generate supplementary income within the same landholding can determine whether a family remains in debt cycles or moves toward economic stability.

However, the full potential of intercropping remains unrealized due to structural barriers such as limited extension services, inadequate access to quality seed, mechanization constraints, and the complexity of farm management. Overcoming these challenges requires coordinated action in research dissemination, input supply systems, and farmer training.

Ultimately, intercropping represents a shift in agricultural thinking from single-output, risk-prone farming to diversified, resilient, and resource-efficient systems. In a country facing mounting water scarcity and climatic uncertainty, such adaptive practices are not merely beneficial innovations; they are essential building blocks of future food security and rural prosperity in Pakistan.

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Eid Ul Adha: Boosting Pakistan's Economy Through Hide Preservation

Eid ul Adha is more than a religious event; it's a chance for Pakistan to enhance its economy. By improving hide preservation and handling, we can prevent losses from sacrificial animals, boost leather exports, to transform a recurring seasonal loss into a national prosperity.

Syed Bassam Akhtar

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Every Eid-ul-Adha, Pakistan experiences one of the largest seasonal economic movements in the country. Livestock markets overflow, transport networks surge, butchers work around the clock, and billions of rupees flow from urban centers to rural households. Yet beneath this celebration lies a largely invisible economic loss that repeats itself year after year: the destruction of animal hides through poor handling, delayed collection, and inadequate preservation.

The scale of the issue is enormous. In 2026, Pakistanis sacrificed an estimated 7.47 million animals during Eid-ul-Adha, according to the Pakistan Tanners Association (PTA). The festival generated economic activity worth nearly Rs. 950 billion. Among these transactions were hides valued at approximately Rs. 8.67 billion, a major raw material input for Pakistan's leather industry, one of the country's important export sectors.

But much of this value never reaches tanneries in usable form. In many neighborhoods, hides are left exposed in heat, folded incorrectly, contaminated with blood and dirt, or collected hours too late. By the time traders reach them, many skins have begun to decay, sharply reducing their quality and market price. What should become export-grade leather for shoes, gloves, jackets, and sports goods often ends up as low-value scrap or complete waste.

The problem is not a shortage of animals or demand. It is a breakdown in the collection chain. Small charities compete for hides without proper storage systems. Many volunteers lack basic knowledge about curing and preservation. Salt, the simplest preservation tool, is often unavailable in sufficient quantities. Municipal waste systems become overwhelmed, and transport delays worsen spoilage.

This is a classic example of value leakage in a rural-urban supply chain. Pakistan already possesses the livestock base, the tanning industry, and international market access. What it lacks is coordination. A modest investment in public awareness, salt distribution, cold-chain logistics, and organized hide collection could save billions of rupees annually. In economic terms, Pakistan is not losing hides because it lacks resources; it is losing them because the system fails in the crucial first 24 hours after slaughter.

From Valuable Asset to Waste: The Six-Hour Race Against Time

One of the least understood facts about Pakistan's leather industry is that the value of an animal hide begins to disappear almost immediately after slaughter. A freshly removed hide is a highly perishable biological material. If it is not preserved properly, bacterial decomposition can begin within six hours, especially under the hot and humid conditions that typically prevail during Eid-ul-Adha. Since the festival now falls during Pakistan's summer and monsoon months, high temperatures and moisture create ideal conditions for bacterial growth, accelerating the deterioration process and rapidly reducing the commercial value of hides.

Fortunately, preserving a hide is neither complicated nor expensive. The most effective method involves applying coarse rock salt to the flesh side of the skin as soon as possible after flaying. Experts recommend using approximately 5 to 8 kilograms of salt per hide and applying it within two hours of slaughter. This simple process draws out moisture, suppresses bacterial activity, and extends the storage life of the hide from a few hours to nearly a month. Such preservation provides sufficient time for transportation, collection, and processing by tanneries without significant quality loss.

Unfortunately, this basic practice is often neglected. Across many cities and villages, hides are commonly left exposed in open spaces, charity collection camps, Madrassa compounds, and roadside collection points for long periods without proper curing. In many cases, volunteers responsible for handling hides have little or no technical training in preservation methods. Hides are frequently stacked improperly, folded while still wet, or left under direct sunlight. Poor skinning techniques also contribute to the problem, as inexperienced butchers often leave deep knife cuts and holes that reduce leather quality and market value.

The consequences are severe. Industry estimates suggest that between 20 and 30 percent of hides collected during Eid-ul-Adha suffer substantial quality deterioration each year, resulting in significant financial losses for charities, traders, tanneries, and the national economy.

The irony is particularly striking because Pakistan possesses one of the largest leather industries in the region. The sector contributes substantially to export earnings through the production of leather garments, gloves, footwear, and accessories sold in international markets. Yet despite having millions of sacrificial animals available annually, domestic shortages of high-quality raw hides force some manufacturers to import skins from countries such as the United Kingdom and New Zealand. In effect, Pakistan loses valuable local raw material through poor post-slaughter management and then spends precious foreign exchange to replace what could have been preserved at a fraction of the cost. This represents not only an avoidable economic loss but also a missed opportunity to strengthen one of the country's most important value-added export industries.

The Missing Link in Pakistan's Hide Collection System

Pakistan does not suffer from a shortage of hide collectors. In fact, few countries can match the scale and reach of the volunteer networks that become active during Eid-ul-Adha. Religious seminaries, mosques, welfare organizations, and charitable foundations mobilize thousands of volunteers to collect sacrificial hides from homes, neighborhoods, and community slaughter points. These organizations have earned public trust over decades and play an important role in raising funds for education, social welfare, and humanitarian activities.

The challenge, however, lies not in collection but in preservation and quality management. Most volunteers involved in hide collection are dedicated community workers rather than leather industry professionals. Their primary objective is to gather as many hides as possible, not necessarily to ensure that each hide retains its maximum market value. As a result, many collectors are unfamiliar with the technical requirements of hide preservation, including proper salting, storage, transportation, and handling procedures.

A hide may appear intact to an untrained eye, but its commercial value can decline dramatically within hours if it is exposed to heat, moisture, or bacterial contamination. Similarly, improper skinning techniques can leave deep knife cuts and holes that permanently reduce leather quality. The difference between an export-grade hides and a low-value scrap skin often depends on a few simple practices: careful flaying, immediate salting, protection from direct sunlight, and timely transportation to processing facilities.

Unfortunately, many collection centers lack access to preservation materials, trained personnel, cold-storage facilities, and technical guidance. This is not a failure of the volunteers themselves but a failure of the broader support system. With proper training programs, awareness campaigns, and basic preservation resources, charities and madrassas could significantly reduce hide losses and help transform millions of rupees in wasted value into additional resources for education, welfare,

and national economic development. The potential exists; what is missing is the knowledge and infrastructure needed to unlock it.

From Rot to Revenue: A Practical Path Forward

Here's the good news: this problem is entirely solvable without building expensive factories or importing foreign technology. Countries like Turkey and Saudi Arabia already face similar Eid-related hide surges, and they have developed low-cost, high-impact systems that Pakistan can adapt immediately. The solution rests on three simple pillars, none of which require billions in infrastructure spending. First, Pakistan needs a relentless public education campaign launched well before Eid. The government, working alongside the Pakistan Tanners Association and the Ministry of Information, should flood television channels, radio stations, social media platforms, and mosque loudspeakers with one clear, memorable message: "Salt your hides within two hours. Five to eight kilograms of rock salt rubbed directly on the flesh side. Save Pakistan's leather." This is not complicated science; it is basic preservation that any household can follow. Second, every major charity collection camp whether run by madrassas, the Al-Khidmat Foundation, or local mosques must have a dedicated salt distribution desk. Local municipal corporations can subsidize industrial-grade rock salt so that volunteers never face the excuse that they lack funds to buy salt. The cost of providing salt is negligible compared to the millions of dollars in leather value that currently rot away. Third, Pakistan's major cities should establish temporary, shaded municipal abattoirs during the three days of Eid. Instead of chaotic backyard slaughters that produce deep knife gashes and unsanitary conditions, these centralized stations would feature clean concrete flooring, professional trained flayers who know how to remove a hide without cutting the grain, and on-site processing lines where salt is applied immediately or hides are moved into basic cold storage. Centralizing the slaughter in this way transforms a chaotic neighborhood event into a controlled, quality-assured process. These three interventions, public awareness, salt access, and temporary abattoirs, require no advanced technology. They require only planning, coordination across government agencies, and the political will to treat Eid hides as the multimillion-dollar national asset they truly are. The return on investment is staggering. If Pakistan saves just half of the 20 to 30 percent of hides it currently loses every Eid, that will instantly add tens of millions of dollars to the export economy, reduce the need for expensive hide imports from the United Kingdom and New Zealand, and push the leather sector closer to the billion-dollar export mark. This Eid, Pakistan has a choice: watch another fortune melt away or finally act.

Conclusion

Eid-ul-Adha is far more than a religious celebration; it is one of Pakistan's largest annual economic events. Yet every year, a significant portion of the value generated through sacrificial animals is lost because of poor hide preservation, inadequate handling, and weak coordination across the collection chain. The tragedy is not that Pakistan lacks animals, tanneries, or export markets. Rather, it lacks the awareness, training, and basic infrastructure needed to protect a valuable national asset during the critical hours following slaughter. Simple measures such as proper skinning, timely salting, improved storage, volunteer training, and organized collection systems could dramatically reduce hide wastage and increase returns for charities, communities, and the leather industry. Preserving animal hides is not merely a technical issue; it is an economic opportunity. By treating Eid hides as a strategic resource rather than a byproduct, Pakistan can strengthen its leather exports, reduce unnecessary imports, generate additional income, and transform a recurring seasonal loss into a source of sustainable national prosperity.

Please note that the views expressed in this article are of the author and do not necessarily reflect the views or policies of any organization.

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Pakistan's Rural Water Crisis: A Call for Action

Pakistan's rural water crisis is not due to a lack of water but a failure in management and distribution. Monsoon rains bring abundance, yet inadequate storage and inefficient irrigation lead to seasonal scarcity.

Nadeem Riyaz

6/17/2026

It is one of the most bewildering contradictions in Pakistan's rural landscape: water arrives in overwhelming abundance during the monsoon, yet within weeks, the same fields lie parched and cracked. Farmers watch helplessly as precious rainwater rushes across their land, carving gullies into the soil and disappearing as quickly as it came. The problem is not that Pakistan lacks rainfall, it is that the country has lost the ability to make water stay. This is not merely an environmental challenge. For millions of small farmers across the country, water has become the thin line between survival and destitution. When the rain fails to linger, entire communities face a crisis that extends far beyond agriculture, threatening food security, livelihoods, and the social fabric of rural life.

Pakistan has long been classified as a water-stressed country. Per capita water availability has fallen to approximately 900-1,000 cubic meters annually, placing the country dangerously close to the internationally recognized water scarcity threshold. Yet the real challenge is not simply the quantity of water available, but the inability to effectively capture, conserve, and manage it. During intense rainfall events, vast quantities of water are lost through surface runoff, eventually flowing into rivers and the sea without contributing to groundwater recharge or agricultural productivity.

The numbers reveal a troubling reality. Agriculture accounts for nearly 90 percent of freshwater withdrawals, yet irrigation efficiency remains among the lowest in the region. The Indus Basin Irrigation System, despite being one of the largest irrigation networks in the world, struggles with aging infrastructure, seepage losses, inequitable water distribution, and poor synchronization with crop requirements. Farmers frequently face water shortages during critical planting and growing periods, reducing yields and increasing production risks.

Groundwater, once considered a dependable safety net, is also under severe pressure. In Punjab and Sindh, excessive pumping has led to declining water tables, forcing farmers to invest in deeper tube wells and higher energy costs. Without significant improvements in rainwater

harvesting, groundwater recharge, and on-farm water management, Pakistan risks facing a future where floods and droughts occur side by side, an increasingly common consequence of climate change and poor water governance.

The Climate Connection

Climate variability is no longer a future threat for Pakistan; it is a present reality that is fundamentally altering agricultural systems and rural livelihoods. Rising temperatures, shifting weather patterns, and increasingly erratic rainfall are disrupting traditional farming calendars that generations of farmers once relied upon. Across much of the country, rainfall is becoming concentrated into shorter periods marked by intense storms, while the intervals between rain events are growing longer and drier. Today, nearly 60 to 70 percent of annual precipitation falls during the monsoon season, often within a few weeks of heavy downpours.

Unfortunately, this sudden influx of water rarely translates into long-term water security. Instead of infiltrating the soil and replenishing groundwater reserves, large volumes of rainwater flow rapidly across the landscape as runoff. This process strips away fertile topsoil, damages crops, floods villages, and carries valuable nutrients into rivers and reservoirs. Ironically, the same communities that experience destructive flooding during the monsoon frequently face severe water shortages only weeks later.

This growing imbalance has created a troubling paradox in Pakistan's agricultural sector: floods and droughts can occur within the same season and often in the same location. Fields submerged in July may suffer moisture stress by August, leaving farmers struggling to sustain crops through critical growth stages.

The Pothohar Plateau provides a striking example of this challenge. Although the region receives substantial seasonal rainfall, inadequate storage facilities, limited rainwater harvesting structures, and poor water retention capacity prevent communities from fully benefiting from this resource. As a result, farmers continue to face recurring water shortages despite receiving significant rainfall. The issue is therefore not the lack of water itself, but the absence of effective systems to capture, store, and manage rainfall in an increasingly unpredictable climate.

The Simple Solution We Ignore

Capturing rainfall where it falls may be one of the simplest, most cost-effective, and yet most neglected solutions to Pakistan’s growing water crisis. While policymakers often focus on large dams, canals, and expensive infrastructure projects, enormous quantities of rainwater continue to be lost every year because communities lack the means to retain it locally. The principle behind rainwater harvesting is straightforward: instead of allowing water to rush away as surface runoff, it should be stored, conserved, and gradually used where it is needed most. Despite its simplicity, this approach remains significantly underutilized across much of rural Pakistan.

At the farm level, small water storage ponds can play a transformative role. These ponds collect excess rainfall during the monsoon and provide a valuable source of supplemental irrigation during dry periods. Even relatively small ponds can support crops such as wheat, maize, pulses, vegetables, and fodder, particularly in rain-fed areas. In regions like the Pothohar Plateau, where rainfall is seasonal and unreliable, farm ponds reduce dependence on groundwater extraction and help farmers withstand short-term droughts. For many households, a single pond can determine whether a crop survives or fails.

At the household level, rooftop rainwater harvesting offers another practical solution. Rainwater collected from roofs can be stored in tanks and used for drinking, livestock, household activities, and kitchen gardening after basic treatment. This not only improves water availability but also reduces pressure on already depleted groundwater resources.

Equally important are groundwater recharge structures such as recharge pits, trenches, and percolation wells. These low-cost systems allow rainwater to seep into underground aquifers, helping restore groundwater levels and improve soil moisture. The technology is neither complex nor expensive. The real challenge lies in promoting widespread adoption through community awareness, technical support, and policy incentives. When integrated into broader water management strategies, these simple interventions can significantly strengthen rural resilience in an era of increasing climate uncertainty.

The Barriers of Adoption and Governance

Pakistan's water crisis is often described as a problem of scarcity, but it is equally a problem of inefficiency, limited investment capacity, and weak governance. Across much of the country, traditional flood irrigation remains the dominant method of watering crops. While familiar and easy to implement, this approach is highly inefficient, with an estimated 30 to 40 percent of applied water lost through evaporation, seepage, and surface runoff before it can benefit crops. Modern alternatives such as drip irrigation, sprinkler systems, furrow irrigation, laser land leveling, and precision water management techniques can dramatically improve water-use efficiency and increase crop productivity without requiring additional water resources.

Despite their proven benefits, adoption rates remain disappointingly low. One major reason is the fragmented nature of Pakistan's agricultural sector. Most farmers cultivate small holdings ranging from one to five acres, making it difficult to achieve economies of scale or justify investment in modern irrigation technologies. Small landowners often struggle to recover installation costs, particularly when agricultural incomes are uncertain and highly dependent on weather conditions. Furthermore, water management is rarely an individual undertaking. Even when a farmer adopts efficient practices, neighboring farms may continue wasting water, reducing the overall effectiveness of localized improvements and discouraging wider adoption.

Financial barriers further deepen the challenge. Many rural households operate with limited savings and face increasing production costs associated with fertilizer, quality seed, pesticides, machinery, and energy. Access to affordable institutional credit remains inadequate, forcing many farmers to rely on informal lenders who charge high interest rates. Under such circumstances, investments in water-saving infrastructure are often viewed as unaffordable luxuries rather than essential necessities. Consequently, a significant gap persists between available technologies and their practical implementation on farms.

Yet technological limitations tell only part of the story. The deeper challenge lies in governance. Effective water management depends on strong institutions capable of coordinating collective action, resolving conflicts, and ensuring equitable distribution of resources. Local village councils, farmer organizations, and water-user associations have the potential to play this role, but their effectiveness varies considerably across regions. In many communities, unequal power relations influence water allocation, leaving smallholders with limited influence over decisions that directly affect their livelihoods.

At the policy level, numerous strategies and development programs have been introduced to improve water management, but implementation often remains fragmented. Coordination among irrigation departments, agricultural extension services, local governments, and rural development agencies is frequently weak. Projects may focus on infrastructure construction while neglecting maintenance, monitoring, and community ownership. As a result, valuable investments

often deteriorate over time, delivering only temporary benefits.

Pakistan's water challenges persist not because solutions are unavailable, but because technical, financial, and institutional interventions are rarely integrated into a coherent system. Sustainable progress will require more than new technologies; it will demand accessible financing, stronger local institutions, farmer participation, and coordinated governance capable of addressing the root causes of inefficiency rather than merely responding to recurring crises.

A Path Forward

Breaking Pakistan's cycle of seasonal water abundance followed by chronic scarcity requires a comprehensive approach built on three interconnected pillars: water storage, efficient use, and effective governance. Addressing only one of these dimensions will provide limited results; lasting water security depends on strengthening all three simultaneously.

The priority is to capture and store water where it falls. Every monsoon, enormous volumes of rainwater are lost as runoff because communities lack the infrastructure needed to retain it. Farm ponds, rooftop rainwater harvesting systems, recharge pits, and small community reservoirs represent practical and affordable solutions that can be implemented across rural Pakistan. These decentralized approaches not only improve local water availability but also reduce dependence on distant canal systems and overstressed groundwater resources. By empowering communities to manage their own water supplies, they build resilience against both droughts and climate-related uncertainties.

The second pillar is improving water-use efficiency. With agriculture consuming most of the country's freshwater resources, even modest efficiency gains can generate substantial benefits. Technologies such as drip irrigation, sprinkler systems, furrow irrigation, and laser land leveling enable farmers to produce more food using less water. The objective is not merely conservation but maximizing productivity from every available drop. As climate change intensifies water stress, efficient water management will become a prerequisite for agricultural sustainability and rural prosperity.

The third pillar is governance. Strong institutions are essential to ensure equitable water distribution, infrastructure maintenance, farmer training, and access to affordable financing. Farmers need reliable extension services, transparent decision-making processes, and policies that encourage long-term investment in water-saving technologies. Local communities must also be actively involved in planning and implementation.

None of these solutions are new. Pakistan already possesses the knowledge, technologies, and human capacity required to address its water challenges. What remains lacking is consistent implementation, institutional coordination, and sustained political commitment. If these barriers can be overcome, the country can transform its water crisis into an opportunity for building a more resilient and productive rural economy.

Conclusion

Pakistan's rural water paradox reflects not a shortage of water, but a systemic failure to capture, manage, and equitably distribute it. Monsoon rains bring abundance, yet weak storage, inefficient irrigation, and declining groundwater reserves convert this opportunity into seasonal scarcity. Climate change has intensified the crisis by compressing rainfall into extreme events that cause flooding and erosion rather than long-term soil moisture recharge. At the same time, institutional weaknesses, fragmented governance, limited farmer capacity, and financial constraints prevent the adoption of proven solutions such as rainwater harvesting, drip irrigation, and groundwater recharge systems. The result is a recurring cycle of flood and drought within the same agricultural season, undermining food security and rural livelihoods. Yet the solutions are well known and technically feasible. Pakistan's challenge is no longer conceptual but operational: scaling up low-cost water storage, improving irrigation efficiency, and strengthening governance structures. With coordinated action, this crisis can be transformed into an opportunity for sustainable rural resilience.

Please note that the views expressed in this article are of the author and do not necessarily reflect the views or policies of any organization.

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Türkiye's Grain Storage: Enhancing Food Security

Explore how Türkiye's grain storage sector is transforming food security and agricultural competitiveness through strategic investments, innovative technologies, and essential reforms. Learn about the licensed warehousing system, supported by digital innovations for improved grain supply.

Mithat Direk

6/19/2026

Across the fertile agricultural plains of Türkiye, where vast fields of wheat, barley, maize, and other cereals form the backbone of national food security, a quiet but significant transformation is underway. While much attention is often focused on improving crop yields and farm productivity, an equally important revolution is occurring after the harvest. Modern grain storage systems are reshaping how Türkiye preserves, manages, and protects millions of tons of cereals that feed its population, support its livestock sector, and contribute to its export earnings.

Every year, Turkish farmers produce enormous quantities of grain that must be safely stored for months before reaching flour mills, feed manufacturers, food processors, and export markets. Without effective storage, a substantial portion of this harvest could be lost to moisture, pests, spoilage, and quality deterioration. Recognizing this challenge, Türkiye has invested heavily in licensed warehousing systems that combine modern infrastructure with advanced digital technologies. Today's storage facilities are far removed from the traditional granaries of previous generations. Equipped with computerized inventory management systems, automated sampling technologies, temperature monitoring devices, and digital traceability tools, these facilities allow operators to monitor grain quality and quantity with remarkable precision.

The benefits of these investments extend throughout the food supply chain. Farmers gain access to safer storage options that reduce post-harvest losses and allow them to market their crops more strategically. Traders and processors benefit from consistent quality standards, while consumers receive safer and more reliable food products. At the national level, improved storage capacity enhances food security, reduces waste, strengthens market efficiency, and improves Türkiye's competitiveness in international grain markets.

Yet despite these advances, important gaps remain. Most routine quality assessments continue to focus primarily on physical and chemical characteristics such as moisture content, grain purity, test weight, and protein levels. While these indicators are essential, they do not provide a complete picture of food safety risks. Biological hazards, particularly fungal contamination and the presence of mycotoxins, often remain less systematically monitored. These invisible threats can develop during storage and pose significant risks to both human and animal health. As Türkiye continues modernizing its grain sector, integrating more comprehensive biological monitoring into storage management systems may represent the next critical step toward ensuring both food quality and food safety.

The Invisible Threat in the Grain Chain

While modern storage facilities have significantly improved the management and preservation of cereals, one of the greatest threats to grain quality remains largely invisible. Unlike insects, rodents, or visible spoilage, biological contaminants can develop silently within stored grain, escaping routine inspections while posing serious risks to food safety, public health, and international trade. Among these hazards, mycotoxins are particularly concerning.

Mycotoxins are toxic substances produced by certain species of fungi that can grow on cereals such as wheat, barley, maize, and other grains under favorable storage conditions. Factors such as excess moisture, poor ventilation, fluctuating temperatures, and prolonged storage periods can encourage fungal growth. What makes mycotoxins especially dangerous is that they are often invisible, odorless, and resistant to many conventional processing methods. Grain may appear healthy while containing contamination levels that exceed food safety standards.

The consequences extend far beyond storage losses. Exposure to mycotoxins has been linked to a range of health problems in humans and livestock, including immune suppression, liver and kidney damage, reduced productivity, and, in severe cases, cancer risks associated with long-term consumption. For the livestock sector, contaminated feed can reduce animal performance and negatively affect meat, milk, and poultry production. From an economic perspective, mycotoxin contamination can be equally devastating. Export shipments that fail to meet international safety standards may be rejected, resulting in financial losses, trade disruptions, and reputational damage for exporting countries.

Despite these risks, routine biological testing remains limited in many grain storage and handling systems. Most quality assessments continue to focus on physical and chemical characteristics such as moisture content, protein levels, grain purity, and test weight. While these indicators are important, they cannot reveal hidden biological contamination. Fortunately, modern diagnostic technologies now allow rapid, reliable, and cost-effective detection of mycotoxins and fungal pathogens.

The challenge becomes even more significant when grain moves from warehouses to flour mills, feed factories, and food processing facilities. At this stage, additional quality checks are commonly conducted, yet they often remain focused on traditional parameters rather than biological safety. This creates a critical gap in the food safety chain. If contamination develops during storage and remains undetected at processing facilities, it can enter the food system and reach consumers. Strengthening biological monitoring throughout the storage and processing continuum is therefore essential for protecting public health, maintaining export competitiveness, and ensuring the long-term integrity of Türkiye's grain sector.

Türkiye's Licensed Warehousing System: A Foundation for the Future

Amid growing concerns about food security, supply chain resilience, and agricultural competitiveness, Türkiye's licensed warehousing system stands out as one of the country's most significant agricultural policy achievements. Over the past two decades, this system has played a central role in modernizing agricultural markets, improving post-harvest management, and creating a more transparent and efficient environment for producers, traders, processors, and financial institutions. While challenges remain, the licensed warehousing framework has established a strong foundation upon which the next generation of agricultural innovations can be built.

Unlike traditional storage systems, licensed warehouses operate under standardized regulations that ensure products are stored, classified, and monitored according to nationally recognized quality standards. This institutional framework has reduced uncertainty in commodity trading and strengthened confidence among market participants. Farmers who once faced pressure to sell immediately after harvest, often when prices were lowest, now have the option to store their products safely and market them at more favorable times. This not only improves farm income but also contributes to greater market stability throughout the year.

One of the most transformative developments within this system has been the introduction of the Electronic Warehouse Receipt (ELÜS) mechanism. Through ELÜS, agricultural commodities stored in licensed warehouses are converted into secure digital assets that can be traded electronically or used as collateral for bank financing. This innovation has significantly improved farmers' access to credit, allowing them to obtain liquidity without immediately selling their crops. For many producers, particularly medium-sized enterprises, the system has reduced financial pressure and strengthened their ability to invest in production, technology, and farm improvements.

The growth of licensed warehouse infrastructure has been equally impressive. Modern storage facilities have expanded across major agricultural regions, including Central Anatolia, the Aegean Region, Southeastern Anatolia, and the Mediterranean production zones. This expansion has increased the country's storage capacity and strengthened food supply security by reducing post-harvest losses and maintaining product quality over longer periods. As a result, fluctuations in supply can be managed more effectively, helping stabilize commodity prices and ensuring a more reliable flow of raw materials to food processors and exporters.

The system has also encouraged greater formalization of agricultural trade. Standardized grading, certified storage conditions, and transparent documentation have reduced transaction risks and improved market transparency. These improvements are particularly important as Türkiye seeks to strengthen its position in international agricultural markets and comply with increasingly stringent quality and traceability requirements imposed by global buyers.

Recognizing that modernization is an ongoing process, the Ministry of Agriculture and Forestry has begun promoting digital monitoring initiatives designed to enhance warehouse management and oversight. The future of grain storage increasingly lies in

integrated digital systems capable of monitoring inventory levels, product movement, temperature, humidity, and quality indicators in real time. Advanced sensors, automated reporting systems, artificial intelligence, and cloud-based data platforms can provide warehouse operators and policymakers with valuable information for rapid decision-making and risk management.

These technological improvements are becoming even more important in the context of climate change. Rising temperatures, changing precipitation patterns, and more frequent extreme weather events create new challenges for grain storage. Higher temperatures and humidity levels increase the likelihood of pest infestations, fungal growth, and mycotoxin contamination. Consequently, storage facilities must evolve from passive storage spaces into actively managed environments capable of continuously monitoring and responding to changing conditions.

At the same time, global food demand continues to rise as populations grow and diets evolve. International organizations estimate that food production must increase substantially by mid-century to meet future demand. However, increasing production alone will not be sufficient. Reducing post-harvest losses, improving storage efficiency, and maintaining food quality throughout supply chains are equally critical. Every ton of grain preserved through better storage represents food that does not need to be produced again, saving land, water, energy, and other valuable resources.

Türkiye occupies a strategically important position at the crossroads of Europe, Asia, and the Middle East, making it both a major agricultural producer and a critical logistics hub for regional food trade. Strengthening its licensed warehousing system therefore carries significance beyond national borders. By continuing to invest in digital technologies, biological monitoring, climate-resilient storage infrastructure, and integrated quality assurance systems, Türkiye can further enhance its role as a regional leader in agricultural logistics, food security, and sustainable post-harvest management. The success achieved so far demonstrates what is possible; the next challenge is ensuring that the system continues to evolve to meet the demands of a rapidly changing world.

The Path Forward

Türkiye has already established a strong foundation for modern grain storage through its extensive licensed warehousing network, advanced logistics infrastructure, and growing adoption of digital technologies. These achievements have significantly improved post-harvest management, strengthened market transparency, and enhanced the efficiency of agricultural commodity trading. However, as food systems become more complex and climate-related risks intensify, the next stage of development must focus not only on expanding storage capacity but also on improving quality assurance, biosafety, and technological integration throughout the supply chain.

A key priority is the incorporation of comprehensive biological monitoring into routine storage management. While physical and chemical quality assessments remain essential, they should be complemented by regular testing for fungal contamination, mycotoxins, and other biological hazards that can threaten food safety and export competitiveness. Early detection systems can prevent losses, protect consumers, and help maintain compliance with increasingly stringent international food safety standards.

At the same time, investment in advanced digital monitoring technologies can transform storage facilities into intelligent management systems. Real-time tracking of temperature, humidity, inventory levels, and product movement can improve operational efficiency, reduce spoilage risks, and support faster decision-making. Processing facilities should also be equipped with the tools and expertise needed to identify biological contaminants before products enter the food and feed chain.

The benefits of these investments extend far beyond individual warehouses. Every Turkish lira invested in modern storage infrastructure helps reduce post-harvest losses, improve product quality, protect public health, and strengthen export opportunities. More importantly, efficient storage systems ensure that a larger share of agricultural production reaches consumers safely and sustainably. In a world facing rising food demand, climate uncertainty, and increasing pressure on natural resources, strengthening grain storage is not simply an agricultural priority, it is a strategic investment in food security, economic resilience, and sustainable development for future generations.

Conclusion

Türkiye's grain storage sector demonstrates how strategic investment in infrastructure, technology, and institutional reform can strengthen food security and agricultural competitiveness. The licensed warehousing system, supported by digital innovations such as Electronic Warehouse Receipts (ELÜS), has significantly improved post-harvest management, market transparency, and farmers' access to finance. Yet as climate change intensifies and food safety standards become more stringent, the next phase of development must focus on addressing hidden biological risks within the grain supply chain. Mycotoxins and fungal contamination pose serious threats not only to public health but also to livestock productivity, export performance, and economic stability. Expanding biological monitoring, integrating advanced digital surveillance systems, and strengthening quality control from storage facilities to processing plants will be essential. By combining modern technology with robust biosafety measures, Türkiye can further reduce post-harvest losses, protect consumers, enhance international market access, and reinforce its position as a regional leader in sustainable grain management and food system resilience.

Please note that the views expressed in this article are of the author and do not necessarily reflect the views or policies of any organization.

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Impact of Wars on Food Prices and Systems

Wars leave behind destruction, but their effects ripple through global food prices and transportation systems. Conflicts disrupt vital supply chains, leading to increased hunger and economic challenges, especially in developing countries like Pakistan. Understand the broader consequences of warfare.

Ammara Azam & Saba Javed

6/2/2026

Imagine waking up one morning to discover that the price of bread has doubled. The wheat is still available in the market, but suddenly it costs far more than it did weeks ago. Consumers often blame traders, retailers, or even local farmers. Yet the farmer who grew the wheat may be facing a crisis of his own. His land is still fertile, his seeds are ready, and his willingness to farm remains unchanged. The real problem may have begun thousands of kilometers away on a battlefield he has never seen, involving countries with which he has no direct connection.

This is one of the least visible consequences of modern conflict. While television screens focus on missiles, destroyed cities, and displaced populations, another crisis unfolds quietly through global supply chains. Food systems have become deeply interconnected, meaning that a war in one region can affect the cost of a family's daily meal on the other side of the world.

The Russia–Ukraine conflict provides a powerful example. Before the war, both countries played a critical role in global agricultural markets. Together they supplied substantial shares of the world's wheat, maize, sunflower oil, and agricultural inputs. Ukraine alone exported enough grain annually to help feed hundreds of millions of people across Africa, the Middle East, and Asia. When military operations disrupted production and shipping through the Black Sea, grain exports slowed dramatically, creating immediate uncertainty in global markets.

Countries heavily dependent on imported wheat, including Pakistan, Egypt, Lebanon, and several African nations, suddenly faced rising procurement costs. Importers were forced to search for alternative suppliers, often located much farther away. Longer shipping routes, higher freight charges, insurance premiums, and increased competition for limited supplies pushed prices upward. As global demand concentrated on fewer exporting countries, international wheat prices surged, eventually filtering down to local flour mills, bakeries, and neighborhood markets.

The result was a painful reminder that food security is no longer determined solely by local harvests. In an interconnected world, wars can travel across oceans through trade routes and commodity markets, reaching household budgets long before the conflict itself appears to end. And wheat, important as it is, represents only the first link in a much larger chain of economic disruption.

When Conflict Turns Fuel and Fertilizer into Food Inflation

Most people do not realize that every meal on their table depends heavily on energy. The bread we eat, the vegetables we buy, and the rice we cook all rely on a long chain of machines, transport systems, and agricultural inputs powered by fuel. Modern farming is no longer simply a farmer working with basic tools in a field. It depends on tractors preparing land, harvesters gathering crops, tube wells pumping irrigation water, and trucks transporting produce from farms to markets. Every stage of this process consumes diesel, petrol, or electricity generated from fuel-based energy sources.

This is why wars and geopolitical conflicts often have consequences far beyond the battlefield. When conflicts disrupt global oil supplies, trigger economic sanctions, or create uncertainty in energy markets, fuel prices rise rapidly. The effects are felt not only in major cities but also in the smallest farming villages. A tractor that previously required a modest fuel budget may suddenly cost twice as much to operate. Irrigation expenses increase, transportation becomes more expensive, and farmers face rising production costs across the board.

For small-scale farmers already operating on narrow profit margins, these increases create difficult choices. Some reduce the amount of land they cultivate, while others switch to lower-cost crops that often generate lower returns. In extreme cases, farmers postpone planting altogether because they cannot afford the upfront expenses. The result is reduced agricultural production and tighter food supplies, which eventually translate into higher prices for consumers.

The challenge extends beyond fuel. Modern agriculture is heavily dependent on fertilizers, and global fertilizer markets are closely linked to international trade. Major producers such as Russia and Belarus supply significant quantities of potash, nitrogen, and phosphate fertilizers to world markets. When conflicts disrupt production, shipping routes, or trade flows, fertilizer prices can surge dramatically.

For farmers, expensive fertilizer creates another painful dilemma. Applying less fertilizer reduces costs in the short term but often leads to lower crop yields. Maintaining recommended fertilizer levels protects production but significantly increases financial pressure. Many farmers choose to reduce fertilizer application, resulting in lower harvests and reduced food availability. Consequently, market prices rise even further.

This chain reaction demonstrates how modern conflicts affect food security far beyond the countries directly involved. A disruption in oil exports, a blocked shipping route, or sanctions on fertilizer suppliers can ultimately influence the cost of producing wheat, rice, vegetables, and livestock products thousands of kilometers away. In today's interconnected world, wars do not merely damage the regions where they occur; they send economic shockwaves through global food systems, affecting farmers, consumers, and entire national economies.

The Human Cost of Conflict and the Cycle of Food Insecurity

When food prices rise, everyone feels the impact, but the burden is not shared equally. For low-income households, especially in developing countries, food inflation can quickly become a humanitarian crisis. In wealthier nations, families typically spend a relatively small share of their income on food. When prices increase, they may adjust by reducing discretionary spending, dining out less frequently, or choosing lower-cost alternatives. While inconvenient, these adjustments are usually manageable.

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For poor households, however, the situation is far more severe. In many developing countries, families spend between half and two-thirds of their income on food. A sharp increase in the price of wheat, rice, cooking oil, or other staples leaves little room for adjustment. Families may reduce the number of meals they eat each day, switch to less nutritious foods, withdraw children from school to cut expenses, or postpone essential healthcare. In such circumstances, food inflation becomes a direct threat to health, education, and long-term human development.

This is why international organizations closely monitor disruptions to global food markets. A conflict that interrupts grain exports from one region can create shortages and price spikes thousands of kilometers away. The consequences are often felt most acutely in import-dependent countries where millions of vulnerable households already struggle to meet basic nutritional needs. Hunger, therefore, is rarely confined to countries directly involved in conflict; it spreads through global supply chains and affects populations far removed from the battlefield.

The challenge becomes even more serious when conflict intersects with climate change. Rising fuel and fertilizer costs limit farmers' ability to cope with droughts, floods, and extreme temperatures. Lower agricultural production then contributes to higher food prices and greater food insecurity. This creates a destructive cycle in which conflict, economic hardship, environmental stress, and hunger reinforce one another. Breaking this cycle requires not only peace and stable trade but also stronger investments in resilient and self-reliant food systems.

Building Food Security in an Uncertain World

No single policy can fully shield a country from the global disruptions caused by war, trade conflicts, or geopolitical instability. However, a combination of practical strategies can significantly reduce vulnerability and strengthen national food security when international supply chains come under pressure.

One of the most important measures is diversifying food import sources. Countries that rely heavily on one or two suppliers for staple commodities such as wheat, maize, or edible oil expose themselves to considerable risk. A conflict, export ban, or transportation disruption affecting a single supplier can create immediate shortages and price spikes. By establishing trade relationships with multiple exporting countries across different regions, governments can spread risk and ensure alternative supply channels remain available during crises.

A second priority is the development of strategic food reserves. Maintaining emergency stocks of wheat, rice, and other essential commodities provides governments with a powerful tool to stabilize markets during periods of uncertainty. When global prices surge or imports are delayed, these reserves can be released to prevent panic buying, control inflation, and protect vulnerable households from food shortages. In many ways, food reserves serve as a national insurance policy against external shocks.

Third, countries must invest more aggressively in domestic agricultural production. Expanding irrigation infrastructure, improving access to quality seeds, strengthening agricultural research, and providing targeted support to farmers can increase national self-sufficiency. The greater a country's capacity to produce its own food, the less vulnerable it becomes to distant geopolitical events. Food production should therefore be viewed not only as an economic activity but also as a strategic national asset.

Finally, reducing agriculture's dependence on imported fossil fuels is becoming increasingly important. Solar-powered irrigation systems, bioenergy generated from agricultural residues, and emerging electric farm machinery can help farmers reduce exposure to volatile fuel markets. Renewable energy investments strengthen both environmental sustainability and food security. In an increasingly uncertain world, resilient food systems will depend not only on productive farms but also on diversified trade, strategic planning, and energy independence.

Conclusion

Wars are often measured by the destruction they leave behind on battlefields, but their consequences extend far beyond the countries directly involved. In today's interconnected world, conflicts disrupt food, fuel, fertilizer, and transportation systems that millions of people rely upon every day. A blocked shipping route, an energy shock, or a fertilizer shortage can quickly translate into higher food prices, reduce farm productivity, and increase hunger thousands of kilometers away. For developing countries such as Pakistan, where large segments of the population spend a significant share of their income on food, these disruptions can have profound economic and social consequences.

The lesson is clear: food security can no longer be viewed solely through the lens of domestic agricultural production. It is equally a matter of trade resilience, energy security, strategic planning, and international stability. Countries that depend heavily on a narrow range of import sources remain vulnerable to external shocks beyond their control. Strengthening local food production, diversifying supply chains, maintaining strategic grain reserves, and investing in renewable energy for agriculture are no longer optional policy choice, they are essential safeguards for national resilience.

Ultimately, the true cost of war is not only counted in damaged cities and lost lives. It is also measured in empty dinner tables, rising food bills, and vulnerable families struggling to secure their next meal. Building resilient food systems today is the best defense against tomorrow's global uncertainties.

Please note that the views expressed in this article are of the author and do not necessarily reflect the views or policies of any organization.

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The Indispensable Role of Plants in Our Lives

Discover how plants are essential for human existence, providing oxygen, food, and medicine. Learn about their remarkable abilities and the importance of sustainability and food security in protecting our planet's future.

Mithat Direk

6/5/2026

If you have ever watched a houseplant lean toward a patch of sunlight or seen a tree push its roots through a crack in a sidewalk, you may have wondered what that plant is trying to achieve. Is it searching for water? Reaching for light? Seeking some form of care? The answer

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reveals one of the most remarkable truths in nature: plants do not "want" things in the way humans and animals do. They have no need to hunt, gather food, build shelters, or seek assistance from others. Instead, they possess an extraordinary ability to produce everything they need for survival using resources freely available in their environment.

Among Earth's countless forms of life, plants stand apart for their self-sufficiency. Through the process of photosynthesis, they capture energy from sunlight and transform water and carbon dioxide into the sugars that fuel their growth. While animals must constantly search for food and consume other organisms to obtain energy, plants manufacture their own. Given adequate sunlight, water, nutrients from the soil, and a place to anchor their roots, they quietly grow, reproduce, and adapt without demanding direct support from any other living creature.

This independence has allowed plants to colonize nearly every corner of the planet. They thrive in deserts where rainfall is scarce, cling to mountain cliffs battered by wind and snow, float on the surfaces of lakes, and spread across tropical rainforests teeming with life. A single seed can grow into a towering tree capable of surviving for centuries, producing countless more seeds and creating habitats for thousands of other organisms along the way.

Yet the greatest irony of all is that while plants can largely survive without us, we cannot survive without them. Every breath of oxygen we take is linked to plant life. The food that sustains humanity originates directly or indirectly from plants. They stabilize soils, regulate water cycles, absorb carbon dioxide, moderate climate, and provide the raw materials for medicines, clothing, shelter, and fuel.

In many ways, plants are the silent engineers of life on Earth. They ask for very little, yet they give almost everything. Their quiet resilience and self-reliance remind us that the foundations of human civilization ultimately rest on the green world that surrounds us.

Why Plants Matter More Than We Realize

Plants are often so familiar that we overlook their importance. Yet they form the silent foundation of life on Earth and support every breath we take. The oxygen that fills our lungs originates largely from the process of photosynthesis, through which plants convert sunlight, water, and carbon dioxide into energy while releasing oxygen into the atmosphere. This remarkable process not only sustains human life but also regulates the climate, supports biodiversity, and forms the base of nearly every food chain. Protecting plants is therefore not merely an environmental concern; it is essential for human survival, public health, and economic well-being.

Despite this dependence, many people living in modern cities rarely notice the green world around them. Surrounded by concrete buildings, roads, and technology, we often forget that trees, grasses, and shrubs quietly work every day to clean the air, reduce urban temperatures, absorb carbon dioxide, and make our surroundings more livable. Yet our connection with plants has not disappeared entirely. It often reappears in a more personal form through the plants we bring into our homes.

A walk through almost any household reveals this enduring relationship. A peace lily brightening a living room corner, a snake plant resting on a bookshelf, or a small succulent placed near a sunny window serves as more than decoration. Houseplants create a sense of comfort and companionship. They become part of daily routines, quietly sharing our living spaces and reminding us of our connection to nature. Studies have shown that indoor plants can improve mood, reduce stress, and create a greater sense of well-being.

The importance of plants extends beyond human companionship. Many of our pets also depend directly or indirectly on plant resources. Birds perch on wooden branches, small animals rest on bedding made from plant fibers, and even the cardboard toys loved by cats originate from trees. Plants support not only human life but also the well-being of countless animals that share our homes and communities.

In many ways, plants are the invisible partners of civilization. They provide food, medicine, oxygen, shelter, raw materials, and beauty while asking for very little in return. Recognizing their value is the first step toward protecting the green world that quietly sustains us every day.

The Remarkable World Hidden Within Plants

Many people lovingly care for the plants inside their homes while paying little attention to the trees, grasses, and wildflowers growing beyond their doors. We water our potted plants, wipe dust from their leaves, and celebrate every new bloom, yet often overlook the immense value of the vegetation that surrounds our neighborhoods, parks, and countryside. The grass beneath our feet, the roadside wildflowers, and the towering trees that have stood for generations deserve the same appreciation and respect. Far from being passive background scenery, plants are dynamic living organisms that play an essential role in sustaining life on Earth.

Recent scientific discoveries have revealed that plants are far more sophisticated than most people imagine. Researchers have found that plants constantly interact with their environment and with one another in ways that were once thought impossible. German forester and author Peter Wohlleben popularized this idea by describing how trees in forests can exchange nutrients and information through underground networks of fungi connecting their root systems. These networks allow trees to support weaker neighbors, share resources during times of stress, and respond collectively to environmental threats such as drought or insect attacks.

Similar insights have emerged from the work of plant physiologist Stefano Mancuso, whose research demonstrates that plants possess remarkable sensory abilities. While plants do not have brains, nerves, or emotions in the human sense, they can detect light, gravity, moisture, chemicals, touch, and vibrations. Experiments suggest that plants can modify their responses based on previous experiences, indicating a form of learning and memory that helps them adapt to changing conditions.

These findings have fueled public curiosity about whether plants can recognize the people who care for them. Although plants cannot hear words as humans do, they can perceive vibrations and subtle environmental changes. Some studies suggest that regular interaction may influence plant growth, not because plants understand language, but because they respond to factors such as touch, movement, humidity, carbon dioxide, and consistent care. When people talk to their plants, they often spend more time observing them, noticing problems early, and providing better growing conditions.

Perhaps this explains why so many people develop a strong attachment to their plants. Caring for a plant creates a quiet connection built on attention, patience, and mutual dependence. Plants may not return affection in human terms, but they respond to care through growth, resilience, and renewal. In doing so, they remind us that even the simplest forms of life are far more complex, interconnected, and extraordinary than we once believed.

Learning from Nature's Oldest Teachers

Perhaps the most important lesson plants offer is also the simplest: respect life in all its forms. Whether a small herb grows on a windowsill or a centuries-old tree stands in a forest, every plant contributes to the intricate web that supports life on Earth. Too often, people view plants merely as scenery, landscaping, or obstacles in the path of development. In reality, they are silent partners in our existence,

providing the oxygen we breathe, the food we eat, the medicines we rely on, and the ecosystems that sustain countless species, including our own.

Human beings are not separate from nature; we are one part of it. Long before schools, books, and modern technology existed, people learned from the natural world. Forests taught patience through slow growth, rivers demonstrated persistence through constant movement, and plants revealed the rhythms of life, death, and renewal. Even today, these lessons remain relevant in a world increasingly disconnected from its ecological foundations.

Many cultures have traditionally believed that plants possess a spirit or a special form of awareness. Whether one accepts such beliefs or not, the practical reality is clear: plants respond to how they are treated. When provided with proper care, water, light, and protection, they flourish. When neglected or damaged, they decline. This simple relationship reminds us that every action has consequences and that care often produces remarkable results.

Plants ask for very little, yet they give humanity immeasurable benefits in return. They provide clean air, fertile soil, shade, food, raw materials, and natural beauty. Protecting them is therefore not merely an environmental responsibility but an investment in our own future. By paying greater attention to the green world around us, we gain more than healthier ecosystems. We develop a deeper appreciation of our place within nature and a stronger sense of responsibility toward future generations. In learning to value and protect plants, we ultimately learn how to become better stewards of the planet that sustains us all.

Conclusion

Plants may be the most overlooked yet indispensable partners in human existence. Their extraordinary ability to sustain themselves through photosynthesis while simultaneously supporting nearly all life on Earth makes them unique among living organisms. They provide the oxygen we breathe, the food we consume, the medicines we depend upon, and the ecosystems that regulate our climate and protect biodiversity. Modern science continues to reveal that plants are far more sophisticated than previously believed, possessing remarkable capacities to sense, adapt, communicate, and respond to their surroundings. At the same time, they offer valuable lessons in resilience, patience, cooperation, and sustainability. In an age marked by environmental degradation, urbanization, and climate uncertainty, reconnecting with the plant world is more important than ever. Protecting plants is not simply about conserving nature; it is about safeguarding human health, food security, economic prosperity, and the future of our planet. By learning to value and respect the green world around us, we ultimately protect the foundations of life itself.

Please note that the views expressed in this article are of the author and do not necessarily reflect the views or policies of any organization.

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Transforming Pakistan's Livestock Sector for Growth

Pakistan's livestock sector is a vital economic force yet faces challenges like low productivity and rural poverty. By investing in animal health, feed security, and digital markets, we can unlock its true potential and enhance rural incomes and national resilience.

Muhammad Abuzar

6/11/2026

Before dawn breaks across the villages of Punjab, Sindh, Khyber Pakhtunkhwa, and Balochistan, millions of rural families begin a daily routine that quietly powers one of Pakistan’s largest economic sectors. Women milk buffaloes and cows, men prepare animals for local markets, and children help feed poultry, goats, and sheep before heading to school. These activities may appear ordinary, but together they form the foundation of a livestock economy that sustains rural livelihoods, supports national food security, and contributes significantly to economic growth.

Livestock is the single largest component of Pakistan’s agricultural sector, contributing nearly 15 percent to the national Gross Domestic Product (GDP) and approximately 64 percent of agricultural value added. In economic terms, the country’s livestock sector generates more value than many manufacturing and industrial subsectors combined. Yet despite its enormous contribution, livestock often receives far less policy attention than major crops such as wheat, cotton, rice, and sugarcane.

The importance of livestock extends far beyond national economic statistics. More than 61 percent of Pakistan’s population lives in rural areas, where employment opportunities are often limited and agricultural incomes remain vulnerable to weather shocks and market fluctuations. For millions of rural households, livestock serves as a dependable source of income throughout the year. An estimated eight million households raise animals, deriving nearly 40 percent of their household earnings from the sale of milk, meat, eggs, wool, hides, and live animals.

For smallholders and landless families, livestock functions as a form of financial security. A buffalo can provide daily cash income through milk sales. Goats and sheep act as living savings accounts that can be sold during emergencies, weddings, or periods of financial hardship. Poultry offers quick returns with relatively low investment requirements, making it especially important for women and low-income households.

Livestock also plays a critical role in nutrition by supplying essential proteins and micronutrients through milk, meat, and eggs. In many rural communities, animals are not simply productive assets; they are an insurance policy against poverty, food insecurity, and economic uncertainty. As climate change, rising feed costs, and animal diseases continue to challenge rural livelihoods, strengthening Pakistan’s livestock sector is not merely an agricultural priority, it is a rural development imperative that directly affects the well-being of millions of families across the country.

A Dairy Giant Hiding in Plain Sight

Despite widespread poverty among livestock keepers, Pakistan ranks among the world’s top five milk-producing countries. In the last fiscal year alone, the country produced approximately 58.3 million tonnes of milk, a figure that places it alongside global dairy leaders such as India, China, and the United States. Buffaloes remain the backbone of this output, contributing to around 43 million tonnes, followed by cows with roughly 27 million tonnes of milk

production. Meat production has also reached nearly six million tonnes, reinforcing livestock as one of the most important pillars of Pakistan's food system and rural economy.

Yet behind these impressive national statistics lies a deep structural contradiction. Most of the Pakistan's livestock productivity is locked in low-efficiency, smallholder systems. Around 80 percent of rural livestock owners keep only one to three animals. These animals are often undernourished, exposed to seasonal heat stress, and left vulnerable to preventable diseases due to limited access to veterinary services. Artificial insemination, balanced feed formulations, and modern herd management practices remain out of reach for most farmers. As a result, productivity per animal is significantly lower than international benchmarks set by countries such as New Zealand or the Netherlands, where scientific breeding, feed optimization, and animal health systems are well established.

This gap between potential and performance means that Pakistan's dairy sector operates far below its productive frontier. In economic terms, the country is not constrained by biological capacity but by institutional and technological bottlenecks. The same animals that sustain millions of rural households could generate substantially higher income if supported by better extension services, veterinary infrastructure, and feed supply chains.

Beyond production figures, livestock plays a critical role in stabilizing rural livelihoods in deeply practical ways. A few liters of milk sold each morning can cover essential household expenses such as food, medicine, or school supplies. A single fattened goat sold at market can finance school fees or debt repayment. Livestock also bridges seasonal income gaps, providing cash flow during periods when crops have not yet been harvested or when agricultural wages are unavailable.

Women are central to this system, often managing daily livestock care, feeding, milking, and backyard poultry operations. Their unpaid but essential labor not only sustains household nutrition but also generates small streams of income that enhance financial autonomy. In many cases, this income becomes the first step toward women's economic empowerment in rural areas.

Livestock also functions as a form of informal insurance. During inflationary shocks, crop failures, or emergencies, animals can be sold quickly to generate liquidity. However, this safety net is fragile. Recent floods in 2025, which displaced hundreds of thousands of people and animals, demonstrated how quickly rural resilience collapses when livestock assets are lost. In effect, Pakistan's dairy sector is not just an economic engine, it is a fragile but indispensable foundation of rural survival.

The Four Horsemen of Rural Livestock Poverty

If livestock is such a powerful engine of rural livelihoods, the obvious question is why widespread poverty persists among those who depend on it most. The answer lies in a reinforcing set of structural constraints that continuously suppress productivity and income at the smallholder level. These constraints operate like "four horsemen," each weakening rural livestock systems in a different but interconnected way.

The first is disease. In recent years, outbreaks such as lumpy skin disease have exposed the fragility of Pakistan's animal health system. This viral infection, which spread rapidly during 2024 and 2025, caused severe suffering in cattle herds across multiple provinces. More than 220,000 cattle were reported to be infected, with around 7,000 deaths. For surviving animals, the economic damage was even more significant, with milk yields declining anywhere between 10 percent and 85 percent. For a household relying on just two buffaloes, such a collapse can turn a modest daily income into near-total loss, pushing families rapidly from vulnerability into acute poverty.

The second constraint is rising feed costs. Inflation, fuel price volatility, and climate-induced disruptions to fodder production have driven animal feed prices up by nearly 60 percent in recent years. For small farmers, livestock is becoming increasingly expensive to maintain. In many cases, the cost of feeding animals now exceeds the income generated from milk sales, forcing distress sales of productive animals and eroding long-term household assets.

The third challenge is market exclusion. Most rural livestock owners are physically and informationally disconnected from fair markets. Poor road infrastructure, limited transport options, and weak digital connectivity prevent them from accessing urban price signals. As a result, intermediaries and middlemen dominate rural procurement systems, often purchasing milk, animals, and hides at significantly lower prices than urban market rates. This structural imbalance transfers value away from producers and concentrate profits in the hands of intermediaries.

The fourth and perhaps most persistent barrier is technological stagnation. Pakistan's livestock sector remains largely dependent on traditional practices passed down through generations. While these methods have cultural and historical value, they are increasingly inadequate in a modern agricultural economy. In contrast, countries with advanced livestock systems use artificial insemination, precision feeding, genetic improvement programs, automated milking systems, and mobile-based veterinary diagnostics. The widening technological gap means that productivity differences are no longer marginal but systemic, leaving Pakistan's small farmers locked in low-output cycles despite rising national demand for livestock products.

A Roadmap Out of Rural Livestock Poverty

The challenges facing Pakistan's livestock sector are significant, but they are not irreversible. In fact, a range of practical, evidence-based interventions already exists that could substantially improve productivity, income, and resilience among smallholder farmers. The experience of countries such as India, Bangladesh, and Vietnam demonstrates that meaningful transformation is possible when policy attention shifts toward empowering small-scale producers rather than concentrating resources in large commercial farms.

The first and most urgent priority is animal health. Preventive vaccination programs for diseases such as lumpy skin disease must be institutionalized rather than launched only in response to outbreaks. Preventive veterinary care is among the most cost-effective investments in agriculture; a small expenditure on vaccines can prevent catastrophic income losses and livestock mortality at the household level.

Second, addressing feed insecurity is essential for improving productivity. Rising feed costs can be mitigated through subsidized feed banks, cooperative fodder production systems, and the cultivation of high-nutrition grasses on marginal and underutilized lands. Local government involvement and community-level coordination can significantly reduce input costs while improving animal nutrition.

Third, improving market access through digital tools offers a major opportunity for reform. Simple mobile-based platforms that provide real-time prices for milk, meat, and livestock in nearby urban markets can dramatically reduce dependence on middlemen. Even basic SMS-based price alerts can enhance transparency and strengthen farmers' bargaining power.

Fourth, targeted investment in women's livestock training can generate widespread rural benefits. Skills development in poultry farming, small-scale dairy processing, and basic financial literacy can transform household-level activities

into sustainable microenterprises. Since women already perform much of the daily livestock work, enhancing their skills directly translates into improved household welfare.

Ultimately, Pakistan must reframe livestock not as a subsistence activity but as a strategic economic sector. With 35-40 million people dependent on it directly or indirectly, even modest improvements can generate large-scale poverty reduction, stronger rural economies, and increased export potential. The foundation already exists; what is needed now is coordinated action and sustained political commitment.

Conclusion

Pakistan's livestock sector represents one of the country's greatest economic strengths and, at the same time, one of its most persistent development failures. It sustains millions of rural households, contributes significantly to GDP, ensures food and nutritional security, and places Pakistan among the world's leading milk-producing nations, yet it remains constrained by low productivity, weak veterinary and feed systems, limited market access, and slow technological adoption. The result is a paradox in which a high-output sector continues to coexist with widespread rural poverty among those who depend on it most. Evidence across disease outbreaks, rising feed costs, market inefficiencies, and technological stagnation shows that the issue is not livestock potential but systemic neglect and fragmented policy attention. However, this challenge is not irreversible. With coordinated investments in animal health, feed security, digital market systems, and women-led livestock enterprises, the sector can shift from subsistence-driven activity to a modern, productivity-oriented engine of rural transformation. Ultimately, livestock must be treated not as a secondary rural occupation but as a strategic pillar of Pakistan's economy; doing so would unlock significant gains in rural incomes, export earnings, and national resilience, while failure to act would mean continued loss of both economic opportunity and rural welfare.

Please note that the views expressed in this article are of the author and do not necessarily reflect the views or policies of any organization.

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Transforming Pakistan Through Agricultural Education

Agricultural education is a key driver of economic transformation in Pakistan. By bridging the gap between modern practices and local farming methods, it boosts productivity, enhances rural livelihood and food security.

Umair Rehman

6/12/2026

When discussions about Pakistan's economic future arise, attention often gravitates toward technology hubs, digital innovation, and urban industrial growth. While these sectors are important, they overlook a more fundamental driver of national prosperity: agriculture. Pakistan remains deeply rooted in agriculture, with nearly 40 percent of its workforce engaged in farming, livestock rearing, and allied rural activities. Yet the sector that sustains such a large share of the population continues to operate with outdated knowledge systems and limited access to modern training.

This disconnect highlights a critical structural weakness. The global agricultural landscape has transformed rapidly over the past two decades, driven by precision farming, satellite-based monitoring, genetic crop improvement, mechanized irrigation, and data-driven decision-making. In contrast, many Pakistani farmers still rely on inherited practices that have changed little over generations. The gap between global agricultural innovation and local practice is widening, directly constraining productivity and rural incomes.

At the heart of this challenge lies a human capital deficit. Human capital refers to the knowledge, skills, and competencies that individuals use to generate economic value. Countries such as South Korea, Malaysia, and China achieved rapid development not only through industrial expansion but by systematically investing in education across all sectors, including rural communities. Pakistan, however, continues to underinvest in agricultural education, extension services, and vocational training.

The consequences are visible across the rural economy. Farmers often lack the ability to interpret soil testing data, adopt efficient irrigation techniques, or manage pest outbreaks scientifically. Livestock keepers frequently operate without access to modern veterinary knowledge, vaccination schedules, or improved breeding practices. These gaps are not individual shortcomings but institutional failures in agricultural education and outreach systems.

Strengthening agricultural education is therefore not simply an academic exercise; it is an economic necessity. A well-trained farmer understands plant physiology, soil nutrition, water management, and market dynamics. Such knowledge translates directly into higher yields, reduced input waste, and improved resilience against climate shocks. Similarly, educated livestock producers can significantly increase productivity through better feeding, disease control, and genetic improvement.

Ultimately, transforming Pakistan's agricultural education system is equivalent to transforming its rural economy. When farmers become skilled entrepreneurs rather than subsistence producers, agriculture shifts from a survival activity into a powerful engine of national growth.

From Traditional Farming to Knowledge-Driven Agriculture

A fundamental principle of economics is that productivity improves when skills improve. In agriculture, this relationship is especially direct. Better training reduces inefficiencies, prevents resource wastage, and increases output per unit of land, labor, and capital. In contrast, lack of knowledge often translates into costly mistakes that quietly erode rural incomes and national competitiveness.

Consider the everyday realities of farming in Pakistan. An untrained farmer may over-irrigate crops, depleting already scarce water resources. Another may apply pesticides incorrectly, destroying beneficial insects along with harmful pests and disrupting ecological balance. A third may sell perishable produce immediately after harvesting due to lack of awareness about storage, grading, or value addition, thereby losing a significant portion of potential income. These are not isolated errors; they are systemic inefficiencies rooted in weak agricultural education and limited extension services.

Proper agricultural training can fundamentally change this trajectory. A skilled agriculturist understands precision farming techniques, including optimal use of water, fertilizers, and seeds based on soil conditions and crop requirements. Knowledge of post-harvest management allows farmers to reduce spoilage, extend shelf life, and access better prices through timing and storage. Familiarity with mechanization improves efficiency in land preparation, harvesting, and transportation, reducing labor costs and increasing productivity.

When such improvements are scaled across millions of farmers, the macroeconomic impact becomes substantial. Higher yields and reduced losses enhance export competitiveness in key crops such as rice, cotton, mangoes, and citrus fruits. This generates foreign exchange earnings, stimulates agro-industries, and increases rural wages, thereby strengthening overall economic stability.

Beyond productivity, agricultural education serves as a catalyst for innovation. Universities and research institutions play a central role in developing new technologies and knowledge systems, but their impact depends on effective linkages with farming communities. Integrating field-based learning with laboratory research can bridge this gap, ensuring that innovations reach the people who need them most.

International experience demonstrates what is possible. Countries like Israel and the Netherlands transformed resource constraints into agricultural strength through sustained investment in education, research, and technology diffusion. Pakistan, with its fertile land, diverse climate, and extensive irrigation system, possesses similar potential but lacks structured application of science and technology in agriculture.

Agricultural education produces a wide range of high-value professionals, including agronomists who enhance crop productivity, food technologists who support value-added processing and exports, veterinarians who improve livestock health and productivity, and hydrologists who ensure efficient water management. These roles represent the future of a modern agricultural economy.

Jobs, Income, and Agricultural Entrepreneurship as a Pathway Out of Poverty

The most immediate and measurable impact of agricultural education is its effect on income generation. In rural economies, knowledge translates directly into productivity, and productivity determines earnings. A farmer with formal training in modern agricultural practices consistently earns more than one relying solely on traditional methods. Similarly, an agricultural graduate who establishes a seed distribution or input supply business does not only secure personal income but also generates employment opportunities for others in the community. Even at the micro level, a woman trained in poultry management can transform a small backyard activity into a stable income source that improves nutrition, education, and overall household welfare.

Pakistan's demographic structure intensifies both the challenge and the opportunity. With one of the youngest populations in the world, the country stands at a critical juncture. If this youth cohort remains unskilled and unemployed, the result will be economic stagnation and rising social pressure. However, if properly trained, this same population can become the foundation of a powerful agricultural workforce and entrepreneurial class. Agricultural education offers a practical and scalable solution because it does not depend on high-cost infrastructure; it relies on accessible resources such as land, livestock, and basic technical knowledge.

Beyond employment, agricultural education plays a crucial role in fostering entrepreneurship. The rural economy is rich with untapped opportunities for small and medium enterprises. Young entrepreneurs can convert agricultural waste into compost production units, develop direct marketing platforms that connect farmers with urban buyers, or establish small-scale dairy processing facilities that add value to raw milk. Each of these ventures not only generates income but also strengthens supply chains and reduces inefficiencies.

These opportunities require more than ambition; they require structured knowledge in areas such as accounting, marketing, food safety, logistics, and supply chain management. Agricultural technical colleges and vocational training centers are essential in equipping young people with these skills.

Ultimately, investment in agricultural education and entrepreneurship does more than create jobs. It diversifies the rural economy, reduces dependence on a narrow set of industries, and builds long-term economic resilience. In doing so, it transforms agriculture from a subsistence activity into a dynamic engine of inclusive growth.

Health, Stability, and the Broader Socioeconomic Impact of Agricultural Education

Agricultural education is often viewed through the narrow lens of productivity and income, but its influence extends much further into public health and societal stability. One of its most important yet overlooked contributions is the improvement of health outcomes across rural communities. A trained farmer is more likely to understand the dangers of excessive chemical fertilizer use, particularly its long-term impact on soil quality and groundwater contamination. Similarly, individuals trained in food handling and processing are better equipped to prevent contamination-related illnesses such as salmonella and other foodborne diseases. In livestock systems, basic veterinary education enables early detection of zoonotic diseases such as avian influenza, reducing the risk of outbreaks that can spread from animals to humans.

Health improvements at the household level also translate into economic gains. Healthier individuals are more productive, miss fewer working days, and spend less on medical treatment. These savings are often redirected toward education, nutrition, and improved living standards for children, reinforcing a long-term cycle of human capital development and poverty reduction.

Beyond health, agricultural education contributes to broader social and economic stability. When rural youth, both men and women, gain access to meaningful skills and employment opportunities, pressures related to unemployment and migration are significantly reduced. Stable rural economies are less prone to social unrest and more attractive to investment. In turn, investment stimulates infrastructure development, including roads, schools, and processing facilities, creating a reinforcing cycle of growth and opportunity.

However, significant structural challenges continue to limit progress. Rural literacy rates remain low, particularly among women, while many educational institutions lack basic facilities such as electricity and sanitation. Teacher shortages and outdated curricula further weaken the effectiveness of agricultural training. Most critically, the agricultural extension system, which should bridge the gap between research and practice, remains severely underfunded and inefficient.

Conclusion

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Agricultural education is a central driver of Pakistan's economic transformation because it directly determines how effectively the country can convert its natural agricultural endowment into productivity, income, and resilience. The persistent gap between modern global agricultural practices and local farming methods reflects a deeper human capital deficit that constrains yields, increases inefficiencies, and limits competitiveness in domestic and export markets. Strengthening agricultural education and extension systems would enable farmers to adopt precision agriculture, improve water and soil management, reduce post-harvest losses, and respond more effectively to climate and market risks. Beyond productivity, its impact extends to rural livelihoods, where better knowledge translates into higher incomes, improved food security, and new entrepreneurial opportunities in areas such as agribusiness, dairy processing, and input supply services. It also contributes to public health and social stability by promoting safer food practices and reducing rural unemployment pressures. Ultimately, agricultural education is not just a supporting sector but a foundational pillar of inclusive economic growth, capable of transforming agriculture from a subsistence-based activity into a dynamic, knowledge-driven engine of national development.

Please note that the views expressed in this article are of the author and do not necessarily reflect the views or policies of any organization.

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Mangrove Restoration in Pakistan's Indus Delta

Discover how Pakistan's mangrove restoration in the Indus Delta exemplifies ecosystem recovery through commitment and community participation. Learn about the benefits for coastal protection, biodiversity, and climate resilience, while addressing ongoing challenges like climate change and pollution.

Nazar Gul

6/24/2026

Imagine a forest that flourishes where most plants cannot survive, rooted in salty coastal waters, enduring daily tidal inundation, and thriving in some of the harshest environmental conditions on Earth. These are mangrove forests, extraordinary ecosystems that serve as nature's frontline defense along tropical and subtropical coastlines. Mangroves possess unique adaptations that allow them to filter salt, stabilize sediments, and survive in oxygen-poor soils. Their intricate root systems provide shelter and breeding grounds for fish, crabs, shrimp, and countless other species while protecting coastal communities from storms, cyclones, erosion, and rising sea levels. Equally important, mangroves are among the world's most efficient natural carbon sinks, storing large quantities of carbon in their biomass and soils and helping mitigate climate change.

Despite their immense ecological and economic value, mangrove forests have been declining globally due to urban expansion, coastal development, pollution, overharvesting, reduced freshwater flows, and the growing impacts of climate change. The loss of these ecosystems not only threatens biodiversity but also exposes coastal populations to greater environmental and economic risks.

Against this backdrop, Pakistan's experience in the Indus Delta stands out as a remarkable conservation success story. Once facing severe degradation caused by seawater intrusion, declining freshwater inflows, and human pressures, the delta's mangrove ecosystem has undergone an impressive recovery. Through sustained restoration programs, community participation, government initiatives, and support from national and international organizations, mangrove cover has expanded dramatically over the past three decades. From approximately 50,000 hectares in 1990, the area under mangroves has grown to more than 101,000 hectares by 2023, representing one of the largest and most successful mangrove restoration efforts in the world.

This achievement demonstrates that degraded ecosystems can recover when science-based management, long-term commitment, and community engagement work together. More importantly, it offers hope and valuable lessons for other countries seeking nature-based solutions to climate change, biodiversity loss, and coastal vulnerability. The revival of Pakistan's mangroves is not merely an environmental success, it is a model of sustainable development, ecological resilience, and climate adaptation.

The Indus Delta: A Global Stronghold of Arid Mangroves

The Indus Delta, situated along Pakistan's southern coastline where the Indus River empties into the Arabian Sea, represents one of the most unique coastal ecosystems in the world. Covering nearly 600,000 hectares across Sindh Province, the delta supports the largest arid-climate mangrove forest on Earth. Unlike tropical mangrove ecosystems that receive abundant rainfall, the Indus Delta survives under extremely harsh conditions, with annual precipitation often below 200 millimeters. Despite this aridity, the delta sustains a rich network of tidal creeks, mudflats, wetlands, and mangrove forests that provide critical ecological, economic, and social benefits.

The significance of this ecosystem extends far beyond Pakistan's borders. Approximately 97 percent of the country's mangrove cover is concentrated within the Indus Delta, while the remaining 3 percent occurs along the Balochistan coastline. The dominant species is the Grey Mangrove (*Avicennia marina*), which has evolved remarkable adaptations to withstand high salinity, tidal inundation, and water scarcity. Three other species, *Rhizophora mucronata*, *Ceriops tagal*, and *Aegiceras corniculatum,* survive in smaller populations, contributing to the region's biodiversity.

These mangrove forests are far more than collections of trees. They serve as nurseries for commercially important fish and shrimp species, provide habitat for migratory birds, stabilize coastlines against erosion, and act as natural barriers against cyclones and storm surges. For more than 28,000 coastal households, mangroves are a vital source of livelihood, supporting fisheries, fuelwood collection, livestock grazing, and other income-generating activities. Studies estimate that the ecosystem services provided by a single hectare of mangroves are worth between USD 33,000 and 57,000 annually through fisheries support, carbon sequestration, coastal protection, and biodiversity conservation. This immense value underscores why protecting and restoring the Indus Delta's mangroves is not only an environmental necessity but also a strategic

investment in sustainable development and climate resilience.

Understanding the Changing Landscape and Emerging Threats

The remarkable expansion of Pakistan's mangrove forests over the past three decades tells only part of the story. Equally important are the structural changes occurring within the ecosystem, many of which indicate improving ecological health and resilience. Landscape analyses show that while the overall number of individual mangrove patches has declined, the remaining patches have become larger, denser, and more interconnected. This pattern suggests that fragmented mangrove stands are gradually merging into more continuous forest systems, creating stronger and more stable ecological networks across the Indus Delta.

The increase in average patch size is particularly significant from both ecological and conservation perspectives. Larger mangrove blocks generally support greater biodiversity, provide more effective coastal protection, and possess a higher capacity for carbon sequestration than smaller isolated patches. They also offer better habitat conditions for fish, crustaceans, migratory birds, and other wildlife that depend on healthy mangrove ecosystems. In addition, the growing proximity and clustering of mangrove stands facilitate critical ecological functions such as nutrient cycling, seed dispersal, species migration, and genetic exchange among plant populations. These processes strengthen ecosystem resilience and enhance the ability of mangroves to recover from environmental disturbances.

Another encouraging finding is that the overall connectivity of the mangrove landscape has remained relatively stable despite substantial changes in forest structure. Maintaining connectivity is essential because it allows ecological processes to function across large areas and reduces the vulnerability of isolated patches to environmental stress. However, some changes warrant careful attention. The gradual simplification of patch shapes, resulting in more regular and less complex forest boundaries, may reduce the diversity of edge habitats that support certain plant and animal species. While this does not currently threaten overall ecosystem health, continued monitoring is necessary to ensure that gains in forest cover do not come at the expense of biodiversity.

Despite this extraordinary recovery, significant challenges remain. Climate change continues to pose one of the greatest threats to the long-term sustainability of Pakistan's mangroves. Rising sea levels, increasing temperatures, changing rainfall patterns, and more frequent extreme weather events are altering the delicate balance between freshwater and saline conditions that mangroves require to thrive. Severe cyclones, including Cyclone 2A in 1999, Cyclone Phet in 2010, and Cyclone Biparjoy in 2023, have caused widespread damage through flooding, erosion, and the destruction of mangrove stands. These impacts are particularly severe for less salt-tolerant species such as the Red Mangrove (*Rhizophora mucronata*), which are more vulnerable to prolonged inundation and storm-related disturbances.

Human pressures further compound these environmental risks. Rapid urban growth, industrial development, coastal infrastructure expansion, and agricultural encroachment continue to degrade mangrove habitats. Pollution from industrial effluents and agricultural runoff introduces harmful chemicals into coastal ecosystems, affecting soil quality, water chemistry, and biodiversity. Perhaps the most critical challenge remains the reduction of freshwater flows into the Indus Delta due to upstream water diversions. Reduced river discharge increases salinity levels, weakens ecosystem productivity, and limits the natural regeneration capacity of mangrove forests.

Evidence from recent decades shows that major cyclonic events often slow or temporarily reverse gains achieved through restoration programs. These setbacks highlight an important lesson: successful mangrove conservation requires more than tree planting alone. Future restoration efforts must incorporate climate adaptation, disaster preparedness, freshwater management, and long-term ecological monitoring to ensure that Pakistan's mangrove success story remains sustainable in the face of growing environmental and human pressures.

Scaling Restoration: Pakistan's Green Response and Global Lessons

Recognizing the growing threats posed by climate change, coastal degradation, biodiversity loss, and declining ecosystem services, Pakistan has embarked on one of the most ambitious environmental restoration efforts in the world: the Ten Billion Tree Tsunami Program (TBTTP). Launched in 2019 with support from the United Nations Environment Program, the initiative represents a landmark commitment to restoring degraded landscapes, enhancing climate resilience, and strengthening the country's natural resource base. While the program covers forests across Pakistan, mangrove restoration has emerged as one of its most significant components, particularly within the ecologically fragile Indus Delta.

The program's achievements have been substantial. Within its initial years, billions of trees were planted or regenerated through natural restoration processes, including extensive mangrove plantations along Pakistan's coastline. However, the initiative extends far beyond tree planting alone. It embraces a broader vision of ecosystem restoration that integrates biodiversity conservation, watershed protection, carbon sequestration, sustainable livelihoods, and disaster risk reduction. Healthy mangrove ecosystems contribute to all these objectives simultaneously by stabilizing coastlines, protecting communities from storms, supporting fisheries, and capturing significant amounts of atmospheric carbon.

A defining feature of Pakistan's restoration strategy has been the active involvement of local communities. Coastal residents, fishermen, farmers, and community organizations have participated directly in plantation campaigns, monitoring activities, and long-term protection efforts. This local ownership is critical because restoration success ultimately depends on the people who live alongside these ecosystems. Strong institutional support from organizations such as the Sindh Forest Department, the Port Qasim Authority, and the Sindh Board of Revenue has further strengthened conservation efforts, with approximately 600,000 hectares of mangrove forests now receiving protected status.

Pakistan's experience offers valuable lessons for countries facing similar environmental challenges. The recovery of the Indus Delta demonstrates that even severely degraded mangrove ecosystems can be restored through sustained investment, supportive policies, scientific planning, and community participation. The success has been aided by the dominance of *Avicennia marina*, a highly resilient species well adapted to saline and arid conditions, as well as by strong government commitment and international collaboration.

Important insights can also be drawn from successful restoration efforts elsewhere, particularly in Indonesia, where community-based management, indigenous knowledge, and economic incentives have significantly improved conservation outcomes. Similar approaches could further strengthen Pakistan's restoration agenda. Mechanisms such as carbon markets, blue carbon financing, payments for ecosystem services, and nature-based livelihood programs could provide long-term financial incentives for local communities to conserve

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mangroves. By combining ecological restoration with economic opportunity, Pakistan can not only secure the future of its coastal ecosystems but also establish a globally recognized model for arid-climate mangrove restoration and climate adaptation.

Securing the Future of Pakistan's Mangroves

The remarkable recovery of Pakistan's mangrove forests demonstrates what can be achieved through long-term commitment, effective policies, and community participation. However, conservation success should not lead to complacency. The future of these valuable ecosystems remains uncertain as climate change, increasing salinity, declining freshwater inflows, coastal development, and population pressures continue to threaten their long-term sustainability. While mangrove cover has expanded significantly, structural changes within the landscape suggest that some areas remain vulnerable to fragmentation and ecological stress, highlighting the need for continued vigilance.

Securing the future of the Indus Delta's mangroves will require a comprehensive and adaptive management approach. Stronger coordination among government agencies, research institutions, local communities, and conservation organizations is essential to ensure that restoration gains are protected and expanded. Continued scientific monitoring can help identify emerging threats, assess ecosystem health, and guide evidence-based management decisions. Expanding protected areas and strengthening enforcement of environmental regulations will further safeguard critical habitats.

Economic incentives can also play an important role. Carbon credit schemes, blue carbon initiatives, and payments for ecosystem services can generate sustainable financing for conservation while creating livelihood opportunities for local communities. At the same time, building resilience to climate-related risks such as cyclones, storm surges, and sea-level rise must remain a priority.

Equally important is public awareness. Greater understanding of the ecological, economic, and social value of mangroves can encourage community stewardship, strengthen policy support, and ensure that future generations recognize these forests not only as environmental assets but also as foundations of coastal resilience and sustainable development.

Conclusion

Pakistan's mangrove restoration in the Indus Delta stands as a powerful example of how degraded ecosystems can recover through sustained commitment, scientific management, supportive policies, and community participation. The doubling of mangrove cover over the past three decades has strengthened coastal protection, enhanced biodiversity, supported livelihoods, and contributed to climate change mitigation. However, this success remains fragile. Climate change reduced freshwater flows, coastal development, pollution, and increasing salinity continue to threaten the long-term health of these ecosystems. Protecting and expanding these gains will require continued investment in conservation, adaptive management, scientific monitoring, and community stewardship. By integrating ecological restoration with sustainable livelihoods and climate resilience strategies, Pakistan can secure the future of its mangroves while offering an inspiring model of nature-based solutions for coastal regions around the world.

Please note that the views expressed in this article are of the author and do not necessarily reflect the views or policies of any organization.

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Pumpkin Seeds: Nutrient-Rich Superfood for Heart Health

Discover the incredible benefits of pumpkin seeds, a nutrient-rich superfood that supports heart health, blood sugar control, and digestive function. Packed with protein, healthy fats, and antioxidants, these tiny seeds are an affordable way to boost your nutrition.

Ayesha Saddiqa, Mian Kamran Sharif & Muneeba Javed

6/4/2026

Every autumn, pumpkins take center stage. We carve them into jack-o'-lanterns, bake them into pies, prepare soups and desserts, and use them as colorful decorations for seasonal celebrations. Yet hidden inside every pumpkin is a nutritional treasure that many people overlook and discard without a second thought: the seed. For generations, pumpkin seeds were treated as little more than agricultural waste. After removing the flesh for cooking, families often threw the seeds away or fed them to animals. Today, however, nutrition scientists are telling a very different story.

Research conducted around the world, including studies highlighted by the National Institute of Food Science and Technology in Pakistan, shows that pumpkin seeds are among the most nutrient-dense foods available. These small green kernels contain an impressive combination of protein, healthy fats, dietary fiber, vitamins, minerals, and powerful plant compounds that support overall health.

What makes pumpkin seeds particularly remarkable is the concentration of nutrients packed into such a tiny package. They are rich in magnesium, zinc, iron, potassium, phosphorus, and manganese, minerals that play essential roles in energy production, immune function, bone health, and heart performance. They also contain high-quality plant protein and beneficial unsaturated fats, including omega-3 and omega-6 fatty acids, which help support cardiovascular health.

Scientists are increasingly interested in pumpkin seeds because of their potential role in preventing and managing chronic diseases. Studies suggest that regular consumption may help improve blood sugar control, lower blood pressure, reduce inflammation, and support healthy cholesterol levels. The seeds are also rich in antioxidants such as carotenoids and vitamin E, which help protect the body's cells from damage caused by harmful free radicals.

Perhaps most surprisingly, emerging research indicates that compounds found in pumpkin seeds may contribute to improved mood, better sleep quality, and a lower risk of certain cancers. In other words, the part of the pumpkin most people throw away may actually be its most valuable contribution to human health. Before discarding those seeds, it may be worth remembering that nature has hidden one of its most powerful nutritional packages inside the pumpkin itself.

Small Seeds, Big Nutrition

At first glance, pumpkin seeds may appear insignificant, but their nutritional value is anything but small. Hidden inside their thin shells is remarkable concentration of energy, protein, healthy fats, vitamins, and minerals that rival many commercially marketed health foods. This is why nutrition experts increasingly describe pumpkin seeds as one of nature's most complete nutrient packages.

A 100-gram serving of shelled pumpkin seeds contains approximately 550 calories, making it a highly energy-dense food capable of providing sustained nourishment throughout the day. This same serving delivers around 30 grams of protein, an amount comparable to many animal-based protein sources. For individuals seeking affordable plant-based nutrition, pumpkin seeds offer an excellent option. They are particularly valuable for vegetarians, athletes, growing children, and anyone looking to increase their protein intake naturally.

The fat content of pumpkin seeds often surprises people, but there is little reason for concern. Nearly all of these facts are beneficial unsaturated fats, including omega-3 and omega-6 fatty acids that support heart health, brain function, and healthy cholesterol levels. Unlike many processed snacks, pumpkin seeds provide healthy fats alongside fiber, protein, and essential micronutrients.

Their mineral content is especially impressive. Pumpkin seeds are rich in magnesium, which supports blood pressure regulation, muscle function, and hundreds of biochemical reactions within the body. They also contain significant amounts of zinc, an important nutrient for immune health, wound healing, and skin maintenance. Iron, phosphorus, and potassium are present in abundance, helping support oxygen transport, strong bones, nerve function, and overall metabolic health.

Perhaps most remarkable is their iron content. A 100-gram serving provides approximately 8.8 milligrams of iron, enough to meet or exceed the daily requirement for many adults. For individuals vulnerable to iron deficiency particularly women, vegetarians, and those experiencing chronic fatigue pumpkin seeds can serve as a simple and affordable nutritional boost. In many ways, these tiny seeds function as a natural multivitamin packaged by nature itself.

Small Seeds with Big Health Benefits

Pumpkin seeds are far more than a crunchy snack. Scientific research increasingly recognizes them as functional foods capable of supporting human health in multiple ways. Their unique combination of healthy fats, dietary fiber, antioxidants, vitamins, minerals, and bioactive compounds makes them particularly valuable in preventing and managing chronic diseases that are becoming increasingly common worldwide. From cardiovascular disorders and diabetes to digestive health and mental well-being, pumpkin seeds offer a remarkable range of benefits packed into a tiny kernel.

One of the most widely recognized benefits of pumpkin seeds is their positive impact on cardiovascular health. Heart disease remains a leading cause of death globally, and diet plays a crucial role in both prevention and management. Pumpkin seeds contain phytosterols, natural plant compounds that help reduce the absorption of low-density lipoprotein (LDL) cholesterol, often referred to as "bad cholesterol." Lower LDL levels reduce the risk of plaque formation in arteries and improve overall cardiovascular function. In addition, pumpkin seeds are rich in magnesium, a mineral essential for regulating blood pressure, maintaining normal heart rhythm, and supporting healthy blood vessels. Their high concentration of unsaturated fatty acids, including omega-3 and omega-6 fats, further contributes to reduced inflammation and

improved circulation, creating a comprehensive nutritional package for heart protection.

Pumpkin seeds also play an important role in blood sugar management. As rates of type 2 diabetes continue to rise, foods that help regulate glucose levels are gaining attention. The dietary fiber found in pumpkin seeds slows digestion and reduces the speed at which sugars enter the bloodstream, helping prevent sudden spikes in blood glucose. Moreover, magnesium contributes directly to insulin sensitivity and glucose metabolism. Research suggests that adequate magnesium intake is associated with a lower risk of developing type 2 diabetes. The antioxidants present in pumpkin seeds, including vitamin E and carotenoids, help protect pancreatic cells responsible for insulin production from oxidative damage, thereby supporting long-term metabolic health.

Emerging evidence also highlights the potential role of pumpkin seeds in cancer prevention. These seeds contain lignans, a group of phytoestrogen compounds that may help regulate hormonal activity and reduce the risk of hormone-related cancers such as breast and prostate cancer. Another group of bioactive compounds known as cucurbitacins has attracted scientific interest because of its potential ability to inhibit the growth of cancer cells and promote apoptosis, the natural process through which damaged or abnormal cells self-destruct. Although pumpkin seeds should not be viewed as a treatment for cancer, regular consumption may contribute to a dietary pattern associated with lower cancer risk and improved cellular health.

The benefits of pumpkin seeds extend beyond physical health to mental and emotional well-being. They are a natural source of tryptophan and 5-hydroxytryptophan (5-HTP), compounds involved in the production of serotonin, a neurotransmitter that regulates mood, sleep, and emotional stability. Adequate serotonin levels are associated with reduced symptoms of anxiety, depression, and sleep disturbances. Zinc, another nutrient found abundantly in pumpkin seeds, supports neurological function and assists in serotonin synthesis. Consequently, incorporating pumpkin seeds into the diet may contribute to improved mood, better sleep quality, and enhanced cognitive performance.

Digestive health is another area where pumpkin seeds demonstrate considerable value. Their fiber content promotes regular bowel movements, supports healthy digestion, and nourishes beneficial gut bacteria. A balanced gut microbiome is increasingly recognized as a cornerstone of overall health, influencing immunity, metabolism, and even mental well-being. Researchers have also identified antimicrobial proteins in pumpkin seeds that may help inhibit the growth of harmful microorganisms. By supporting a healthier microbial balance, pumpkin seeds contribute to stronger immune defenses and improved gastrointestinal function.

In addition to these specific health benefits, pumpkin seeds provide substantial nutritional support for bones, muscles, and immune function. Their high levels of phosphorus, potassium, zinc, and iron contribute to strong bones, healthy blood formation, effective nerve signaling, and enhanced resistance to infections. For populations vulnerable to nutrient deficiencies, including children, pregnant women, vegetarians, and older adults, pumpkin seeds offer an affordable and accessible source of essential micronutrients.

Taken together, the evidence suggests that pumpkin seeds deserve their growing reputation as a superfood. They are not a miracle cure, nor should they replace medical treatment when needed. However, as part of a balanced diet, these small seeds provide a powerful combination of nutrients and protective compounds that can support cardiovascular health, blood sugar control, digestive function, immunity, mental wellness, and long-term disease prevention. What was once discarded as agricultural waste is increasingly being recognized as one of nature's most nutrient-dense foods.

Easy and Delicious Ways to Add Pumpkin Seeds to Your Diet

One of the greatest advantages of pumpkin seeds is that they are both highly nutritious and remarkably versatile. While many people recognize their health benefits, the challenge often lies in incorporating them into everyday meals in ways that remain enjoyable over time. Fortunately, pumpkin seeds, commonly known as pepitas when sold without their shells, have a mild, buttery, and slightly nutty flavor that complements a wide variety of foods.

The simplest option is to enjoy them as a snack. Raw pumpkin seeds can be lightly coated with olive oil and seasoned with salt, paprika, black pepper, or cinnamon before roasting in the oven. The result is a crunchy, satisfying snack that can easily replace less nutritious alternatives such as chips or processed crackers. Stored in an airtight container, roasted seeds remain fresh for weeks.

Pumpkin seeds also make an excellent addition to breakfast. Sprinkling a spoonful over oatmeal, yogurt, porridge, or smoothie bowls instantly boosts protein, healthy fats, and essential minerals while adding texture and flavor. For those seeking a more filling breakfast, pumpkin seeds can be mixed into homemade granola or muesli.

In salads, pumpkin seeds serve as a nutritious substitute for croutons. Their crunch pairs particularly well with leafy greens, tomatoes, cucumbers, cheese, and vinaigrette dressings. They can also be incorporated into baked goods such as bread, muffins, cookies, and biscuits, enhancing both nutritional value and taste.

For more creative uses, soaked pumpkin seeds can be blended with water to produce a dairy-free milk alternative rich in nutrients. They can also be combined with garlic, herbs, olive oil, and lemon juice to create a flavorful pesto sauce suitable for pasta, sandwiches, or roasted vegetables.

When choosing pumpkin seeds, consumers will find both hulled and unhulled varieties. While the white outer shell provides additional dietary fiber, the green hulled kernels generally offer better digestibility and improved absorption of important minerals such as zinc, iron, and magnesium. For most people, hulled pumpkin seeds provide the most convenient and nutritionally efficient option, making them an easy addition to a healthy daily diet.

Conclusion

Pumpkin seeds remind us that some of nature's most valuable foods come in the smallest packages. What was once discarded as a byproduct of pumpkin consumption is now recognized as a nutrient-rich superfood capable of supporting heart health, blood sugar control, digestive function, immunity, and mental well-being. Packed with high-quality protein, healthy fats, dietary fiber, essential minerals, and powerful antioxidants, pumpkin seeds offer an affordable and accessible way to improve nutritional quality without relying on expensive supplements or processed health products.

Their versatility makes them particularly attractive for modern diets. Whether eaten as a snack, added to breakfast cereals, mixed into salads, incorporated into baked goods, or blended into healthy beverages, pumpkin seeds can easily become part of everyday meals. For countries like Pakistan, where micronutrient deficiencies and diet-related diseases remain important public health concerns, promoting the consumption of locally available nutrient-dense foods such as pumpkin seeds could provide significant health benefits.

Ultimately, pumpkin seeds demonstrate that nutrition does not always require exotic ingredients or costly interventions. Sometimes, the key to better health is already sitting in our

kitchens, hidden inside foods we consume every day. The next time you cut open a pumpkin, think twice before throwing away its seeds, they may be the most valuable part of the entire fruit.

Please note that the views expressed in this article are of the author and do not necessarily reflect the views or policies of any organization.

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Pakistan's Inflation Relief: Food Prices Strain Budgets

Pakistan has seen a recent decline in headline inflation, yet many households face ongoing challenges as food prices remain high, especially in rural areas. The reliance on cheaper foods reveals a nutrition and public health crisis.

MahNoor Fatima

6/18/2026

In the bustling markets of Lahore, the crowded streets of Karachi, and the villages scattered across rural Punjab and Sindh, one reality continues to shape everyday life in 2026: food remains expensive despite signs of broader economic stabilization. Although Pakistan has made notable progress in reducing overall inflation from the exceptionally high levels recorded during the previous few years, the benefits have not been felt equally across society. For millions of households, particularly low-income families, the cost of putting food on the table remains one of the greatest economic challenges.

Pakistan's inflationary experience between 2021 and 2026 has been marked by dramatic fluctuations. Following years of double-digit inflation driven by currency depreciation, energy price adjustments, supply-chain disruptions, and global commodity shocks, inflation began to moderate significantly in 2025. According to the Pakistan Economic Survey 2025–26, average inflation for the fiscal year stood at approximately 6.7 percent, lower than the annual target of 7.5 percent and substantially below the levels experienced during the peak inflationary period. This decline was welcomed as evidence that macroeconomic stabilization measures were beginning to take effect.

However, aggregate figures often conceal important realities. While average inflation eased, periodic spikes continued to place pressure on household budgets. During July–April FY2026, average Consumer Price Index (CPI) inflation remained around 6.2 percent, but inflation accelerated sharply in April 2026, reaching 10.9 percent. Rising international crude oil prices increased domestic fuel and transportation costs, which quickly filtered through the economy and affected the prices of food and other essential goods. By May 2026, overall inflation had risen further to 11.70 percent, while food inflation approached 8 percent.

The burden has been particularly severe in rural areas. Rural households generally spend a larger share of their income on food than urban households and often have fewer opportunities to supplement income during periods of rising prices. Consequently, rural food inflation of 4.7 percent during FY2026 exceeded urban food inflation of 3.6 percent, highlighting the continuing vulnerability of Pakistan's rural population to food price shocks and economic uncertainty.

The Food Crisis: More Than Just Numbers

Perhaps the most troubling aspect of Pakistan's food inflation crisis is not reflected in price statistics alone but in the changing diets of ordinary households. Recent data from the Pakistan Economic Survey 2025–26 reveal a steady decline in the consumption of several essential food items, highlighting the growing struggle of families to afford nutritious diets. Since 2018–19, monthly per capita wheat consumption has fallen from 7.0 kilograms to 6.59 kilograms, while rice consumption has declined from 1.06 kilograms to 0.86 kilograms. Pulses, a major source of affordable protein for low-income households, have dropped from 0.35 kilograms to 0.26 kilograms per person per month.

The decline is equally visible in nutrient-rich foods. Fresh milk consumption has decreased from 6.85 kilograms to 6.15 kilograms, while meat consumption, including beef, mutton, and poultry, has fallen from 0.61 kilograms to 0.50 kilograms per capita. These reductions suggest that many families are being forced to cut back on foods essential for healthy growth, particularly for children and pregnant women.

In contrast, vegetable ghee consumption has increased dramatically from 0.69 kilograms to 1.25 kilograms per person per month, reflecting a shift toward cheaper calorie sources. This trend points to declining dietary diversity as households prioritize affordability over nutrition. Such changes carry serious long-term consequences, including higher rates of malnutrition, stunting, micronutrient deficiencies, and chronic health problems. Ultimately, the food crisis is not only an economic issue but also a public health and human development challenge that could affect Pakistan's future productivity and well-being.

Why Food Prices Remain Under Pressure

Despite improvements in Pakistan's overall inflation outlook, several interconnected factors continue to keep food prices elevated and household budgets under strain. The country's food economy remains vulnerable to production shocks, policy uncertainty, energy price fluctuations, and global economic developments, creating what many analysts describe as a perfect storm for consumers.

A major source of concern is the wheat sector, which serves as the backbone of Pakistan's food security system. Following a record harvest in 2024–25, wheat production is projected to decline significantly in 2025–26. Reduced cultivated area, prolonged dry weather conditions, and changing market incentives have combined to lower expected output. The government's decision to discontinue guaranteed wheat procurement has altered farmer expectations, leading some producers to shift land toward alternative crops. While lower wheat prices have provided some relief to consumers compared to the exceptionally high levels witnessed in previous years, they have also reduced profitability for many farmers. At the same time, restrictions on wheat imports and exports have created uncertainty in the market, making it difficult for producers, traders, and consumers to make informed decisions.

Energy prices remain another powerful driver of food inflation. Although macroeconomic stability has improved, Pakistan remains highly exposed to international oil market fluctuations. Rising global crude oil prices increase transportation costs throughout the supply chain, from moving agricultural inputs to farms to delivering food products to wholesale and retail markets. Higher fuel and electricity costs

also raise the expenses associated with irrigation, machinery operation, food processing, storage, and distribution. These additional costs are eventually passed on to consumers through higher food prices.

The government has achieved some important economic gains. Foreign exchange reserves have strengthened, remittances have reached record levels, and fiscal indicators have improved considerably. These developments provide policymakers with greater room to support vulnerable populations and stabilize markets. Efforts to strengthen price monitoring and improve coordination among federal and provincial authorities have also helped moderate some price pressures.

At the provincial level, authorities continue to rely on inspections, enforcement campaigns, and market monitoring to discourage profiteering. Innovative digital tools, such as Punjab's market-price information platforms and Khyber Pakhtunkhwa's inflation-monitoring systems, are helping improve transparency. However, these measures can only achieve limited success when deeper structural problems persist. Weak supply chains, inadequate storage facilities, transportation bottlenecks, fragmented agricultural markets, and climate-related production risks continue to exert upward pressure on food prices. Until these underlying challenges are addressed, food affordability will remain a major concern for millions of Pakistani households.

Building a More Resilient Food System

Addressing Pakistan's persistent food affordability challenge requires a comprehensive policy framework that balances market efficiency, domestic production, social protection, and timely information. While recent improvements in macroeconomic indicators are encouraging, sustainable food security will depend on reforms that address both immediate pressures and long-term structural weaknesses.

One important priority is the continued reform of the wheat sector. As the government moves away from guaranteed procurement and support prices, an opportunity has emerged to create a more efficient and competitive wheat market. However, market liberalization should be accompanied by safeguards that protect food security and farmer livelihoods. Maintaining a modest strategic grain reserve for emergencies can help stabilize supplies during production shocks, while resources previously devoted to large-scale procurement can be redirected toward supporting smallholder farmers, promoting climate-resilient farming practices, and strengthening nutrition programs for vulnerable populations.

Reducing dependence on food imports is equally important. Pakistan continues to spend valuable foreign exchange on importing wheat, edible oils, pulses, and other essential commodities. Although agricultural exports such as rice remain a bright spot, greater investment in domestic production is needed to narrow supply gaps. Expanding climate-smart agriculture, improving seed quality, strengthening extension services, and investing in water-efficient technologies can help boost productivity and reduce reliance on international markets.

Strengthening social safety nets must remain a central policy objective. Rising food prices have forced many households to substitute nutritious foods with cheaper, less diverse alternatives. Expanding and better targeting programs such as Ehsaas and the Benazir Income Support Program can help low-income families maintain access to adequate nutrition, particularly for children, pregnant women, and other vulnerable groups.

Finally, Pakistan should develop a more robust food security monitoring and forecasting system. Building existing price-monitoring mechanisms, policymakers need real-time information on production, stocks, trade flows, weather conditions, and input availability. Greater collaboration with the private sector can improve transparency and enable early identification of shortages or market disruptions. Better data, combined with timely policy action, can significantly enhance the country's ability to manage food price volatility and strengthen long-term food security.

Conclusion

Pakistan's recent success in lowering headline inflation offers welcome relief, but the reality for millions of households remains far more challenging. Food prices continue to strain family budgets, particularly in rural areas where incomes are lower and food expenditures consume a larger share of household resources. The decline in the consumption of wheat, pulses, milk, and meat, alongside increased reliance on cheaper calorie-dense foods, reveals that food affordability has become a nutrition and public health crisis as much as an economic one. Structural vulnerabilities, including climate-related production shocks, energy price fluctuations, market inefficiencies, and dependence on food imports, continue to keep food inflation elevated despite macroeconomic improvements. Addressing these challenges requires more than short-term price controls. Pakistan must strengthen domestic food production, improve market efficiency, expand targeted social protection, and invest in robust food security monitoring systems. Ensuring affordable access to nutritious food is not only essential for household welfare but also for the country's long-term economic productivity, health outcomes, and social stability.

Please note that the views expressed in this article are of the author and do not necessarily reflect the views or policies of any organization.

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Emerging Infectious Diseases in Pakistan's Livestock Sector

Emerging infectious diseases pose serious threats to Pakistan's livestock sector, impacting animal health, rural livelihoods, and food security. Diseases like LSD and FMD are causing significant production losses and placing growing financial pressure.

Mudasir Khan Kakar

6/25/2026

Livestock farming remains the backbone of rural Pakistan and serves as a critical pillar of the national agricultural economy. For millions of rural households, cattle, buffaloes, sheep, goats, and poultry are far more than productive assets, they are sources of income, nutrition,

savings, and financial security. Livestock provides milk, meat, eggs, wool, hides, manure, and draft power, while also acting as a safety net during times of economic hardship, crop failure, or unexpected household expenses. The sector contributes significantly to agricultural value added and supports a vast network of farmers, traders, veterinarians, transporters, feed suppliers, processors, and retailers. However, this vital sector is increasingly threatened by an often-overlooked challenge: the emergence and spread of infectious livestock diseases.

Pakistan possesses one of the largest livestock populations in the world, spread across diverse ecological zones ranging from the fertile plains of Punjab and Sindh to the arid landscapes of Balochistan and the mountainous regions of Khyber Pakhtunkhwa and Gilgit-Baltistan. Yet the conditions that support livestock production are changing rapidly. Rising temperatures, shifting rainfall patterns, prolonged droughts, floods, increased movement of animals across provinces, weak disease surveillance systems, and inadequate biosecurity measures have created an environment where infectious diseases can spread more easily than ever before.

The consequences for farmers can be devastating. Diseases such as foot-and-mouth disease, hemorrhagic septicemia, peste des petits ruminants (PPR), lumpy skin disease, and various parasitic infections reduce animal productivity and increase mortality risks. When livestock become sick, milk production declines, weight gain slows, fertility rates fall, and veterinary treatment costs rise. In severe outbreaks, entire herds can be lost within weeks. For smallholder farmers who depend on daily milk sales or livestock trading to meet household expenses, even a temporary decline in production can create serious financial stress. As emerging diseases continue to threaten animal health and rural livelihoods, strengthening disease prevention, surveillance, and livestock health management has become essential for protecting Pakistan's food security, rural economy, and agricultural future.

Emerging Livestock Diseases

Among the various livestock diseases affecting Pakistan's rural economy, few have generated as much concern in recent years as **Lumpy Skin Disease (LSD)**. This viral disease, which primarily affects cattle, has emerged as a major threat to dairy production and livestock-based livelihoods across the country. Characterized by high fever, swollen lymph nodes, sharp declines in milk production, and the appearance of painful skin nodules across the body, LSD can severely weaken affected animals. Infected cattle often experience reduced appetite, weight loss, reproductive problems, and prolonged recovery periods, leading to substantial economic losses for farmers. The disease spreads mainly through biting insects such as mosquitoes, flies, and ticks, making it particularly difficult to control during warm and humid seasons when vector populations increase rapidly. In many rural areas, limited access to veterinary services, delayed diagnosis, and inadequate vaccination coverage have allowed outbreaks to spread quickly. Although vaccination remains the most effective preventive measure, many smallholder farmers remain unaware of vaccination schedules or lack access to affordable animal health services.

While LSD represents a relatively recent challenge, **Foot-and-Mouth Disease (FMD)** continues to be one of the most persistent and economically damaging livestock diseases in Pakistan. Affecting cattle, buffaloes, sheep, and goats, FMD is highly contagious and can spread rapidly through direct contact, contaminated equipment, animal products, and livestock movements. Infected animals develop fever, excessive salivation, and painful blisters on the mouth, tongue, and feet. These symptoms make eating, drinking, and walking extremely difficult, resulting in severe weight loss, reduced milk yields, and lower market value. Although mortality rates among adult animals are generally low, productivity losses can be devastating, particularly for dairy farmers who depend on daily milk sales for household income. The growing movement of livestock across districts, provinces, and international borders without adequate health screening or quarantine measures has increased the risk of disease transmission. Furthermore, the presence of multiple virus strains complicates vaccination efforts and requires continuous monitoring and updating of disease-control strategies.

Small ruminants, particularly sheep and goats, face their own serious disease threats. Among the most destructive is **Peste des Petits Ruminants (PPR)**, commonly known as goat plague. This highly contagious viral disease causes fever, mouth lesions, diarrhea, respiratory distress, and high mortality rates, especially among young animals. For pastoral communities and landless households that depend heavily on small ruminants as their primary source of income and savings, a PPR outbreak can wipe out years of investment within a matter of weeks. The disease remains widespread in areas where animal movement is poorly regulated and vaccination coverage remains inadequate. Limited veterinary infrastructure in remote and mountainous regions further increases vulnerability, allowing outbreaks to persist and spread across communities.

Adding to these challenges is the growing threat of **tick-borne diseases**, whose prevalence has increased as a result of climate change. Rising temperatures, changing rainfall patterns, and warmer winters have created favorable conditions for ticks to survive, reproduce, and expand into new geographic areas. Diseases such as theileriosis and babesiosis, transmitted through tick bites, are becoming increasingly common in many livestock-producing regions. Affected animals often suffer from fever, anemia, weakness, reduced feed intake, weight loss, and significant declines in milk and meat production. In severe cases, mortality rates can be high, particularly when diagnosis and treatment are delayed. Beyond direct animal losses, farmers face additional expenses related to veterinary treatment, medicines, and reduced reproductive performance.

The growing burden of these diseases highlights the urgent need for stronger livestock health systems. Expanding vaccination programs, improving disease surveillance, strengthening veterinary services, promoting farm biosecurity, and increasing farmer awareness are essential steps for protecting livestock assets. As climate change and increasing animal movement continue to create favorable conditions for disease emergence, proactive disease management will be critical for safeguarding Pakistan's livestock sector, strengthening rural livelihoods, and ensuring long-term food security.

Prevention and Collective Action: Safeguarding Pakistan's Livestock Future

Preventing livestock diseases is far more effective, affordable, and sustainable than treating outbreaks after they occur. In a country where millions of rural households depend on livestock for income, nutrition, and financial security, disease prevention should be viewed as an essential investment rather than an optional expense. Vaccination remains the cornerstone of livestock health management. Timely immunization against major diseases such as Foot-and-Mouth Disease (FMD), Lumpy Skin Disease (LSD), Hemorrhagic Septicemia, and Peste des Petits Ruminants (PPR) can significantly reduce animal mortality and productivity losses. For farmers, the cost of a vaccine is minimal compared to the economic damage caused by the loss of a productive animal or a decline in milk and meat production. Expanding vaccination coverage, particularly in remote rural areas, can therefore play a critical

role in strengthening national livestock resilience.

Equally important are strong biosecurity measures at the farm level. Farmers should carefully screen and quarantine newly purchased animals before introducing them into existing herds. Proper sanitation, regular cleaning of animal housing, safe disposal of manure and waste, and controlled access to farms can greatly reduce the risk of disease transmission. Maintaining clean drinking water and high-quality feed also helps strengthen animal immunity and improve overall productivity. Regular observation of livestock is essential because early detection often determines whether a disease outbreak remains localized or spreads throughout an entire community. Signs such as fever, reduced appetite, respiratory distress, abnormal skin lesions, excessive salivation, or sudden drops in milk production should be reported immediately to veterinary professionals.

Protecting Pakistan's livestock sector is a shared responsibility. Farmers, veterinarians, researchers, private industry, and government institutions must work together to strengthen disease surveillance, improve veterinary outreach, and enhance farmer education. Investment in modern diagnostic laboratories, disease-monitoring systems, and research on emerging livestock diseases is equally important. By promoting preventive healthcare and collaborative action, Pakistan can build a healthier livestock sector that supports rural livelihoods, strengthens food security, and contributes to long-term agricultural and economic development.

Conclusion

Emerging infectious diseases are becoming one of the most serious challenges facing Pakistan's livestock sector, threatening animal health, rural livelihoods, food security, and economic stability. Diseases such as Lumpy Skin Disease, Foot-and-Mouth Disease, Peste des Petits Ruminants, and various tick-borne infections are causing significant production losses and placing growing financial pressure on livestock-dependent households. Climate change, increased animal movement, inadequate biosecurity, and limited disease surveillance are further intensifying these risks. However, many of these threats can be effectively managed through timely vaccination, improved farm hygiene, stronger veterinary services, and early disease detection. Building a resilient livestock sector requires coordinated efforts among farmers, veterinarians, researchers, and policymakers. Investing in animal health is not merely an agricultural priority; it is a strategic investment in rural development, poverty reduction, public health, and national food security. By strengthening disease prevention and preparedness today, Pakistan can protect millions of livestock-dependent families and ensure the long-term sustainability and competitiveness of its livestock industry.

Please note that the views expressed in this article are of the author and do not necessarily reflect the views or policies of any organization.

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Sustainable Agriculture: Key to Public Health

Explore the vital role of sustainable agriculture in enhancing public health, maintaining healthy ecosystems, and fostering environmental sustainability. Discover how nutritious food systems and green spaces contribute to human well-being and a resilient future.

Mithat Direk

6/12/2026

When most people think about agriculture, they imagine vast wheat fields, tractors moving across farmland, livestock grazing in rural landscapes, or fresh produce displayed at local markets. Yet agriculture is far more than the production of food and fiber. It is one of the most important determinants of public health, influencing everything from nutrition and disease prevention to environmental quality and mental well-being. In many ways, the health of a population is closely linked to the health and productivity of its agricultural systems.

For thousands of years, agriculture's primary purpose was straightforward: to provide enough food to sustain human life and prevent famine. The development of farming allowed civilizations to flourish, populations to grow, and communities to become more stable. Without agriculture, modern society simply could not exist. However, the relationship between agriculture and human health has evolved significantly over time. Today, the challenge is no longer just producing enough calories but producing nutritious, safe, and sustainable food for a growing global population.

Modern agriculture directly affects the quality of the food people consume. The fruits, vegetables, grains, dairy products, meat, and pulses produced on farms provide essential nutrients that support growth, immunity, cognitive development, and overall health. Agricultural policies and farming practices influence whether communities have access to diverse and nutritious diets or face problems such as malnutrition, micronutrient deficiencies, and food insecurity.

Agriculture also affects public health indirectly through its impact on the environment. Forests, farmland, and green spaces improve air quality, regulate temperatures, conserve water resources, and support biodiversity. Studies increasingly show that access to green environments can reduce stress, improve mental health, encourage physical activity, and enhance overall quality of life.

As populations expand, climate change intensifies, and health challenges become more complex, agriculture is emerging as a critical partner in public health policy. Understanding the connections between food systems, environmental sustainability, and human well-being is essential for building healthier communities. Agriculture is not simply about feeding people, it is about creating the conditions that allow people to live longer, healthier, and more productive lives.

Building Health Through Better Diets

The most direct connection between agriculture and public health is the food that reaches our plates every day. The quality, diversity, and availability of agricultural products largely determine the nutritional status of the population. For decades, many developing countries relied heavily on diets dominated by cereals, bread, rice, and other starchy foods. While these staples provide the calories necessary for survival, they often fail to supply enough high-quality protein, essential fatty acids, vitamins, and minerals required for optimal growth, immunity, and cognitive development.

Türkiye provides an interesting example of how economic development can gradually transform dietary patterns. Over the past decade, researchers have observed a noticeable shift away from diets centered primarily on bread and other carbohydrate-rich foods toward greater consumption of protein-rich products such as milk, yogurt, eggs, poultry, fish, and meat. This transition reflects rising incomes, urbanization, and growing awareness of nutrition. As living standards improve, consumers tend to diversify their diets and seek foods that offer greater nutritional value rather than simply satisfying hunger.

Despite this progress, important nutritional challenges remain. Although average protein intake in Türkiye is generally sufficient, a significant share still comes from plant-based sources such as wheat, legumes, and cereals. These foods are valuable components of a healthy diet, but optimal nutrition requires a balanced combination of both plant and animal proteins. Animal-source foods provide highly bioavailable protein as well as critical nutrients such as vitamin B12, iron, zinc, calcium, and essential amino acids that are particularly important for children, adolescents, pregnant women, and older adults.

Ensuring access to nutritious food should therefore be viewed as a public health investment rather than merely an agricultural objective. Achieving this goal requires policies that support sustainable livestock development, improved animal genetics, better feed production, stronger veterinary services, and responsible pasture management. The challenge facing modern agriculture is no longer simply producing enough food to prevent hunger. It produces diverse, safe, and nutrient-rich foods that enable people to lead healthier and more productive lives. In this sense, agriculture serves not only as the foundation of food security but also as a cornerstone of national health and human development.

Green Spaces and Mental Well-Being: Nature's Role in Public Health

The contribution of agriculture to public health extends far beyond the food we consume. A healthy society depends not only on adequate nutrition but also on environments that support mental and emotional well-being. In this broader context, forests, agricultural landscapes, parks, and other green spaces function as valuable public health assets. They provide opportunities for recreation, social interaction, and psychological restoration, helping people cope with the growing pressures of modern life.

Rapid urbanization has transformed the way people live and work. Large cities offer economic opportunities, education, and access to services, but they also expose residents to a range of stressors. Air pollution, traffic congestion, noise, overcrowding, long commuting hours, and limited contact with nature can negatively affect mental health. Studies around the world have linked urban living to higher rates of anxiety, depression,

stress-related disorders, and social isolation. As populations continue to concentrate in urban centers, these challenges are becoming increasingly significant public health concerns.

Green spaces offer a natural solution to many of these problems. Research has consistently shown that spending time in parks, forests, gardens, and other natural environments can lower stress levels, reduce blood pressure, improve mood, and enhance overall psychological well-being. Exposure to nature encourages physical activity, strengthens social connections, and provides a sense of calm that is often difficult to find in densely populated urban areas. Even short walks through tree-lined streets or visits to neighborhood parks can have measurable benefits for mental health.

Unfortunately, growing urban expansion and environmental degradation are placing increasing pressure on forests and green areas. Deforestation, land conversion, pollution, and the loss of biodiversity threaten not only ecological sustainability but also human well-being. Protecting and expanding green spaces should therefore be viewed as an investment in public health rather than merely an environmental objective. By preserving forests, promoting urban parks, and integrating green infrastructure into development planning, societies can create healthier, more resilient communities while improving both physical and mental health outcomes for future generations.

Sustainable Development and the Responsibility to Future Generations

The concept of sustainable development emerged as a global response to growing concerns about environmental degradation and resource depletion. In 1983, the United Nations established the World Commission on Environment and Development, which later introduced a definition that remains influential today: sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. This principle emphasizes that economic growth, environmental protection, and social well-being must advance together rather than at the expense of one another.

In practical terms, sustainable development requires societies to use natural resources responsibly while maintaining economic progress. Forests provide a clear example of this challenge. In Türkiye, forests cover approximately one-quarter of the national land area, yet only a portion of these forests consists of healthy, productive woodland capable of delivering their full ecological and economic benefits. Similar concerns exist in many countries where urban expansion, industrial development, and population growth continue to place pressure on natural ecosystems.

Forests and green spaces should therefore be recognized as essential public assets. They produce oxygen, improve air quality, protect watersheds, conserve biodiversity, moderate temperatures, and provide recreational opportunities that support physical and mental health. Sustainable agricultural and forestry policies are therefore inseparable from broader development planning. Future cities must be designed not only with roads, housing, and infrastructure in mind but also with green corridors and natural spaces that connect people to nature and enhance long-term quality of life.

Conclusion

Agriculture is far more than a source of food; it is a cornerstone of public health, environmental sustainability, and human well-being. From providing nutritious foods that support physical growth and disease prevention to maintaining forests and green spaces that improve mental health, agriculture influences nearly every aspect of our lives. As populations grow and environmental pressures intensify, the connection between healthy ecosystems, sustainable food systems, and public health becomes increasingly important. Ensuring access to diverse and nutritious diets, protecting natural resources, and preserving green spaces are not separate policy goals but interconnected investments in society's future. Sustainable agricultural and forestry practices can help create healthier communities, stronger economies, and more resilient environments. Ultimately, improving public health requires looking beyond hospitals and healthcare systems to the farms, forests, and landscapes that sustain life. By recognizing agriculture as a vital partner in human development, societies can build a future that is healthier, more sustainable, and better prepared for the challenges ahead.

Please note that the views expressed in this article are of the author and do not necessarily reflect the views or policies of any organization.

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Climate Change Threatens Pakistan's Livestock Sector

Climate change poses an immediate threat to Pakistan's livestock sector, impacting rural livelihoods, food security, and public health. Rising temperatures and extreme weather events necessitate protecting both animal and human health through One Health.

Muhammad Umair

6/24/2026

When discussions about climate change in Pakistan arise, attention is usually drawn to dramatic disasters such as catastrophic floods, prolonged droughts, intense heatwaves, and melting glaciers. These highly visible events dominate media coverage because their impacts are immediate and devastating. Yet beneath these headline-grabbing crises lies a quieter and often overlooked threat that is steadily weakening the foundations of rural livelihoods: the growing impact of climate change on livestock.

Unlike floods or storms that strike suddenly, climate-related pressures on livestock develop gradually. Rising temperatures, erratic rainfall patterns, shrinking water resources, deteriorating grazing lands, and the spread of new animal diseases are placing increasing stress on livestock production systems across the country. These changes may be less visible, but their long-term consequences are profound for food security, economic stability, and public health.

Livestock occupies a central position in Pakistan's economy and rural society. According to the Pakistan Economic Survey 2022–23, the livestock sector contributes 60.6 percent of agricultural value added and around 14 percent of the national Gross Domestic Product (GDP). It remains the single largest

component of the agricultural economy and plays a critical role in supporting rural development.

The importance of livestock extends far beyond economic statistics. More than eight million rural households depend directly on animals for their livelihoods. Cattle, buffaloes, sheep, goats, and poultry provide milk, meat, eggs, wool, hides, manure, and draft power. They also function as a form of household savings and insurance, allowing families to cope with emergencies, crop failures, and unexpected expenses.

For many rural households, livestock income helps pay school fees, purchase medicines, improve nutrition, and maintain basic living standards. Entire rural value chains including feed suppliers, veterinary services, dairy processors, meat traders, transporters, and leather industries depend on a healthy livestock sector. As climate change intensifies, protecting animal health and productivity is therefore not merely an agricultural concern; it is essential for safeguarding livelihoods, reducing poverty, and strengthening the resilience of Pakistan's rural economy.

Climate Change and the Growing Fragility of Rural Livelihoods

Pakistan faces one of the greatest climate injustices of the modern era. Despite contributing less than one percent of global greenhouse gas emissions, the country ranks among the most climate-vulnerable nations in the world. This vulnerability stems largely from its geographical and environmental characteristics. Home to nearly 13,000 glaciers, the largest concentration outside the polar regions, Pakistan is highly exposed to climate-induced glacier melt, water insecurity, extreme weather events, and ecological disruption. Rising temperatures, erratic rainfall patterns, prolonged droughts, and increasingly intense floods are creating unprecedented challenges for agriculture, livestock production, and rural livelihoods.

The devastating floods of 2022–2023 provide a stark illustration of these risks. Triggered by exceptionally heavy monsoon rains and accelerated glacial melt, the disaster submerged nearly one-third of the country and affected approximately 33 million people. More than eight million individuals were displaced, while hundreds of thousands of homes were destroyed or damaged. Critical infrastructure suffered extensive losses, including thousands of kilometres of roads and railway tracks, disrupting markets, supply chains, and economic activity across large parts of the country.

The livestock sector was among the hardest hit. Millions of rural households lost a vital source of income and food security as an estimated 800,000 to 1.16 million animals perished during the floods. In addition, more than 4.4 million acres of agricultural land were damaged, reducing the availability of fodder and feed resources. Surviving animals faced severe nutritional stress, contaminated water supplies, disease outbreaks, and declining productivity. Milk yields dropped, reproductive performance weakened, and animal mortality rates increased, placing enormous pressure on already vulnerable households.

The economic consequences were equally severe. Total damages and losses exceeded US$30 billion, while recovery and reconstruction requirements surpassed US$16 billion. Millions of people were pushed deeper into poverty as livelihoods, assets, and employment opportunities disappeared almost overnight. Scientific assessments indicate that climate change significantly increased the likelihood and intensity of the rainfall that contributed to the disaster. As global temperatures continue to rise, similar extreme events are expected to become more frequent, making climate resilience an urgent priority for Pakistan's livestock-dependent rural economy.

Climate Change, Livestock Diseases, and Public Health Risks

Beyond the immediate destruction caused by floods, droughts, and heatwaves, climate change is reshaping the disease landscape of Pakistan's livestock sector in ways that are often less visible but equally damaging. Rising temperatures, changing rainfall patterns, and increasing humidity are creating favorable conditions for the emergence, spread, and persistence of animal diseases. This represents a slow-moving crisis that threatens livestock productivity, rural incomes, food security, and public health.

Heat stress has become one of the most significant challenges facing livestock producers. Prolonged exposure to high temperatures reduces feed intake, weakens immunity, lowers fertility rates, and decreases milk and meat production. Animals under thermal stress are more vulnerable to infections and recover more slowly from illness. High-yielding exotic breeds are particularly susceptible because they are less adapted to Pakistan's harsh climatic conditions than indigenous breeds.

At the same time, warmer temperatures and altered precipitation patterns are expanding the habitats of disease-carrying vectors such as ticks, mosquitoes, flies, and other parasites. As a result, outbreaks of economically important diseases are becoming more frequent. Hemorrhagic septicemia, a highly fatal bacterial disease, continues to threaten cattle and buffalo populations, while foot-and-mouth disease remains a major constraint to livestock productivity and trade. Tick-borne diseases and parasitic infestations are also increasing, causing weight loss, reduced milk yields, reproductive problems, and higher mortality rates.

These health challenges create a chain reaction throughout rural economies. Disease outbreaks reduce livestock productivity, increase veterinary expenses, disrupt milk and meat supply chains, and force many households to sell animals prematurely to meet immediate financial needs. Such distress sales often erode the long-term asset base of rural families, pushing vulnerable households deeper into poverty.

The risks extend beyond agriculture. Climate-sensitive zoonotic diseases such as Crimean-Congo Hemorrhagic Fever (CCHF) and Avian Influenza pose growing threats to human health, particularly among farmers, veterinarians, butchers, and dairy workers who interact closely with animals. Since many emerging infectious diseases originate in animals, strengthening livestock health systems is also an investment in public health security. Protecting animal health, therefore, is not only essential for sustaining rural livelihoods but also for safeguarding communities against future health emergencies.

Building Resilience Through a One Health Approach

Confronting the growing climate-related challenges facing Pakistan's livestock sector requires a shift from fragmented responses toward a comprehensive and integrated strategy. The One Health approach, which recognizes the close links between human health, animal health, and environmental sustainability, offers a practical framework for strengthening resilience in rural communities. As climate change increases the frequency of heat stress, disease outbreaks, droughts, floods, and food insecurity, solutions must address these interconnected risks simultaneously rather than in isolation.

A key priority is expanding veterinary services in underserved rural areas where livestock owners often have limited access to professional animal healthcare. Improved veterinary

coverage can help detect diseases early, reduce mortality, and improve animal productivity. Strengthening diagnostic laboratories is equally important, enabling rapid identification of emerging diseases and facilitating timely responses before outbreaks spread widely.

Pakistan also needs climate-sensitive disease surveillance systems capable of monitoring environmental changes, tracking disease vectors, and providing early warnings of potential outbreaks. Such systems can significantly reduce the economic and health impacts of livestock diseases. Promoting climate-smart livestock practices including improved housing, heat-stress management, better nutrition, water conservation, and resilient breeding strategies can further enhance the adaptive capacity of farmers and their animals.

Investment in research and the development of locally adapted vaccines is another critical area. Indigenous solutions tailored to Pakistan's climatic conditions can improve disease control while reducing dependence on imported technologies. The economic case for these investments is strong. Every rupee spent on disease prevention, surveillance, and climate adaptation can save many more in avoided livestock losses, reduced treatment costs, improved productivity, and lower public health risks. Ultimately, strengthening livestock resilience is not only an agricultural necessity but also a strategic investment in rural livelihoods, food security, poverty reduction, and national economic stability in an increasingly uncertain climate future.

Conclusion

Climate change is no longer a distant environmental concern for Pakistan; it is an immediate threat to the livestock sector that underpins rural livelihoods, food security, and public health. As rising temperatures, extreme weather events, and emerging animal diseases become more frequent, millions of livestock-dependent households face growing economic and social vulnerability. The devastating floods of recent years and the increasing spread of climate-sensitive diseases highlight the urgent need for proactive action rather than reactive responses. Strengthening veterinary services, disease surveillance, climate-smart livestock management, and One Health interventions can help build resilience while protecting both animal and human health. Investing in livestock adaptation is not simply an agricultural priority, it is an investment in poverty reduction, rural development, food security, and national economic stability. Safeguarding Pakistan's livestock sector today will help ensure a more resilient, healthier, and more prosperous rural economy in the face of an increasingly uncertain climate future.

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