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From Crisis to Crop Resilience: MNSUAM's 5Gs Framework and the Fight for Pakistan's Food Security

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Pakistan's agricultural export sector is facing a serious crisis, with cotton production declining sharply from a record 14.6 million bales in 1991–92 to around 8 million bales today. The decline has affected export earnings and increased economic hardships among farming communities in southern Punjab and upper Sindh.

Climate change, rising temperatures, irregular rainfall patterns, pest attacks including whitefly and pink bollworm, and declining soil quality have severely impacted cotton production.

Meanwhile, countries such as the United States, China, Australia and Brazil are rapidly adopting biotechnology to develop climate-resilient and high-yielding crop varieties, widening the productivity gap.

To address these challenges, the National Crop Genomics and Speed Breeding Center for Agriculture Sustainability (NCG&SBCAS) has been established at Muhammad Nawaz Sharif University of Agriculture Multan (MNSUAM) under the leadership of Vice Chancellor Prof. Dr. Asif Ali (T.I.).

The advanced research facility aims to transform Pakistan's agricultural sector through genome sequencing, germplasm development, genomic breeding, gene discovery, gene editing and advanced scientific training. Equipped with modern genomics laboratories, bioinformatics

facilities, high-performance computing systems, speed breeding chambers and molecular biology labs, the centre is designed to support climate-smart agriculture.

The centre is working on the innovative "5Gs" framework, which provides a complete roadmap from understanding plant DNA to developing improved varieties for farmers. The five pillars include Genome, Germplasm, Genes, Genomic Breeding and Gene Editing.

Under the Genome pillar, researchers have completed whole genome resequencing of 40 cotton and 16 wheat varieties, creating valuable genetic information for future breeding programmes.

The Germplasm pillar focuses on collecting and studying diverse plant resources. A cotton germplasm database and gene bank containing around 6,000 lines has been developed at MNSUAM to identify valuable genes linked with better productivity and stress tolerance.

The Genes pillar uses advanced technologies including genomics, transcriptomics, metabolomics and phenomics to discover how crops respond to challenges such as drought, heat and disease. These technologies allow scientists to identify superior crop traits faster and more accurately than traditional methods.

Genomic Breeding applies this genetic knowledge to develop improved crop varieties. Advanced molecular markers and genomic selection techniques can significantly reduce breeding time by identifying promising plants at early stages. International experiences show that genomics-based

breeding can improve yield stability and water efficiency under difficult environmental conditions.

The fifth pillar, Gene Editing, uses technologies such as CRISPR-Cas9 to introduce precise genetic improvements. Scientists can enhance desirable traits by modifying specific genes linked with disease resistance, productivity and climate resilience.

Experts believe that the work at NCG&SBCAS represents an important step towards restoring Pakistan's agricultural competitiveness. The initiative aims to bridge the gap between advanced laboratory research and practical farming solutions, particularly for crops like cotton that remain vital to the country's economy.

However, successful implementation will require continued government support, increased research funding, strong public-private partnerships and updated regulatory policies for gene-edited crops.

With sustained investment in agricultural science and biotechnology, Pakistan can strengthen food security, improve export potential and help farmers overcome the growing challenges posed by climate change. The genomics-based approach offers a pathway towards a more resilient and self-reliant agricultural future.

The success of this scientific initiative will depend on translating research achievements into

field-level benefits for farmers. Strengthening collaboration among universities, research institutions, government agencies and private industry will be essential to ensure timely availability of improved seeds and modern farming solutions.

By empowering researchers and farmers with advanced technologies, Pakistan can rebuild its agricultural productivity, enhance exports and create new opportunities in rural economies. The NCG&SBCAS initiative provides a foundation for a long-term strategy to secure the country's agricultural future in an era of environmental uncertainty.

The integration of modern biotechnology with traditional farming knowledge can help Pakistan develop sustainable agricultural practices, reduce dependence on imports and compete more effectively in global markets. Continued innovation, scientific investment and farmer-focused policies will be key to achieving lasting agricultural growth.