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From Crisis to Cure

Building Agricultural Systems that Heal Our Planet and Nourish Our Communities

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Cultivating Resilience in Sustainable Agriculture

The November 2025 editorial of the Agricultural Economist highlights the urgent need for sustainable transformation in global food systems. It addresses the interconnected challenges of climate change and sustainable agriculture.

EDITORIAL

Muhammad Khalid Bashir

11/1/2025

As harvests end across much of the world, November invites reflection—not only on what we have achieved, but on how we can build a more resilient agricultural future. This month, *The Agricultural Economist* launches a special call under the theme "From Crisis to Cure: Building Agricultural Systems that Heal Our Planet and Nourish Our Communities." We invite our global network of researchers, practitioners, and policymakers to contribute fresh insights and transformative ideas.

The urgency could not be clearer. The recent 2025 monsoon floods in Pakistan, which devastated 2.23 million acres of cropland and uprooted thousands of farming families, underscore the fragility of our systems (World Bank, 2025). Yet, within this tragedy lies opportunity—proof that agriculture must not only survive crises but lead the way in solving them. Agriculture is both the frontline victim and the most powerful instrument to combat the intertwined crises of climate change, food insecurity, and economic instability.

Throughout November, several international observances offer guideposts for shaping this transformation:

- World Science Day (Nov 10): Innovation is the foundation of resilience. We welcome research on scaling proven solutions such as drought-resistant wheat from UAF or AI-driven pest management systems and strategies to make these accessible for smallholders.
- World Diabetes Day (Nov 14): Nutrition begins in the field. As malnutrition and diabetes rise in tandem, we invite analyses on value chains for biofortified and nutrient-dense crops like those pioneered by PARC that can simultaneously boost farm incomes and public health.
- World Toilet Day (Nov 19): Healthy farms require healthy communities. Programs such as Suthra Punjab demonstrate that WASH (Water, Sanitation, and Hygiene) investments directly enhance rural productivity. We seek field-based studies linking sanitation to agricultural resilience.
- World Children's Day (Nov 20): The next generation holds the key to sustainable growth. We encourage stories on youth-focused agri-tech and entrepreneurship initiatives like the Honahaar Scholarship Program that make agriculture a viable and aspirational career.
- International Day for the Elimination of Violence Against Women (Nov 25): True resilience requires equity. Women are central to agricultural production but remain underrepresented in access to land, finance, and technology. We invite policy papers and case studies showcasing gender-transformative interventions, building on the work of the Aurat Foundation and others.

Encouragingly, frameworks such as Pakistan's National Initiative for Sustainable Agriculture (NISA) and the Agriculture Transformation Plan demonstrate progress. Successful examples like cold storage networks in Sindh and farmer cooperatives in Punjab show what works when policy and practice align. The next step is scale and replication.

We now call on you academics, field researchers, and policy innovators to move from analysis to action. Share your contributions on:

- Climate-Smart Technologies and On-Farm Adoption
- Nutrition-Sensitive Agriculture and Food Systems
- Financing Models for Smallholder Resilience
- Gender-Transformative Approaches in Rural Economies
- Policy Innovations for Water, Soil, and Biodiversity Management

Together, we can design agricultural systems that are **productive, equitable, and climate-resilient.** The time to act now, let us cultivate solutions that secure both our planet and our people.

Muhammad Khalid Bashir

Managing Editor, The Agricultural Economist

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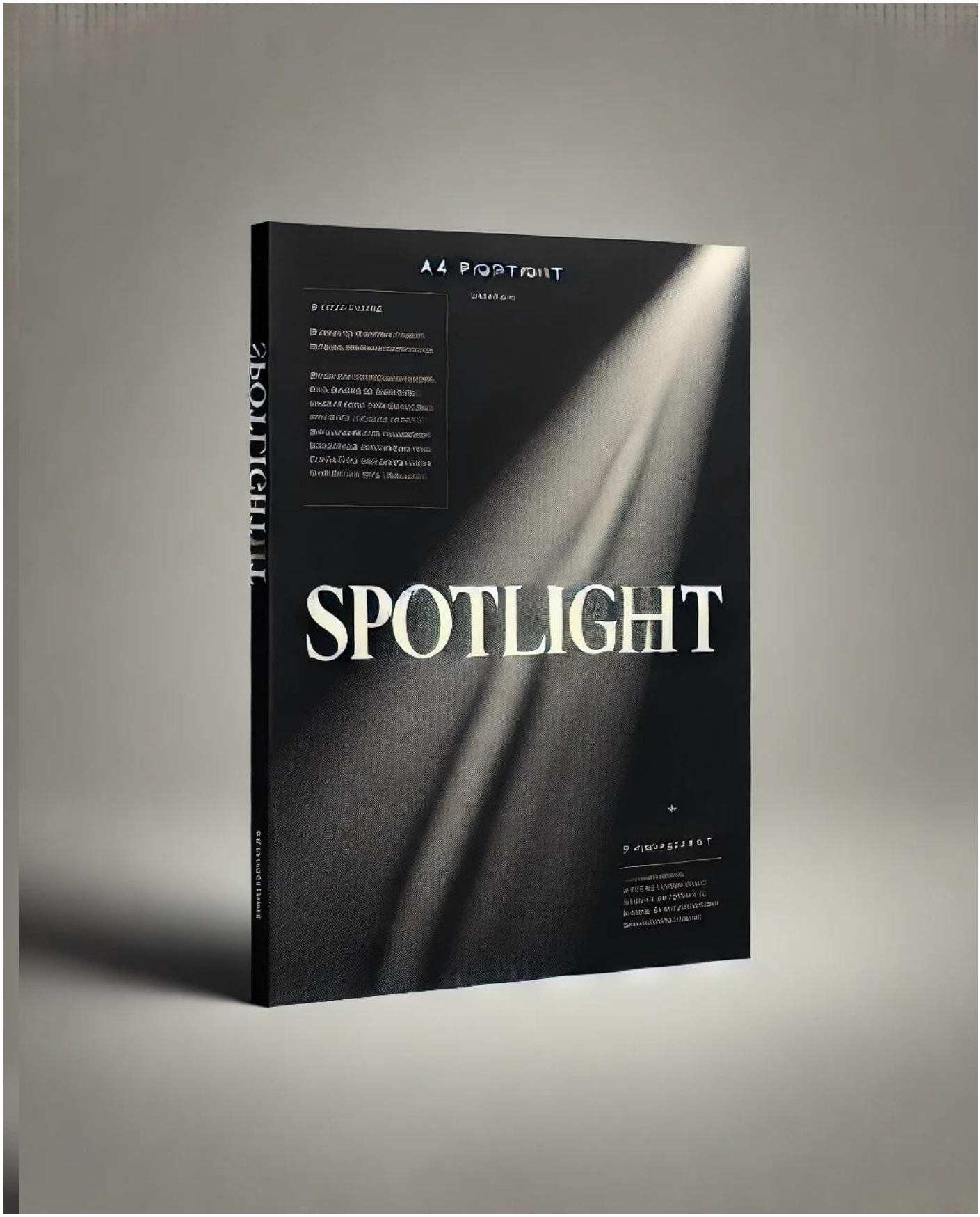

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Biodiversity-Focused Forest Management Strategies

Explore effective forest management strategies that enhance biodiversity and ecosystem services. Learn how holistic approaches can combat deforestation, habitat loss, and climate change while promoting resilience and sustainability in forest ecosystems.

Musfira Maqbool, Ahtisham ul Haq & Shahid Hafeez

11/24/2025

Forests preserved through robust biodiversity possess a remarkable ability to withstand ecological disturbances, recover from stress, and maintain long-term functionality. High levels of species richness ensure that multiple plant and animal communities perform overlapping ecological roles, making forest systems more resilient to shocks such as disease outbreaks, invasive species, wildfires, and extreme climatic events. This biological diversity supports the continuous delivery of essential ecosystem services, including carbon sequestration, soil stabilization, nutrient cycling, pollination, and natural water filtration. These services are not only vital for environmental health but also form the foundation of rural livelihoods, climate regulation, and global food security.

Despite their immense value, forest ecosystems are under severe and accelerating pressure from human activities. Agricultural expansion driven by rising food demand continues to be the primary cause of deforestation, especially in tropical regions. Logging, both legal and illegal, further degrades habitat quality, while infrastructure development fragments forests, isolates wildlife populations, and facilitates easier access for exploitation. Overlaying these pressures is the growing impact of climate change, which intensifies heatwaves, alters rainfall patterns, and increases the frequency of droughts and wildfires. Together, these stressors compromise forest resilience and diminish their biodiversity.

According to the Food and Agriculture Organization (FAO, 2020), approximately 420 million hectares of forest were lost between 1990 and 2020, illustrating the scale of the challenge. This unprecedented loss underscores the need for urgent action. Effective management for biodiversity conservation now requires a deeper integration of ecological science with socio-economic realities. Strategies must prioritize sustainable land-use planning, community-centered conservation policies, strengthened governance, and innovative financial mechanisms that incentivize protection rather than destruction. Overcoming implementation barriers such as weak enforcement, limited funding, and competing economic pressures is essential if forests are to continue functioning as resilient, life-supporting ecosystems for future generations.

Best Practices for Biodiversity-Friendly Forest Management

Biodiversity-friendly Forest management emphasizes maintaining the ecological integrity of forest ecosystems while sustaining their ability to provide essential services. One of its foundational principles is the preservation of structural complexity, which refers to the layered and multi-dimensional arrangement of forest components, including canopy stratification, varied tree ages, fallen logs, and standing deadwood. Structurally complex forests support numerous ecological niches, allowing a diverse range of plant and animal species to coexist. Modern silviculture increasingly adopts variable retention harvesting, a method that leaves behind legacy trees, snags, and coarse woody debris to replicate natural disturbance regimes. A global meta-analysis by Chaudhary et al. (2016) demonstrated that such retention forestry practices significantly outperform clear-cutting in conserving biodiversity, as they preserve more of the habitat conditions found in natural forests.

Equally important is the maintenance and enhancement of habitat heterogeneity. Forest ecosystems that incorporate a mix of habitat types such as riparian buffers, canopy gaps, wetlands, and dense understory patches tend to harbor greater species richness. This variety of microhabitats is especially critical for moisture-sensitive species and for supporting ecological functions such as pollination, seed dispersal, and nutrient cycling. The work of Mori et al. (2017) highlights the importance of beta-diversity, or diversity between habitat types, in enhancing overall ecosystem resilience. Their findings emphasize that maintaining heterogeneous landscapes strengthens ecological stability, allowing forests to better absorb and recover from disturbances.

Promoting native species remains a core best practice, as native flora forms the backbone of resilient forest ecosystems. Native species are evolutionarily adapted to local soils, climate, and biological interactions, making them essential for sustaining ecosystem functions. Assisted natural regeneration (ANR), which reduces barriers to natural forest recovery by controlling weeds, protecting seedlings, or reducing grazing pressure, is recognized as a highly effective and cost-efficient restoration strategy. In contrast, reliance on monocultures, particularly of exotic, fast-growing species, often leads to a decline in soil quality, increased vulnerability to pests, and reduced habitat value. This is why initiatives such as the Bonn Challenge prioritize restoration efforts that favor native species and biodiverse landscapes (IUCN, 2021).

Another key component involves expanding protected areas and establishing ecological corridors that connect fragmented habitats. Protected areas are crucial for safeguarding key biodiversity hotspots, but they must be complemented by ecological linkages that allow species to migrate, disperse, and

adapt to shifting climatic conditions. As climate change accelerates, static protected areas are no longer sufficient on their own. The global "Thirty by 30" conservation target underscores the need for effectively managed and well-connected protected area networks to mitigate biodiversity loss (Convention on Biological Diversity, 2022).

Finally, biodiversity-friendly forest management must incorporate climate-smart strategies. Climate-smart forestry includes selecting drought- or pest-resistant tree genotypes, regulating forest density to reduce water competition, and promoting diverse age structures to buffer ecosystems against climate extremes. As highlighted by Yousefpour et al. (2017), these measures build adaptive capacity, enabling forests to withstand and recover from climate-induced stresses while maintaining ecological functions.

Contemporary Challenges to Biodiversity-Oriented Forest Management

Biodiversity-oriented Forest management faces an increasingly complex set of contemporary challenges, many of which interact and compound one another in ways that strain even the most resilient ecosystems. Climate change stands at the forefront of these pressures, acting as a powerful threat multiplier. Rising temperatures, shifts in rainfall patterns, and more frequent extreme weather events are accelerating tree mortality and forcing species to shift their geographical ranges. These climatic disruptions weaken forest health and heighten vulnerability to pests, pathogens, and catastrophic wildfires. The unprecedented scale of recent events illustrates this trend; for example, Canada's 2023 wildfire season burned a record 18.5 million hectares, releasing enormous amounts of stored carbon and causing severe biodiversity loss (Witze, 2023). Such large-scale disturbances complicate long-term planning and challenge traditional conservation models.

Simultaneously, habitat fragmentation continues to erode ecological integrity. The division of once-continuous forests into small, isolated patches limits species movement, reduces genetic exchange, and increases edge effects. Even well-managed fragments cannot sustain biodiversity in the absence of ecological connectivity. Research by Haddad et al. (2015) shows that fragmentation can reduce biodiversity by 13 to 75%, undermining essential ecosystem functions such as pollination, seed dispersal, and nutrient cycling.

Economic pressures add another layer of complexity. Global markets drive demands for timber, agricultural expansion, and land development, creating incentives for practices that conflict with conservation goals. In many developing countries, forest governance is constrained by insufficient funding, weak institutional capacity, and inadequate enforcement mechanisms, further impeding progress toward biodiversity-friendly management (Agrawal et al., 2014). Invasive species, accelerated by global trade and movement, intensify these challenges by outcompeting native species, altering ecological processes, and demanding expensive, long-term control measures. Together, these intertwined threats underscore the urgent need for adaptive, well-resourced, and scientifically informed forest management strategies.

Conclusion

Managing forests for biodiversity in the Anthropocene demands a holistic, science-driven, and socially grounded approach capable of addressing unprecedented ecological pressures. The evidence is clear: biodiversity-rich forests are inherently more resilient, more productive, and more capable of delivering essential ecosystem services that sustain both environmental and human well-being. Yet accelerating deforestation, habitat fragmentation, climate change, and invasive species continue to threaten these systems at scales never witnessed before. This reality underscores the urgency of adopting best management practices such as maintaining structural complexity, enhancing habitat heterogeneity, promoting native species, and establishing ecological corridors that strengthen ecosystem functionality and adaptive capacity.

However, implementing these practices requires overcoming substantial socioeconomic and institutional barriers. Effective governance, adequate funding, community engagement, and long-term monitoring must form the backbone of future conservation efforts. Climate-smart forestry, coupled with evidence-based restoration initiatives, offers a pathway toward resilient landscapes capable of withstanding the rapid environmental changes of the coming decades. Ultimately, safeguarding forest biodiversity is not only an ecological imperative but also a socio-economic necessity. By integrating ecological science with sustainability-oriented policy and inclusive management frameworks, societies can ensure that forests continue to function as stable, life-supporting ecosystems for generations to come.

References: Agrawal et al; Chaudhary et al; Convention on Biological Diversity; FAO; Haddad et al; IPBES; IUCN; Mori et al; Witze; Yousefpour et al.

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 Shift to Value-Added Agricultural Exports

Pakistan is at a pivotal point to enhance its agricultural exports. By addressing export structure inefficiencies and focusing on value-added agriculture, the country can leverage its rich resources and strategic location to become a competitive player in global markets.

Laraib Samoon

11/6/2025

Agriculture remains a cornerstone of Pakistan's economy, contributing about 22.7% to the national GDP and providing livelihoods for 37.4% of the labor force (Pakistan Economic Survey, 2023–24). Despite its pivotal role, Pakistan's agricultural export performance has not kept pace with its potential or regional competitors. While countries such as India, Vietnam, and Thailand have diversified into high-value and processed agricultural products ranging from packaged foods to value-added horticultural exports. Pakistan's export profile continues to rely heavily on raw and semi-processed goods like rice, cotton, and fruits. This overreliance on low-value exports exposes the country to price fluctuations in global markets and limits income growth for farmers and exporters alike.

Several deep-rooted structural barriers underpin this underperformance. Low crop productivity, outdated farming practices, and limited access to quality inputs constrain efficiency at the production stage. Post-harvest losses, estimated at over 25% for fruits and vegetables, weaken profitability and supply chain reliability. Furthermore, non-compliance with international sanitary and phytosanitary (SPS) standards and a lack of effective certification systems often restrict market access to high-income countries. Weak logistics, insufficient cold storage, and inadequate export financing compound these problems, discouraging small and medium agribusinesses from entering global markets.

However, Pakistan's potential for agricultural export growth remains immense. The country's strategic geographic location linking South Asia, Central Asia, and the Middle East combined with its diverse agro-climatic zones offers opportunities for year-round production and market diversification. By addressing value-chain inefficiencies through technological modernization, enhanced extension services, and targeted policy reforms such as export facilitation, digital traceability, and incentives for agro-processing, Pakistan can shift toward a high-value, globally competitive agricultural economy. Strategic coordination between the public and private sectors can enable this transformation, helping the country reclaim a stronger foothold in the international agri-market and secure sustainable rural prosperity.

Current Status and Global Standing of Agricultural Exports

Pakistan's agricultural export profile remains narrow and heavily dependent on a few staple commodities. Rice continues to dominate, accounting for nearly $2.5 billion, or around 41.6% of total agricultural exports during FY 2022–23 (TDAP, 2023). Other key exports include fruits, especially mangoes and citrus followed by cotton-based textile products that indirectly rely on domestic agricultural inputs. While export volumes to traditional markets such as the Gulf Cooperation Council (GCC) countries, China, and the United Kingdom have shown modest growth, Pakistan's export basket still lacks diversification and sophistication.

A major weakness in this export structure lies in the low share of high-value and processed products, which remain below 15% of total agricultural exports. This stands in sharp contrast to regional competitors such as India (around 25%) and Thailand (approximately 30%) (World Bank, 2023). These countries have successfully invested in food processing, value addition, and compliance with international standards, areas where Pakistan continues to lag. As a result, even when Pakistan performs well in terms of volume, it captures only a fraction of the potential export value.

Globally, Pakistan ranks as the fourth-largest exporter of rice, yet it earns considerably less in the premium Basmati segment compared with India, largely due to weaker branding, packaging, and quality control systems. In horticulture, Pakistan is the sixth-largest producer of mangoes (FAO, 2022), but its share in the global mango trade remains under 5% because of high post-harvest losses, inadequate cold storage, and inefficient logistics. This dependence on bulk, low-margin commodities expose Pakistan's agricultural economy to significant risks, including global price fluctuations, demand shocks, and climate-related disruptions. To enhance resilience and profitability, Pakistan must transition from a volume-based export strategy toward a value-driven, diversified agricultural export model.

Structural Constraints and Missed Opportunities in Pakistan's Agricultural Export Growth

Pakistan's agriculture sector, despite its vast potential and diversity, continues to be held back by deep-rooted structural challenges that limit its competitiveness in global markets. At the core of these challenges lie productivity gaps, weak infrastructure, and regulatory shortcomings that prevent the sector from realizing its true export capacity.

A major issue is low productivity and technological stagnation. The yield levels of Pakistan's major crops remain well below global averages. Wheat yield stands at around 3 tons per hectare, compared to 5.5 tons in China, while maize yield is only 6.5 tons per hectare versus 10.5 tons in Egypt (FAOSTAT, 2022). These

productivity gaps stem from outdated farming methods, inadequate mechanization, and limited use of high-yield, climate-resilient seed varieties. Furthermore, water-use inefficiency remains a chronic concern. The dominance of flood irrigation wastes up to 40% of available water resources (World Bank, 2023), posing long-term threats to both crop productivity and sustainability.

Another major constraint is the absence of modern post-harvest infrastructure. Pakistan lacks an integrated system of cold storage, warehousing, and processing facilities, leading to massive post-harvest losses estimated between 15% and 40% for fruits and vegetables (UNCTAD, 2023). For a high-value product such as mangoes, this translates into a loss of nearly USD 150 million (PKR ~42 billion) annually in potential export earnings (Pakistan Horticulture Development & Export Company, 2023). These inefficiencies drastically reduce exportable surplus, compromise quality, and undermine the country's credibility in international markets.

Compliance with Sanitary and Phytosanitary (SPS) standards further hampers access to premium destinations like the European Union and Japan. Limited certification facilities, weak traceability systems, and inadequate inspection mechanisms make it difficult for exporters to meet strict international requirements related to pesticide residues, hygiene, and product grading.

Despite these weaknesses, Pakistan's agro-climatic diversity provides a strong foundation for export expansion. The country can grow a broad spectrum of crops from tropical mangoes in Sindh and Punjab to temperate fruits in Balochistan, yet this natural advantage remains underutilized. While competitors such as Thailand and Malaysia have developed thriving agro-processing and halal food industries, Pakistan continues to focus on exporting raw materials. The global halal food market, projected at USD 2.8 trillion by 2025, and the organic food market worth over USD 188 billion (FiBL, 2024), both represent untapped opportunities for Pakistan's exporters.

Policy frameworks such as the Strategic Trade Policy Framework (STPF) 2020–25 and various TDAP programs exist to promote agricultural exports, but their implementation has been weak. Exporters continue to face bureaucratic delays, limited credit access for SMEs, and a lack of timely market intelligence. Even preferential trade agreements, such as the China-Pakistan Free Trade Agreement (CPFTA), are underutilized, with usage rates below 30% (International Trade Centre, 2023). This underutilization largely stems from exporters' limited awareness of tariff lines, technical standards, and the complex Rules of Origin requirements.

A Strategic Path Forward for Revitalizing Pakistan's Agri-Exports

To elevate Pakistan from a regional commodity supplier to a globally competitive agri-exporter, a comprehensive and forward-looking strategy is essential. The transformation requires coordinated action across value chains, infrastructure, policy, and international engagement, ensuring that agriculture becomes not only more productive but also more profitable and sustainable.

The foremost priority is to shift toward value addition. Pakistan must move beyond exporting raw commodities by promoting agro-processing and packaging industries. Incentivizing private investment through public-private partnerships (PPPs), tax rebates, and export-oriented financing can accelerate this transition. High-potential areas such as horticulture, dairy, livestock (especially halal meat), and organic produce offer immense promise for expanding Pakistan's footprint in high-value global markets. Developing small-scale processing units near production hubs can also create rural employment while reducing post-harvest losses.

Equally important is modernizing supply chains. The government should invest in integrated cold chain logistics, warehousing, and modern packaging facilities, while enabling private sector participation through concessional financing and infrastructure support. Establishing accredited quality testing laboratories and digital traceability platforms will help meet international standards, ensure transparency, and strengthen buyer confidence are the key prerequisites for accessing premium export markets such as the EU and Japan.

Bridging the compliance gap remains crucial. Nationwide farmer training programs focused on GlobalG.A.P., HACCP, and other international certifications can enhance product credibility. Digitalizing phytosanitary certification and inspection systems will reduce procedural delays, eliminate human error, and improve efficiency in cross-border trade.

Finally, Pakistan must leverage trade diplomacy more effectively. Embassies and trade missions should play an active role in identifying niche opportunities, facilitating business-to-business linkages, and sharing real-time market intelligence through data analytics. By strategically targeting emerging markets in Africa, East Asia, and the Middle East, Pakistan can diversify its export destinations and reduce dependence on a limited set of buyers.

Conclusion

Pakistan stands at a crucial crossroads in its journey toward becoming a globally competitive agricultural exporter. While the country possesses vast natural resources, a rich agro-climatic diversity, and a strategic geographic location linking major regional markets, its export structure remains constrained by systemic inefficiencies and outdated practices. Overdependence on low-value commodities such as rice, cotton, and unprocessed fruits has limited Pakistan's ability to capture higher returns and withstand international market volatility. To break this cycle, Pakistan must pursue a decisive shift toward value-added, technology-driven, and sustainability-oriented agricultural exports.

Investments in cold chain logistics, agro-processing, and digital traceability systems can substantially enhance product quality and compliance with global standards. Similarly, empowering farmers through

training and certification programs will help bridge the compliance gap and expand access to premium markets. The public and private sectors must work collaboratively to promote innovation, facilitate export financing, and streamline regulatory processes. Trade diplomacy should also be used strategically to identify niche opportunities in emerging markets while strengthening Pakistan's presence in traditional destinations.

References: FAO; FiBL & IFOAM; Government of Pakistan; ITC; PHDEC; State of the Global Islamic Economy Report; TDAP; UNCTAD; World Bank.

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 Vegetable Sector: Unlocking Export Potential

Pakistan's vegetable sector is at a crucial turning point, rich in potential yet facing systemic inefficiencies. With diverse agro-climatic conditions and strategic market access, the country can become a leading exporter of fresh and processed vegetables.

Mashooq Ali Khuwaja

11/10/2025

Agriculture continues to serve as the backbone of Pakistan's economy, contributing around 22.7% to the national GDP and employing 37.4% of the total labor force (Pakistan Economic Survey, 2023–24). Within this broad sector, vegetable cultivation has emerged as a crucial sub-sector for income generation, employment creation, and food security, especially in rural areas. Key vegetables such as onions, potatoes, tomatoes, chilies, and okra are widely grown in the fertile plains of Punjab and Sindh, which together account for most of the national output. The increasing urbanization, population growth, and rising awareness about healthy diets have significantly boosted domestic demand.

At the same time, export opportunities are expanding due to the growing demand for fresh and processed vegetables in regional and global markets. However, Pakistan's performance remains below potential compared to competitors like India, China, and Thailand, mainly because of outdated farming practices, low yields, lack of modern cold-chain infrastructure, and difficulties in complying with international Sanitary and Phytosanitary (SPS) standards. Vegetable farming offers multiple comparative advantages. It provides higher economic returns per acre and allows for several cropping cycles in a year, making it a profitable choice for smallholder farmers. Moreover, the sector has a strong gender dimension women play a central role in harvesting, sorting, grading, and packaging, thereby contributing to household income and food security. Nutritionally, vegetables are essential for improving dietary diversity and combating the widespread micronutrient deficiencies often called "hidden hunger" that affect large segments of the population (FAO, 2023). On a national scale, improving vegetable production and export competitiveness would diversify Pakistan's agricultural export base, moving away from low-value bulk commodities such as raw cotton and rice. Such diversification can enhance foreign exchange earnings, improve rural livelihoods, and contribute to a more resilient and sustainable agricultural economy.

Current Production and Yield Analysis

Pakistan produces approximately 6.8 million tonnes of vegetables annually, reflecting the sector's importance to both rural livelihoods and national food security (Pakistan Bureau of Statistics, 2024). Among major vegetables, potatoes account for about 5.9 million tonnes, primarily cultivated in Punjab and Khyber Pakhtunkhwa, while onion production stands at 2.5 million tonnes, with Sindh, Balochistan, and Punjab serving as key producing regions. Tomato production, though smaller in volume at around 0.7 million tonnes, remains vital for both domestic consumption and processing industries in Sindh, Punjab, and Khyber Pakhtunkhwa. These crops together form the backbone of Pakistan's vegetable economy, supporting thousands of smallholder farmers, traders, and supply chain workers across the country.

However, despite this considerable output, Pakistan's vegetable yields remain significantly below global averages by nearly 30% to 50% in some cases. The average yield of potatoes, for example, is around 20.1 tonnes per hectare, compared to the global average of 48.6 tonnes per hectare (FAOSTAT, 2023). Similar productivity gaps are observed in onion and tomato crops, largely due to low adoption of improved seed varieties, inadequate fertilizer application, and outdated farming techniques. Inefficient irrigation practices and limited mechanization further reduce yield potential. Additionally, pest infestations, plant diseases, and the absence of effective extension services contribute to post-harvest losses, estimated at 25–40% in some regions.

The growing unpredictability of climate conditions including erratic rainfall, floods, and heatwaves has intensified these challenges, making yields even more vulnerable. Addressing these constraints requires a strategic shift toward climate-smart agriculture, the use of certified high-yielding seed varieties, and better training for farmers in integrated pest and water management. With targeted interventions, Pakistan can narrow its yield gap, enhance productivity, and strengthen its position in both domestic and international vegetable markets.

Export Performance and Market Dynamics

Pakistan's vegetable exports have shown remarkable progress in recent years, reflecting growing demand for its fresh produce in international markets. According to the Trade Development Authority of Pakistan (TDAP, 2024), export earnings surged from USD 300 million in FY 2023 to USD 430 million in FY 2024, marking a notable 43% increase within a year. Major destinations for Pakistani vegetables include the United Arab Emirates, Saudi Arabia, Malaysia, Qatar, and the United Kingdom markets that value Pakistan's proximity, competitive pricing, and seasonal advantage. Among the top export commodities are onions, potatoes, and chilies, which together account for more than two-thirds of total vegetable exports. This growth underscores the potential of

the sector to contribute significantly to foreign exchange earnings and rural income generation.

However, the growth trajectory remains unstable due to multiple structural and policy-related challenges. Frequent export bans during periods of domestic supply shortages create uncertainty among international buyers and damage Pakistan's reliability as a supplier. Additionally, 25–40% of total vegetable production is lost post-harvest due to poor handling, inadequate cold chain facilities, and inefficient transportation systems (World Bank, 2023). These losses sharply limit the volume of exportable produce and reduce farmer profits.

In a regional context, Pakistan's performance remains modest compared to neighboring countries. India's vegetable exports, valued at USD 1.87 billion, and Iran's at USD 1.02 billion (International Trade Centre, 2024), far surpass Pakistan's figures. These competitors benefit from advanced processing facilities, quality certification systems, and strong branding strategies. Nonetheless, Pakistan's diverse agro-climatic zones offer a distinct advantage in producing off-season vegetables for Gulf and European markets. To fully realize this potential, investments are urgently needed in cold storage, packaging, value addition, and internationally recognized quality certification systems that can strengthen Pakistan's position in the global vegetable trade.

Key Constraints and Challenges in Pakistan's Vegetable Export Sector

Despite the strong potential of Pakistan's vegetable sector, its growth and global competitiveness are constrained by a series of structural, institutional, and policy-related barriers. One of the most pressing issues is high post-harvest losses, with estimates suggesting that up to 40% of total production is wasted each year (World Bank, 2023). These losses occur primarily due to poor harvesting practices, lack of cold storage facilities, and the absence of modern packaging and transportation systems. Such inefficiencies not only reduce the exportable surplus but also erode the profitability of smallholder farmers, who already operate on thin margins.

Another major obstacle is non-compliance with international Sanitary and Phytosanitary (SPS) standards. Only a small percentage of farms in Pakistan are certified for Good Agricultural Practices (GAP), and the country's testing laboratories lack the technical capacity and international accreditation required for high-value markets like the EU or Japan. Consequently, shipments are frequently rejected or downgraded, undermining Pakistan's credibility in global trade.

Limited access to finance further constrains productivity and export readiness. Most small-scale farmers are unable to secure affordable credit for quality seeds, irrigation systems, and compliance certifications. Similarly, fragmented market information systems mean that farmers and exporters lack real-time data on international demand, price trends, and evolving regulatory standards.

Finally, inconsistent trade policies, particularly the sudden imposition of export bans during domestic shortages, disrupt supply chains and damage long-term buyer relationships. Such unpredictability discourages investment and weakens Pakistan's standing in global markets.

Addressing these interconnected challenges through infrastructure upgrades, financial inclusion, farmer training, and stable trade policies is essential to unlock the full export potential of Pakistan's vegetable sector and position it as a reliable supplier in regional and international markets.

Policy Recommendations and Projected Economic Impact

Unlocking the true potential of Pakistan's vegetable sector requires a coordinated, evidence-based, and multi-dimensional policy framework that simultaneously addresses infrastructure deficits, quality assurance, finance, and market positioning. First, modernizing supply chain infrastructure should be prioritized through targeted incentives for public-private partnerships (PPPs). The establishment of cold storage facilities, pack houses, and refrigerated transportation near production zones in Punjab, Sindh, and Khyber Pakhtunkhwa would drastically reduce post-harvest losses, currently estimated at 30–40%.

Second, enforcing quality and certification regimes is vital to enhancing export competitiveness. Government support in subsidizing Good Agricultural Practices (GAP) and Global G.A.P. certifications for smallholder farmers would promote compliance with international standards. Equally important is the upgrading of federal and provincial Sanitary and Phytosanitary (SPS) laboratories to internationally accredited levels, ensuring product safety and minimizing export rejections.

To strengthen farmers' financial capacity, tailored credit products must be developed through partnerships between commercial and microfinance banks, supported by credit guarantee schemes. These would enable investments in modern irrigation, improved seeds, and compliance certifications. Simultaneously, enhancing research and development (R&D) within provincial agricultural institutes should focus on developing high-yield, climate-resilient, and disease-resistant vegetable varieties to ensure sustainable productivity growth.

A national branding initiative, such as "Pure Pakistani Produce," can further elevate Pakistan's image in global markets by emphasizing quality, safety, and traceability. Finally, policy stability is critical moving away from ad hoc export bans toward predictable, data-driven trade policies would restore international buyer confidence and encourage long-term partnerships.

If effectively implemented, these strategies could yield transformative results by 2030: vegetable exports reaching USD 1 billion annually, the creation of 250,000 new jobs across the supply chain, post-harvest losses reduced below 15%, and Pakistan emerging as a dependable supplier of premium-quality horticultural products in global markets.

Conclusion

Pakistan's vegetable sector stands at a crucial turning point rich in potential but constrained by systemic inefficiencies that limit its global competitiveness. With its diverse agro-climatic conditions, year-round production capacity, and strategic proximity to high-value Gulf and Asian markets, the country has all the prerequisites to become a leading exporter of fresh and processed vegetables. However, persistent challenges such as low productivity, post-harvest losses, inadequate cold-chain infrastructure, and weak compliance with international standards continue to undermine this potential. The sector's underperformance is not due to lack of capacity, but rather the absence of coherent policy direction, investment in technology, and institutional coordination.

The pathway forward lies in adopting a comprehensive, innovative-driven reform agenda that modernizes the supply chain, strengthens SPS and GAP compliance, facilitates access to finance, and fosters climate-smart agricultural practices. Public-private partnerships can play a transformative role in bridging infrastructure gaps and ensuring quality consistency. Simultaneously, stable trade policies and national branding initiatives such as *"Pure Pakistani Produce"* can enhance Pakistan's credibility in global markets. With sustained commitment and coordinated policy implementation, Pakistan's vegetable sector could achieve exports exceeding USD 1 billion by 2030, generate hundreds of thousands of jobs, and contribute meaningfully to rural prosperity and national economic resilience.

References: FAO; ITC; PBS; Ministry of Finance, Government of Pakistan; TDAP; World Bank; PHDEC; MNFSR.

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 Climate Change on Pakistan's Agriculture

Climate change is reshaping agricultural systems in Pakistan, with evidence from Sindh highlighting changes in weather patterns, shifting crop cycles, and declining farm incomes. Key crops like wheat and cotton are experiencing significant stress.

Nazar Gul & Hafiz Abdul Salam

11/11/2025

Scientists around the world agree that climate change caused by human activity is happening faster than ever. The Intergovernmental Panel on Climate Change (IPCC) reported in 2021 that the Earth's surface temperature during 2011–2020 was about 1.09°C warmer than it was between 1850 and 1900. This warming is mainly due to the burning of fossil fuels, deforestation, and industrial pollution. Although Pakistan contributes less than 1% of global greenhouse gas emissions, it is among the countries most affected by climate change. The World Bank (2022) warns that by the 2050s, the average annual temperature in Pakistan could rise by 1.5–2.5°C under a low-emission scenario, or 2.5–3.5°C if emissions continue to increase. Such warming will worsen water shortages, harm food production, and make life more difficult for rural communities, especially in Sindh province.

Data collected from Tando Jam, Hyderabad, between 1987 and 2020, clearly show that the local climate is changing. The average temperature has risen by about 0.45°C. Even a small rise like this can make crops grow and mature too quickly, leading to lower yields. Some studies predict that crop cycles could shorten by up to 50 days by the end of the century if the warming continues.

Rainfall in the area has also changed. It has increased by nearly 60%, from about 129 mm to 204 mm per year, but now it comes in heavy bursts rather than steady showers. These sudden rains often flood fields, causing waterlogging and salinity problems that already affect over 40% of Sindh's irrigated farmland. This reduces soil quality and crop health.

At the same time, wind speed has fallen while humidity has changed, reducing evaporation and altering irrigation needs. Farmers are finding it harder to plan water use because traditional patterns no longer apply. These shifts show that climate change is already affecting Sindh's agriculture, and there is an urgent need for actions such as using heat-tolerant crops, better irrigation systems, and improved soil and water management to help farmers adapt to the new climate reality.

Impacts on Agricultural Systems and Crop Productivity

Climate change has begun to reshape Pakistan's agricultural landscape, with Sindh emerging as a critical hotspot for climate-related impacts on crop productivity. Field-based evidence from Tando Jam and simulation models across Pakistan both reveal that rising temperatures, erratic rainfall, and shifting seasonal patterns are directly influencing crop water use, growth cycles, and yield stability.

For wheat, one of Sindh's major winter crops, rising temperatures and prolonged sunshine hours have led to increased evapotranspiration (ET), meaning that more water is now needed to sustain plant growth. This intensifies pressure on already scarce irrigation resources in the Indus Basin. Despite these challenges, adaptive measures have shown promising outcomes. The introduction of heat-tolerant and early-maturing wheat varieties such as *NIA-Sarang* has increased yields by 46–53% compared to the levels achieved in the 1980s (Gul et al., 2023). This demonstrates that the adoption of climate-smart agricultural technologies and resilient crop genetics can partially offset the negative impacts of climate stress.

Cotton, however, paints a more concerning picture. Its growing season has shortened by approximately 21 days due to higher temperatures accelerating plant development. Although ET rates have declined, this apparent advantage is misleading. Intensified monsoon rains during the crucial lint formation period (June–September) have frequently resulted in waterlogging, boll rot, and pest outbreaks, causing yield losses of up to 66% in extreme years such as 2020.

These localized findings align with national modeling results. Studies using the Agricultural Production Systems Simulator (APSIM) model estimate that from 1961–2015, climate variability caused an 18.2% decline in cotton yields in Punjab, primarily because of shorter growth periods (Arshad et al., 2021). Similarly, research by Raza and Ahmad (2015) found that rising temperatures have had an even stronger negative effect in Sindh compared to Punjab. Collectively, both empirical and simulated evidence confirm that climate change poses a growing threat to Pakistan's crop productivity, necessitating urgent adaptation through research, innovation, and regional coordination.

Socio-Economic Impacts on Household Incomes

The consequences of climate change are not confined to fields and farms they ripple through the broader rural economy, affecting household incomes, employment, and overall community well-being. In Pakistan, where nearly 60% of the population depends directly or indirectly on agriculture, even minor shifts in temperature or rainfall patterns can have major economic implications.

According to a national-level econometric study by Maqbool et al. (2023), a 1°C rise in average annual temperature results in a 3.3% income decline for agricultural households and a 0.4% reduction for non-

agricultural households. This shows that while farmers are hit hardest due to their direct dependence on weather-sensitive production, climate shocks also spill over into the non-farm rural economy, affecting transporters, input dealers, and local businesses that rely on agricultural activity. Furthermore, a 1°C increase in temperature variability, representing greater uncertainty in weather conditions, leads to an average income reduction of 4% across both agricultural and non-agricultural sectors.

Rainfall changes produce similarly mixed effects. Although higher average rainfall can enhance crop yields and temporarily boost farm income, irregular or unpredictable precipitation patterns tend to undermine this benefit. Erratic rainfall often leads to floods, delayed sowing, or water shortages at critical crop stages all of which reduce productivity and increase household vulnerability.

These findings highlight that climate change is not merely an environmental challenge but a profound socio-economic threat. It erodes the resilience of low-income households, deepens existing inequalities, and pushes more families below the poverty line. The cumulative effect undermines Pakistan's rural development goals, contributing to migration pressures, food insecurity, and growing demand for government support. Strengthening adaptive capacity through diversified livelihoods, climate insurance, and social protection programs is therefore essential to safeguard household incomes in the face of increasing climate variability.

Policy Recommendations for Building Climate-Resilient Agriculture in Pakistan

Climate change is no longer a distant concern it is an urgent and unfolding crisis reshaping Pakistan's agricultural landscape today. The increasing frequency of heatwaves, erratic rainfall, and water shortages has already begun to undermine productivity, farm incomes, and food security. To safeguard rural livelihoods and national food supply, policymakers must adopt a two-pronged approach centered on adaptation and resilience-building.

The modernization of irrigation systems and water management practices is the first crucial step. Provincial irrigation departments should update crop water requirement data using current climate records and promote the use of High-Efficiency Irrigation Systems (HEIS) such as drip and sprinkler technologies. These systems, supported by targeted subsidies, can help farmers adapt to shifting evapotranspiration patterns and mitigate the effects of water scarcity.

Equally important is the rapid expansion of climate-resilient crop varieties. Scaling up research, breeding, and distribution of heat-tolerant, drought-resistant, and short-duration cultivars such as the NIA-Sarang wheat and climate-smart cotton will enhance productivity under extreme conditions. Parallel investments in climate-proof infrastructure, particularly drainage and salinity management in Sindh, are vital to address the impacts of increasing rainfall intensity.

Strengthening of meteorological services is another high priority. A robust early warning system can deliver localized forecasts and agro-advisories, enabling farmers to make informed decisions about planting and irrigation. Government agencies should also officially revise planting calendars, such as advancing cotton sowing to early April to reduce exposure to monsoon-related yield losses.

Lastly, financial and social protection measures must be expanded. Climate-indexed insurance schemes and flexible social safety nets like the Benazir Income Support Program (BISP) can protect vulnerable farmers from income shocks. By integrating these policy actions into provincial and national frameworks, Pakistan can build a more resilient, climate-adaptive agricultural economy capable of withstanding future challenges.

Conclusion

Climate change is already reshaping Pakistan's agricultural systems, and its impacts are no longer theoretical they are visible in changing weather patterns, shifting crop cycles, and declining farm incomes. Evidence from Sindh, particularly Tando Jam, shows measurable increases in temperature, erratic rainfall, and altered evapotranspiration patterns that directly affect water use and crop productivity. Wheat and cotton, two of Pakistan's most important crops, are experiencing significant stress, with shorter growing periods, increased pest infestations, and rising irrigation demands. Although adaptive innovations such as the introduction of heat-tolerant wheat varieties have shown encouraging results, these efforts remain limited in scale and unevenly implemented across regions.

The socio-economic repercussions are equally serious. Even a modest rise in temperature can substantially reduce rural household incomes, worsen poverty, and heighten economic vulnerability. With agriculture forming the backbone of rural employment and national food security, climate change poses a systemic threat to Pakistan's development goals.

Moving forward, immediate policy action is imperative. Modernizing irrigation, investing in resilient crop research, improving weather forecasting, and expanding financial safety nets are not just adaptive measures, they are survival strategies. By embedding climate resilience into agricultural planning and governance, Pakistan can transform its vulnerability into strength and secure a more sustainable future for its farmers and food systems.

References: Arshad et al; Bouras et al; Eckstein et al; Gul et al; IPCC; Maqbool et al; PCRWR; Raza & Ahmad; World Bank.

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Climate-Resilient Global Food System at COP30

Explore the critical role of agriculture in addressing climate change and shaping a sustainable global food system. Discover the opportunities for adaptation and mitigation through innovative practices.

Muhammad Afaq Ashraf, Noor Muhammad & Ali Hussnain Arif

11/25/2025

The global food system stands at a critical turning point, functioning simultaneously as a powerful driver of climate change and one of its most vulnerable casualties. Food production, processing, transportation, and land-use together account for nearly 30% of total global greenhouse gas emissions (IPCC, 2022). These emissions arise from methane released by livestock, nitrous oxide from fertilizers, carbon losses through deforestation, and the growing energy demands of globalized supply chains. Yet the very system contributing to planetary warming is also suffering the most severe consequences of that warming.

Scientific projections indicate that for every 1°C increase in global temperature, yields of key crops such as maize, wheat, and rice could decline by 3–10%, a devastating trend for developing countries that rely heavily on climate-sensitive agriculture (World Bank, 2023). The escalating frequency of climate-induced shocks, prolonged droughts, erratic monsoons, flash floods, heatwaves, and invasive pest outbreaks, has pushed global agriculture into a state of chronic instability. In 2022 alone, weather-related disasters caused over $30 billion in agricultural losses across low- and middle-income countries, wiping out harvests, destroying livestock, and disrupting rural livelihoods (FAO, 2023). These shocks translate directly into volatile food prices, rising production costs, and disrupted logistics, all of which place immense pressure on already fragile supply chains. As a result, millions of people face deepening food insecurity, with the poorest households bearing the greatest burden as climate extremes shrink food availability and affordability.

Against this backdrop, the upcoming COP30 in Brazil stands as a historic opportunity for the world to redefine the role of food systems in climate action. Transforming agriculture from a major climate problem into a cornerstone of global climate solutions must be central to the negotiations. This includes integrating climate-smart practices, sustainable land management, resilient crop varieties, and policies that protect both small farmers and the planet's ecological foundations.

COP30's Blueprint: Building Sustainable and Resilient Food Systems

As the world approaches COP30, the direction for global agriculture is unmistakable: the sector must undergo a rapid and systemic transformation toward climate resilience and environmental sustainability. Agriculture can no longer be treated solely as a victim of climate change; it must instead become a central pillar of climate solutions. The COP30 framework is therefore expected to elevate climate-smart, regenerative, and technologically enabled food systems as foundational components of the global climate agenda.

Climate-smart agriculture (CSA) provides one of the most immediately scalable pathways. Practices such as drought-tolerant crop varieties, precision irrigation systems, conservation fertilizers, and integrated pest management have already demonstrated the capacity to boost yields by 15–25%, even under increasingly volatile climate conditions (World Bank, 2023). At the same time, these practices reduce emissions by cutting water waste, lowering synthetic input use, and improving soil efficiency, directly addressing agriculture's carbon footprint.

Regenerative agricultural models push this transformation further by rebuilding ecosystem health. Techniques like cover cropping, agroforestry, diversified crop rotations, and conservation tillage enhance soil organic matter and restore degraded landscapes. Current research shows that regeneratively managed soils could sequester more than 2 billion tons of carbon annually, offering a low-cost, nature-based mitigation opportunity capable of offsetting a meaningful share of global agricultural emissions (Nature, 2023). These practices also contribute to drought resilience, improved water infiltration, and enhanced biodiversity, making farms more robust in the face of extreme weather.

Technology will serve as the backbone of implementation. Digital advisory platforms, satellite-based early warning systems, AI-enabled crop monitoring, and climate-informed big data are rapidly expanding farmers' ability to make precise, adaptive decisions. COP30 must integrate these solutions into a unified global strategy, one that aligns sustainable production with resilient storage, distribution, and consumption systems. By doing so, the conference can set the stage for a food system that feeds the world while healing the planet.

Economics and Innovation: Financing Green Transition

Achieving a climate-resilient and sustainable global food system hinges on one central challenge: mobilizing the financial resources necessary to turn ambition into measurable action. Despite growing political commitments, current funding for agricultural climate action remains strikingly insufficient. Recent estimates show that transforming global agri-food systems in line with climate and sustainability goals will require approximately $1.3 trillion annually, yet existing financial flows amount to less than 20% of this requirement (Climate Policy Initiative, 2024). This vast funding gap represents one of the greatest barriers to achieving the goals expected at COP30.

Closing this deficit demands a bold rethinking of how agricultural finance is structured and deployed. A crucial starting point is the strategic repurpose of the $700 billion in annual agricultural subsidies, much of which currently incentivizes resource-intensive farming, excessive fertilizer use, and environmentally damaging practices. Redirecting even a fraction of this sum toward climate-smart agriculture, regenerative practices, and rural clean-energy technologies could dramatically accelerate decarbonization and resilience efforts (UNDP, 2023).

In addition, innovation in financial instruments will be essential. Blended finance models, combining public, private, and philanthropic capital, can reduce investment risks for climate initiatives in vulnerable regions. Green bonds and sustainability-linked loans offer powerful tools for channeling large-scale investments into regenerative agriculture, reforestation, water-efficient technologies, and resilient crop systems. Meanwhile, well-regulated carbon markets can unlock new revenue streams for farmers by adopting practices such as agroforestry, soil carbon sequestration, and methane reduction.

However, the success of COP30 will ultimately depend on whether global financial mechanisms align with local agricultural realities. Smallholder farmers, who produce one-third of the world's food, often lack collateral, credit access, and financial literacy. Directing capital toward them through microfinance schemes, digital payment systems, and targeted incentive programs will be critical for scaling technologies such as solar-powered irrigation, climate-smart seeds, and sustainable intensification practices. Only through inclusive, well-designed financial innovation can the world deliver a genuinely green and resilient food system.

Bringing Everyone into the Field: Bridging Gaps in Agriculture

A truly just agricultural transition requires that climate resilience and sustainability reach those who need them most. Around the world, smallholder farmers, who grow more than one-third of the global food supply, remain disproportionately exposed to climate shocks despite having the fewest resources to adapt (IFAD, 2023). Intensifying droughts, floods, heatwaves, and pest outbreaks continue to erode their already fragile livelihoods. At the same time, land degradation affects 3.2 billion people globally, undermining soil fertility, reducing agricultural productivity, and exacerbating rural poverty (UNCCD, 2022). These overlapping vulnerabilities make equity, access, and inclusion central pillars of the climate agenda.

For COP30 to deliver a meaningful global commitment, it must embed explicitly inclusive and gender-responsive agricultural policies at the heart of its outcomes. Women, who account for 43% of the world's agricultural labor force, remain among the least recognized contributors to food systems (FAO, 2023). Despite their critical role, ranging from seed selection and irrigation management to post-harvest processing and food security, they face systematic obstacles in securing land titles, agricultural credit, extension services, and modern technologies.

Empowering women is not simply a matter of fairness; it is a proven development strategy. Evidence shows that when women farmers gain access to land, credit, inputs, and training, farm productivity can increase by 20–30%, strengthening household nutrition, raising incomes, and accelerating community-level climate resilience (World Bank, 2023). Gender equality in agriculture is therefore indispensable for achieving global food security under climate stress.

Finally, bridging global adaptation gaps will demand robust international partnerships. Technology transfer, climate finance, and capacity-building from developed to developing nations are not acts of charity but strategic investments in global stability. Ensuring that all farmers, women, smallholders, and marginalized communities, are equipped to thrive in a changing climate is essential for building a resilient global food system.

The Road Ahead: Turning Pledges into Action

Building a climate-resilient global food system now depends on whether countries can convert declarations into real, measurable progress. The debates that will unfold at COP30 matter only if they translate into action that farmers, consumers, and ecosystems can feel on the ground. That requires aligning science, finance, and locally rooted innovation rather than treating them as separate tracks. Climate-smart agriculture isn't a slogan anymore; it's becoming a set of proven solutions waiting to be scaled.

We already know what works. In Brazil, agroforestry models have reshaped degraded land into productive, carbon-rich landscapes, doubling yields while capturing close to 10 tons of carbon per hectare each year. Across Africa, regenerative farming, built on practices like minimal tillage, mulching, and diverse crop rotations, has boosted drought resilience by about 40 percent while raising farm incomes. These are not pilot projects; they are evidence that agriculture can deliver climate adaptation and mitigation simultaneously. Meanwhile, tackling inefficiencies in the broader food chain offers quick wins. Cutting food waste in half would reduce global emissions by nearly the same amount as taking every aviation fleet off the planet. Shifting diets toward lower-emission foods and adjusting trade policies to reward sustainable production provide additional pathways that complement on-farm change.

The real test for COP30 will be whether leaders can commit to targets that are traceable, financed, and equitably implemented. Farmers need access to climate-resilient seeds, water-efficient technologies, and fair markets. Countries need frameworks that reward soil health, biodiversity, and lower emissions. And the world needs a coordinated strategy that treats food systems as a centerpiece of climate action, not an afterthought. If COP30 can move the global community from promises to practice, it could set the milestone where feeding the world and protecting the planet finally become

aligned goals rather than competing priorities.

Conclusion

The road to a climate-resilient global food system runs directly through the decisions that will be made at COP30. Agriculture is no longer a passive victim of climate change; it is a decisive factor shaping the planet's future. The evidence presented throughout this article shows that food systems are simultaneously fragile and full of opportunity: they generate nearly a third of global emissions, yet they also contain some of the most powerful solutions for adaptation, mitigation, and sustainable growth. From regenerative farming and agroforestry to precision irrigation and climate-smart seeds, the tools for transformation already exist. What has been missing is scale, financing, and political commitment.

COP30 offers a moment to correct course. Turning pledges into real change will require bold financing mechanisms, redirected subsidies, and inclusive policies that reach smallholders, women farmers, and climate-vulnerable communities. It also demands deep cooperation among governments, research institutions, private investors, and civil society. If the global community can align around measurable targets, rooted in science, equity, and accountability, agriculture can shift from a major emitter to a cornerstone of climate recovery.

References: AGRA; CPI; FAO; IPCC; IFAD; Nature; Science; UNCCD; UNDP; UNEP; World Bank.

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Climate Change and Global Food Security Challenges

The contemporary assessment of climate change highlights the urgent need for global action to ensure food security. As agriculture faces threats from declining yields, droughts, and soil degradation, decisive interventions are essential to protect livelihoods and ecological resilience.

Mithat Direk

11/28/2025

A truly just agricultural transition requires that climate resilience and sustainability reach those who need them most. Around the world, smallholder farmers, who grow more than one-third of the global food supply, remain disproportionately exposed to climate shocks despite having the fewest resources to adapt (IFAD, 2023). Intensifying droughts, floods, heatwaves, and pest outbreaks continue to erode their already fragile livelihoods. At the same time, land degradation affects 3.2 billion people globally, undermining soil fertility, reducing agricultural productivity, and exacerbating rural poverty (UNCCD, 2022). These overlapping vulnerabilities make equity, access, and inclusion central pillars of the climate agenda.

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Finally, bridging global adaptation gaps will demand robust international partnerships. Technology transfer, climate finance, and capacity-building from developed to developing nations are not acts of charity but strategic investments in global stability. Ensuring that all farmers, women, smallholders, and marginalized communities are, equipped to thrive in a changing climate is essential for building a resilient global food system.

A Multifaceted Threat to Agricultural Systems

Climate change poses a complex and far-reaching threat to agriculture, undermining global food security through multiple, interconnected pathways. The Intergovernmental Panel on Climate Change (IPCC) confirms with high confidence that climate change has already reduced agricultural productivity worldwide, and its impact is distributed unevenly across regions, with developing countries facing disproportionate risks (IPCC, 2022). This multifaceted challenge affects crops, soils, water resources, and livestock, placing the entire agricultural system under stress.

Rising temperatures exert a profound influence on crop performance. Even modest increases in global mean temperature can trigger substantial declines in staple crops: a 1°C rise is associated with yield reductions of 6.0% in maize, 3.1% in wheat, and 3.2% in rice (Jägermeyr et al., 2021). These impacts occur not only because crops exceed their optimal temperature thresholds but also because heat stress during sensitive stages like flowering significantly suppresses grain formation. Higher temperatures accelerate plant growth rates, shortening the crop cycle and reducing biomass accumulation, which further undermines yields (Zhao et al., 2017).

In parallel, climate change is drastically altering rainfall patterns, fueling more frequent and longer droughts. Droughts have increased by 29% since 2000, affecting over 2.3 billion people and placing immense pressure on agricultural water demands (UNCCD, 2023). As rainfall becomes unreliable, farmers increasingly depend on irrigation, accelerating the depletion of groundwater aquifers. Critical farming regions such as Northwest India and the North China Plain are experiencing severe groundwater declines, jeopardizing future production (World Bank, 2021).

Warming temperatures also expand the reach and intensity of agricultural pests and diseases. Insects alone are projected to increase crop losses by 10–25% per additional degree of warming, as they reproduce faster and invade new territories (Deutsch et al., 2018). This amplifies pesticide use, raising economic burdens and environmental risks.

Soils, already under pressure from intensive farming, face further degradation. Extreme rainfall increases erosion, while heat accelerates the breakdown of organic matter. Globally, 25–40 billion tonnes of topsoil are lost annually, diminishing long-term fertility (IPBES, 2018).

Livestock systems are equally threatened. Heat stress reduces feed intake, weakens immunity, impairs reproduction, and lowers milk and meat yields. The FAO estimates that over 5 million tonnes of milk are lost annually due to heat stress alone, a figure expected to rise (FAO, 2021). Poultry, highly temperature-sensitive, experiences elevated mortality and reduced egg production under heat extremes.

These converging pressures illustrate that climate change is not a single threat but an

intricate web of challenges destabilizing global agricultural systems and demanding urgent, coordinated adaptation measures.

The Path Forward

The path to safeguarding global food security in the era of climate change requires bold, coordinated, and science-driven action. The evidence is unequivocal: climate change is not a distant or theoretical future threat, it is a present, accelerating force that is already reducing yields, depleting water resources, and degrading natural ecosystems. As global temperatures continue to rise, the combined pressures of shifting rainfall patterns, expanding pest ranges, and soil degradation will intensify, placing unprecedented strain on agricultural systems. In this context, strengthening both mitigation and adaptation measures is no longer optional but an urgent necessity for all nations.

Mitigation strategies within agriculture such as climate-smart agriculture, low-emission livestock systems, and soil carbon sequestration hold the potential to significantly reduce the carbon footprint while improving productivity. Practices such as agroforestry, conservation tillage, biochar application, and diversified cropping systems not only store carbon but also enhance soil health and resilience. Equally important are adaptation strategies that protect farming communities from climate shocks. Developing and disseminating drought- and heat-resistant crop varieties, improving water-use efficiency through precision irrigation, and expanding agricultural insurance programs can help buffer farmers against climate-induced risks.

A severely underrecognized but powerful opportunity lies in addressing global food loss and waste. Nearly 30% of all food produced is lost or wasted along the supply chain from inefficient harvesting and inadequate storage to consumer-level waste (UNEP, 2021). Reducing this loss represents a dual benefit: it lowers agricultural emissions while easing pressure on food production systems. Strengthening cold chains, investing in rural storage facilities, improving transport infrastructure, and promoting circular food economy models are essential steps.

Building a resilient, climate-ready food system will require integrated solutions that connect sustainable production with robust distribution networks and equitable access. Such a transformation demands political will, financial investment, and global cooperation, but the cost of inaction will be far greater.

Conclusion

The contemporary assessment of climate change and agriculture makes one reality unmistakably clear: the future of global food security depends on how effectively and how quickly the world adapts to an increasingly unstable climate. The mounting evidence, from declining crop yields and intensifying droughts to expanding pest ranges and widespread soil degradation, underscores the urgency of coordinated global action. Agriculture, the foundation of human survival, is now at the frontline of climate vulnerability, and without decisive intervention, these pressures will continue to erode productivity, livelihoods, and ecological resilience.

A just and sustainable transition must prioritize those most at risk smallholder farmers, women, and resource-poor rural communities. Empowering these groups through equitable access to land, finance, technology, and climate-smart innovations can significantly boost productivity and strengthen adaptive capacity. At the global level, partnerships for technology transfer, climate finance, and capacity-building will be crucial, especially for developing nations facing disproportionate climate burdens.

The path forward requires an integrated strategy that blends mitigation such as regenerative agriculture and soil carbon sequestration with robust adaptation measures, including climate-resilient crops, efficient irrigation, and comprehensive risk-management tools like agricultural insurance. Reducing food loss and waste must also become a global priority, as it offers immediate gains for both climate mitigation and food availability.

Ultimately, safeguarding agriculture in a warming world will demand political will, scientific innovation, and international solidarity. With urgent and collective action, a resilient, productive, and more equitable global food system remains within reach.

References: Deutsch et al; FAO; IPBES; IPCC; Jägermeyr et al; UNEP; UNCCD; World Bank; Zhao et al.

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Halophyte Agriculture in the Indus Delta

The Indus Delta faces critical challenges from climate change, freshwater scarcity, and land degradation. This policy brief explores how halophyte-based agriculture can restore ecological integrity.

Nazar Gul & Hafiz Abdul Salam

11/28/2025

Global freshwater scarcity is intensifying, with over 1.5 billion people facing water scarcity and agriculture accounting for approximately 70% of all freshwater withdrawals (UN Water, 2021). Concurrently, soil salinity is a growing threat, affecting over 833 million hectares of land globally, an area equivalent to the size of Brazil (FAO, 2021). In this context, developing sustainable biological production systems that utilize saline water, and land is not just an opportunity but a necessity.

Halophytes, plant species naturally adapted to saline conditions, represent a cornerstone of this "bio-saline" approach. Pakistan, with its diverse climatic zones spanning from the Arabian Sea to northern mountains, is a hotspot for halophytic diversity. While earlier studies reported 410 halophyte species in Pakistan (Khan and Qaiser, 2006), recent research suggests the country hosts a significant proportion of the world's known halophytes, with many species possessing untapped economic potential for use as forage, fodder, fuel, medicine, and ornamentals (Abideen et al., 2020).

Beyond their economic value, halophytes provide critical ecosystem services. They are effective agents of phytoremediation, actively removing salt from the soil. Certain halophytic trees, like some Eucalyptus species, can transpire up to 2000 mm of water annually, naturally lowering saline water tables and reclaiming degraded land (Yadav et al., 2021). This makes them a powerful, nature-based solution for land rehabilitation.

The Crisis and Opportunity in the Indus Delta

The Indus Delta stands at a defining crossroads, an ecological crisis layered with untapped potential for climate-resilient innovation. Once nourished by the mighty Indus River, the delta now receives barely a fraction of the freshwater it historically did; flows have fallen by over 80% compared to the pre-dam era (WWF-Pakistan, 2022). This drastic reduction has triggered severe seawater intrusion, pushing salinity far inland and degrading croplands that once supported thriving rural communities. As soil and water salinization intensify, farmers are losing productive land at an alarming pace, contributing to widespread poverty, unemployment, and forced migration. Entire villages have been displaced as agricultural systems collapse under rising salinity and declining freshwater availability.

The ecological repercussions extend beyond agriculture. The Indus Delta hosts one of the largest arid-zone mangrove forests in the world, serving as a critical buffer against storms, erosion, and rising sea levels. However, the decline in freshwater flows has undermined mangrove regeneration, diminishing their ability to safeguard coastlines and support fisheries. With natural drainage poor and heavy clay soils trapping saline water, conventional engineering solutions such as large drainage schemes or chemical soil amendments are financially inaccessible and environmentally unsustainable for most households.

Yet, within this crisis lies a powerful opportunity. Community-driven mangrove restoration has already shown remarkable success in rejuvenating degraded coastal zones, proving that local stewardship can drive ecological recovery. A similar model, adapted for inland saline agriculture, offers a path forward. Large-scale cultivation of halophytes, salt-tolerant plants capable of thriving in hostile saline soils, could reclaim degraded lands, restore biodiversity, generate fodder and biomass, and offer new income streams to affected communities. By aligning traditional knowledge with modern ecological science, the Indus Delta can transform from a symbol of climate vulnerability into a living laboratory for sustainable adaptation and resilient agricultural futures.

Promising Halophyte Species for Climate-Resilient Agriculture in the Indus Delta

The Indus Delta's rapidly expanding saline landscapes demand innovative, nature-based solutions, and halophyte cultivation stands out as one of the most viable pathways for ecological restoration and livelihood support. Several native and adapted halophyte species have shown remarkable tolerance to extreme salinity, waterlogging, and arid conditions, making them ideal candidates for large-scale rehabilitation of degraded lands. Their potential extends beyond ecological recovery, offering economic, nutritional, and industrial benefits that can directly improve the resilience of delta communities.

Salicornia spp. (Glasswort) is among the most promising species for coastal saline zones. As a natural phytoremediator, Salicornia absorbs and stabilizes salt in the soil, improving land quality over time. It has the added advantage of being a high-value commercial crop. Its seeds contain 30–35% premium oil rich in linoleic acid, suitable for health foods, nutraceuticals, and biofuel production. Green biomass is equally valuable, used as livestock fodder, gourmet salad ingredients, and raw material for industrial processing. Given its short growth cycle and high market value, Salicornia-based farming could generate new income streams for coastal farmers.

Atriplex spp. (Saltbush) offers another powerful tool for restoring degraded inland areas. Known for thriving under intense

salinity and drought, it provides protein-rich forage essential for sustaining sheep, goats, and camels in harsh environments. This makes Atriplex cultivation particularly beneficial for pastoral households that depend on resilient grazing systems.

Eucalyptus camaldulensis (Suphaida), despite concerns regarding water use, can play a targeted role in severely waterlogged and saline soils. When strategically managed, it helps lower rising water tables, provides fast-growing timber and biomass, and supports rural energy needs.

Salvadora persica (Pilu), a native species deeply embedded in local ecosystems, thrives in saline and waterlogged conditions. While famous for its use as Miswak, it also yields seeds with 40–45% non-edible oil ideal for bioenergy. Its seed cake enriches soil as an organic fertilizer.

Key Policy Recommendations for Scaling Halophyte-Based Solutions in the Indus Delta

Unlocking the full potential of halophyte-based agriculture in the Indus Delta requires a cohesive, forward-looking policy framework that integrates environmental restoration with economic opportunity. Given the growing severity of salinity, waterlogging, and climate-induced land degradation, these recommendations offer a strategic roadmap for transforming the region's fragile landscapes into resilient, productive ecosystems. The first step is to formally integrate halophytes into provincial agricultural planning. By recognizing "Bio-saline Agriculture" as a distinct land-use category, the Government of Sindh can legitimize halophyte cultivation as a mainstream climate adaptation strategy rather than a niche or experimental practice. This recognition would open pathways for institutional support, budget allocations, and farmer training programs specifically designed for saline and marginal lands.

Building on this foundation, the launch of a "Halophyte for Green Recovery" program is essential. Modeled after the successful community-led mangrove restoration initiatives, such a program would provide seed funding for large-scale halophyte plantations focused on land reclamation, fodder production, and carbon sequestration. These community-based efforts would not only rehabilitate degraded landscapes but also generate green livelihoods and strengthen local resilience.

Equally important is sustained investment in research, development, and value chain formation. Funding should support rigorous scientific work to identify productive native varieties, optimize cultivation practices, and test economic models through demonstration plots. Developing markets for halophyte-derived products such as fodder pellets, medicinal extracts, and bio-oils will attract private-sector participation and increase farmer incentives.

A participatory co-management framework is necessary to ensure long-term success. Secure land tenure, along with technical and financial support, will empower local communities to take ownership and benefit equitably from halophyte plantations. Finally, mainstreaming halophytes into climate finance strategies can unlock global funding opportunities. As nature-based solutions offering both adaptation and mitigation benefits, halophyte initiatives are well-positioned to attract support from mechanisms like the Green Climate Fund, enabling large-scale, sustainable transformation of the Indus Delta.

Conclusion

The Indus Delta stands at a pivotal moment in its history, one where escalating climate pressures, freshwater scarcity, and rapid land degradation threaten both the ecological integrity of the region and the livelihoods of its people. Yet, this crisis also presents a unique opening for innovation through the strategic adoption of halophyte-based agriculture. As this policy brief demonstrates, halophytes offer a powerful, nature-based solution capable of reclaiming saline soil, lowering water tables, restoring biodiversity, and creating new economic opportunities for vulnerable communities. Their multifaceted benefits, from phytoremediation and fodder production to bioenergy and high-value commercial uses, position them as a cornerstone of sustainable development in the delta.

Realizing this potential, however, requires decisive and coordinated action. Provincial policies must formally integrate bio-saline agriculture, while targeted investments in research, community-driven restoration, and value chain development are essential to scale these solutions. By strengthening local ownership through participatory management frameworks and aligning halophyte initiatives with international climate finance, Sindh can transform its most degraded landscapes into productive, climate-resilient ecosystems.

Ultimately, embracing halophytes is more than an environmental strategy, it is a pathway toward climate adaptation, rural revitalization, and long-term regional resilience. With the right policies and partnerships, the Indus Delta can shift from vulnerability to leadership in sustainable saline agriculture.

References: Abideen et al; FAO; Khan & Qaiser; Rafay et al; UN Water; Ventura et al; WWF-Pakistan; Yadav et al.

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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Rural Sustainability: A Path to Prosperity in Pakistan

Discover how true rural sustainability in Pakistan can be achieved through the integration of economic growth, environmental integrity, and social justice. Embrace community participation and resource management to transform rural heartland into a hub of innovation, productivity, and resilience.

Asad Ali Khuwaja

10/29/2025

Sustainable rural development has evolved from a policy aspiration into a national necessity as Pakistan faces overlapping challenges of climate change, resource degradation, and socioeconomic disparity. According to the World Bank (2022), more than 80% of Pakistan's poor live in rural areas, where dependence on agriculture, weak infrastructure, and limited access to financial and technological resources make livelihoods highly vulnerable. Climate change now acts as a "threat multiplier," magnifying these existing inequalities through floods, droughts, and heatwaves that erode productivity and deepen poverty cycles.

The urgency to balance economic growth, environmental integrity, and social equity has never been greater, particularly in provinces such as Punjab, Sindh, Balochistan, and Khyber Pakhtunkhwa, where rural resilience directly determines national stability. At its core, rural sustainability in Pakistan means creating systems that empower communities to meet current needs without compromising the prospects of future generations. This involves promoting diversified livelihoods, adopting climate-smart agricultural practices, and ensuring equitable access to water and energy resources. Education, gender inclusion, and digital connectivity must also play central roles in strengthening rural economies and enabling informed decision-making.

Moreover, sustainable rural development cannot succeed without participatory governance and institutional coordination. Local governments, private enterprises, and civil society must work together to integrate sustainability into policy design and rural investment. By shifting from short-term relief measures to long-term adaptive strategies, Pakistan can transform its rural landscape into one that is not only productive and resilient but also environmentally sound and socially inclusive. Sustainable rural development, therefore, is not merely an option it is the cornerstone of Pakistan's journey toward equitable prosperity and climate resilience.

Integrated Resource Management: The Foundation of Resilience

Effective management of land, water, and energy forms the cornerstone of sustainable rural growth and climate resilience. Pakistan stands among the most water-stressed nations globally, with per capita water availability hovering near 1,000 cubic meters an alarming figure that edges dangerously close to the scarcity threshold (PCRWR, 2023). Agriculture, the mainstay of Pakistan's rural economy, consumes more than 90% of the country's freshwater, yet much of it is lost through inefficient irrigation practices. In Punjab, traditional flood irrigation systems continue to dominate, leading to massive water wastage and rapidly declining groundwater tables. In contrast, Sindh faces a different yet equally pressing challenge water salinity, which affects over half of the province's irrigated land, eroding soil fertility and reducing crop yields (IUCN, 2021).

Encouragingly, recent efforts toward resource efficiency and modernization signal a positive shift. The government's promotion of High-Efficiency Irrigation Systems (HEIS), such as drip and sprinkler technologies, across 100,000 acres has demonstrated water savings of up to 60% compared to conventional methods (MNFSR, 2023). Such technologies not only conserve water but also enhance crop productivity and energy efficiency by reducing pumping costs.

However, integrated resource management extends beyond irrigation. It requires harmonizing land use, water allocation, and renewable energy generation at the local level. Solar-powered tube wells, rainwater harvesting, and watershed restoration projects can help balance resource use while reducing environmental pressure. Equally important is the role of community-led water user associations to ensure equitable distribution and maintenance.

By linking technological innovation with participatory governance, Pakistan can build an integrated system where land, water, and energy are managed in synergy. This holistic approach is essential to safeguarding the nation's agricultural base, securing rural livelihoods, and ensuring long-term resilience against climate change.

Empowering Rural Pakistan: Building Inclusive Communities for Sustainable Growth

Sustainability takes root and flourishes only when it is nurtured from within communities. Empowering rural populations to take charge of their own development fosters ownership, accountability, and long-term resilience. Across Pakistan, several community-driven initiatives illustrate that real progress emerges when local people are equipped with the tools, knowledge, and institutional support to identify and solve their own problems. One inspiring example is the Tando Soomro village model in Sindh, where collective community action transformed a once-struggling settlement into a thriving example of self-sufficiency. Through cooperative management of resources, improved education, and social cohesion, Tando Soomro demonstrated how locally led governance can achieve what many top-down programs often fail to deliver sustained, inclusive development.

Nationally, social safety nets have been a lifeline for millions of vulnerable households. The Benazir Income Support Program (BISP) and its expansion under the Ehsaas framework represent two of Pakistan's most significant interventions in poverty alleviation. By 2023, Ehsaas had disbursed over PKR 544 billion to more than seven million families, with a major share reaching rural women and children (Ehsaas, 2023). These initiatives have not only provided direct financial relief but have also enhanced women's participation in household decision-making and improved access to health and education. When paired with skill development and microfinance opportunities, such social protection measures can serve as powerful instruments of economic empowerment and rural revitalization.

Beyond financial aid, sustainability in rural Pakistan depends on creating diverse and resilient income sources. Promoting eco-tourism and cultural preservation offers a unique pathway to rural prosperity. Pakistan's rural landscapes, home to mango orchards in Multan, citrus groves in Sargodha, and ancient crafts in Sindh and Khyber Pakhtunkhwa, hold immense potential for eco-tourism and green entrepreneurship. The "Made in Pakistan" initiative under the National Tourism Strategy (UNWTO & Government of Pakistan, 2022) aims to harness this cultural wealth to attract visitors, create jobs, and preserve heritage. Eco-tourism not only generates income but also reinforces environmental stewardship and pride in local identity.

A parallel shift toward climate-smart and organic agriculture is also reshaping rural economies. Techniques like zero tillage, precision irrigation, and intercropping are enhancing productivity while conserving resources. Currently, over three million acres in Punjab's rice–wheat belt are cultivated using zero-tillage practices, demonstrating tangible water savings and improved soil health (CIMMYT, 2022). Meanwhile, the gradual rise of certified organic farms in Pakistan signals a growing awareness of sustainable production and international market demand for eco-friendly goods.

However, these transformations can only succeed if backed by strong educational and infrastructural foundations. The digital divide continues to constrain rural progress, with net enrollment rates in rural schools still at 68% and gender disparities persisting (ASER, 2022). Vocational and digital training, particularly in solar technology, irrigation management, and rural e-commerce, can equip youth with employable skills while enabling innovation in agriculture and enterprise.

Finally, infrastructure resilience remains crucial. The catastrophic 2022 floods, which affected over 33 million people (NDMA, 2022), underscored the fragility of rural housing, transport, and irrigation networks. Building flood-resilient structures, promoting renewable energy micro-grids, and integrating environmental safeguards into all development projects are vital for future-proofing rural livelihoods.

Empowered communities, supported by equitable safety nets and sustainable innovations, represent Pakistan's best hope for achieving inclusive rural development. By investing in people, preserving culture, and reinforcing resilience, Pakistan can transform its villages into engines of sustainability and national prosperity.

Conclusion

Sustainable rural development is no longer a distant goal, it is the foundation upon which Pakistan's economic stability, environmental resilience, and social harmony must rest. The challenges of climate change, water scarcity, and persistent poverty demand a transformative approach that integrates economic efficiency with ecological preservation and community empowerment. As demonstrated through efforts in high-efficiency irrigation systems, community-led initiatives like Tando Soomro, and national programs such as Ehsaas and BISP, Pakistan has begun to lay the groundwork for a more equitable and resilient rural future.

The path forward requires strengthening local governance, promoting digital and financial inclusion, and investing in climate-smart infrastructure. Empowering rural women and youth through education, entrepreneurship, and technology adoption can unleash vast untapped potential, ensuring that development benefits reach the most marginalized. Moreover, integrating renewable energy, eco-tourism, and sustainable agriculture can diversify incomes while conserving the environment.

True rural sustainability will emerge only when economic growth, environmental integrity, and social justice move forward together. By embracing integrated resource management and community participation, Pakistan can transform its rural heartland into a hub of innovation, productivity, and resilience paving the way for a prosperous, climate-secure, and inclusive national future.

References: ASER; CIMMYT; Ehsaas; IUCN; Ministry of National Food Security & Research; NDMA; PCRWR; UNWTO; Government of Pakistan; World Bank.

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Intercropping Benefits for Sustainable Agriculture in Pakistan

Discover how intercropping enhances productivity and reduces environmental impact in sugarcane-based systems in Pakistan. Learn about the challenges and the need for coordinated efforts to increase adoption among farmers for sustainable agricultural development.

Nazar Gul & Hafiz Abdul Salam

11/6/2025

In Pakistan, where water scarcity and climate change continue to threaten agricultural sustainability, intercropping has emerged as a practical and efficient solution to enhance productivity and strengthen food security. Intercropping refers to the cultivation of two or more crop species simultaneously on the same field during a single growing season (Khan et al., 2023). This system ensures the efficient utilization of vital resources such as soil nutrients, water, and sunlight, leading to higher overall yields per unit of land (Wang et al., 2007). It remains a time-tested yet modern approach that boosts total productivity and farm income particularly in densely populated regions where per capita land availability is limited (Dasbak and Asiegbu, 2009).

Sindh province, despite its agricultural potential, faces increasing challenges due to limited water resources and erratic rainfall patterns linked to climate change. This calls for a transition from conventional monocropping to more adaptive and resource-efficient systems like intercropping. Properly implemented, intercropping can serve as a game-changing practice for farmers allowing them to achieve higher economic returns, better resource conservation, and greater resilience to climatic stress. Although this system demands careful planning, timely management, and commitment, the resulting gains in productivity and income make it an attractive option for sustainable agricultural development in Pakistan.

Intercropping offers several notable benefits, including water conservation, yield stability, resource efficiency, and enhanced profitability. When combined with ridge planting, it conserves substantial amounts of irrigation water compared to traditional flood irrigation. It also stabilizes crop yields ensuring that intercrops like onion and wheat maintain near-identical productivity to their sole crops, while sugarcane yield declines only slightly (by 5–10%). Intercropping further improves resource efficiency, doubling nutrient and water use effectiveness compared to conventional systems. The economic benefits are equally impressive, as intercropping lowers input costs related to fertilizers, land preparation, and labor.

However, the adoption of intercropping in Sindh remains limited due to low farmer awareness, the need for precise management, and higher seed costs. Farmers must adhere closely to schedules for sowing, irrigation, and fertilizer application, as delays in one crop can negatively affect others. Despite these challenges, intercropping remains a practical and rewarding method for smallholders seeking to boost income and improve food security.

Currently, there is insufficient research on the input requirements, seasonal production patterns, and management practices associated with intercropping. Although some provincial institutes and universities have investigated sugarcane-based systems, comprehensive data on production costs, profitability, and yield determinants remain scarce. Nonetheless, farmers who have adopted sugarcane intercropping systems report significantly higher earnings. A range of short-duration crops such as potato, tomato, onion, garlic, lentil, wheat, peas, mustard, and sunflower can be effectively integrated with sugarcane, depending on seasonal conditions.

Intercropping Economics and Productivity

Field experiments at the Agriculture Research Institute, Tandojam, have shown that although pure sugar beet cultivation produces the highest yield (76.5 t/ha), intercropping systems yield greater profitability. For instance, sugar beet intercropped with wheat generated the highest net return (Rs. 86,418/ha), followed by lentil (Rs. 83,665/ha) and barley (Rs. 76,783/ha). These findings highlight that while yields may slightly decline under intercropping, improved resource utilization and diversification significantly enhance overall income (Usmanikhail et al., 2013).

Similarly, a study conducted in Muzaffargarh district revealed that onion–tomato intercropping achieved a benefit-cost ratio of 1.59, surpassing that of sole onion (1.37) and tomato (1.48) cultivation. The land equivalent ratio of 1.31 indicated higher land-use efficiency, proving that intercropping not only maximizes income but also promotes ecological sustainability through complementary crop interactions (Khan et al., 2023).

For long-duration crops like sugarcane, intercropping provides an excellent opportunity to utilize open space between rows for short-duration crops such as lentil, gram, peas, mustard, garlic, and sunflower. Research from the University of Agriculture, Faisalabad (Nazir et al., 2002) confirmed that these combinations substantially increased net incomes over sole sugarcane cultivation. The highest benefit-cost ratio (2.78) was recorded for sugarcane intercropped with lentil, followed by garlic (2.72) and peas (2.63). These results confirm that integrated cropping systems can simultaneously enhance productivity, profitability, and resource efficiency.

In essence, intercropping maximizes the use of sunlight, water, and nutrients while reducing the risks associated with monocropping. For Pakistan's small and resource-constrained farmers, it presents a sustainable pathway toward economic resilience, food security, and climate adaptation.

Essential Precautions for Successful Intercropping

To ensure successful outcomes, several key precautions must be followed. The intercrop should always be treated as a supplementary, not dominant, crop aimed at generating additional income. Planting should occur in inter-row spaces, maintaining appropriate spacing (3–4 feet) to prevent excessive competition. Wider row spacing minimizes intercrop competition, especially in sugarcane systems, where ridge planting benefits vegetables. Farmers should prefer short-stature, short-duration varieties to avoid yield suppression of the main crop. For instance, late-planted sunflower or long-duration mustard may hinder sugarcane growth, whereas early planting (September–November) ensures compatibility.

In some cases, relay cropping where vegetables like chilies or onions are planted first, followed by sugarcane can yield better results. The use of organic manure (FYM) is strongly recommended, as it enhances soil fertility and supports high intercrop productivity. Exhaustive crops such as maize or sunflower can perform well when grown on organically enriched soil. Adequate fertilizer application, proper irrigation (avoiding over-flooding), and timely weed management are also crucial. After harvesting the intercrop, farmers must immediately focus on inter-row cultivation and nutrient management for the main crop to sustain overall yield potential.

Conclusion

Intercropping has proven to be a powerful tool for achieving sustainable agricultural development in Pakistan, particularly in sugarcane-based systems. Its multiple advantages, enhanced productivity, improved income stability, and reduced environmental impact, make it a win-win approach for farmers. Despite its potential, adoption remains limited due to low awareness and management constraints. To unlock its full benefits, coordinated efforts among policymakers, researchers, and farmers are essential.

Expanding intercropping practices, particularly by identifying suitable short-duration crops for integration, can transform the economic outlook of rural farming communities. Intercropping also aids in weed control, reducing the need for chemical herbicides and lowering production costs. Moreover, simultaneous planting of crops such as sugarcane and wheat during November–December can increase sugarcane productivity without compromising wheat yield.

In Pakistan's irrigated agro-ecosystems, crop diversification through intercropping pulse crops with sugarcane can significantly improve resource-use efficiency, including nitrogen, water, and weed control. Incorporating crop residues further enriches soil organic carbon, mitigating the effects of chemical fertilizer dependence. By strategically growing short-duration cereals, pulses, vegetables, and spices as intercrops, sugarcane growers can ensure steady interim returns and long-term sustainability. Intercropping thus stands as a cornerstone of climate-smart agriculture, providing smallholders with a reliable path toward increased income, efficient resource use, and food security in an era of environmental uncertainty.

References: Dasbak & Asiegbu; Khan et al; Nazir et al; Usmanikhail et al; Wang et al.

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Türkiye's Agricultural Sector: Rising Energy Costs

Explore the challenges facing Türkiye's agricultural sector as rising energy costs and environmental pressures impact farming expenses. Discover how these factors shape production and investment decisions.

Mithat Direk

11/14/2025

Energy security and food security are deeply intertwined challenges that increasingly shape national policy agendas, particularly in countries like Türkiye where agriculture plays a central economic and social role. As the sector has moved from traditional labor-intensive methods to highly mechanized, technology-driven production, its dependence on energy, especially fossil fuels, has grown substantially. Today, nearly every stage of agricultural production relies on energy inputs: land preparation, irrigation pumping, fertilizer manufacturing, harvesting, processing, storage, and transportation.

This dependence makes the sector highly vulnerable to fluctuations in global energy prices, geopolitical tensions, and domestic supply constraints. When energy costs rise, production expenses climb sharply, squeezing farmer incomes and threatening food affordability for consumers. Türkiye's agricultural energy profile reflects a heavy reliance on diesel for mechanization, electricity for irrigation, and natural gas–based fertilizers. Volatile international oil and gas markets, coupled with exchange rate fluctuations, have intensified cost pressures on farmers in recent years. For many producers, particularly smallholders' energy has become one of the largest components of total production costs, sometimes accounting for up to 40% of expenditure on irrigated systems. These rising costs undermine profitability, limit investment in modern technologies, and may push farmers to reduce input use, ultimately lowering yields.

Beyond economic impacts, Türkiye's agricultural energy dependency contributes to environmental challenges such as greenhouse gas emissions, groundwater depletion from energy-intensive irrigation, and soil degradation associated with chemical fertilizer use. As climate change intensifies, these environmental stresses pose additional risks to agricultural productivity and national food security.

This article therefore argues for an urgent transition toward energy-efficient technologies and renewable energy solutions such as solar-powered irrigation, biogas systems, precision agriculture, and improved machinery efficiency. By diversifying energy sources and reducing dependence on imported fuels, Türkiye can strengthen agricultural resilience, lower production costs, enhance environmental sustainability, and protect its long-term food security.

The Global Energy Context and its Agricultural Implications

The global energy system is undergoing a profound transformation, driven by rising climate concerns, technological advancements, and shifting geopolitical dynamics. For decades, fossil fuels (oil, coal, and natural gas) have supplied the bulk of the world's energy demand. However, mounting environmental pressures and the declining costs of renewable technologies have accelerated a transition toward cleaner energy sources. According to the International Energy Agency (IEA), renewable energy reached a historic milestone in 2023 by contributing 30% of global electricity generation, and projections indicate that renewables will become the single largest source of global electricity by 2025 (IEA, 2024). This transition marks a critical turning point not only for energy markets but also for sectors deeply intertwined with energy availability and pricing, including agriculture.

Agriculture already accounts for about 5% of global final energy consumption, with energy needs spanning machinery operation, irrigation, fertilizer production, processing, storage, and transportation. As global demand for food continues to rise, population growth, urbanization, and changing diets energy use within the agricultural sector is expected to increase further. Irrigation alone, one of the most energy-intensive agricultural activities, is projected to grow substantially as climate change intensifies droughts and alters rainfall patterns. Likewise, the production of synthetic fertilizers, heavily reliant on natural gas, remains one of the largest contributors to greenhouse gas emissions.

These dynamics create a direct link between global energy trends and the affordability, sustainability, and stability of food systems. Fluctuations in fossil fuel prices, whether due to geopolitical tensions, supply chain disruptions, or currency volatility translate into higher production costs for farmers and increased food prices for consumers. At the same time, reliance on carbon-intensive energy sources deepens agriculture's environmental footprint, contributing to climate change and further threatening long-term food security.

Energy Profile of Türkiye: High Dependency Amid a Changing Landscape

Türkiye's energy system sits at the intersection of rising domestic demand, structural constraints, and a persistent reliance on imported fuels. This dependency shapes the country's economic stability and influences the competitiveness of almost every productive sector, including agriculture, manufacturing, and transport. Despite steady progress in renewables, the overall picture remains one of vulnerability,

shaped by global price fluctuations and geopolitical uncertainty.

By 2023, Türkiye's energy import bill had climbed to $69.1 billion, a figure that underscores how deeply external markets determine the cost of doing business domestically. Roughly 70% of the country's primary energy supply is sourced from abroad, leaving the national economy exposed whenever international oil and gas prices spike or regional supply chains are disrupted. This condition is not new, but the scale of demand growth driven by urbanization, industrialization, and rising household consumption has made the stakes higher. Energy-intensive industries absorb much of the shock, but the ripple effects extend broadly. Agriculture, for example, faces increased costs for irrigation pumping, cold storage, fertilizer production, and mechanization cost pressures that directly influence food prices and rural livelihoods.

Yet the landscape is not static. Türkiye has emerged as one of the more dynamic renewable-energy markets in its region, steadily expanding hydropower, wind, and solar generation capacity. During the first half of 2024, renewables supplied more than 48% of total electricity generation, marking a tangible shift toward cleaner and domestically sourced power. Solar and wind installations continue to accelerate, supported by target incentives and a mature private-sector investment pipeline. Even so, renewables have made stronger inroads in electricity than in total primary energy supply, which remains dominated by natural gas, coal, and petroleum products.

Energy Use in Turkish Agriculture: Rising Pressure on Productivity and Profitability

Energy has become one of the defining factors shaping the cost structure, competitiveness, and long-term viability of agriculture in Türkiye. Although the sector accounts for a modest share of national energy use about 4–5% of total final energy consumption according to TUIK, the impact of energy prices on agricultural performance is disproportionately large. This is because energy is embedded in nearly every stage of production: diesel powers tractors and harvesters, electricity drives irrigation pumps, cold storage, and greenhouse systems, and energy-intensive inputs such as fertilizer depend heavily on global fuel markets. When energy prices rise, agricultural costs rise with them.

Over the past decade, this relationship has become increasingly visible. From 2010 to 2020, energy use in Turkish agriculture grew by more than 40%, reflecting the expansion of irrigated land, mechanization, and controlled-environment farming. What might have been a sign of advancing productivity has instead turned into a vulnerability, as energy costs escalated much faster than farmgate prices. The combined effect of rising global fuel prices and the depreciation of the Turkish Lira sharply increased the cost of diesel and electricity the two lifelines of modern farming. For many producers, especially small and medium-scale farmers, fuel and electricity now rank among the highest recurring expenses each season.

These pressures shape production decisions in very tangible ways. High irrigation costs push farmers in arid regions toward less water-intensive crops or reduce total cultivated areas. Greenhouse producers, heavily reliant on electricity, struggle to maintain competitiveness. Diesel-intensive operations such as field crop harvesting and livestock transport become more expensive, narrowing profit margins. Ultimately, these rising energy costs contribute directly to food inflation, affecting urban consumers as well as rural livelihoods.

In this environment, energy policy and agricultural policy are inseparable. Any effort to stabilize food prices, strengthen farm profitability, or support rural development must contend with the growing weight of energy in Türkiye's agricultural economy.

Environmental Impacts and the Efficiency Imperative in Turkish Agriculture

Energy use in Türkiye's agricultural sector carries significant environmental implications that go beyond rising costs. Diesel-powered machinery, electricity generated largely from fossil fuels, and energy-intensive inputs contribute to air pollution, carbon emissions, and the depletion of natural resources. Agriculture is caught in a dual reality: it is increasingly threatened by climate change through droughts, heatwaves, and erratic rainfall while simultaneously adding to the very pressures that drive these changes. This circular vulnerability underscores the urgency of improving energy efficiency across the farming landscape.

Efficiency is no longer a technical preference but an environmental and economic necessity. Research demonstrates meaningful gains from the right set of practices. Conservation of tillage, for instance, can cut tractor passes by up to 40%, lowering diesel consumption and reducing soil disturbance. Similarly, shifting from flood irrigation to drip systems improves both water and energy efficiency by more than 30%, a crucial advantage in water-scarce regions. These technologies not only conserve resources but also reduce greenhouse gas emissions, creating a direct link between farm-level decisions and national climate goals.

Solar-powered irrigation is another promising avenue gaining momentum. As electricity costs rise, solar pumps offer farmers predictable energy expenses, reduced dependence on the grid, and lower long-term operating costs. The combination of renewable energy with efficient irrigation has the potential to transform small and medium-sized farms, enabling them to sustain yields with fewer environmental impacts.

Moving forward, the path to a more resilient and competitive agricultural sector hinges on a multi-layered strategy. Expanding incentives for solar and biogas systems can turn farmers into energy

producers rather than passive consumers. National extension services must lead the shift toward precision agriculture, modern machinery, and efficient water management. Finally, stronger research and development investments are essential for scaling locally suited, low-energy technologies and climate-resilient crop varieties. Together, these measures can place Türkiye on a more sustainable and secure agricultural trajectory.

Conclusion

Türkiye's agricultural sector is standing at a turning point where rising energy costs, environmental pressures, and structural vulnerabilities intersect. The growing reliance on diesel, electricity, and natural gas has made farming increasingly expensive and exposed to global price shocks, eroding profitability for smallholders and larger producers alike. These cost pressures ripple across the food system, shaping what farmers grow, how much they invest, and ultimately what consumers pay. At the same time, the sector's heavy use of fossil fuels deepens its environmental footprint, accelerating soil degradation, water stress, and greenhouse gas emissions problems that climate change is already amplifying.

Yet the challenges outlined in this analysis also reveal a clear pathway forward. By embracing energy-efficient technologies, investing in renewable energy solutions, and modernizing production systems, Türkiye can reduce vulnerability while strengthening both competitiveness and sustainability. Solar-powered irrigation, conservation tillage, precision agriculture, and biogas systems are not abstract aspirations; they are practical tools that can lower costs, stabilize yields, and reduce environmental harm. Achieving this transition will require coordinated policy support, accessible financing, and targeted technical guidance for farmers.

References: FAO; IEA; MENR; Özalp et al; TUIK; World Bank.

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Pakistan's Agricultural Future: Precision Agriculture

Pakistan's agricultural future is at a crossroads due to climate change, water scarcity, and technological stagnation. This article explores how precision agriculture is essential for overcoming challenges posed by climate change.

Umar Abbas

11/19/2025

Pakistan's agricultural sector, long regarded as the backbone of the national economy and the primary livelihood source for more than 37% of the workforce (World Bank, 2022), is now confronted by a convergence of existential threats unlike any in its history. Climate change, once a distant concern, has become a lived reality as rising temperatures, erratic rainfall, and unprecedented floods repeatedly devastate farmlands. Simultaneously, water scarcity has reached a critical threshold. Per-capita water availability has declined by over 80% since 1960, pushing Pakistan to the brink of becoming a water-scarce nation. These environmental stresses have been compounded by the slow pace of technological modernization, particularly in smallholder-dominated regions where outdated practices prevail.

The Indus Basin Irrigation System (IBIS), the lifeline of Pakistan's agrarian economy, is increasingly vulnerable to hydrological volatility. Glacial melt, unregulated groundwater extraction, and seasonal unpredictability have made irrigation scheduling erratic and unreliable. Under such conditions, the challenge is shifting from optimizing agricultural inputs to ensuring that farming remains physically possible. Farmers across Punjab and Sindh are already reporting declining yields, diminished soil health, and shrinking planting windows, clear indicators of a system under acute stress.

In this context, Precision Agriculture (PA) emerges as a transformative solution capable of enhancing water productivity, improving crop resilience, and maximizing output from shrinking resources. Technologies such as remote sensing, GIS mapping, moisture probes, climate-smart irrigation, and variable-rate application offer the potential to substantially reduce waste and increase efficiency. Yet, despite this promise, PA remains out of reach for most smallholders due to high upfront costs, limited digital literacy, inadequate extension services, and poor rural connectivity.

The Triple Threat: Climate Change, Hydrology, and Food Security

Pakistan is confronted with a convergence of climate, water, and food system challenges that together constitute a national security threat. Ranking among the top ten most climate-vulnerable countries globally (Global Climate Risk Index, 2021), Pakistan's exposure to climate extremes has translated into staggering economic damage. The 2022 monsoon floods, one of the most destructive climate events in recent history, caused more than $30 billion in losses and destroyed nearly 4 million acres of crops, plunging millions into acute food insecurity and disrupting rural livelihoods on an unprecedented scale (World Bank, 2022).

Climate change in Pakistan is now defined by rising temperatures and erratic weather patterns, both of which directly undermine agricultural productivity. Heat stress has emerged as a critical constraint for major crops. Scientific assessments show that increasing temperatures, especially during the reproductive stages of wheat and rice, can reduce yields by 5–15% (Ullah et al., 2023). At the same time, the country is experiencing a dangerous pattern of alternating floods and droughts. Super-floods wash away standing crops and destroy stored grains, while post-flood drought conditions delay sowing, distort cropping calendars, and cripple farmer finances, making agricultural planning increasingly unpredictable.

These climate pressures are compounded by an intensifying water scarcity crisis. Pakistan's per capita water availability has fallen to roughly 1,000 cubic meters, dangerously close to absolute scarcity (PCRWR, 2023). The Indus Basin Irrigation System, once a national asset, has become overstretched and inefficient, losing up to 60% of water through seepage and outdated flood irrigation practices. As surface water declines, farmers increasingly rely on groundwater extraction, accelerating aquifer depletion and raising production costs.

Precision Agriculture (PA) as a Paradigm Shift: A Digital Lifeline

Precision Agriculture (PA) marks a profound shift in the way farming is understood and practiced, offering a science-based, data-driven alternative to conventional agriculture. In a country like Pakistan where water scarcity, rising input costs, and climate volatility now constrain production more than land availability the strength of PA lies not simply in boosting yields but in maximizing resource efficiency. PA seeks to ensure that every drop of water, every gram of fertilizer, and every spray of pesticide is used exactly where and when it is needed. This precision minimizes waste, reduces production costs, and enhances climate resilience by aligning agricultural practices with real-time field conditions.

The PA ecosystem is built on a coordinated set of technologies that collectively transform raw information into smart decisions. Remote sensing, through satellites and drones, allows farmers to visualize crop vigor, detect stress using tools like NDVI, and assess field variability with unprecedented accuracy. At the soil level, IoT-based sensors capture continuous data on moisture, temperature, and nutrient availability, providing a granular understanding of field microenvironments. These data streams feed into analytical platforms powered by artificial intelligence and machine learning, which translate complex datasets

into practical recommendations for irrigation, fertilization, and pest management. The final step, Variable Rate Application (VRA), enables machinery and irrigation systems to execute these recommendations by applying inputs in varying amounts across different field zones, rather than uniformly.

Global evidence underscores PA's transformative potential. VRA irrigation systems can reduce water use by 20–40% without compromising productivity, a critical benefit for Pakistan's drought-prone regions (FAO, 2021). Site-specific nutrient strategies can decrease fertilizer consumption by 15–20%, lowering costs for farmers while reducing environmental pollution and soil degradation. In essence, PA provides a digital lifeline for Pakistan's agriculture, a pathway to sustainable farming that reconciles productivity with environmental stewardship.

Intractable Barriers to the Adoption of PA in Pakistan

Despite the transformative promise of Precision Agriculture (PA), its actual adoption in Pakistan remains extremely limited, largely restricted to research trials and a small number of large commercial farms. The underlying barriers are not merely technological, they are systemic, structural, and deeply embedded within Pakistan's agricultural economy. The most fundamental challenge stems from economic constraints and land fragmentation. With nearly 80% of farmers operating on less than five hectares and already struggling with narrow profit margins, the upfront investment required for PA tools such as drones, soil sensors, automated irrigation systems, and decision-support software remains far beyond reach. Conventional lending mechanisms offer little relief, and while Islamic banking has expanded financing options for agriculture, it still lacks tailored, Shariah-compliant risk-sharing instruments like Musharakah-based co-investment models that could make high-tech assets financially viable for smallholders.

Infrastructure deficiencies further compound this challenge. PA depends on uninterrupted digital connectivity and reliable electricity to power sensors, transmit data, and automate field operations. Yet many rural regions remain "connectivity deserts," lacking stable 3G/4G networks (GSMA, 2023). Energy shortages and frequent load-shedding disrupt equipment functionality, undermining the consistency of data collection. The human capital gap is equally significant. Most farmers possess limited digital literacy, and the public extension system, already understaffed and underfunded, is not equipped to train farmers in advanced digital tools or data interpretation, resulting in a significant usability barrier.

Institutional fragmentation presents another major obstacle. Pakistan currently lacks a unified national framework for digital agriculture, leading to scattered initiatives that fail to scale. Research and development support is inadequate, with imported sensors often poorly calibrated for Pakistan's unique soils and climatic conditions. Domestic ag-tech innovators face financing hurdles, and unresolved issues surrounding data privacy, ownership, and governance impede the construction of integrated, nationally relevant agricultural data ecosystems. Collectively, these barriers have created a landscape where PA remains an aspiration rather than a reality.

Policy Interventions for Scalable Adoption

Achieving widespread adoption of Precision Agriculture (PA) in Pakistan requires a coordinated national strategy that addresses the systemic constraints holding back its diffusion. A foundational step is prioritizing digital and energy infrastructure, without which PA cannot function. This demands substantial public investment in expanding rural broadband, reducing "connectivity deserts," and improving energy reliability. Government-led solarization of tubewells and rural mini-grids supported through state-backed Ijarah (leasing) models can create a sustainable, uninterrupted power supply for digital equipment, sensors, and automated irrigation systems. Positioning energy and connectivity as strategic infrastructure is crucial for transforming the rural economy.

Localization of technology through Public-Private Partnerships (PPPs) is another core pillar. Rather than encouraging individual ownership of high-cost PA tools, the focus should shift toward shared service delivery. Establishing Ag-Tech Service Hubs at the union council level would allow smallholders to access drone spraying, AI-based soil diagnostics, and satellite-driven advisory on a pay-per-use basis. Parallel investment in local R&D can help create low-cost, climate-appropriate PA solutions rather than relying on foreign technologies that are often incompatible with Pakistan's agro-ecology.

Financial innovation is equally essential. Traditional credit systems are ill-suited for high-tech investment, and Islamic financial institutions can play a transformative role by developing Musharakah-based risk-sharing products for farmers and ag-tech startups. Integrating satellite and sensor-based data into parametric insurance models could also provide farmers with automatic payouts during droughts or extreme weather events, reducing the financial risks associated with adopting new technologies.

Finally, Pakistan's agricultural extension system must undergo a comprehensive modernization. Extension workers should be retrained as Ag-Tech Facilitators, capable of interpreting digital data and guiding farmers in technology use. Academic institutions must revise curricula to build a workforce skilled in drone operation, IoT maintenance, and data-driven decision-making. Together, these policies offer a scalable path toward embedding PA into Pakistan's agricultural future.

Conclusion

Pakistan's agricultural future hinges on its ability to confront the intertwined crises of climate change, water scarcity, and technological stagnation with bold, coordinated action. As the evidence throughout this article makes clear, traditional farming systems are no longer capable of sustaining productivity under worsening environmental pressures. The

accelerating frequency of floods, droughts, heatwaves, and hydrological instability has fundamentally altered the calculus of agricultural planning, pushing the sector beyond the point where incremental improvements can suffice. Precision Agriculture (PA), therefore, is not merely an innovation, it is a necessity for survival.

The promise of PA lies in its capacity to maximize resource efficiency, enhance climate resilience, and reduce input waste at a time when every drop of water and every unit of energy matters. Yet the persistently low adoption of these technologies' underscores deep structural barriers: financial limitations, fragmented landholdings, weak digital and energy infrastructure, and inadequate institutional support. Overcoming these challenges will require a national commitment to digital transformation, backed by investment, policy coherence, and multisectoral collaboration.

Ultimately, safeguarding Pakistan's food security and rural livelihoods will depend on how effectively the country can embed data-driven agriculture into its economic fabric. If supported by targeted reforms and inclusive financing mechanisms, Precision Agriculture offers a viable pathway toward a resilient, sustainable, and self-reliant agricultural economy, one capable of withstanding the arid future that climate change is rapidly bringing into view.

References: FAO; GSMA; Germanwatch; PCRWR; Ullah et al; World Bank.

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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Oil Palm Cultivation: A Strategic Opportunity for Pakistan

Discover how oil palm cultivation can help Pakistan reduce its dependency on imported edible oils and enhance food security. Explore the potential of Sindh and Balochistan for sustainable production and the need for innovative breeding programs to tackle environmental challenges.

Nazar Gul & Hafiz Abdul Salam

11/22/2025

Agriculture remains a cornerstone of Pakistan's economy, contributing nearly 24% to the national GDP and providing livelihoods for about half of the country's population. Beyond meeting domestic needs, agriculture plays a vital role in generating foreign exchange, with major export commodities such as rice, sesame, fruits, and meat earning nearly USD 8 billion in the 2024 fiscal year (TADA, 2024; Rauf, 2025). Despite these strengths, Pakistan continues to face a widening gap between agricultural production and consumption. This is most visible in the edible oil sector, where domestic production satisfies only a fraction of the national requirement. The shortfall forces Pakistan to import large quantities of vegetable oils, creating a heavy financial burden and exposing national food security to global market volatility.

Pakistan comprises about 22 million hectares of cultivable land, of which approximately 18 million hectares are irrigated, primarily across Punjab and Sindh (Rauf, 2025). These irrigated plains are the backbone of major cash crops such as cotton, sugarcane, mango, rice, and citrus. Meanwhile, the rain-fed regions produce wheat, fodder crops, olives, and peanuts. However, rising climate variability has begun to adversely affect agricultural productivity. Increasing frequencies of drought, salinity, soil erosion, and waterlogging are undermining the integrity of Pakistan's agricultural land, reducing yields and increasing costs.

Pakistan's Edible Oil Crisis

Oils and fats are essential components of the human diet, supplying energy, essential fatty acids, fat-soluble vitamins (D and K), and health-promoting compounds such as sterols and tocopherols (Meijaard et al., 2024). Yet edible oil remains one of Pakistan's largest import commodities. Palm oil alone accounts for nearly 31% of total agricultural imports, while soybean oil represents an additional 11%. Other major imports include lentils (10%) and tea (8%). Together, edible oils, mainly palm and soybean, comprise nearly 42% of Pakistan's agricultural import bill, underscoring their enormous economic significance.

Pakistan is among the world's largest importers of palm oil, most of which arrives from Indonesia and Malaysia. In 2024, Pakistan spent roughly USD 4.08 billion on palm and vegetable oil imports (Agriculture Statistics of Pakistan, 2024; Rauf, 2025). Moreover, the country imported 860,260 tonnes of palm oil from Malaysia in 2024, an increase of 14.2% from the previous year. Projections suggest that Pakistan may need to import nearly four million tonnes of palm oil in 2025, costing approximately USD 3.5 billion (Ali, 2021; Rauf, 2025). As the food processing sector expands at an estimated 7.5% annual growth rate, the demand for refined palm oil, specialty fats, and oleo-chemicals is expected to increase sharply.

Domestic edible oil production accounts for only about 15% of total demand, largely deriving from cottonseed, canola, and sunflower. Historically, cottonseed has been a major source of edible oil (Yadav & Chattopadhyay, 2024; Rauf, 2025). However, the cotton sector has suffered significant decline due to climatic stresses in southern Punjab and shifting cropping patterns. Farmers replacing cotton with sugarcane and maize have contributed to a drastic reduction in cottonseed availability, from 3.15 million metric tons (MMT) in 2018 to just 1.57 MMT in 2022 (FAOSTAT, 2022; Rauf, 2025). Growing population levels and increased consumption from the restaurant and deep-frying industries further widen the edible oil deficit, putting pressure on national food security.

Oil Palm: A Promising Opportunity

To bridge the edible oil deficit, the cultivation of oil palm (Elaeis guineensis L.) has emerged as a viable long-term strategy. Oil palm is recognized globally as one of the most productive and reliable oil-yielding crops. With a productive lifespan extending up to 25 years and a short juvenile phase of 2–3 years, it offers rapid returns and consistent yields (Murphy et al., 2021). Multiple research reports and policy analyses recommend expanding oil palm cultivation in Pakistan to reduce dependence on imports (Hussain et al., 2023).

One of the most compelling advantages of oil palm is its exceptionally high oil yield. While Brassica crops produce around 0.5–0.6 tons of oil per hectare, oil palm can yield 3.5–5 tons—up to ten times more (Mathur et al., 2023; Rauf, 2025). In addition, intercropping with bananas, papaya, or vegetables during the early growth years can provide farmers with supplementary income (Rauf, 2025).

Climate and Environmental Constraints

Despite its potential, oil palm cultivation is highly specific to areas meeting particular photo-thermal requirements. Native to West Africa, oil palm thrives in humid tropical climates with temperatures between 25–34°C, rainfall between 1600–2500 mm annually, and sunlight exceeding 1800 hours per year. It grows optimally near the equator between 10°

north and south latitude (Punnuri & Singh, 2013).

Globally, the crop is concentrated in Latin America, Central America, and Southeast Asia, regions with abundant tropical rainforests that also face ecological concerns (Yadav & Chattopadhyay, 2025). Rapid expansion in these areas is environmentally contentious due to forest degradation.

In Pakistan, coastal regions such as Badin, Thatta, Hub, Pasni, and Gwadar show potential for oil palm cultivation, but significant challenges remain. Annual rainfall in these areas is only 151–203 mm, humidity levels range between 25–34%, and temperatures can exceed 50°C (Rauf, 2025). These harsh conditions necessitate advanced irrigation systems such as rain guns and drip irrigation as well as breeding programs focused on heat- and drought-tolerant genotypes (Corley, 2018). Studies indicate strong genotype × environment interactions, showing that varieties performing well under optimal conditions often fail under heat and drought stress.

Extreme temperatures above 45°C may cause gametophytic sterility, reduced fruit formation, and lower oil percentages (Murphy et al., 2021). Thus, rigorous screening of germplasm, followed by selecting drought- and heat-tolerant progenies, will be critical to improving the crop's viability (Murphy et al., 2021).

Performance of Oil Palm in Pakistan's Coastal Belt

Experimental plantations along Sindh's coastal belt, supported by the Malaysian Palm Oil Board, demonstrate promising potential. Mesocarp oil content recorded in Pakistan ranged from 62–68%, exceeding global averages. Kernel oil content varied from 26–28%, with lauric acid comprising approximately 45% of kernel oil (Saleem & Sultana, 2010). These results indicate favorable biochemical characteristics for commercial production.

Growth performance trials of varieties such as the 3-way Cross and Yangambi PB14 at the Dalda Agriculture Research Station (DARS), Mirpur Sakro, showed encouraging outcomes. Under varying fertilization treatments, Yangambi PB14 performed best, achieving a seedling height of 94 cm and a trunk girth of 21 cm within seven months (Memon et al., 2023).

Key Challenges and the Path Forward

A major limitation to oil palm expansion in Pakistan is the restricted adaptability of imported germplasm. Most global oil palm varieties are tailored to humid tropics and may not perform well in arid, saline, or extreme temperature environments (Rauf, 2025). Introducing new genetic resources from diverse global collections and evaluating them across Pakistan's agro-ecological zones will be essential.

Drought and heat tolerance remain priorities, as oil palm is highly sensitive to water scarcity (Murugesan et al., 2017). Developing or introducing heat-tolerant and drought-resistant varieties through breeding and biotechnology is crucial (Li et al., 2019; Wei et al., 2021). Additionally, coastal salinity poses significant risk, necessitating the identification or development of salt-tolerant cultivars (Vieira et al., 2020).

Beyond agro-climatic factors, market readiness and industrial infrastructure will determine the long-term success of oil palm cultivation. Establishing local fruit-crushing facilities and refining industries is essential to avoid high transportation costs and post-harvest losses. Farmers must receive subsidized seedlings, financial support, and opportunities for intercropping to reduce investment risks. A reliable supply of disease-free, high-performing planting material is also necessary to guarantee successful establishment.

Sustainable agricultural practices such as soil fertility management, reduced pesticide use, and protection of fragile ecosystems like coastal mangroves must guide expansion. Efficient irrigation systems, rainwater harvesting, and modern water management strategies will be pivotal for long-term viability.

Conclusion

Oil palm cultivation presents a strategic and long-term opportunity for Pakistan to reduce its heavy dependence on imported edible oils and strengthen national food security. Pakistan's coastal regions, particularly in Sindh and Balochistan, demonstrate promising biochemical and agronomic potential for oil palm production, as shown by early trials supported by international research institutions. Yet the crop's success will rely on a coordinated, science-driven, and market-ready approach. Addressing challenges such as extreme heat, drought, salinity, and the limited adaptability of imported germplasm requires sustained investment in breeding programs, varietal evaluation, and biotechnology to develop heat- and drought-tolerant cultivars suited to local environments.

Equally critical is the establishment of supportive infrastructure, including nurseries, crushing mills, refineries, and efficient supply chains to ensure that growers have access to high-quality planting material and profitable market linkages. Farmers must be encouraged through subsidized seedlings, crop insurance, and intercropping options that generate income during the juvenile phase of oil palm. Public-private partnerships can accelerate research, technology transfer, and commercialization, enabling the edible oil sector to evolve into a competitive domestic industry. With strategic planning, scientific rigor, and sustainable management practices, oil palm cultivation has the potential to become a transformative agricultural innovation for Pakistan's coastal economy and a vital contributor to national self-reliance in edible oil production.

References: Agriculture Statistics of Pakistan; Ali; Corley; FAOSTAT; Hussain et al; Li et al; Mathur et al; Meijaard et al; Memon et al; Murphy et al; Murugesan et al; Punnuri & Singh; Rauf; Saleem & Sultana; TADA; Vieira et al; Wei et al; Yadav & Chattopadhyay.

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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Floods 2025: Pakistan's Agricultural Crisis

The floods 2025 have highlighted Pakistan's agricultural vulnerability as a national economic emergency. This critical moment calls for coordinated, science-based responses to build resilience and adapt to future challenges, learning from global best practices.

Noor Muhammad & Muhammad Afaq Ashraf

11/4/2025

The devastating floods of 2025 did not merely inundate land; they drowned Pakistan's agricultural future under vast, silent lakes, serving as a grim reminder that the climate crisis is no longer a distant threat it is a recurring national emergency. From the fertile plains of Sindh to the productive heartlands of Punjab, the floodwaters erased decades of progress within days. Crops were destroyed, livestock perished, and rural communities that depend on agriculture for survival were left in despair. The disaster exposed not only environmental vulnerability but also deep-rooted institutional and infrastructural weaknesses in Pakistan's disaster preparedness and agricultural resilience.

According to the National Disaster Management Authority (NDMA, 2025 Post-Flood Assessment Report), more than 4.5 million people across Punjab, Sindh, and Khyber Pakhtunkhwa were affected, as riverine floods and glacial lake outbursts submerged entire districts. In Punjab alone, nearly 800,000 hectares of productive farmland disappeared under water, wiping out critical crops such as cotton, rice, and sugarcane key contributors to Pakistan's exports and GDP (World Bank, 2025). The Food and Agriculture Organization (FAO, 2025) estimated direct agricultural losses at US $4.2 billion, equivalent to more than PKR 1.17 trillion, while national crop output fell by over 12%. Satellite imagery confirmed the destruction of 250,000 hectares of rice fields, an area three times the size of Islamabad.

In some flood-hit districts, vegetable crops suffered up to 90% losses, and over 8,000 livestock deaths further weakened household economies and food supply chains (PMD, 2025). These shocks caused a surge in food prices, deepened rural indebtedness, and worsened food insecurity nationwide. Each monsoon now brings renewed fear to millions of farmers who live on the frontline of climate change, facing not only the floods but the looming threat of agricultural and economic collapse.

Global Lessons in Climate-Resilient Agriculture

Pakistan is not alone in facing the mounting challenges of climate-induced disasters. Around the world, countries vulnerable to extreme weather events are investing heavily in climate-resilient agriculture to secure their food systems and rural livelihoods. The global approach has evolved from the reactive model of *"building back better"* after each disaster to a proactive philosophy of *"building smart before the next flood"* (World Bank, 2024). This shift emphasizes anticipation, adaptation, and innovation long before the next crisis strikes.

Bangladesh stands at the forefront of this transformation with its "climate-smart villages." Farmers there have adopted raised seedbeds and floating gardens, locally known as *baira*, to sustain vegetable production even during prolonged flooding. Additionally, submergence-tolerant rice varieties such as Swarna-Sub1 can survive underwater for up to two weeks, minimizing crop loss and ensuring food security (IFPRI, 2023). In Vietnam, the Mekong Delta has been revolutionized through integrated rice–aquaculture systems that combine rice cultivation with fish farming. This not only maintains food supply but also stabilizes household incomes during flood seasons, demonstrating how ecosystem-based approaches can sustain livelihoods.

The Netherlands offers another compelling model through its "Room for the River" program, which abandons the traditional idea of building higher dikes and instead designates floodplains to safely channel and store excess water. This innovative strategy has protected both agricultural and urban areas from flood devastation. In Africa, Kenya has shown how digital innovation can enhance resilience. The adoption of index-based livestock insurance, linked with mobile weather alerts, enables pastoralists to receive compensation automatically when drought indicators are triggered, helping them recover swiftly (ILRI, 2024).

These global experiences illustrate a vital truth: real resilience is not forged during disasters but in periods of stability through forward-looking planning, local empowerment, and strong institutions grounded in science and technology.

A Blueprint for a Resilient Pakistan

Building a climate-resilient agricultural future for Pakistan requires a holistic and forward-looking approach that integrates infrastructure development, scientific innovation, financial inclusion, and community empowerment. The increasing frequency of floods, droughts, and extreme weather events calls for a shift from crisis management to long-term resilience planning. This vision must be rooted in policies that combine modern technology with local knowledge to ensure sustainability and inclusiveness.

The first step lies in rethinking infrastructure and water management. Rather than focusing solely on post-disaster repairs, Pakistan must adopt nature-based and preventive measures. Revitalizing natural drainage networks, reinforcing embankments, and

developing strategic water retention areas inspired by the Netherlands' "Room for the River" model can help mitigate future flood risks. Additionally, promoting small-scale, on-farm water reservoirs can capture monsoon rainfall for later use during dry periods, ensuring year-round water security for farmers.

Adopting Climate-Smart Agriculture (CSA) is equally vital. Encouraging crop diversification, flood- and drought-tolerant varieties such as PARC's new rice hybrids, and techniques like intercropping and crop rotation can improve soil fertility and stabilize farmer incomes (PARC, 2024). Lessons from Bangladesh's raised-bed and floating agriculture systems can be tailored to Pakistan's flood-prone regions, offering low-cost and adaptable solutions.

Technology must serve as the backbone of resilience. AI-driven weather forecasting, mobile-based early warning systems, and local disaster response committees can bridge the gap between information and action. Financial empowerment through parametric micro-insurance and flexible credit lines will protect farmers from falling into debt traps after disasters (State Bank of Pakistan, 2024).

Finally, a stronger agricultural extension system is indispensable. Expanding and training extension workers to translate scientific research into field-based practices will ensure that innovation reaches every farm. Only through such an integrated framework can Pakistan transform its vulnerabilities into resilience, securing a sustainable agricultural future for generations to come.

Conclusion

The floods of 2025 have reaffirmed that Pakistan's agricultural vulnerability is not just an environmental issue but a national economic emergency that demands immediate, coordinated, and science-based responses. The country stands at a critical juncture where the choice is between repeating cycles of destruction and rebuilding or adopting forward-looking strategies that make agriculture more adaptive, inclusive, and resilient. Learning from international best practices from Bangladesh's floating farms to the Netherlands' water management systems Pakistan can design its own resilience model rooted in local realities and supported by modern technology, strong institutions, and empowered farming communities.

Investments in climate-smart agriculture, digital early warning systems, and nature-based water management solutions must become policy priorities, not post-disaster afterthoughts. Equally important is ensuring financial resilience for farmers through micro-insurance, flexible credit, and access to reliable market information. Strengthening agricultural extension services will help translate scientific innovations into practical field applications, enabling farmers to make informed, sustainable decisions.

Ultimately, Pakistan's agricultural future depends on how effectively it transforms adversity into opportunity. By embracing proactive adaptation and integrating resilience into its development agenda, Pakistan can not only safeguard its food systems but also secure the livelihoods of millions, ensuring that its fields remain fertile and its farmers hopeful for generations to come.

References: FAO; IFPRI; ILRI; NDMA; PMD; PARC; State Bank of Pakistan; World Bank.

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Food Insecurity and Human Migration: A Global Challenge

Explore the complex interplay between food insecurity and human migration. This analysis highlights how food scarcity drives migration and affects migrants long after they leave their homes, revealing a global challenge that requires comprehensive solutions.

Fatima Sajid

11/12/2025

Food security and human migration are linked to a powerful, two-way relationship that shapes the lives of millions across the globe. Increasing evidence from regions such as Central America, Sub-Saharan Africa, South Asia, and even migrant-receiving high-income countries shows that food insecurity is not just a background factor but a core driver of both voluntary and forced migration. When households face persistent hunger, crop failures, unaffordable food prices, or the collapse of rural livelihoods, migration often becomes a survival strategy. Families may send one or more members to urban centers or abroad in search of income and stability. In rural agricultural societies, where climate change, droughts, and conflict further strain access to food, migration decisions are increasingly shaped by the urgent need to secure basic nutrition.

However, the relationship operates in both directions. Migration itself can create new layers of vulnerability. Migrants frequently encounter unstable jobs, legal uncertainties, and limited social protection, especially in host countries where labor markets are informal or discriminatory. These conditions can deepen food insecurity for migrants, who may struggle to meet daily food needs despite earning wages. Simultaneously, households left behind often depend on remittances for survival. If migrants face exploitation, unemployment, or rising living costs, the flow of remittances becomes unpredictable, increasing the food insecurity of families who rely heavily on this income.

The cyclical nature of food insecurity and migration has broader implications for development policy and humanitarian planning. A failure to address root causes such as climate vulnerability, poverty traps, land degradation, and weak social safety nets can accelerate displacement and destabilize communities. Understanding this bidirectional relationship is therefore essential for designing integrated responses that reduce forced migration, enhance resilience, and promote sustainable livelihoods. Effective solutions must combine social protection, climate adaptation, rural development, and migrant support systems to break the cycle and ensure long-term food security for both migrants and their families.

Food Insecurity as a Driver of Migration

Food insecurity is emerging as one of the most powerful and immediate triggers of human mobility across the world, especially in regions where livelihoods depend heavily on climate-sensitive agriculture. In Central America's Dry Corridor, which includes parts of Honduras, Guatemala, and El Salvador, years of drought, erratic rainfall, and economic fragility have pushed millions into chronic hunger. According to the World Food Program (2023), nearly half of food-insecure households in Honduras and Guatemala now have at least one member considering migration, a dramatic rise compared to previous years. This illustrates how, when daily survival becomes uncertain, migration turns from an option into a necessity. Families often resort to distress strategies such as selling land, livestock, or work tools, taking on high-interest loans, or pooling community resources to cover migration costs. These decisions may secure short-term hope, but they also increase long-term vulnerability if migration attempts fail or lead to exploitation. The risks are particularly high for indigenous communities, who face structural inequalities, limited access to markets, and higher exposure to violence along migration routes.

A similar trend exists in Sub-Saharan Africa, where food insecurity is both widespread and worsening. Analysis of Gallup World Poll data shows that increases in food insecurity correlate strongly with increases in the desire to migrate by as much as 7% for every standard deviation rise in the Food Insecurity Experience Scale (Rigaud et al., 2023). However, this region also demonstrates the stark "aspiration–action gap." The households most affected by hunger often cannot afford to migrate, despite wanting to. Irregular migration routes to Europe, for example, can cost over $5,000 (IOM, 2024), a sum far beyond the reach of most rural households. As a result, the very people who suffer the most severe hunger are often trapped in place, unable to escape deteriorating conditions. This immobility represents a hidden crisis, one where hunger not only drives the desire to migrate but simultaneously prevents people from acting on that desire, leaving them increasingly vulnerable as conditions worsen.

The Persistence of Food Insecurity After Migration

Food insecurity often remains a persistent challenge long after individuals leave their home countries, even when they resettle in high-income nations. Refugees and asylum-seekers are among the most vulnerable groups globally, and research increasingly shows that migration does not automatically translate into improved nutritional well-being. A 2023 meta-analysis published in *The Lancet* reported that food insecurity among refugees in

Europe and North America ranges from 40% to 80%, levels dramatically higher than those experienced by host populations. This underscores that the migration journey, although intended to escape scarcity, can lead to new forms of deprivation and nutritional instability.

Economic constraints are a major contributor. Many migrants face prolonged periods of unemployment or are restricted to low-wage, precarious jobs due to legal barriers, language limitations, or difficulties transferring professional credentials. These economic barriers make it difficult to afford healthy and diverse diets in countries where the cost of living, especially housing and food, is significantly higher than what migrants were accustomed to.

Acculturation stress further complicates the situation. Migrants must navigate unfamiliar supermarkets, food labels, and dietary norms, often without adequate linguistic or cultural support. A study on Syrian refugees in Germany found that limited access to culturally familiar foods not only reduced dietary diversity but also contributed to heightened anxiety and depression (Borg et al., 2023). The inability to maintain traditional diets can disrupt family dynamics, cultural identity, and overall well-being.

Another emerging concern is the "food insecurity–obesity paradox." Migrants facing economic pressures often rely on inexpensive, calorie-dense, ultra-processed foods common in high-income countries. This increases the risk of obesity, type 2 diabetes, and cardiovascular disease conditions less prevalent in their home countries (Nicolas et al., 2024). Thus, even when caloric intake improves, nutritional quality may deteriorate.

These overlapping challenges illustrate that migration does not end the struggle for food security; instead, it often reshapes it in complex ways. Addressing these issues requires targeted social policies, culturally sensitive food assistance programs, and integration support that recognizes food as central to both physical health and cultural belonging.

Health Impacts and Structural Vulnerabilities

The intersection of food insecurity and migration produces profound consequences for both physical and mental health, particularly among already vulnerable populations. Numerous studies have shown that migrants experiencing food insecurity are at significantly higher risk of developing mental health conditions. According to Elgar et al. (2021), food-insecure migrants report elevated levels of depression, anxiety, and post-traumatic stress disorder, a result of both pre-migration trauma and the cumulative stress of navigating new environments with limited resources. The psychological burden is often intensified by social isolation, language barriers, discrimination, and uncertainty about legal status, all of which compound the impact of food-related hardship.

Children are disproportionately affected by these structural vulnerabilities. Research by Fazel et al. (2022) reveals that refugee children from the Middle East and North Africa resettled in the United States exhibit higher rates of stunting, anemia, and developmental delays compared to native-born children. These outcomes stem from disrupted early-life nutrition, prolonged exposure to conflict, and inadequate access to appropriate food during displacement and resettlement. Poor nutrition during critical growth periods can result in long-term cognitive and physical impairments, limiting educational attainment and future livelihood opportunities.

Structural factors also shape who can migrate in the first place. Social capital, particularly diaspora networks, plays a significant role in reducing the financial and informational barriers to migration. Evidence indicates that having family or community members abroad can increase the likelihood of migration by more than 15%, as these networks help with initial settlement costs, job searches, and housing (Rigaud et al., 2023). Conversely, individuals without such support remain "immobile," trapped in contexts of extreme food insecurity but unable to migrate due to the high financial and logistical barriers. This creates a structural divide in which the most food-insecure populations are often the least able to seek safety or opportunity elsewhere.

Toward Integrated Policy Solutions

Addressing the complex relationship between food insecurity and migration requires a holistic, multi-layered policy approach that tackles both the root causes of displacement and the challenges migrants face along their journeys and in their destination countries. At the point of origin, policy efforts must prioritize resilience-building to reduce the pressures that force individuals and families to leave their homes in search of survival. Investments in climate-smart agriculture such as drought-resistant crops, efficient irrigation technologies, and sustainable land management are essential for stabilizing food production in climate-vulnerable regions. Equally important are social protection systems, including targeted cash transfers, school feeding programs, and public works employment, which help households absorb shocks without resorting to distress migration (FAO, 2023). Diversifying rural livelihoods through training, microenterprise support, and rural infrastructure development can further expand economic opportunities and reduce reliance on climate-sensitive sectors.

At the same time, recognizing that migration will continue as a strategy for risk management, governments must expand safe and regular migration pathways. Seasonal agricultural labor agreements, bilateral work contracts, and humanitarian visa programs can create legal avenues that reduce the reliance on dangerous irregular routes and protect migrants from trafficking, exploitation, and abuse. These pathways not only enhance migrant safety but also support labor needs in destination countries, creating a mutually beneficial system.

For migrants who arrive in host countries, integration policies must be comprehensive. Beyond meeting immediate needs such as shelter and emergency food assistance, successful integration requires language training, recognition of skills and qualifications, social inclusion programs, and access to affordable, healthy, and culturally appropriate foods.

Finally, integrated policy solutions must prioritize vulnerable and marginalized groups. Women, indigenous communities, and households caught in prolonged food crises face disproportionate risks and barriers. Policies that incorporate gender and equity lens such as tailored livelihood programs, protection services, and culturally sensitive food support are essential for ensuring that no group is left behind as resilience strategies evolve.

Conclusion

The multidimensional relationship between food insecurity and human migration reveals a deeply interconnected global challenge, one that cannot be effectively addressed through isolated policies or short-term humanitarian interventions. As this analysis demonstrates, food insecurity acts both as a powerful driver of migration and as a persistent consequence for migrants long after they leave their home countries. From climate-hit rural communities in Central America and drought-stricken regions of Sub-Saharan Africa to refugees navigating high-cost food environments in Europe and North America, the cycle of hunger and mobility shapes lives in complex, often inequitable ways.

Crucially, migration does not automatically alleviate food insecurity. Many migrants face new vulnerabilities stemming from precarious employment, cultural barriers, and unstable legal status, while families left behind remain dependent on fluctuating remittances. These interconnected risks highlight the urgent need for integrated and forward-looking policy responses that address both the structural drives of hunger and the lived realities of migrants. Strengthening climate resilience, expanding social protection, creating safe migration pathways, and ensuring culturally sensitive integration support are essential steps toward breaking the cycle.

Ultimately, ensuring food security is not only a matter of agricultural productivity but also of human dignity, social inclusion, and economic justice. By adopting policies that recognize the shared roots of hunger and displacement, governments and global institutions can build pathways toward more resilient communities, safer migration experiences, and sustainable livelihoods for both migrants and the families and societies they support.

References: Borg et al; Elgar et al; Fazel et al; FAO; IOM; Nicolas et al; Rigaud et al; WFP.

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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Empowering Rural Women for Pakistan's Agriculture

Discover how empowering rural women in Pakistan is crucial for its agricultural future. As climate change impacts farming, these resilient women play a vital role in food security and sustainable development, despite facing significant barriers.

Nadeem Riyaz

11/25/2025

In the sun-scorched fields of Sindh and the terraced farms of Khyber Pakhtunkhwa, a critical workforce toils in near-total invisibility. Rural women, whose hands are worn from years of sowing, weeding, harvesting, and tending livestock, form the unacknowledged backbone of Pakistan's agrarian economy. Their labor sustains the soil, preserves indigenous farming knowledge, maintains household nutrition, and keeps the rural economy functioning, yet their contributions remain systematically unrecorded, undervalued, and underpaid. Despite working longer hours than many men in agricultural households, much of their work is categorized as "family help," rendering it invisible in official statistics and in policy formulations that shape agricultural development.

Agriculture is the lifeline of Pakistan's economy, employing 37.4% of the national labor force and contributing 22.9% to the Gross Domestic Product (GDP) (Pakistan Economic Survey, 2023–24). However, this vital sector is under unprecedented pressure. Climate change is intensifying heatwaves, disrupting rainfall patterns, and accelerating the spread of pests and diseases. Simultaneously, Pakistan faces acute water scarcity, land fragmentation, and progressive soil degradation, all of which threaten agricultural productivity and rural livelihoods. In such a fragile landscape, the country's pathway toward food security, climate resilience, and sustainable development hinges on transforming its agricultural practices.

This transformation is impossible without empowering rural women. Women already play a central role in seed preservation, crop diversification, small-scale irrigation, and household-level climate adaptation, yet they often lack access to land ownership, agricultural credit, digital tools, extension services, and formal training. Strengthening their skills, decision-making power, and economic autonomy would not only improve household well-being but also enhance farm productivity and ecological stewardship. Recognizing and investing in the rural women of Pakistan is therefore not just a matter of gender justice, it is a strategic imperative for the country's agricultural sustainability and long-term economic stability.

The Invisible Pillars of Agriculture

Rural women constitute a staggering 50–60% of Pakistan's agricultural labor force (World Bank, 2021), yet their contributions remain largely unseen within formal economic systems. Their involvement spans the entire agricultural value chain, beginning with seed selection and soil preparation and extending through planting, weeding, irrigation, harvesting, post-harvest processing, fodder cutting, livestock care, and water collection. Beyond these tasks, women manage household nutrition, preserve indigenous seed varieties, and often serve as custodians of community-level ecological knowledge. Despite this immense burden of labor, only 4.5% of women in Pakistan legally own the land they cultivate (Pakistan Bureau of Statistics, 2023). This stark gap between contribution and ownership reflects not only gender inequality but also a profound economic inefficiency and environmental oversight.

The Food and Agriculture Organization (FAO) has long emphasized that closing the gender gap in access to resources such as land, credit, extension services, and technology could increase agricultural yields by 20–30% (FAO, 2011). Such improvement could significantly reshape Pakistan's food security landscape at a time when climate change, water scarcity, and soil degradation threaten agricultural productivity. Rural women's unpaid and often unrecognized labor contributes an estimated PKR 680 billion (about USD 2.4 billion) annually to the rural economy (Pakistan Gender Gap Report, 2024), making them indispensable economic actors even though their work rarely appears in policy documents or national accounts.

Furthermore, research shows that when women control household income, they reinvest up to 90% of it into their children's health, nutrition, and education (UN Women, 2022). This creates a transformative multiplier effect that strengthens community resilience, reduces intergenerational poverty, and enhances human development indicators. Empowering rural women is therefore not merely a moral imperative but a strategic pathway to building a more food-secure, equitable, and economically robust Pakistan.

Systemic Barriers and the Climate Change Nexus

The immense potential of rural women in Pakistan is constrained by a deeply rooted system of patriarchal norms, restrictive legal frameworks, and structural neglect within agricultural institutions. Although women perform a majority of on-farm and off-farm labor, they are seldom recognized as farmers. Instead, they are labeled as "helpers," a classification that not only erases their contributions but also excludes them from critical decision-making roles. As a result, rural women face substantial barriers in accessing land titles, agricultural credit, modern farming tools, and government subsidies that are routinely available to men. This marginalization is reinforced by the

alarmingly low literacy rate among rural women, below 45% (UNESCO, 2023), which limits their ability to navigate bureaucratic systems or pursue agricultural entrepreneurship. Compounding the issue is the gender imbalance in extension services: less than 10% of agricultural extension beneficiaries are women (Asian Development Bank, 2022), leaving millions of female farmers without technical guidance or climate-smart training.

The vulnerabilities created by these systemic inequalities are further intensified by climate change. Because rural women are primarily responsible for managing natural resources, collecting water, preparing fodder, saving seeds, and ensuring family nutrition, they are on the front lines of environmental stress. When climate shocks occur, women's workloads expand dramatically as they struggle to secure dwindling resources. The catastrophic 2022 floods, which submerged one-third of Pakistan, devastated rural livelihoods and affected women disproportionately. Many lost livestock, standing crops, stored food grains, and tools essential for home-based food processing. Additionally, displacement increased their caregiving burdens and exposed them to heightened health and safety risks (UNDP, 2023). Thus, climate change not only threatens agricultural productivity but also deepens existing gender disparities, making the empowerment of rural women a central requirement for building climate resilience in Pakistan.

A Blueprint for an Inclusive and Sustainable Future

Creating an agricultural system that truly recognizes and uplifts the role of rural women demands a holistic and forward-looking strategy, one that simultaneously strengthens legal rights, expands technological access, and reforms institutional structures. Legal and economic empowerment form the foundation of this transformation. Provinces must move beyond policy statements and fully implement joint land titling programs so that women gain secure ownership and decision-making power over the land they cultivate. Simplifying inheritance procedures through women-focused facilitation desks would remove major bureaucratic hurdles. Equally important is the introduction of a national "Women for Green Growth" credit line, enabling women farmers to access low-interest loans for climate-smart technologies such as solar-powered irrigation systems, composting units, and small-scale biogas plants. Such tools can reduce labor burdens while enhancing environmental sustainability.

Knowledge and technology transfer is another pillar of inclusive development. Agricultural extension must be redesigned to reach women where they are, not where institutions assume them to be. Setting a national target such as ensuring that at least 40% of extension officers are women by 2030 would help reshape the system. In an increasingly digital era, access to technology is indispensable. A National Rural Women Agri-App offering climate-resilient farming tutorials, weather alerts, and real-time market prices in local languages could dramatically narrow the information gap.

Strengthening market integration is crucial for translating labor into income. Women-only cooperatives in seed production, dairy processing, and organic food chains would formalize their economic participation, especially if supported through tax incentives and guaranteed market linkages. Institutional reforms must accompany these efforts. Ensuring women's representation in farmer organizations, irrigation boards, and provincial agriculture departments, through dedicated Gender and Sustainability Cells, would embed their perspectives into decision-making structures long dominated by men. Finally, data-driven accountability remains essential. A "Gender in Agriculture Index," developed by the Ministry of National Food Security & Research, would track provincial performance and guide evidence-based reforms. Together, these measures offer a transformative roadmap for a more equitable and sustainable agricultural future.

Conclusion

Pakistan's agricultural future depends on recognizing, valuing, and empowering the rural women who form its most resilient yet overlooked workforce. As climate change intensifies and traditional farming systems confront unprecedented ecological stress, rural women continue to hold communities together through their labor, indigenous knowledge, and adaptive strategies. However, their contributions remain constrained by systemic barrier-limited land rights, restricted access to finance, inadequate extension services, and exclusion from institutional decision-making. These gendered inequalities not only diminish women's economic potential but also weaken national efforts to achieve food security, climate resilience, and sustainable rural development.

Empowering women is therefore not an optional social agenda; it is a strategic necessity. Policies that secure land rights, expand credit access, and promote climate-smart technologies can dramatically increase agricultural productivity. Investments in digital literacy, women-centered extension services, and inclusive market structures can unlock new economic opportunities while strengthening household resilience. Equally important is institutional reform that ensures women's representation in agricultural governance, enabling them to shape policies affecting their livelihoods.

By placing women at the center of agricultural transformation, through legal, technological, and structural reforms, Pakistan can cultivate a more equitable, prosperous, and climate-resilient rural economy. The path to sustainable agriculture is undeniably a path led by empowered women.

References: ADB; FAO; Pakistan Bureau of Statistics; Government of Pakistan; Pakistan Gender Gap Report; UNDP; UNESCO; UN Women; World Bank.

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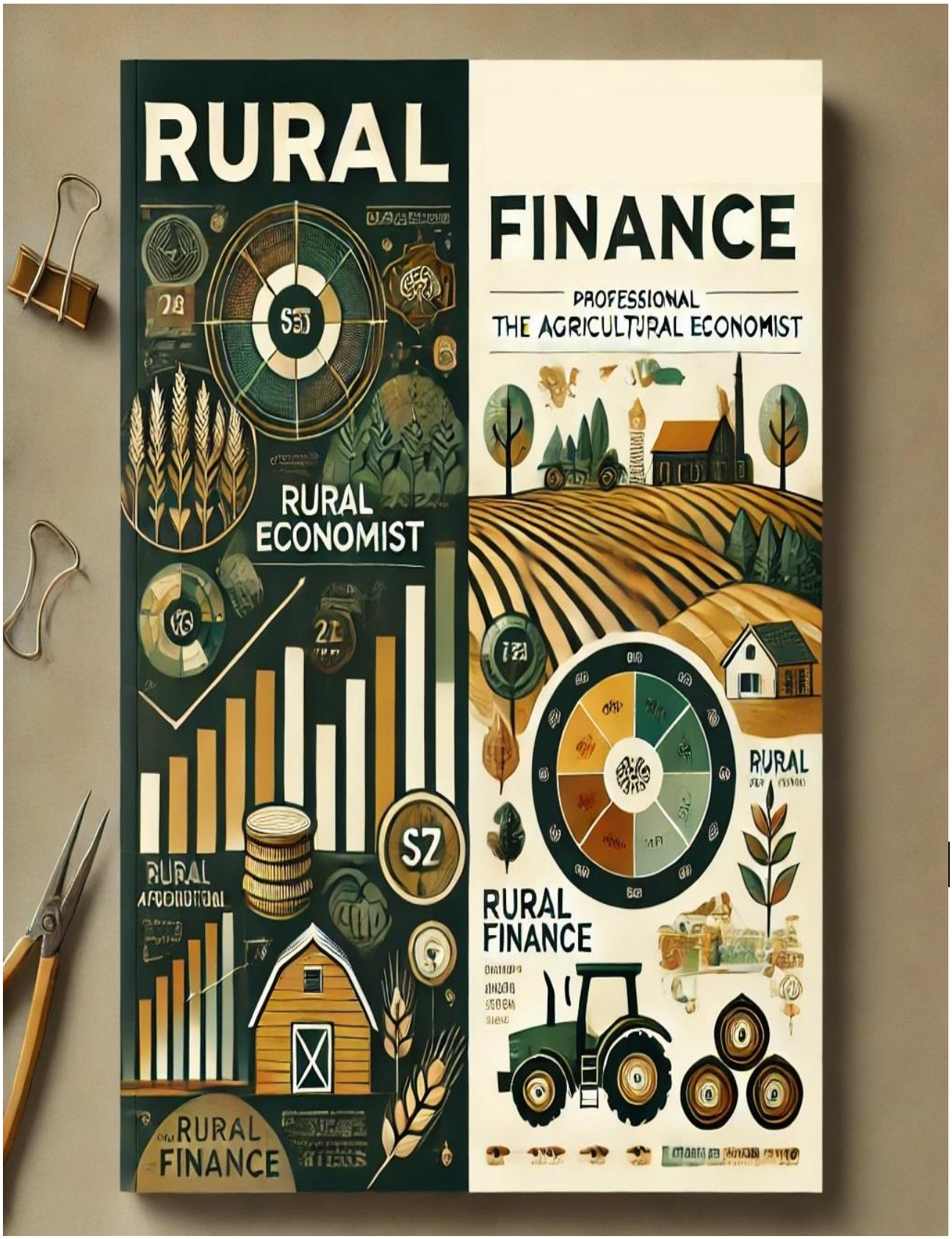

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Building Financial Literacy in Pakistan

Financial literacy in Pakistan requires collaboration among government, academia, and communities. Initiatives like 'Digital Pakistan' and community-based training programs highlight the transformative potential of such partnerships

Jamal Nasir Jarwar

11/3/2025

Financial literacy, the ability to understand and effectively use financial skills such as budgeting, saving, investing, and managing debt, is fundamental to individual empowerment and national development. In Pakistan, the lack of financial literacy remains a significant barrier to achieving economic stability and inclusive growth. According to the *World Bank's Global Findex Report (2021)*, only about 21% of adults in Pakistan possess basic financial knowledge, compared to 24% in India and 34% in Bangladesh. This stark gap limits the ability of individuals, especially farmers and students, to make informed financial choices and to participate effectively in the modern economy.

For farmers, inadequate financial literacy often translates into poor management of farm revenues and expenses, excessive reliance on informal credit sources, and vulnerability to exploitative lending practices. Without a proper understanding of loan terms, interest rates, or investment opportunities, many smallholders struggle to expand productivity or withstand economic shocks. Similarly, students, the future workforce, face challenges in managing educational loans, planning savings, and navigating emerging financial technologies. A lack of early financial education leaves them unprepared for the responsibilities of adulthood and limits their capacity to contribute to Pakistan's evolving digital economy.

Improving financial literacy is not merely an educational reform; it is an economic necessity. Programs aimed at integrating financial education into school curricula, farmer training centers, and digital literacy initiatives can build the foundation for more resilient communities. When citizens understand how to budget, save, and invest wisely, they are better equipped to escape poverty, support entrepreneurship, and drive sustainable development. Therefore, strengthening financial literacy among farmers and youth must be prioritized as a strategic policy goal to ensure inclusive, long-term economic progress in Pakistan.

Financial Literacy and the Resilience of Rural Farmers

Agriculture remains the backbone of Pakistan's economy, employing 37.4% of the labor force and contributing nearly 22.9% to the national GDP (Pakistan Economic Survey, 2023–24). However, the sector faces persistent vulnerabilities arising from climate variability, unpredictable market prices, and fragmented value chains. For rural farmers, especially smallholders, these challenges are worsened by limited financial literacy, which hinders their ability to manage income fluctuations, access affordable credit, or invest in productivity-enhancing technologies. Lacking knowledge of formal financial systems, many farmers turn to informal moneylenders who charge extremely high interest rates. A recent Pakistan Institute of Development Economics (PIDE, 2023) study revealed that about 60% of smallholder farmers depend on informal credit, often paying interest rates that exceed 100% per year. This dependence keeps them trapped in a vicious cycle of debt, poverty, and low productivity.

Building financial literacy among rural farmers can dramatically alter this situation. Through structured training programs, mobile-based learning, and community-level awareness campaigns, farmers can learn to manage finances effectively, understand interest rates, and use formal credit systems wisely. As highlighted by Salman, Rauf, and Murtaza (2024), when financial literacy is integrated with digital access such as mobile banking, digital wallets, and online payment systems it accelerates rural financial inclusion. Their research found that financially trained farmers using digital tools were 40% more likely to save through formal channels and 30% more likely to invest in improved seeds, fertilizers, and farm machinery.

Ultimately, financial literacy fosters resilience among farmers by enabling better risk management, investment in sustainable practices, and long-term planning. By empowering rural households with knowledge and digital access, Pakistan can create a more financially secure and climate-resilient agricultural sector, contributing to national food security and inclusive rural development.

Cultivating Fiscal Responsibility in the Next Generation

University students are the foundation of Pakistan's future economy, yet many lack the knowledge and discipline needed to manage their personal finances effectively. The transition from adolescence to adulthood often coincides with greater financial independence such as managing allowances, tuition fees, and living expenses but without proper guidance, students frequently make poor financial decisions. A recent survey by the State Bank of Pakistan (SBP, 2025) revealed that more than 75% of university students do not keep a budget, while only 15% have any form of savings or investment. This widespread financial unpreparedness leads to excessive spending, unmanageable debt, and delays in achieving economic independence.

In response to these challenges, the State Bank of Pakistan launched the National Financial Education Roadmap 2025–2029, an initiative designed to integrate financial education into school and university programs. The roadmap emphasizes teaching practical skills such as budgeting,

responsible borrowing, understanding interest rates, and basic investment principles. These measures are intended to help young people make informed financial choices, plan their careers wisely, and contribute productively to the national economy.

According to Paradigm Shift (2025), enhancing youth financial literacy not only improves personal financial well-being but also reduces unemployment and stimulates entrepreneurship. Financially educated youth are better positioned to start small businesses, manage risks, and seize investment opportunities. For instance, students who understand credit systems and taxes can make smarter borrowing decisions and develop sustainable business ventures.

Cultivating fiscal responsibility among students thus extends far beyond personal benefit it nurtures a financially aware generation capable of driving innovation, building resilient communities, and contributing to Pakistan's sustainable economic growth. Embedding financial literacy in education today will ensure a more self-reliant and economically empowered Pakistan tomorrow.

Building a Collaborative Framework for a Financially Aware Society

Creating a financially literate society requires a coordinated, multi-stakeholder effort involving government agencies, educational institutions, financial organizations, and community networks. Financial awareness cannot be achieved through isolated efforts; rather, it demands sustained collaboration and innovative delivery methods tailored to diverse audiences. For Pakistan's rural communities, where literacy levels and access to formal financial systems remain limited, leveraging existing local infrastructure is essential. Agricultural extension offices, rural support programs, and cooperatives can host interactive workshops that teach farmers the fundamentals of budgeting, saving, borrowing, and insurance. Integrating these efforts with mobile-based educational tools and regional-language content ensures accessibility, especially for remote populations.

For students, financial literacy should move beyond textbooks. Universities can embed experiential learning through financial simulations, budgeting challenges, and partnerships with banks or fintech companies. Internship programs with microfinance institutions and digital banks can help students understand real-world financial systems, credit mechanisms, and investment opportunities. This practical exposure builds confidence, critical thinking, and responsible money management habits.

The effectiveness of such collaboration is evident in initiatives like "Digital Pakistan", which aims to close the digital gap across the country. According to Karandaaz (2024), over five million new mobile banking accounts were opened in rural areas within a single year, providing a strong foundation for integrating financial education through digital platforms.

A financially aware society is one that can make informed decisions about spending, saving, and investing, thereby fostering economic resilience. When citizens, both farmers and students are equipped with the tools and understanding to manage their finances, they become active contributors to national stability and growth. Through a shared commitment to education and inclusion, Pakistan can build a financially empowered and economically sustainable future.

Conclusion

Financial literacy stands as a cornerstone for Pakistan's journey toward inclusive and sustainable economic development. As this article demonstrates, empowering both farmers and students with financial knowledge can significantly enhance resilience, productivity, and long-term prosperity. For rural farmers, understanding financial principles enables them to move away from exploitative informal lending and adopt smarter budgeting, saving, and investment strategies. When coupled with digital tools, financial education becomes a catalyst for rural transformation, fostering greater participation in formal markets and improving overall agricultural sustainability.

Similarly, cultivating financial awareness among university students is crucial for preparing the next generation of economic leaders. Integrating financial education into academic programs, as envisioned in the State Bank's National Financial Education Roadmap 2025–2029, will equip young Pakistanis with the practical skills to manage money responsibly, reduce debt, and pursue entrepreneurial ventures with confidence.

A financially literate society cannot be built overnight; it requires consistent collaboration among government institutions, academia, financial organizations, and local communities. Initiatives such as "Digital Pakistan" and community-based financial training programs illustrate the transformative potential of such partnerships. Ultimately, widespread financial literacy will not only empower individuals but also strengthen Pakistan's economic foundations laying the groundwork for a more self-reliant, equitable, and prosperous nation.

References: Demirgüç-Kunt et al; Karandaaz; OECD; Government of Pakistan; Paradigm Shift; PIDE; Salman et al; State Bank of 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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Transforming Pakistan's Financial Landscape with Ethical Banking

Explore how ethical banking can reshape Pakistan's financial system towards resilience, inclusivity, and sustainability. Discover the potential of ethical finance to address socio-economic disparities, promote financial inclusion, and align with Islamic finance values and global ESG standards.

Mashooq Ali Khuwaja

11/14/2025

The global financial landscape is undergoing a profound and rapid transformation. In an era characterized by overlapping crises ranging from intensifying climate change to widening economic inequality and declining public confidence in formal institutions, the traditional role of banks as neutral allocators of capital is being fundamentally questioned. A banking model driven solely by profit maximization can unintentionally channel funds toward activities that degrade the environment, exploit vulnerable communities, or deepen structural disparities.

Conversely, a financial system anchored in ethics and social responsibility has the potential to redirect capital toward socially beneficial and environmentally sustainable outcomes. Such a shift aligns banking practices with the broader global agenda of the Sustainable Development Goals (SDGs), fostering a financial ecosystem where economic returns coexist with positive societal impact. For Pakistan, the urgency of embracing ethical banking is particularly pronounced. The country faces a complex combination of structural vulnerabilities, including chronic poverty, financial exclusion, environmental degradation, climate-related disasters, and governance challenges. Ethical banking, grounded in the principles of fairness, transparency, accountability, equity, and long-term sustainability, provides a compelling framework for addressing these intertwined issues. It also aligns naturally with the philosophical foundations of Islamic finance, which emphasizes social welfare, risk-sharing, and the prohibition of exploitative practices. Furthermore, global Environmental, Social, and Governance (ESG) standards are becoming increasingly relevant for countries seeking investment, requiring financial institutions to integrate sustainability considerations into their operations.

This article explores why ethical banking is no longer a theoretical ideal but an urgent necessity for Pakistan. It evaluates the current banking landscape, highlighting gaps in regulatory enforcement, product innovation, and consumer awareness. It also identifies persistent challenges such as limited ESG integration, weak accountability mechanisms, and insufficient financial literacy. Finally, it proposes a strategic roadmap for developing a more responsible, resilient, and inclusive banking system capable of supporting Pakistan’s long-term development aspirations.

Defining the Ethical Banking Paradigm

Ethical banking represents a fundamental shift from viewing financial institutions merely as profit-driven entities to positioning them as agents of societal well-being. It emphasizes that profitability and responsibility are not mutually exclusive; rather, long-term financial stability is strengthened when banks prioritize ethical conduct and social purpose. At its core, ethical banking is grounded in value-based decision-making, where every financial product, investment, and policy is assessed not only for economic returns but also for its broader impact on people and the environment.

Transparency forms the cornerstone of this paradigm. Ethical banks provide customers with clear, accessible, and jargon-free information about financial products, associated risks, and hidden costs. Such openness builds trust and equips individuals, especially those with limited financial literacy with the ability to make informed decisions. Fairness complements transparency by ensuring equitable access to financial services. This includes designing affordable credit products, eliminating predatory lending, and creating mechanisms that protect vulnerable consumers from exploitation.

Financial inclusion is another defining element, particularly in developing countries like Pakistan. Ethical banking prioritizes underserved communities such as women entrepreneurs, smallholder farmers, informal workers, and Micro, Small, and Medium-sized Enterprises (MSMEs). These groups often lack collateral or formal credit histories, yet they form the backbone of local economies. By extending access to finance, ethical banking promotes economic empowerment, reduces inequality, and strengthens resilience.

Sustainability further broadens the ethical mandate. Banks play a pivotal role in shaping development trajectories by deciding which sectors receive capital. Ethical institutions channel investments into renewable energy, climate-smart agriculture, low-carbon transport, and other green initiatives, steering economies toward environmentally responsible growth.

In Pakistan, these principles align naturally with Islamic banking, which emphasizes social justice, shared risk, and the avoidance of harm. However, true ethical banking requires moving beyond procedural Shariah compliance toward achieving real developmental impact. This means ensuring that financial activities genuinely support welfare, equity, and sustainability, reflecting both the spirit and substance of ethical finance.

The Pakistani Context: A Compelling Case for Ethical Finance

Pakistan presents one of the strongest cases for transitioning toward ethical finance, driven by a combination of socio-economic vulnerabilities, environmental risks, and evolving global financial norms. Ethical banking offers a comprehensive framework that not only addresses long-standing gaps in financial inclusion and environmental stewardship but also aligns with national priorities for equitable development and stability.

A major challenge facing Pakistan's financial sector is the persistent exclusion of large segments of the population from formal banking services. Despite recent progress, nearly half of Pakistani adults remain unbanked as of 2023. Low trust in financial institutions, limited awareness, and products that fail to reflect cultural and ethical values, especially in rural communities, continue to drive disengagement. Ethical banking, grounded in principles of transparency, fairness, and accountability, has the potential to bridge this trust deficit. The rapid rise of Islamic banking, now holding over one-fifth of total assets and deposits, illustrates the population's clear preference for value-driven financial solutions. This momentum can be leveraged to expand ethical and inclusive finance more broadly.

At the same time, Pakistan faces acute environmental challenges. Ranked among the world's most climate-vulnerable nations, the country has already experienced devastating climate-related disasters, most notably the 2022 floods that inflicted losses exceeding $30 billion. The banking sector plays a crucial role in shaping environmental outcomes by determining which industries and projects receive financing. By incorporating Environmental and Social Risk Management (ESRM) systems in lending decisions, banks can avoid supporting unsustainable practices while actively promoting climate-resilient agriculture, renewable energy, and green infrastructure. SBP's Green Banking Guidelines provide a strong regulatory foundation for embedding sustainability into mainstream financial operations.

Pakistan's financial system also operates within a rapidly changing global landscape. International investors are increasingly prioritizing sustainability and ethical governance in their investment decisions. By aligning with global ESG standards and demonstrating commitment to responsible banking, Pakistani financial institutions can improve their international reputation, attract foreign capital, and unlock concessional financing from multilateral development organizations. The SBP's mandatory ESRM framework signals Pakistan's readiness to integrate international best practices.

Finally, ethical banking offers a powerful pathway for promoting equitable economic development. By channeling resources toward underserved groups such as small businesses, smallholder farmers, and women entrepreneurs ethical finance can stimulate job creation, enhance productivity, and reduce poverty. Successful microfinance models in Pakistan demonstrate the transformative potential of targeted, inclusive financial services. Ethical banking can build on these successes to strengthen resilience and foster shared prosperity nationwide.

Strategic Recommendations for Advancing Ethical Banking in Pakistan

Ethical banking has evolved from an abstract concept into a strategic imperative for Pakistan's financial sector. As the country navigates climate vulnerability, rising inequality, and a trust deficit in financial institutions, an ethical and sustainability-centered banking model provides a credible pathway to balance economic growth with social justice and environmental protection. By blending the core principles of Islamic finance i.e. fairness, risk sharing, and social welfare with global ESG (Environmental, Social, and Governance) standards, Pakistan can position its banking system at the forefront of responsible finance. Digital innovation further strengthens this shift by expanding outreach, lowering transaction costs, and enabling inclusive financial services for underserved communities.

The transition, however, demands coordinated and sustained action. Regulatory leadership is essential. The State Bank of Pakistan (SBP) must continue enhancing its Green Banking Guidelines and Environmental and Social Risk Management (ESRM) frameworks, ensuring that banks actively assess and mitigate environmental and social risks in lending decisions. Strong enforcement mechanisms, capacity-building programs, and incentives for sustainable finance can help accelerate sector-wide adoption.

Equally important is the commitment of the banking industry itself. Boards and senior management must embed ethical principles into core business strategies rather than treating sustainability as a compliance checkbox. This includes integrating ESG considerations into risk assessment, product development, and performance evaluation. Banks that embrace this shift will be better positioned to attract international capital, strengthen resilience, and build long-term credibility.

Stakeholder awareness is the third pillar of this transition. Customers, investors, and civil society must understand the value of ethical banking and actively support institutions that prioritize fairness, transparency, and sustainability. Public education campaigns, disclosure of ESG performance, and community engagement can help build this culture of accountability.

Ultimately, ethical banking is not only morally sound but economically wise. It strengthens financial stability, enhances public trust, and supports a more inclusive and climate-resilient economy making it essential for Pakistan's sustainable future.

Conclusion

Ethical banking presents a timely and transformative pathway for reshaping Pakistan's financial landscape toward resilience, inclusivity, and sustainability. As the country grapples with widening socio-economic disparities, persistent financial exclusion, and escalating

climate risks, traditional banking models centered solely on profit maximization no longer suffice. The evidence presented in this article highlights how ethical finance, anchored in transparency, fairness, accountability, and environmental stewardship, can directly address these structural challenges. By aligning ethical banking principles with the long-standing values of Islamic finance and emerging global ESG standards, Pakistan can build a financial system that not only supports economic growth but also protects vulnerable communities and natural resources.

The transition toward ethical banking is not simply a moral aspiration; it is a strategic necessity for long-term economic stability. With nearly half the population still unbanked, trust in financial institutions lagging, and international capital increasingly tied to sustainability commitments, Pakistan stands at a critical juncture. Embracing ethical banking provides an opportunity to rebuild public confidence, attract global investment, and ensure that financial flows support sectors that enhance social welfare and climate resilience.

Moving forward, the combined efforts of policymakers, financial institutions, and the public will be essential. Through coherent regulation, institutional commitment, and stronger financial literacy, Pakistan can foster a banking system that serves people equitably while safeguarding the environment. Ethical banking, therefore, offers not only a viable blueprint for a stronger financial sector but also a foundation for a more just, sustainable, and prosperous Pakistan.

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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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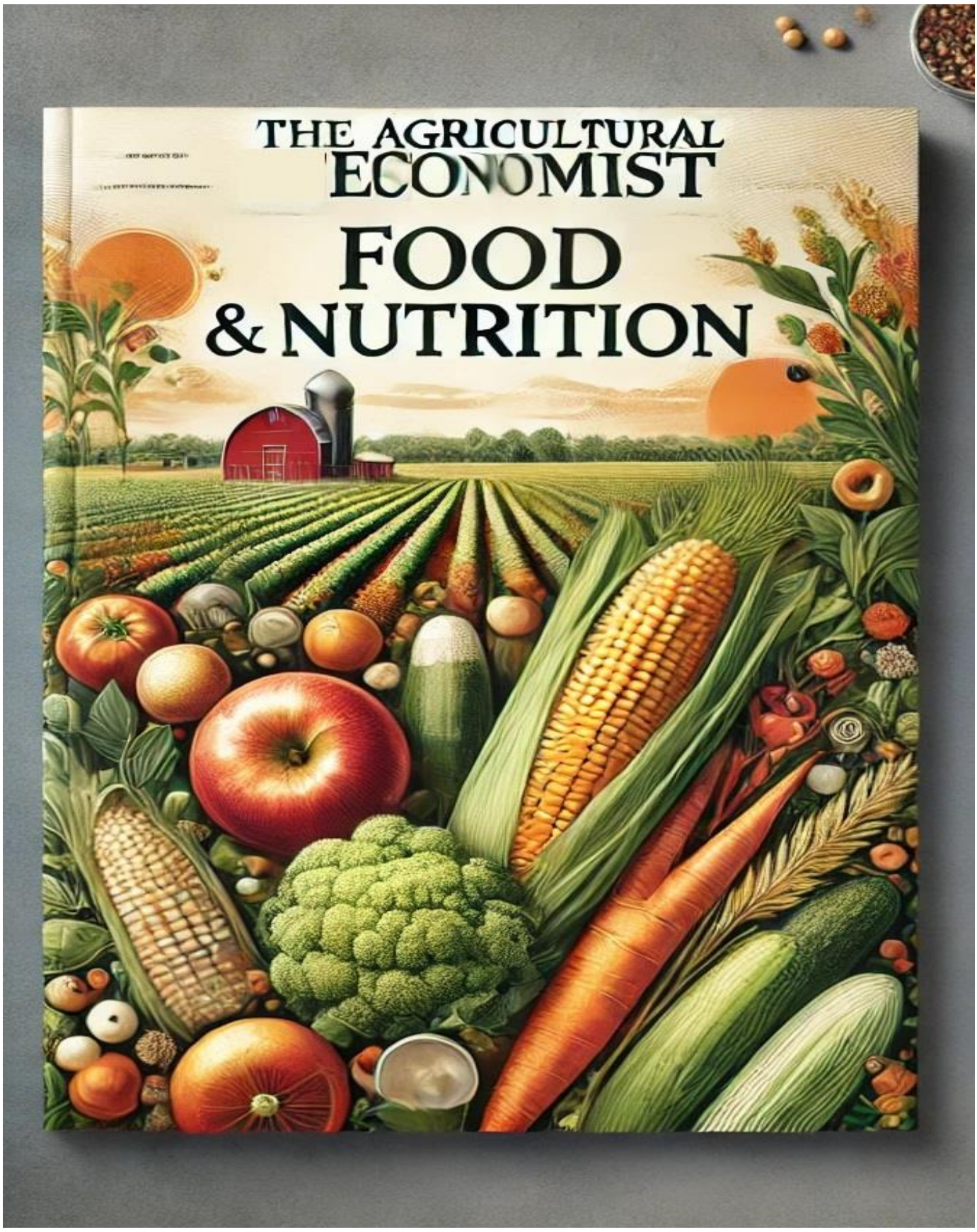

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Global Food Supply Chain: A Critical Crossroads

The global food supply chain faces unprecedented challenges due to climate shocks, pandemics, and geopolitical conflicts. Reports from FAO and WFP highlight the rising food insecurity affecting millions. Explore how interconnected crises threaten food security and global stability.

Ali Ahsan

11/7/2025

Food is a basic human necessity, yet the journey it takes from farms to consumers' tables is increasingly fragile and uncertain. The modern food supply chain, an intricate global network that connects production, processing, transportation, storage, and retail, operates as the backbone of food security. When this system functions efficiently, it ensures that people everywhere can access diverse, affordable, and nutritious food. However, when disrupted, it can quickly lead to shortages, price spikes, and nutritional deficiencies, directly threatening the well-being of millions. According to the Food and Agriculture Organization (FAO, 2008), food security exists only when all people, always, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their dietary needs and preferences.

Recent global events have exposed the fragility of this interconnected system. The COVID-19 pandemic caused major breakdowns in transportation networks, labor availability, and international trade, leading to temporary food shortages and inflation in both developing and developed countries. Meanwhile, climate-related disasters such as floods, droughts, and heatwaves have disrupted harvests, damaged storage facilities, and reduced agricultural productivity. Ongoing geopolitical conflicts, including those affecting major grain-exporting regions, have further intensified food insecurity by restricting global trade flows and driving up input costs like fuel and fertilizer.

This article explores the complex ways in which these disruptions undermine food supply chains and impact global food security. It also examines how nations can strengthen resilience through climate-smart agriculture, digital supply chain management, and regional cooperation in food reserves. Building a sustainable and adaptive food system requires integrated strategies combining innovation, policy reform, and global collaboration to ensure that future generations can enjoy reliable access to safe and nutritious food.

The Interconnected Food Supply Chain

The global food supply chain functions as a tightly interlinked system where each stage depends critically on the next. It begins with production, which involves cultivating crops and rearing livestock to meet domestic and international food demands. This stage forms the foundation of food security, but it is also the most exposed to risks such as extreme weather, pest outbreaks, and rising input costs. The next stage, processing and packaging, transforms raw agricultural output into safe and consumable goods. This step adds value and extends shelf life, yet it requires reliable access to energy, water, and skilled labor resources that can be disrupted during crises.

The storage and warehousing phase ensure the preservation of food quality through controlled environments, including temperature and humidity regulation. Inadequate storage capacity, particularly in developing countries, often leads to significant post-harvest losses, reducing both food availability and farmers' income. Distribution and transportation then link producers to markets across vast distances, relying heavily on fuel, road infrastructure, and international logistics networks. Any disruption such as port closures, trade restrictions, or fuel shortages can create ripple effects throughout the entire food system.

Finally, retail and marketing bring products to consumers through supermarkets, local markets, and online platforms. Price fluctuations, supply shortages, or logistical delays at earlier stages are most visible here, affecting household food access and affordability.

Because these stages are deeply interconnected, failure at any single point can trigger a chain reaction of disruptions. For example, a harvest failure due to drought can reduce processing volumes, raise retail prices, and limit food accessibility for vulnerable populations. Recognizing these interdependencies is essential for building resilient, adaptive, and sustainable food systems capable of withstanding future shocks.

Contemporary Drivers of Supply Chain Disruption

The modern food supply chain faces multiple overlapping crises that threaten its stability and resilience. Among the most critical are climate shocks, which are becoming more frequent and severe. In 2022 alone, extreme weather events caused more than $30 billion in agricultural losses across key producing regions (FAO, 2023). Floods in Pakistan submerged vast croplands and destroyed transportation infrastructure, while prolonged droughts in the Horn of Africa led to crop failures and livestock deaths. These disruptions not only reduce immediate food availability but also damage long-term productivity by eroding soil health and depleting water resources.

Geopolitical conflicts have added another layer of complexity. The Russia–Ukraine war, for instance, demonstrated how localized conflict can have global repercussions. Ukraine, often referred to as the world's breadbasket, saw its grain exports plummet due to port blockades in the Black Sea. This single event sparked a 23% increase in global food prices in

2022 (World Bank, 2022), triggering food insecurity in import-dependent regions such as North Africa and South Asia.

Simultaneously, economic pressures driven by inflation, high fuel prices, and supply chain bottlenecks have reduced consumers' purchasing power. According to FAO (2023), around 3.4 billion people, or 42% of the world's population, could not afford a healthy diet in 2023. For low-income countries, this has deepened malnutrition and widened inequality.

The COVID-19 pandemic further exposed the fragility of global supply systems. Lockdowns caused severe labor shortages, border delays, and logistical breakdowns. Farmers faced the painful irony of wasted harvests due to transport restrictions, while urban consumers struggled with empty shelves and price surges. These combined factors reveal that food supply chains are no longer merely economic systems they are vital lifelines vulnerable to global instability, demanding urgent adaptation and resilience-building measures.

Impacts of Disruption on Food Security

The cascading disruptions across global food supply chains have far-reaching consequences for food security, affecting every dimension i.e. availability, access, utilization, and stability. Reduced availability and soaring prices are among the most immediate effects. When key production or trade hubs are disrupted, supply tightens, shelves empty, and food inflation escalates. In March 2022, the FAO Food Price Index reached its highest recorded level, driven largely by the Ukraine conflict and energy price shocks (FAO, 2022). For import-dependent countries like Pakistan, rising global prices translate directly into higher domestic food inflation and reduced affordability for millions of households.

Massive food loss and waste represent another critical fallout. Perishable goods especially fruits, vegetables, dairy, and meat are extremely sensitive to transport and market disruptions. During the COVID-19 pandemic, widespread restaurant and export closures caused an estimated 20–25% increase in on-farm food waste in developed economies (IFPRI, 2020). In developing nations, weak storage and logistics systems magnified these losses, compounding shortages and price volatility.

These disruptions also lead to a deterioration in dietary quality. As prices rise, consumers shift from fresh and nutritious foods to cheaper, calorie-dense alternatives like refined grains, oils, and processed foods. This contributes to the double burden of malnutrition, where undernutrition coexists with increasing obesity and related non-communicable diseases.

Ultimately, these dynamics have exacerbated global hunger. The World Food Program (2023) reports that the number of people facing acute food insecurity surged from 135 million in 2019 to 345 million in 2023, reversing nearly a decade of progress. The disruptions of recent years reveal that food systems are not merely fragile they are deeply interconnected and vulnerable to compounding crises, underscoring the urgent need for resilient, diversified, and technology-driven global food security strategies.

Conclusion

The global food supply chain stands at a critical crossroads i.e. complex, interconnected, and increasingly vulnerable to multiple overlapping crises. The combined effects of climate shocks, pandemics, and geopolitical conflicts have exposed deep systemic weaknesses that threaten global food security. Disruptions in one part of the world now have immediate ripple effects across continents, impacting availability, affordability, and nutrition. As the FAO (2023) and WFP (2023) reports illustrate, millions more people have fallen into food insecurity in just a few years, highlighting the fragility of current systems.

To safeguard the future of global food security, countries must prioritize resilience-building over short-term efficiency. Investing in climate-smart agriculture, digitalized supply chain management, and regional food storage networks can minimize disruptions and enhance coordination during crises. Similarly, empowering smallholder farmers through improved access to finance, technology, and training will strengthen the foundation of food systems from the ground up. International cooperation is equally vital open trade channels, transparent data sharing, and joint emergency responses can mitigate global shocks before they escalate into humanitarian crises.

References: FAO; IFAD; UNICEF; WFP; WHO; IFPRI; The Guardian; World Bank.

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Addressing Hidden Hunger: A Global Health Crisis

Hidden hunger, driven by micronutrient deficiencies, poses a critical threat to global health and development. This analysis explores its impact on child growth, maternal mortality, and economic productivity, focusing on vulnerable regions like Pakistan. Discover the urgent need for action.

Mahnoor

11/13/2025

While global attention frequently centers on caloric undernourishment and visible forms of hunger, a more silent yet pervasive crisis, hidden hunger, continues to affect billions of people worldwide. Micronutrient malnutrition arises when individuals fail to consume or absorb adequate amounts of essential vitamins and minerals necessary for proper physiological functioning. Unlike overt starvation, hidden hunger can occur even when caloric intake is sufficient, masking its severity and making it harder to detect through conventional indicators such as weight or body mass index. This subtlety renders it one of the most underestimated public health challenges of the 21st century.

The most common deficiencies include iron, vitamin A, iodine, zinc, and folate, each carrying serious health consequences. Iron deficiency is the leading cause of anemia globally, reducing cognitive performance, weakening immunity, and increasing maternal mortality risks. Vitamin A deficiency compromises vision and immune function, leaving children especially susceptible to infections. Iodine deficiency, a key contributor to preventable intellectual disabilities, continues to affect populations in regions where iodized salt is not widely consumed. Zinc deficiency weakens immunity and slows growth, while folate deficiency is directly linked to birth defects and poor pregnancy outcomes.

Hidden hunger disproportionately affects pregnant women, infants, adolescents, and young children, whose nutrient needs are exceptionally high during periods of rapid growth. In low- and middle-income countries, limited access to diverse foods, poverty, monotonous cereal-based diets, and inadequate maternal nutrition compound the crisis. Even in higher-income countries, processed food consumption and unhealthy dietary patterns contribute to micronutrient gaps.

The consequences of hidden hunger extend far beyond individual health. It undermines national productivity, increases healthcare costs, increases susceptibility to disease outbreaks, and perpetuates cycles of poverty. As such, addressing hidden hunger requires integrated solutions including biofortification, dietary diversification, targeted supplementation, food fortification, and maternal-child nutrition programs to ensure that populations receive not just enough food, but the right nutrients essential for lifelong health and development.

Global Prevalence: A Crisis of Scale

The global burden of hidden hunger represents one of the most extensive yet least visible nutrition crises of our time. Despite progress in combating caloric undernourishment, micronutrient deficiencies continue to affect billions, undermining health, productivity, and socio-economic development. Recent international data highlights the alarming scale of this crisis across key micronutrients. Iron deficiency, the foremost cause of anemia, affects an estimated 1.8 billion people worldwide (WHO, 2024). Beyond causing persistent fatigue and weakened immunity, iron deficiency has profound consequences for women of reproductive age, contributing significantly to maternal mortality and increasing the risk of premature and low-birthweight infants.

Vitamin A deficiency remains equally devastating, with approximately 190 million children under five affected globally (UNICEF, 2023). This deficiency heightens susceptibility to severe infections such as measles and diarrhea and is a leading cause of preventable childhood blindness. Iodine deficiency, often overlooked due to its subtle early symptoms, threatens nearly 1.8 billion people (Iodine Global Network, 2023). Inadequate iodine intake can lead to goiter, thyroid dysfunction, and irreversible intellectual impairments in children, reducing educational attainment and future earning potential.

Similarly, zinc deficiency continues to impose a heavy toll, affecting over 30% of the global population. Its impact on immune systems is especially acute, contributing to an estimated 116,000 child deaths each year due to diarrhea and pneumonia (Lancet, 2023). These conditions disproportionately affect children in regions with high rates of poverty, infection, and food insecurity, where diets are often monotonous and low in bioavailable micronutrients.

Importantly, hidden hunger is not limited to low- and middle-income countries. Even in high-income nations, significant pockets of deficiency persist among the elderly, people living in food deserts, individuals relying heavily on processed foods, and those with chronic illnesses affecting nutrient absorption. This global prevalence underscores that hidden hunger is a universal issue requiring coordinated international action, robust public health strategies, and sustained political commitment.

The Challenge in Pakistan: A National Case Study

Pakistan is facing one of the most critical hidden hunger crises in South Asia, with micronutrient deficiencies posing a major threat to public health, economic productivity, and human development.

Recent national assessments show the depth and persistence of the problem. According to the National Nutrition Survey (2023), more than 53.7% of children under five are anemic, largely due to iron deficiency, while 51.5% lack adequate Vitamin A, placing them at heightened risk of infections, impaired vision, and developmental delays. Compounding this, Vitamin D deficiency has reached endemic levels, affecting 62.9% of children and a significant proportion of women of reproductive age. These deficiencies undermine bone health, immune function, and growth, creating long-term health challenges that persist in adulthood.

Among pregnant women, the situation is especially concerning. Studies such as Khan et al. (2023) indicate that over 40% suffer from iron deficiency anemia, a condition linked to maternal mortality, preterm births, and low birthweight infants. These early-life deficiencies perpetuate intergenerational cycles of malnutrition, poor health, and diminished cognitive potential.

The roots of Pakistan's hidden hunger lie primarily in poor dietary diversity. Large segments of the population rely heavily on low-cost staples like wheat and rice, which provide calories but lack essential vitamins and minerals. Widespread poverty and food insecurity severely restrict access to nutrient-dense foods such as fruits, vegetables, pulses, dairy, and meat. Additionally, frequent exposure to infectious diseases exacerbated by inadequate water, sanitation, and hygiene (WASH) conditions reduces nutrient absorption, further intensifying micronutrient deficiencies.

Although Pakistan has implemented food fortification programs targeting wheat flour and cooking oil, challenges in regulation, industry compliance, and quality monitoring have significantly reduced their effectiveness. As a result, the country's micronutrient crisis persists, demanding stronger policy enforcement, improved public health interventions, and greater investment in nutrition-sensitive agriculture and social protection systems.

Root Causes and Consequences: Understanding the Hidden Hunger Crisis

Hidden hunger stems from a complex interplay of structural, environmental, economic, and behavioral factors that collectively undermine nutritional well-being. At its core is the prevalence of monotonous diets dominated by calorie-rich but micronutrient-poor staples such as wheat, rice, and maize. These foods provide energy but lack essential vitamins and minerals, leaving individuals vulnerable to deficiencies despite adequate caloric intake. Poverty and food insecurity exacerbate this imbalance, forcing millions of households to prioritize quantity over quality when purchasing food. With limited financial resources, nutrient-dense items like fruits, vegetables, legumes, dairy, and meat become inaccessible luxuries rather than daily diet components.

Agricultural systems in many low- and middle-income countries compound the issue. Policies and practices often emphasize high yields and staple production rather than nutritional diversity. This narrow focus reduces the availability of micronutrient-rich foods and contributes to significant post-harvest losses, further limiting access. The impact of climate change adds to another layer of vulnerability: extreme weather events disrupt production cycles, while rising temperatures are known to reduce the nutrient density of staple crops such as wheat and rice (FAO, 2023). Poor health and sanitation conditions represent yet another driver, as recurrent infections, intestinal parasites, and diarrheal diseases common in areas with inadequate WASH infrastructure impair the body's ability to absorb and retain nutrients. Additionally, socio-cultural norms and limited nutritional awareness can restrict dietary diversity, particularly for women and children, who may receive smaller or less nutritious portions within households.

The consequences of hidden hunger are profound and span the entire lifespan. Children are among the most severely affected, with deficiencies in iron, iodine, and zinc contributing to stunting, impaired cognitive development, and diminished academic performance, potentially reducing lifetime earning potential by up to 10% (World Bank, 2023). Compromised immune systems make individuals more vulnerable to infections, leading to higher morbidity and mortality, especially among young children. For pregnant women, micronutrient deficiencies elevate risks of maternal mortality, stillbirths, and congenital disorders such as neural tube defects. At the macroeconomic level, hidden hunger undermines national productivity: anemia in adults alone can reduce GDP by as much as 2% in severely affected countries (Global Panel on Agriculture and Food Systems for Nutrition, 2023). Together, these impacts highlight hidden hunger as not only a public health emergency but also a critical development challenge requiring urgent, multisectoral action.

Combating Hidden Hunger: A Multifaceted Approach

Effectively addressing hidden hunger requires a coordinated, multisectoral effort that tackles both the immediate deficiencies and the systemic drivers of micronutrient malnutrition. Central to this approach is the promotion of dietary diversity, which remains the most sustainable pathway to improved nutrition. Nutrition-sensitive agriculture, home gardening, and community awareness campaigns can shift diets away from monotonous staples toward a richer mix of fruits, vegetables, legumes, and animal-source foods. Social behavior change communication is essential to empower households particularly women with the knowledge, skills, and motivation to adopt healthier dietary practices.

Scaling up food fortification provides a complementary, population-wide strategy with proven effectiveness. Fortification of salt with iodine, wheat flour with iron and folic acid, and vegetable oil with vitamins A and D can drastically reduce deficiencies when programs are properly monitored and enforced. For low-income households that rely heavily on processed staples, fortified foods offer an achievable

way to improve micronutrient intake without changing daily consumption patterns.

Another promising strategy is biofortification, which enhances the nutrient content of crops through plant breeding. Biofortified varieties such as zinc-enriched wheat, vitamin A-rich sweet potatoes, and iron-fortified beans provide a sustainable, cost-effective source of essential micronutrients for rural communities (HarvestPlus, 2023). These crops are particularly valuable in regions where access to diverse foods is limited.

Targeted micronutrient supplementation remains critical for vulnerable groups. High-dose vitamin A capsules for young children and iron–folic acid tablets for pregnant women can prevent life-threatening deficiencies during key life stages. However, supplementation must be paired with improved water, sanitation, and hygiene (WASH) conditions to ensure that nutrients consumed are effectively absorbed. Reducing the burden of diarrheal diseases and intestinal parasites directly enhances the impact of nutritional interventions.

Finally, combating hidden hunger requires strong policy support. Governments must integrate nutrition priorities into agricultural, health, and education policies, strengthen regulatory frameworks, and ensure effective monitoring of fortification programs. Public procurement such as school meals and social safety nets should prioritize nutrient-dense and fortified foods. Only through such comprehensive, aligned action can the global community hope to end hidden hunger and secure healthier futures.

Conclusion

Hidden hunger represents one of the most urgent yet overlooked threats to global health and human development. As this analysis demonstrates, micronutrient deficiencies silently erode the well-being of billions, from impairing child growth and cognitive development to increasing maternal mortality and reducing national productivity. The crisis persists across countries of all income levels, but its impact is most severe in low- and middle-income regions such as Pakistan, where poverty, diet monotony, poor WASH conditions, and fragile health systems deepen nutritional vulnerabilities. In such contexts, hidden hunger becomes an intergenerational challenge, trapping families in cycles of poor health, reduced educational attainment, and economic insecurity.

Addressing hidden hunger requires more than isolated nutritional interventions it demands systemic change. Sustainable solutions lie in transforming food systems to prioritize nutrient density, not just caloric sufficiency. Strengthening biofortification, food fortification, and supplementation programs, alongside promoting dietary diversity and improving sanitation, can create meaningful, long-term improvements in population nutrition. Equally essential are policies that embed nutrition into agriculture, health, education, and social protection frameworks, ensuring that the most vulnerable groups including women, children, and the rural poor are not left behind.

Ultimately, combating hidden hunger is not only a public health imperative but a moral obligation. By investing in comprehensive, multisectoral strategies, countries can safeguard future generations, enhance economic resilience, and build healthier, more equitable societies.

References: FAO; IFAD; UNICEF; WFP; WHO; Global Nutrition Report; HarvestPlus; Iodine Global Network; Khan et al; Government of Pakistan; Stevens et al; World Bank.

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Double Burden of Malnutrition in Pakistan

Explore the urgent public health challenge of the double burden of malnutrition in Pakistan, where chronic undernutrition coexists with rising obesity. Understand the factors like poverty, climate stress, and food price volatility that contribute to this nutritional paradox affecting millions.

Sidra Kousar

11/17/2025

The global landscape of malnutrition has undergone a fundamental transformation. For decades, international development efforts centered primarily on combating undernutrition, addressing hunger, micronutrient deficiencies, and stunting in low- and middle-income countries. However, this narrative has shifted dramatically with the rapid rise of overweight, obesity, and diet-related non-communicable diseases (NCDs). Today, countries around the world, including Pakistan, are confronted with the double burden of malnutrition (DBM), the simultaneous presence of undernutrition and overnutrition within the same populations, communities, and even households (Popkin et al., 2020). This paradox reflects the increasingly complex food environments shaped by globalization, rapid urbanization, aggressive marketing of ultra-processed foods, and reductions in physical activity.

The economic implications of this dual crisis are enormous. Childhood stunting still affecting more than 140 million children worldwide has long-term consequences for cognitive development, educational attainment, and adult earnings. The World Bank (2023) estimates that affected countries lose 2–3% of their GDP annually due to diminished productivity and weakened human capital. At the same time, the surge in overweight and obesity is generating an equally severe economic strain. Globally, obesity-related healthcare expenditures, lost productivity, and premature deaths cost an estimated $2 trillion each year, a burden comparable to that of smoking or armed conflict (World Obesity Atlas, 2023).

Pakistan exemplifies this double burden vividly. While millions of children suffer from stunting, wasting, and micronutrient deficiencies, obesity and diabetes are rising at alarming rates. The national economic cost of malnutrition, estimated at $7.6 billion annually or about 3% of GDP, is a stark reminder of its scale (World Bank, 2023). Meanwhile, the country faces one of the fastest-growing diabetes epidemics in the world, with over 33 million adults affected (IDF, 2021). This convergence of undernutrition and NCDs places extraordinary pressure on a healthcare system already stretched thin, undermining progress toward poverty reduction, human development, and long-term economic stability.

Pakistan exemplifies the double burden of malnutrition (DBM) with remarkable intensity, reflecting deep structural inequalities in its food and health systems. The coexistence of widespread undernutrition and rapidly rising overweight and obesity underscores a nutritional landscape marked by contradiction and fragmentation. National Nutrition Survey (2018) data reveal that 40.2% of children under five are stunted, indicating chronic undernutrition that impairs physical and cognitive development. Additionally, 17.7% of children experience wasting, a sign of acute food insecurity and recurrent illness. These figures remain among the highest in South Asia and reflect persistent vulnerabilities tied to poverty, inadequate maternal nutrition, poor sanitation, and limited access to diverse diets.

At the same time, Pakistan is facing an escalating epidemic of overweight and obesity. Recent estimates show that more than 50% of adults are overweight or obese, with women disproportionately affected (NCD-RisC, 2023). This surge is driven by rapid urbanization, lifestyle changes, and a food environment increasingly dominated by ultra-processed, calorie-dense, nutrient-poor products. These foods are often cheaper, more convenient, and more heavily marketed than healthy alternatives, making them a default option for low- and middle-income households. The nutritional transition is further accelerated by declining physical activity, expanding sedentary occupations, and the normalization of sugary beverages and fast foods across all socio-economic groups.

One of the most striking manifestations of this crisis is the intra-household double burden, where an undernourished child and an overweight or obese mother coexist under the same roof (Ali et al., 2020). This phenomenon highlights the deep disconnect between food quantity and diet quality, revealing that access to calories does not necessarily translate into access to nutrients. It also reflects gendered inequalities in food distribution, caregiving responsibilities, and health awareness within households.

Compounding these issues are economic instability, recurrent climate-induced disasters, and rising food prices, all of which disproportionately affect vulnerable populations. As families cope by prioritizing cheaper, filling foods over nutritious options, the cycle of malnutrition, both under and over, continues to intensify.

Gaps in Literature

Despite increasing global attention to the double burden of malnutrition (DBM),

significant research gaps limit the ability of policymakers and practitioners to design effective, evidence-based interventions in Pakistan and similar low- and middle-income countries. One of the most pressing gaps is the lack of life-course evidence. While it is well established that early childhood undernutrition can increase the risk of obesity and chronic diseases later in life, there is limited longitudinal research from South Asian populations that follows individuals across childhood, adolescence, and adulthood. Without such data, policymakers struggle to understand how early nutritional deficits interact with later exposure to ultra-processed foods, sedentary behaviors, and socio-economic pressures.

A second gap concerns the gendered dimensions of malnutrition, particularly the disproportionately high rates of overweight and obesity among women in Pakistan. Existing evidence points to sociocultural norms, restricted mobility, heavy domestic burdens, and limited access to recreational facilities as contributing factors. However, comprehensive studies that unpack these dynamics in rural versus urban settings, or across income groups, remain inadequate. This limits the development of targeted interventions that address women's unique vulnerabilities.

Another critical shortcoming lies in integrated nutritional monitoring. Pakistan's existing surveillance systems tend to measure undernutrition indicators such as stunting and wasting, while data on overweight, obesity, and diet-related NCDs receive far less systematic attention. The absence of sub-national, regularly updated databases that track both forms of malnutrition simultaneously makes it difficult to monitor trends, identify hotspots, or evaluate the effectiveness of programs.

Finally, psychosocial drivers of dietary behavior, especially among youth, are insufficiently explored. The influence of mental health stressors, aggressive marketing of unhealthy foods, digital media exposure, and shifting aspirations on food choices is poorly documented. Without understanding these behavioral determinants, nutrition interventions risk oversimplifying the complex environment shaping young people's diets.

Global Stance and the Rise of "Double-Duty Actions"

The global response to the double burden of malnutrition (DBM) reflects a growing awareness that undernutrition and overnutrition are not isolated challenges, but interconnected outcomes of the same dysfunctional food and health systems. Recognizing this complexity, international organizations such as the World Health Organization (WHO) have championed the concept of "double-duty actions" strategies that can address both forms of malnutrition at once. These interventions maximize impact by leveraging shared drivers and overlapping pathways. For example, promoting and protecting breastfeeding not only reduces infant mortality and stunting, but also lowers the risk of childhood obesity and related chronic diseases later in life. Similarly, fiscal measures like Mexico's sugar-sweetened beverage tax, which successfully reduced consumption by 7.6% within two years (Colchero et al., 2017), demonstrate how economic levers can reshape dietary patterns at a population level.

Global frameworks continue to reinforce this integrated approach. Pakistan's participation in the Scaling Up Nutrition (SUN) Movement since 2013 reflects a national commitment to multi-sectoral action, bringing together government, civil society, and development partners. The 2021 UN Food Systems Summit further emphasized the need to realign agricultural, trade, and food policies with nutrition-sensitive outcomes, stressing that food systems must nourish people rather than simply supply calories.

Understanding the root causes of DBM is essential for designing these effective, dual-purpose interventions. In Pakistan, the drivers form a "perfect storm" of biological, economic, and social factors. Early-life undernutrition primes the body for rapid weight gain later a phenomenon explained by the "thrifty phenotype" hypothesis. This vulnerability is amplified by increasingly obesogenic food environments, where ultra-processed, high-calorie foods are widely available, heavily marketed, and often cheaper than nutritious alternatives. Rapid urbanization has further constrained opportunities for physical activity, while shifts in work and lifestyle patterns promote sedentary behaviors.

Cultural perceptions also play a role, with larger body size sometimes equated with prosperity or good health, slowing recognition of obesity as a major health concern. Meanwhile, fragmented health systems, designed historically to fight infectious diseases or, more recently, non-communicable diseases (NCDs), struggle to deliver integrated preventive nutrition services.

New Strategies for a New Challenge

Addressing the double burden of malnutrition (DBM) requires a fundamental shift from isolated, single-issue interventions to holistic and interconnected strategies. Because undernutrition and overnutrition share many underlying drivers, including poverty, weak food systems, and inadequate health services, solutions must be designed to work across sectors and create benefits at multiple levels of society. One of the most effective approaches begins with strengthening maternal and child health (MCH). Proven interventions such as exclusive breastfeeding for the first six months of life, micronutrient fortification, and balanced protein-energy supplementation have long-term benefits, reducing the risk of both stunting in early childhood and obesity or metabolic disorders later in life. Evidence shows that early-life nutrition sets the foundation for future health, making MCH a critical entry point for double-duty policies.

Creating healthier food environments is equally vital. Fiscal tools such as taxes on sugar-sweetened beverages and subsidies for fruits, vegetables, and other nutrient-rich foods can shift consumer behavior

on a large scale. Complementing these policies with strong regulations such as front-of-package warning labels and restrictions on marketing junk foods to children helps reshape dietary choices and protect vulnerable populations from the influence of unhealthy food marketing. Social protection programs also play a transformative role. Pakistan's Ehsaas Nashonuma initiative illustrates how conditional cash transfers linked to health and nutrition counselling can improve diet diversity and maternal-child health outcomes in low-income households.

Strengthening and integrating health systems is another key strategy. Frontline health workers must be equipped to address both undernutrition and obesity, offering screening, counselling, and referrals for NCD prevention within primary healthcare settings. Finally, tackling DBM requires strong multisectoral governance. Effective coordination between health, agriculture, finance, education, and social protection ministries ensures that national policies are aligned and nutrition sensitive. Together, these new strategies form a comprehensive blueprint to confront a complex nutritional landscape and build a healthier, more resilient population.

Conclusion

The double burden of malnutrition (DBM) presents one of the most urgent and complex public health challenges of our time, and Pakistan stands at its epicenter. The coexistence of chronic undernutrition and rapidly rising overweight, obesity, and diet-related non-communicable diseases reflects deep structural weaknesses in the food, health, and economic systems. This article has highlighted how poverty, climate stress, food price volatility, and aggressive penetration of ultra-processed foods intersect to create a nutritional paradox that affects millions across the country. The intra-household double burden where undernourished children and overweight adults live side by side captures the profound disconnect between caloric intake and true nutritional well-being.

Addressing this crisis demands integrated, evidence-based action. Global momentum around "double-duty actions" offers a powerful opportunity to design interventions that can reduce both stunting and obesity simultaneously. At the national level, Pakistan must prioritize investments in maternal and child nutrition, regulate unhealthy food environments, enhance social protection programs like Ehsaas Nashonuma, and strengthen primary healthcare to address undernutrition and NCD risks together. Equally important is the need for improved data systems and gender-sensitive research to fill critical knowledge gaps.

References: Ali et al.; Colchero et al; Heidkamp et al; IDF; NCD-RisC; Government of Pakistan; Popkin et al; Raza et al; World Bank; WHO; World Obesity Federation.

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Plant-Based Diets: Opportunities and Challenges

Explore the global rise of plant-based diets and their impact on public health, environmental sustainability, and nutrition equity. Learn how to ensure nutritional adequacy while enjoying the benefits of reduced chronic disease risks and environmental footprints.

Palwasha Gul

11/20/2025

The global shift toward plant-based diets marks one of the most significant transitions in contemporary food consumption, reflecting a collective response to rising concerns about health, environmental sustainability, and animal welfare. Once considered niche, plant-based eating is now increasingly mainstream. According to recent market projections, the global plant-based food industry is expected to grow from USD 44.2 billion in 2024 to USD 95.5 billion by 2029, underscoring rapid consumer adoption and expanding investment in plant-based alternatives (Fortune Business Insights, 2024). This surge is fueled by growing awareness of the health advantages associated with plant-forward diets, including reduced risks of cardiovascular diseases, obesity, type 2 diabetes, and certain cancers.

At the same time, plant-based diets offer substantial environmental benefits. Research indicates that shifting from animal-based to plant-based eating can reduce diet-related greenhouse gas emissions by 29–70%, conserve land, and decrease water use (Poore & Nemecek, 2018). However, the accelerating popularity of plant-based diets raises an important public health question: Is this dietary transition nutritionally adequate and equitable for all populations? While plant-based diets can be nutrient-rich when appropriately planned, they may also pose risks of deficiencies in key micronutrients such as vitamin B12, iron, calcium, zinc, iodine, and omega-3 fatty acids especially in low-income settings where fortified foods and supplements are less accessible. Children, pregnant women, older adults, and individuals with limited dietary diversity may face higher vulnerability if plant-based diets are adopted without proper guidance.

Beyond biological nutrition, plant-based dietary patterns are shaped by socioeconomic realities. Affordability, cultural food norms, geographic accessibility to diverse plant foods, and the availability of fortified options all determine whether populations can meet their nutrient needs. Additionally, disparities in food literacy and inequitable food environments may exacerbate nutritional gaps.

Therefore, ensuring the safe and equitable adoption of plant-based diets requires robust policy interventions—including food fortification programs, subsidies for nutrient-dense plant foods, clear dietary guidelines, and public education campaigns. This article explores these dimensions in depth, offering a comprehensive evaluation of the nutritional adequacy of plant-based diets and the policy frameworks needed to support healthy, inclusive dietary transitions.

Understanding Nutritional Security in a Plant-Based Context

Nutritional security, as defined by leading global frameworks, goes far beyond the simple availability of food. It encompasses continuous access to safe, affordable, diverse, and culturally acceptable foods that meet an individual's dietary needs for growth, health, and an active life. In the context of plant-based diets, this concept becomes even more nuanced. The Food and Agriculture Organization (FAO) highlights that nutritional security requires attention not only to the quantity of food but also to its utilization, including nutrient absorption, bioavailability, and overall diet quality (FAO, 2023). This means that a plant-based diet must be evaluated not solely on what it includes but on how effectively the body can use the nutrients it provides.

To be considered nutritionally secure, a plant-based dietary pattern must deliver a well-balanced macronutrient profile. While plant foods can supply adequate protein, careful selection of complementary sources such as legumes, whole grains, nuts, and seeds is essential to ensure all essential amino acids are met. Similarly, ensuring adequate intake of essential fatty acids, particularly omega-3s, requires thoughtful incorporation of foods like flaxseeds, chia seeds, walnuts, or fortified products.

Equally important is the prevention of micronutrient deficiencies, a challenge commonly associated with poorly planned plant-based diets. Critical nutrients such as iron, vitamin B12, calcium, vitamin D, zinc, and iodine often have lower bioavailability in plant sources due to compounds like phytates and oxalates. Fortified foods and supplementation may be necessary, especially for vulnerable groups such as children, pregnant women, and older adults.

At the same time, plant-based diets provide significant strengths, including high fiber content and an abundance of phytonutrients that support gastrointestinal, cardiovascular, and metabolic health. Thus, achieving nutritional security in a plant-based context requires intentional dietary planning, supportive food environments, and public education to ensure that individuals can meet both their macronutrient and micronutrient needs sustainably and equitably.

Health Benefits and the Evidence Base

A growing body of high-quality scientific research strongly supports the health advantages of well-designed plant-based diets. A major 2023 umbrella review

published in *BMJ Nutrition, Prevention & Health* synthesized results from dozens of global studies and reaffirmed several key benefits. Individuals who follow predominantly plant-based diets have a 23% lower risk of cardiovascular disease mortality (Tong et al., 2023), reflecting the cardioprotective effects of high fiber intake, low saturated fat levels, and abundant antioxidants. These diets are also consistently associated with reduced incidence of type 2 diabetes, owing to improved insulin sensitivity, and lower rates of overweight and obesity, linked to higher satiety from fiber-rich foods and lower overall energy density. Additionally, plant-based diets promote healthier gut microbiome diversity, supporting immunity, mental health, and metabolic function**.**

However, these well-documented benefits are tied primarily to whole-food plant-based dietary patterns, which emphasize vegetables, fruits, whole grains, legumes, nuts, and seeds. In contrast, the rapid rise of ultra-processed plant-based alternatives, such as mock meats and vegan cheeses, introduces new nutritional challenges. Research by Monteiro et al. (2019) warns that ultra-processed foods, whether animal- or plant-based, tend to be high in salt, sugar, saturated fats, and additives, potentially undermining the health advantages traditionally attributed to plant-forward diets.

The Pakistani Context: A Tapestry of Tradition and Transition

Pakistan provides a unique landscape for understanding plant-based nutrition because of its deep-rooted culinary traditions and shifting socioeconomic dynamics. Traditional diets, particularly among low- and middle-income households, revolve around plant-based staples like *daal chawal*, *sabzi*, *roti*, and *chana*. These meals are naturally rich in fiber and plant proteins. Yet, meat and dairy carry cultural prestige and are central to hospitality and celebration, often symbolizing wealth, strength, and status, making the widespread adoption of fully plant-based diets culturally challenging.

Despite the relative affordability of plant foods, Pakistan struggles with a severe nutrition crisis shaped by poverty, poor dietary diversity, and limited awareness. The National Nutrition Survey (2018) shows 40.2% of children under five are stunted, while over 50% face deficiencies in iron and vitamin A. This reflects a crisis not of caloric insufficiency but of diet quality, where micronutrient gaps persist even in predominantly plant-based traditional diets.

Urbanization, Dietary Transition, and the Micronutrient Challenge

Urbanization in Pakistan is reshaping dietary patterns at an unprecedented pace, driving a rapid shift away from traditional home-cooked plant-based meals toward processed, energy-dense, and animal-based foods. As cities expand and lifestyles become more fast-paced, convenience foods often high in sugar, unhealthy fats, and salt are becoming dietary staples. This shift has created a double burden of disease, where long-standing undernutrition persists alongside a growing epidemic of overweight, obesity, and diet-related non-communicable diseases (NCDs). According to the National Nutrition Survey (NNS 2018), 47% of women of reproductive age are overweight or obese, reflecting the deep nutritional imbalance emerging across socioeconomic groups. Simultaneously, diabetes rates continue to surge nationwide, highlighting the need for healthier diets and improved food environments to mitigate both malnutrition and NCDs.

Within this context, plant-based diets offer promising health benefits, but only when implemented with attention to micronutrient adequacy. Vitamin B12 poses the most critical challenge, as it is found almost exclusively in animal-source foods. Evidence from the region underscores the seriousness of this issue; a 2022 study in *Annals of Nutrition and Metabolism* reported that up to 86% of Indian adults had low B12 levels (Shridhar et al., 2022), suggesting similar risks for Pakistani populations. Fortification strategies and supplements are therefore essential for vegan individuals and those consuming minimal animal products.

Iron and zinc deficiencies are also common. Because plant-based iron (non-heme iron) has lower bioavailability and is inhibited by phytates in cereals and legumes, traditional preparation methods such as soaking, sprouting, and fermenting is vital to improving absorption. Pairing iron-rich foods with vitamin C sources such as citrus or tomatoes can further enhance uptake.

For omega-3 fatty acids, plant foods like flaxseeds and walnuts provide ALA, but the body converts only a small fraction into EPA and DHA, which are crucial for heart and brain health. Algal oil supplements are a reliable alternative, though affordability and access remain challenges in Pakistan.

Finally, widespread calcium and vitamin D deficiencies, already prevalent among Pakistani women, could worsen if dairy intake declines without adequate substitutes. Fortified plant milks, sesame seeds, chickpeas, and leafy greens can help fill the gap, but structural interventions such as mandatory food fortification remain essential.

Public Health Policy Recommendations for Safe and Equitable Adoption of Plant-Based Diets

Ensuring that plant-based diets contribute positively to public health in Pakistan requires a coordinated, multisectoral policy strategy that addresses both nutrient adequacy and structural barriers to healthy eating. The first and most impactful intervention is the mandatory fortification of staple foods. Pakistan's experience with iodized salt demonstrates how fortification can reach millions at minimal cost. Expanding this model to include wheat flour fortified with iron, folic acid, vitamin B12, and zinc would tackle widespread micronutrient deficiencies, especially among women and children. The World Health Organization endorses large-scale fortification as one of the most cost-effective nutrition policies for low- and middle-income countries, making it a

vital pillar of plant-forward public health strategies.

Equally important is integrated nutrition education, which should begin early and extend across school systems, community health programs, and mass media. Public messaging must emphasize practical skills such as planning balanced plant-based meals, combining plant proteins for complete amino acid profiles, and employing traditional food processing methods like soaking and fermenting to enhance mineral bioavailability. Empowering households with this knowledge ensures that plant-based eating supports, rather than undermines, long-term health.

To make nutritionally rich plant foods accessible, Pakistan must strengthen local food systems, particularly for legumes, pulses, fruits, and indigenous vegetables. Investments in improved storage, cold chains, and local market infrastructure will reduce seasonal price fluctuations and post-harvest losses, ensuring year-round affordability of nutrient-dense foods.

Finally, targeted policies are needed to protect those at highest risk. Vulnerable groups, pregnant and lactating women, young children, and the elderly, require subsidized supplements (B12 and Vitamin D) and fortified foods delivered through primary healthcare and existing programs like Ehsaas Nashonuma. Prioritizing these groups ensures that plant-based dietary trends do not inadvertently exacerbate existing nutritional inequities, and instead contribute to a healthier, more resilient population.

Conclusion

The global rise of plant-based diets presents both an opportunity and a challenge for public health, environmental sustainability, and nutrition equity. While plant-forward eating patterns offer clear advantages, including reduced risks of chronic diseases and a significantly lower environmental footprint, their benefits can only be fully realized when nutritional adequacy is ensured across all population groups. As this article highlights, plant-based diets are not inherently synonymous with nutritional security. Their success depends on intentional planning, adequate micronutrient intake, access to diverse foods, and supportive policy environments.

In Pakistan, where traditional diets already incorporate many plant-based staples, but micronutrient deficiencies remain widespread, the transition toward healthier plant-based patterns must be guided by strong policy frameworks. Mandatory fortification, nutrition education, investments in local food systems, and targeted protections for vulnerable groups are essential to avoid deepening existing nutrition disparities. Without these interventions, the shift toward plant-based diets may inadvertently widen gaps in micronutrient intake and exacerbate the country's persistent double burden of malnutrition.

Ultimately, plant-based diets hold immense promises for improving health outcomes and reducing environmental pressures. But their success hinges on equitable access, informed choices, and strategic public health support. With the right policies, Pakistan can harness the benefits of plant-based nutrition while safeguarding the wellbeing of all its citizens, building a healthier, more resilient future.

References: CABI; FAO; IFAD; UNICEF; WFP; WHO; Fortune Business Insights; Monteiro et al; National Nutrition Survey; Poore & Nemecek; Shridhar et al; Tong et al.

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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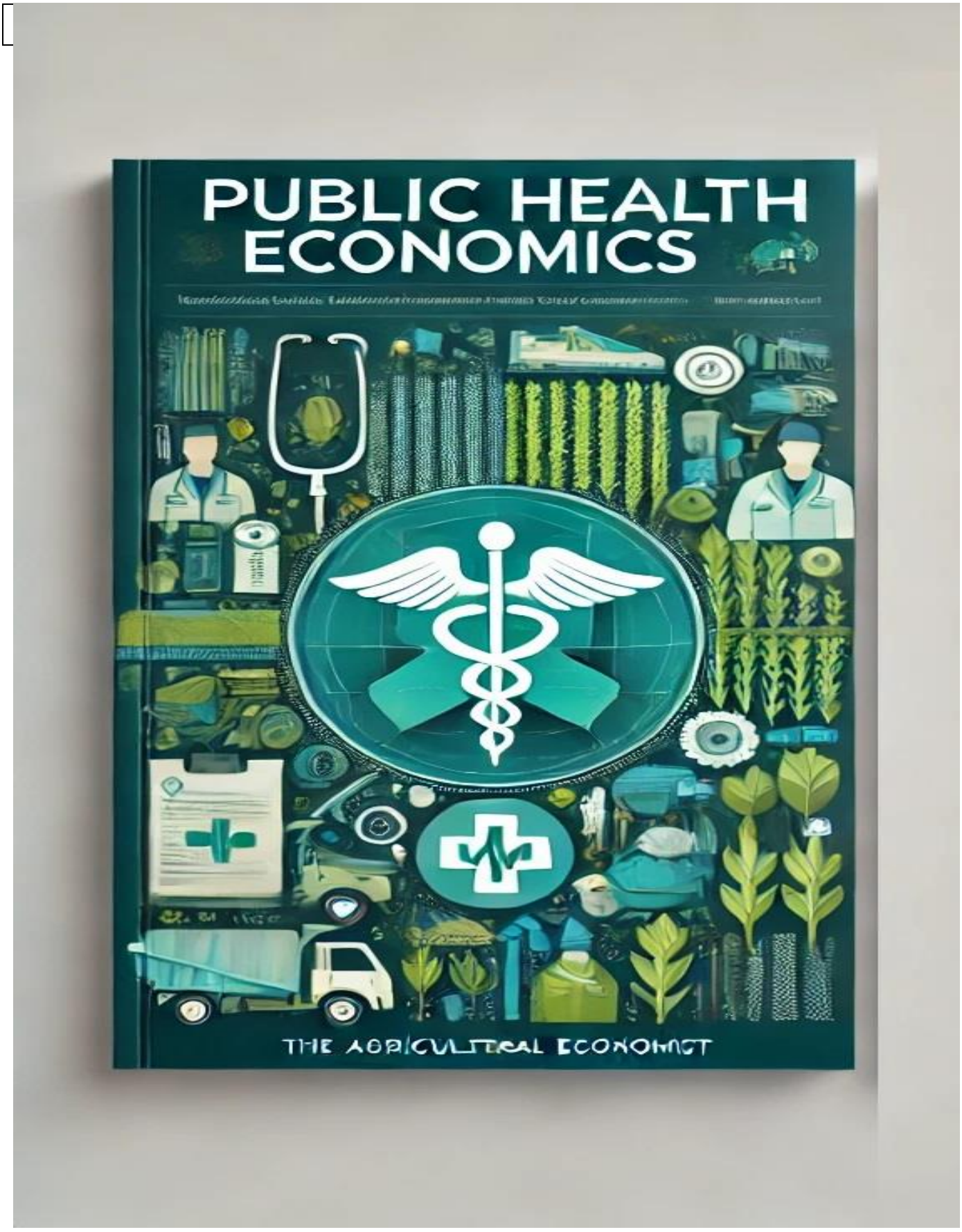

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Global Impacts of Mycotoxin Contamination

Explore the extensive implications of mycotoxin contamination on food safety, human health, agricultural productivity, and trade stability. This article highlights the economic burdens caused by aflatoxins, ochratoxins, and fumonisins.

PUBLIC HEALTH ECONOMICS

Mithat Direk

11/7/2025

Mycotoxins are chemically stable and highly toxic secondary metabolites produced by filamentous fungi, primarily belonging to the *Aspergillus*, *Penicillium*, and *Fusarium* genera. According to the Food and Agriculture Organization (FAO, 2023), nearly 25–30% of the world's crops are contaminated with mycotoxins each year, posing a serious challenge to global food safety and agricultural sustainability. Among the most harmful groups are aflatoxins, ochratoxins, fumonisins, and trichothecenes, each associated with a range of health risks such as liver cancer, kidney failure, immune suppression, and growth retardation in humans and livestock.

Beyond health implications, the economic consequences of mycotoxin contamination are profound. Contaminated grains, nuts, and animal feed often fail to meet international safety standards, leading to the rejection of export consignments and the imposition of costly trade restrictions. This results in reduced incomes, market instability, and higher food prices. The World Bank estimates that developing countries lose billions of dollars annually due to crop rejections and the need for testing, monitoring, and detoxification processes. For smallholder farmers, especially in tropical regions, the lack of awareness, inadequate storage, and limited access to testing facilities exacerbate the problem.

Climate change is now intensifying this threat by altering temperature and humidity patterns that favor fungal growth and toxin production. Rising global temperatures and extreme weather events create new hotspots for contamination, extending risks to regions previously considered safe. Consequently, managing mycotoxin contamination requires an integrated approach combining better agricultural practices, early detection technologies, and international cooperation in food safety standards. This paper consolidates recent evidence on the complex impacts of mycotoxins, focusing on their economic and trade dimensions, and highlights the urgent need for adaptive policies in a changing climate.

The Global Health and Economic Burden of Mycotoxin Contamination

The contamination of the global food supply with mycotoxins represents one of the most persistent and underestimated challenges to both public health and economic stability. These toxic fungal metabolites infiltrate staple crops such as maize, wheat, rice, groundnuts, and animal feed, creating a systemic issue with far-reaching consequences.

From a health perspective, chronic exposure to mycotoxins is a growing global concern. Aflatoxins, the most potent among them, are classified as Group 1 carcinogens by the International Agency for Research on Cancer (IARC). They are directly linked to hepatocellular carcinoma (liver cancer), accounting for an estimated 25,000 to 155,000 deaths each year (IARC, 2023). In addition to carcinogenic effects, prolonged consumption of contaminated food weakens the immune system, hampers nutrient absorption, and contributes to growth impairment and child stunting particularly in low-income countries where dietary diversity is limited. The Global Burden of Disease (GBD) framework has increasingly recognized mycotoxins as a major contributor to disability-adjusted life years (DALYs), reflecting their severe impact on population health.

Economically, mycotoxin contamination inflicts enormous losses on the global agricultural sector. The Food and Agriculture Organization (FAO, 2023) estimates that annual global losses exceed $30 billion due to crop destruction, export rejections, and the costs of monitoring and detoxification. For instance, the European Union's Rapid Alert System for Food and Feed (RASFF) reported in 2022 that mycotoxins were the leading cause of border rejections, especially in nuts, cereals, and dried fruits. Indirectly, contamination drives up healthcare expenses, reduces livestock productivity, and limits farmers' market access. Chronic exposure to fumonisins and deoxynivalenol (DON) in animal feed diminishes efficiency and weight gain, resulting in billions of dollars in annual losses for the poultry and swine industries (Wu et al., 2024). Collectively, these effects demonstrate how mycotoxins undermine global food safety, health, and economic resilience.

Trade and Regulatory Challenges in the Era of Climate Change

The global effort to regulate mycotoxin contamination reflects a necessary but complex balance between consumer safety and trade accessibility. Stringent international food safety standards, particularly those in the European Union (EU), aim to protect public health but often impose heavy burdens on exporters from developing nations. The EU's Maximum Levels (MLs) for mycotoxins are among the strictest worldwide. For instance, the permissible limit for Aflatoxin B1 in animal feed is set at just 0.02 mg/kg, while total aflatoxins in nuts intended for direct human consumption cannot exceed 4 µg/kg, as stipulated by EU Commission

Regulation 2023/915. Compliance with such rigorous standards requires advanced testing facilities, quality control systems, and cold storage infrastructure resources that are often unavailable or unaffordable for smallholder farmers and exporters in Africa and Asia. Consequently, these countries face recurring trade rejections and costly export losses, estimated to reach hundreds of millions of dollars annually (World Bank, 2023). Such trade disruptions not only undermine national economies but also discourage agricultural participation and investment, perpetuating cycles of poverty and food insecurity.

Compounding these regulatory and trade pressures is the growing influence of climate change, which acts as a powerful amplifier of mycotoxin risks. Increasing global temperatures, erratic rainfall, and extended droughts create favorable conditions for toxin-producing fungi, particularly *Aspergillus flavus*, the main source of aflatoxins. Previously temperate regions, including parts of Southern and Eastern Europe, are now facing contamination levels once confined to tropical zones. Recent studies indicate that even a 2°C rise in global mean temperature could potentially double aflatoxin risk in maize crops across Europe (Moretti et al., 2023). This northward shift of fungal prevalence underscores the urgency of climate-resilient agricultural practices, continuous monitoring, and globally harmonized regulations that balance safety with trade equity.

The Case of Türkiye: A Regional Snapshot and Pathways Forward

Türkiye presents an important case study in understanding both the challenges and opportunities associated with managing mycotoxin contamination in agricultural commodities. The country's diverse agro-climatic conditions and strong export orientation make it particularly susceptible to mycotoxin-related risks. Contamination has been documented in key commodities such as figs, pistachios, cereals, and spices products that form the backbone of Türkiye's agri-food exports. The Turkish Food Codex, which closely aligns with European Union (EU) standards, enforces strict Maximum Levels (MLs) for mycotoxins to ensure consumer safety and maintain export competitiveness. Despite these regulatory measures, surveillance data continues to reveal pockets of non-compliance. A 2023 national monitoring report indicated that nearly 8% of maize samples exceeded the permissible limit for total aflatoxins (Turkish Ministry of Agriculture, 2023). These findings underscore persistent vulnerabilities in both pre-harvest management and post-harvest handling, particularly under fluctuating climate conditions that favor fungal proliferation.

A significant gap remains in assessing the national economic burden of mycotoxin contamination. Without comprehensive cost-benefit analyses, policymakers face difficulties in designing and prioritizing mitigation strategies that address both public health and trade dimensions. To move forward, Türkiye needs to adopt a holistic risk management framework encompassing all stages of the agricultural value chain. Pre-harvest interventions should emphasize Good Agricultural Practices (GAPs), resistant crop varieties, and the use of biological control agents such as atoxigenic strains of *Aspergillus flavus*. Post-harvest efforts must focus on rapid drying, improved storage infrastructure, and hermetic sealing technologies to prevent fungal growth. Equally crucial is investment in rapid diagnostic testing, early warning systems, and farmer education. Future research should explore climate-mycotoxin linkages, economic modeling of contamination costs, and affordable, scalable technologies tailored to smallholder farmers, ensuring Türkiye's agricultural sector remains safe, resilient, and globally competitive.

Conclusion

The global and national implications of mycotoxin contamination extend far beyond food safety—they directly influence human health, agricultural productivity, and international trade stability. As this study illustrates, mycotoxins such as aflatoxins, ochratoxins, and fumonisins are not only potent carcinogens and growth inhibitors but also significant economic burdens, causing billions of dollars in annual losses worldwide. Developing nations face the greatest challenges, as limited testing infrastructure, poor post-harvest management, and stringent international regulations restrict their market access and profitability. Türkiye's experience reflects these broader dynamics, revealing that even countries with strong regulatory frameworks continue to struggle with compliance and climate-induced contamination risks.

Moving forward, addressing the mycotoxin challenge requires a multi-dimensional approach integrating science, policy, and practice. Climate-resilient agriculture, improved surveillance systems, and public–private partnerships for technology adoption can significantly reduce exposure risks. International collaboration is equally vital to harmonize food safety standards and support capacity-building in vulnerable regions. Ultimately, ensuring global food security in an era of rising climate variability depends on proactive investments in prevention, education, and innovation. Only through coordinated action can nations safeguard both public health and agricultural trade from the silent but growing threat of mycotoxins.

References: FAO; IARC; Moretti et al; RASFF; Turkish Ministry of Agriculture and Forestry; World Bank; Wu et al.

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 Power of Breastfeeding for Infant Nutrition

Breastfeeding is a vital natural intervention that ensures optimal health and nutrition for infants. It supports brain development, boosts immunity, and reduces chronic disease risks while offering for lifelong well-being.

Kinza Mubben

11/19/2025

The rapid pace of brain development during gestation and the first two years of life, often referred to as the "first 1000 days", is unmatched by any other stage of the human life cycle. During this critical developmental window, billions of neural connections are formed, foundational organ systems mature, and long-term physiological pathways are established. Optimal nutrition during this period is therefore essential not only for ensuring healthy physical growth but also for shaping cognitive development, emotional regulation, immune competence, and metabolic programming. Research shows that inadequate or imbalanced nutrition during these early stages can predispose individuals to lifelong vulnerabilities, including impaired learning capacity, weakened immunity, stunting, obesity, and a higher risk of non-communicable diseases such as diabetes and cardiovascular disorders (Pérez-Escamilla & Moran, 2017; Marshall et al., 2022).

Given the unparalleled importance of this developmental phase, global health authorities emphasize breastfeeding as the gold standard for infant nutrition. Breast milk provides the ideal balance of macronutrients, micronutrients, bioactive compounds, and antibodies that support neurological maturation and immune protection. It reduces the risk of infections, lowers infant mortality, and promotes optimal cognitive outcomes. For mothers, breastfeeding reduces the risk of postpartum hemorrhage, ovarian and breast cancers, and helps strengthen maternal-infant bonding.

Both the American Academy of Pediatrics (AAP) and the World Health Organization (WHO) strongly recommend exclusive breastfeeding for the first six months of life. After six months, nutritionally rich and age-appropriate complementary foods should be introduced while continuing breastfeeding up to two years of age or beyond (AAP, 2022; WHO, 2021). This combined approach ensures that children receive the energy, protein, essential fatty acids, vitamins, and minerals required for sustained growth and brain development. Ultimately, investing in optimal nutrition during the first 1000 days is one of the most powerful strategies for promoting lifelong health, human capital development, and resilience against chronic disease.

The Unique Composition of Human Breast Milk

Human breast milk (HBM) is widely regarded as the gold standard of infant nutrition because of its exceptional and biologically adaptive composition. Unlike formula, which is static, breast milk evolves over time, changing from colostrum to transitional milk and then to mature milk, to meet the infant's changing physiological and developmental needs. Its dynamic nature enables it not only to nourish but also to protect, regulate, and support the infant in ways no artificial substitute can replicate.

HBM is composed of approximately 87–88% water, ensuring that infants remain properly hydrated even in hot climates or during illness. The remaining macronutrients are carefully balanced: around 7% carbohydrates mainly lactose, which fuels brain development and aids calcium absorption; roughly 3.5% fats that provide nearly half of an infant's caloric intake and supply essential fatty acids critical for neural and retinal development; and approximately 1% protein, which is highly bioavailable and easily digestible. Notably, colostrum, the first milk produced, contains significantly higher protein levels (14–16 g/L) compared to mature milk (8–10 g/L), offering newborns concentrated immune protection and growth factors (Lessen & Kavanagh, 2015).

Beyond macronutrients, HBM is a rich source of bioactive compounds that actively shape infant immunity and gut health. Secretory IgA coats the infant's gastrointestinal tract, preventing pathogens from attaching and causing infection. Lactoferrin inhibits bacterial growth, lysozyme destroys harmful microbes, and human milk oligosaccharides (HMOs) serve as prebiotics that cultivate a diverse and beneficial gut microbiome crucial for digestion, immunity, and long-term disease prevention (Wu & Chen, 2009).

Breast milk also contains a spectrum of vitamins, minerals, and hormones. While most vitamins are present in sufficient amounts, vitamin D levels can be low, making maternal or infant supplementation essential (AAP, 2022). Hormones such as cholecystokinin help infants feel full and promote restful sleep, supporting healthy feeding patterns.

Immunological Protection and Long-Term Health Benefits

Breastfeeding plays an unparalleled role in shaping an infant's immediate and long-term health, functioning as both a source of optimal nutrition and a powerful immunological shield. Often described as a baby's "first vaccine," human breast milk delivers a sophisticated blend of antibodies, antimicrobials, and immune-modulating compounds that protect infants during the early months of life when their own immune systems are still immature. These immunological protections are not only passive but actively support the development and regulation of the infant's innate and adaptive immunity, forming a biological foundation for lifelong health.

One of the most critical protective components is secretory IgA (SIgA),

which coats the infant's gastrointestinal tract and prevents harmful pathogens from binding to the gut lining. This front-line defense mechanism significantly decreases the likelihood of infections. Lactoferrin, another abundant protein in breast milk, has strong antibacterial, antiviral, and anti-inflammatory properties, helping to neutralize pathogens and reduce inflammation. These bioactive elements explain why breastfed infants experience far fewer infections. Large-scale global evidence, particularly the landmark Lancet Breastfeeding Series (2016), reveals that breastfeeding can prevent more than half of all diarrhea episodes and nearly one-third of respiratory infections in early childhood, two of the leading causes of morbidity and mortality among infants in low- and middle-income countries.

Beyond infection prevention, breastfeeding offers profound long-term health benefits. Epidemiological studies demonstrate that children who are breastfed have a reduced risk of developing chronic conditions such as asthma, allergic diseases, and both type 1 and type 2 diabetes (Greer et al., 2019). Furthermore, breastfeeding is associated with a lower likelihood of childhood obesity, partly due to better self-regulation of appetite and the presence of hormones like leptin in breast milk. Evidence also shows a protective effect against childhood leukemia, underscoring the broad-reaching biological advantages of human milk (Victora et al., 2016).

The Global and National Landscape: Statistics and Initiatives

Despite decades of scientific consensus on the irreplaceable benefits of breastfeeding, global and national data continue to reveal large gaps between recommendations and practice. Worldwide, breastfeeding rates remain far below the targets established by global health agencies. UNICEF reports that only 44% of infants under six months are exclusively breastfed, far short of the WHO Global Nutrition Target of 50% by 2025. The implications of this shortfall are significant: achieving near-universal breastfeeding could prevent 823,000 deaths each year, primarily by reducing infection-related mortality and improving nutritional status. This makes breastfeeding one of the most cost-effective public health interventions globally (UNICEF, 2018).

In Pakistan, the situation is even more concerning. The National Nutrition Survey (2018) shows that exclusive breastfeeding rates stand at just 37.7%, while only 18% of newborns receive breast milk within the first hour of birth, an evidence-based practice that dramatically improves neonatal survival. Because of suboptimal infant feeding practices, the country continues to grapple with severe nutritional challenges: 40.2% of children under five are stunted, reflecting long-term, chronic undernutrition and signaling deep-rooted structural issues in food security, maternal health, and healthcare access.

Pakistan has introduced several policy and programmatic interventions aimed at improving breastfeeding practices. The Protection of Breastfeeding and Child Nutrition Ordinance seeks to regulate the marketing of formulas and safeguard mothers from misinformation. The country's participation in the Scaling Up Nutrition (SUN) movement underscores its commitment to multi-sectoral action. International partners such as UNICEF, WHO, and Nutrition International collaborate with provincial governments to strengthen counselling services, train healthcare workers, and promote breastfeeding through community campaigns.

Despite these efforts, persistent barriers hinder progress including cultural myths surrounding milk insufficiency, widespread availability and marketing of breastmilk substitutes, limited maternity leave policies, and inadequate support for working mothers. Addressing these bottlenecks requires stronger enforcement of existing laws, investment in mother-friendly workplaces, and sustained community-level awareness to shift norms and empower mothers to breastfeed optimally.

Recommendations for Strengthening Breastfeeding Practices

Improving breastfeeding rates requires more than individual awareness, it demands coordinated, structural, and culturally grounded action across health systems, communities, and policymaking institutions. Breastfeeding is not simply a personal choice; it is a proven, cost-effective public health intervention that safeguards infant survival, promotes optimal growth, and supports maternal well-being. In countries like Pakistan, where child malnutrition and preventable illnesses remain pressing concerns, promoting breastfeeding becomes a national development priority. Strengthening breastfeeding practices must therefore be approached through a comprehensive, multi-sectoral strategy that addresses policy gaps, cultural barriers, and systemic weaknesses.

A critical first step is to enhance enforcement of the International Code of Marketing of Breast-milk Substitutes. Despite its adoption, aggressive and unethical promotion of formulas continues to influence maternal decisions, especially in urban and low-income communities. Strong regulatory oversight, routine monitoring, and penalties for violations are essential to counter misleading marketing that undermines breastfeeding.

Equally important is the enactment of paid maternity leave policies that align with international standards, such as the International Labor Organization's recommendation of at least 14 weeks of paid leave. Many women in Pakistan's informal and private sectors return to work soon after childbirth, lacking the protected time and support needed to establish successful breastfeeding. Comprehensive maternity protection along with breastfeeding-friendly workplaces can significantly improve exclusive breastfeeding rates.

At the community level, expanding counseling and lactation support services is vital. Trained community health workers, midwives, and peer counselors can help mothers overcome practical challenges, build confidence, and dispel pervasive myths surrounding breastfeeding. Integrating breastfeeding counseling into antenatal, postnatal, and routine child health services ensures consistent support throughout the early stages of motherhood.

Finally, sustained national media campaigns are needed to shift social norms and raise awareness about the unmatched benefits of breastfeeding. Addressing misconceptions, engaging fathers and families, and promoting positive cultural narratives can create an enabling environment for mothers. By prioritizing, protecting, and promoting breastfeeding through these coordinated actions, nations invest not only in child health but also in long-term human development, economic productivity, and the overall well-being of future generations.

Conclusion

Breastfeeding stands as one of the most powerful, natural interventions for securing optimal health, nutrition, and development during the earliest and most formative period of life. The evidence throughout this article makes clear that human breast milk is far more than food, it is a biologically sophisticated, immunologically active substance uniquely designed to meet the needs of infants in ways no substitute can replicate. From supporting brain development and strengthening immunity to reducing the risks of infections, chronic diseases, and mortality, breastfeeding lays the foundation for lifelong well-being. For mothers, it offers substantial health benefits, including reduced risks of postpartum complications and certain cancers, while fostering emotional bonding and psychological resilience.

Despite the overwhelming scientific consensus, breastfeeding practices in many countries, including Pakistan, remain far below global recommendations. Structural barriers, cultural misconceptions, inadequate maternity protection, commercial pressures from formula marketing, and limited support systems continue to undermine breastfeeding rates and infant health outcomes. These challenges highlight the urgent need for stronger policies, community-based support, and sustained public awareness that empowers families to make informed decisions.

Ultimately, investing in breastfeeding is an investment in human capital. By prioritizing breastfeeding promotion, protection, and support, nations can improve child survival, reduce healthcare costs, enhance cognitive development, and strengthen societal well-being. The pathway to a healthier, more resilient future begins in the first 1000 days and breastfeeding is at its core.

References: American Academy of Pediatrics; Balogun et al; Greer et al; Lessen & Kavanagh; Marshall el at; Government of Pakistan; Pérez-Escamilla & Moran; UNICEF; Victora et al; WHO; Wu & Chen.

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Understanding Consumer Behavior in Türkiye's Marketplace

Explore the complexities of consumer behavior in Türkiye's rapidly evolving marketplace. Learn how psychological insight, cultural awareness, and technology shape consumer expectations, as businesses adapt to a digitally empowered and socially influenced market.

Mithat Direk

11/22/2025

In today's hyper-connected global marketplace, consumer behavior is increasingly shaped by a complex interplay of psychological motivations, cultural values, economic conditions, and rapidly advancing technologies. Türkiye exemplifies this evolving landscape. As a bridge between Europe and Asia, the Turkish market blends modern digital consumption patterns with deeply rooted traditions, creating a distinctive consumer profile that is both opportunity-rich and highly competitive. For businesses operating in Türkiye, from multinational brands to local SMEs, success now depends on moving beyond transactional selling and adopting system-based strategies that can anticipate and satisfy shifting consumer expectations.

Turkish consumers are digitally empowered, socially influenced, and value conscious. The rapid expansion of e-commerce, accelerated by platforms such as Trendyol, Hepsiburada, and N11, has fundamentally transformed purchasing habits. Meanwhile, rising smartphone penetration and social media usage, particularly among younger demographics, mean that consumer journeys often begin online long before a purchase is made. Simultaneously, economic volatility and fluctuating purchasing power compel consumers to weigh value, trust, and quality more carefully than ever. As a result, businesses must craft holistic strategies that address both emotional and rational drivers of decision-making.

To decode these evolving patterns, three foundational models, Factual, Logical, and Theoretical, serve as indispensable analytical tools. The Factual Model helps firms understand real buying behavior based on empirical data, such as Türkiye's fast-growing adoption of digital payments or preferences for local brands. The Logical Model breaks down the decision-making process, revealing how Turkish consumers compare prices, seek recommendations, and evaluate product benefits. Meanwhile, the Theoretical Model provides insight into deeper cultural and behavioral influences, such as collectivist norms, brand loyalty patterns, or risk perceptions.

Integrating these models with modern tools like the BCG Matrix enables firms to manage product portfolios strategically, identifying high-potential categories aligned with Türkiye's evolving consumer landscape. Together, these frameworks offer a comprehensive roadmap for businesses aiming not just to compete, but to thrive in Türkiye's dynamic and culturally rich marketplace.

The Consumer Decision Journey in Türkiye's Evolving Market

The consumer decision journey in Türkiye is a multi-stage process shaped by cultural norms, digital connectivity, and shifting economic realities. Although the classical five-stage model, problem recognition, information search, evaluation of alternatives, purchase decision, and post-purchase behavior, remains foundational, the Turkish context adds layers of complexity that make the journey far more dynamic.

The process often begins with problem recognition, triggered not only by personal needs but also by strong social influences. In Türkiye's collectivist culture, recommendations from family and friends frequently spark new consumption needs. This moves seamlessly into the information search stage, where Turkish consumers rely heavily on digital platforms. With some of the highest social media usage rates in the region, platforms such as Instagram, TikTok, and YouTube play a critical role. Influencers, micro-influencers, and user-generated reviews on Trendyol and Hepsiburada shape perceptions before the consumer even reaches the evaluation stage.

During the evaluation of alternatives, Turkish consumers balance quality, price, and brand trust. Economic fluctuations and inflationary pressures mean value-for-money assessments have become increasingly rigorous. Local brands, often perceived as cost-effective and culturally aligned, compete strongly with international players.

The purchase decision is also influenced by Türkiye's rapid digital transformation. The rise of mobile wallets, installment-based payments, and same-day delivery services has made online purchasing more convenient than ever. Yet, traditional physical retail, especially in local bazaars and shopping malls, still holds emotional and cultural significance for many consumers.

Finally, post-purchase behavior is highly visible in Türkiye's digital ecosystem. Consumers are active reviewers, frequently sharing experiences on e-commerce platforms and social media. Positive experiences can generate strong brand loyalty, while dissatisfaction spreads rapidly online, shaping the perceptions of future buyers.

Understanding Consumer Purchasing Through Three Foundational Models

Consumer purchasing behavior can be viewed through multiple theoretical lenses, each offering distinct insight into why individuals choose certain products or brands. The Factual, Logical, and Theoretical Models present three complementary perspectives that help businesses understand not only what

consumers do, but how and why they move through the buying journey.

The Factual Model simplifies purchasing into a narrated sequence of events based purely on consumer recall. In this model, the consumer recounts the exact thoughts, emotions, and actions taken during recent purchases such as feeling dissatisfied with an old laptop, searching online for alternatives, comparing models, and finally buying a new one. This retrospective storytelling provides rich qualitative insight into motivations and triggers. However, its limitations lie in heavy dependence on memory accuracy. As Kahneman (2011) explains, human recollection is prone to distortion, rationalization, and selective recall. Thus, what consumers *say* they did may not fully reflect what happened. Nevertheless, in contexts like Türkiye—where social norms influence purchasing, these narratives can still reveal emotional drivers, trust anchors, and cultural cues shaping decisions.

The Logical Model shifts the focus from the narrative sequence to the reasoning behind each choice. It assumes consumers behave as rational problem-solvers evaluating brands, prices, sellers, and payment methods. But in modern markets, especially Türkiye's digitally influenced environment, rationality is blended with behavioral biases. Brand loyalty may arise from repeated exposure to social media rather than objective superiority. Loyalty programs, widely used by Turkish retailers like Migros and Trendyol, further reinforce repeat purchasing. According to Bond's 2023 report, loyalty program members generate 60–80% of many companies' sales, demonstrating the powerful economic logic behind cultivating committed customers.

The Theoretical Model offers the most comprehensive framework, drawing on structured behavioral theories. Models such as the Stimulus-Response framework or the Engel-Kollat-Blackwell system dissect external stimuli, marketing messages, cultural cues, digital trends, interact with internal consumer characteristics. In Türkiye, where cultural identity, price sensitivity, and social media influence are strong determinants, this model helps decode how demographic factors, shifting lifestyles, and digital exposure shape final choices. The "black box" emphasizes that what happens inside the consumer's mind, motivation, perception, learning, cannot be directly observed but can be inferred from responses like brand preference, purchase timing, and retailer selection.

Strategic Application: The BCG Growth-Share Matrix in Modern Portfolio Management

The Boston Consulting Group (BCG) Growth-Share Matrix remains one of the most powerful and enduring tools for strategic portfolio management because it allows firms to translate insights about consumer behavior into actionable resource-allocation decisions. By categorizing products or Strategic Business Units (SBUs) based on two indicators, market growth rate and relative market share, the matrix helps companies determine where to invest, maintain, harvest, or divest. In today's rapidly shifting digital and global marketplace, the BCG Matrix is even more relevant, as product life cycles have shortened and consumer preferences evolve more quickly than ever.

Stars represent products in high-growth markets with strong market share. These offerings carry substantial strategic importance because they shape the company's future leadership. Although they generate significant revenue, they also require heavy investment to sustain growth. Modern examples include NVIDIA's AI chips, which dominate a rapidly expanding artificial intelligence industry.

Cash Cows are the foundation of corporate stability. Operating in mature markets with low growth but high share, these products consistently generate surplus cash. Companies rely on Cash Cows to fund the development of Stars and Question Marks. Microsoft's Windows and Office suites remain classic examples, contributing to reliable cash flow despite limited market growth.

Question Marks, high-growth but low-share products, are the most uncertain category. They exist in attractive markets but have not yet gained dominance. Strategic decisions are critical here, as these products can either evolve into Stars or drain resources. For example, companies in the plant-based meat sector, such as Beyond Meat during 2023–24, operate in a growing market but face fierce competition, making their long-term position unpredictable.

Dogs, characterized by low market share and low growth, typically offer limited strategic value. Although some may break even, they rarely justify ongoing investment, and divestiture is often recommended. Legacy brands that failed to transition into the digital era, such as obsolete DVD rental services, exemplify this category.

In the digital age, where markets shift swiftly and new competitors emerge rapidly, the BCG Matrix has transformed from a static framework into a dynamic decision-making tool, requiring continuous reassessment to ensure alignment with evolving consumer patterns and technological advancements.

Conclusion

Understanding consumer behavior in Türkiye's rapidly evolving marketplace requires a multidimensional approach that blends psychological insight, cultural awareness, economic analysis, and technological adaptability. As Türkiye continues to bridge traditional values with accelerating digital transformation, consumer expectations are becoming more sophisticated, fluid, and interconnected. Businesses that rely solely on transactional strategies risk falling behind in a market where consumers are digitally empowered, socially influenced, and increasingly value conscious.

The frameworks explored in this article, the Factual, Logical, and Theoretical Models, offer powerful lenses through which firms can decode the complex motivations guiding Turkish consumers. When combined with strategic tools such as the BCG Growth-Share Matrix, these models enable companies to make informed decisions about market positioning, product portfolio

management, and long-term resource allocation. In an environment shaped by economic uncertainty, strong cultural norms, and rapid digital adoption, such structured analysis becomes essential.

Ultimately, success in Türkiye's contemporary marketplace depends on a company's ability to translate deep consumer understanding into agile strategy. Firms that embrace data-driven insights, respect cultural dynamics, and adapt proactively to digital behaviors will not only meet consumer needs but also cultivate loyalty, resilience, and sustainable competitive advantage.

References: Bond; Kahneman; Kotler & Keller; Solomon.

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