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The Importance of Science Diplomacy in Agriculture for the Global South: A Case Study of Pakistan

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Abstract

This paper explores the role of science diplomacy in advancing agricultural development in the Global South, with a focus on Pakistan as a case study. It aims to examine how international scientific collaboration contributes to addressing agricultural challenges such as climate change, food insecurity, and technological inequality. Using a qualitative, document-analysis method, the study reviews official reports from international organizations and academic literature to identify key patterns in the interaction between diplomacy, science, and agriculture. Grounded in Global Governance and Soft Power theories, the paper analyzes Pakistan's historical agricultural evolution, its participation in global research networks, and its partnerships in biotechnology and water management. The findings show that while Pakistan has benefited from projects supported by institutions such as the World Bank and CIMMYT, weak institutional coordination, outdated legal frameworks, and limited research capacity hinder progress. Comparative analysis with India and Brazil highlights how stronger institutional mechanisms and strategic diplomatic frameworks can transform science diplomacy into a long-term development tool. The study concludes that institutionalizing science diplomacy within Pakistan's agricultural and foreign policy frameworks can enhance technology transfer, climate resilience, and food security. It recommends creating coordinated national structures, modernizing biosafety and intellectual property regulations, strengthening monitoring and evaluation systems, and expanding South-South cooperation. Overall, the paper underscores that for countries in the Global South, science diplomacy is not merely a diplomatic choice but a strategic necessity for sustainable agricultural growth and global integration.

***Keywords*:** agriculture, climate change, food security, global south, Pakistan, science diplomacy

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Introduction

Agriculture remains the backbone of many economies in the Global South. It provides jobs for millions of people and contributes greatly to the national income. However, the sector is now facing serious global challenges such as climate change, soil damage, water shortages, pest attacks, and unstable global trade (Cantillo et al., 2021). These interconnected problems are complex and transboundary in nature, making traditional solutions based solely on national policies or local practices insufficient. In response, modern agriculture is shifting toward science-based methods like biotechnology, climate-smart farming, digital agriculture, and precise irrigation systems (Pardey et al., 2016). These innovations offer sustainable pathways to enhance productivity, improve resource efficiency, and build resilience against environmental stress. Still, access to science, technology, and resources is not equal across countries. This gap makes science diplomacy important because it connects science and international cooperation (Gluckman et al., 2017). For countries in the Global South that lack money, infrastructure, and trained experts, science diplomacy helps them gain new technology, build research skills, and strengthen global relationships.

Pakistan presents a relevant case in this context. It is an agricultural country that produces wheat, rice, cotton, and dairy, thus playing a vital role in the regional food system. However, it faces persistent challenges like climate risks, low yields, and poor use of resources (World Bank, 2022). By using science diplomacy, Pakistan can connect with global research programs, access new technologies, and improve its food security. Despite the recognized potential of science diplomacy, there is limited scholarly attention on how it can be effectively utilized to strengthen agriculture in countries like Pakistan. This paper addresses this gap and analyses how science diplomacy supports agriculture, reviews Pakistan's efforts in this area, and compares its experience with other countries in the Global South.

The paper is structured into five parts. The second section presents a literature review, followed by the methodology. The third section offers findings, the fourth section presents discussion, and the last section contains the conclusion and recommendations.

Science Diplomacy in Pakistan's Agriculture

Historical Context

Pakistan's agricultural history is largely divided into periods defined by prevailing economic ideologies and government policies.

The 1950s: Stagnation and Orthodox Foundations

In the 1950s, Pakistan's agricultural sector remained largely stagnant. Economic thinking at the time was heavily influenced by Western theories that emphasized market mechanisms and the importance of capital formation as the basis for market-driven development. The widespread assumption was that agricultural productivity could be considerably enhanced through increased use of physical inputs and reliance on private incentives (Khan, 1981).

The 1960s: Undifferentiated Growth and the Green Revolution

The 1960s witnessed the development of more structured, albeit limited, economic inquiry. The ideology of uniform growth characterized this period, "growth now and distribution later", which received backing from Western economic assistance programs (Khan, 1981, p. 195). The policy during this time period was to provide cheap physical inputs to farmers along with price incentives, so that they would be able to produce more crops. The implementation of Mexican wheat and IRRI rice varieties in the mid-1960s (the Green Revolution) generated a substantial increase in studies concentrating on resource utilization, production levels, and employment effects (Khan, 1981).

The 1970s: Rhetoric Distribution and Policy Backlash

Following political turmoil, the early 1970s brought a global and domestic shift towards "distributive justice with growth" (Khan, 1981, p. 196), reflected in phrases like "growth with distribution" (Khan, 1981, p. 196). The Pakistan People's Party (PPP) government launched a series of reforms, including the 1972 land reform programme, and nationalized private-sector activities to aim for self-efficiency. Following the removal of the PPP government, public policy returned to the technocratic approach, characteristic of the 1960s. Priority was given to providing the supply of physical inputs to the farmers and greater dependence on market mechanisms, accompanied by pricing policies and agricultural advisory services (Khan, 1981).

1988 - 1994: The Post-Zia Transition and Productivity Crisis

The agricultural sector saw measurable growth during this transition, though its importance in the national economy declined. Cotton became almost as important as wheat, accounting for 28 percent of total crop earnings by 1994-95. Growth was achieved largely through expansion rather than productivity gains. During this time, they prioritized market liberalization but pushed the government out of the working of the market (Faruqee, 1999).

The 2000s: The Musharraf Era of Macroeconomic Stabilization

The Musharraf regime focused intensely on fiscal, financial, and trade stabilization to overcome the crisis inherited from the 1990s. The sector benefited indirectly from high overall economic growth but suffered from poor performance toward the end of the period. While the economy was generally expanding, the momentum slowed down in 2007/2008, leading to a parlous state (Husain, 2023).

Zardari Era

After Musharraf was ousted, the 18th amendment was passed where agriculture was devolved to the province level. Moreover, there were floods in 2010 which displaced around 20 million people and wiped out major kharif crops, rice, and cotton (Resnick & Rana, 2017).

Nawaz Sharif's Government

There was notable growth in agriculture during 2013-2014, but in 2015 a severe pest outbreak in cotton crops led to a decline in overall agricultural performance. However, after this setback, the sector recovered steadily. The government introduced farmer-friendly policies such as revised support prices, targeted subsidies, and improved liquidity, which contributed to a late-period rebound in growth (Profit by Pakistan Today, 2018).

Areas of Engagement

Biotechnology & GM Crops: Collaborations with USDA and Private Firms

The Center of Environmental Risk Assessment (CERA), identified as a Washington-based agency, launched a funding program from 2011 to 2014 under the South Asia Biosafety programs. This program funded over 20 projects on risk assessment in Pakistan, and the findings were shared at the

2nd South Asia Biosafety Conference held in 2014. It focused on enhancing risk assessment studies related to Genetically Modified Organisms (GMOs) in Pakistan. This program was part of broader efforts to ensure thorough risk assessment studies conducted before the commercialization of GMOs in Pakistan, especially considering that Pakistan's biosafety rules stress the need for such studies (Babar et al., 2019)

Moreover, the foundational Bt cotton - a genetically modified (GM) cotton variety containing genes from the soil bacterium Becillus thuringiensis (Bt) - (Mon-531), utilized in Pakistan, came from Monsanto, a U.S. based company. This event is significant because it represents the only transgenic crop approved for widespread cultivation in Pakistan. The gene was patented in USA but entered Pakistan through unknown sources. Once available, the gene was used to breed resistance in local cotton varieties. This led to the widespread development and commercialization of various Bt cotton varieties. Pakistani farmers rapidly embraced Bt cotton, and within two years of its introduction in 2005, nearly all cotton-growing areas in the country were planted with this variety (Babar et al., 2019).

Pakistan has actively participated in international research programs such as CIMMYT's 34th Elite Spring Wheat Yield Trial (ESWYT) conducted from 2014 to 2015. The country is part of the global collaborative network established under CIMMYT's Global Wheat Program. CIMMYT provides annual replicated yield trials, including the ESWYT, through a worldwide system of more than 300 collaborators. These trials are mainly distributed to partners in developing nations, notably Pakistan, Egypt, and India. The Global Wheat Program aims to sustainably increase global wheat productivity, resilience, and food security. It does so through the development and worldwide distribution of improved, climate-resilient wheat varieties and related technologies. According to the analysis of the 34th ESWYT, the top-performing wheat lines in Pakistan demonstrated impressive results, producing 35.7% more grain than the benchmark variety Attila and 17.5% more than local varieties (Crespo-Herrera et al., 2017).

Water Management: Joint Projects with the World Bank

A project was launched in Sindh, with the help of the World Bank, called the Sindh Water and Agriculture Transformation Project. The main aim of the project was to increase agricultural water productivity, meaning it focused on increasing the number of crops produced for each drop of

irrigation water used. Productivity improvements are designed to enable farmers to earn more money using the same amount of water, potentially freeing up water for other purposes. The project also includes the renovation of the Akram Wah canal. This upgrade is projected to support around 50,000 farming households by enhancing the reliability of the irrigation water supply within the command area. The project will support small and medium-sized farmers in recovering from the 2022 floods through cash transfers (World Bank, 2022).

The Punjab Private Sector Groundwater Development Project was a significant joint initiative between Pakistan and the World Bank, focusing on agricultural water management in Punjab. The project aimed to rehabilitate and transfer approximately 4,200 public tubewells to farmer organizations. It also sought to reduce water leakage from all types of canals and enhance the efficiency of water distribution across both communal and on-farm watercourses. The project proved successful, as the predicted Economic Rate of Return (ERR) was 23.9%, while the actual ERR reached 29.0%, indicating a strong economic performance (World Bank, 2006).

Another notable project centered on collaboration between the World Bank and Pakistan was the Baluchistan Community Irrigation and Agriculture Project. It was identified as a specialized Agricultural Water Management (AWM) initiative, meaning that over half of its total funding was allocated to irrigation and drainage (I&D) activities. A central objective was the development and improvement of irrigated land, reflected in the planned irrigated area of 4,089 hectares. The project aimed to generate a satisfactory economic benefit, with a predicted Economic Rate of Return (ERR) of 14.0%, while the actual ERR reached 11.4%. Although slightly below expectations, the overall outcome remained economically viable (World Bank, 2006).

Gaps

A considerable gap existed between the planned and actual implementation of financial sustainability measures. Cost-recovery goals were described as overly ambitious and unrealistic due to insufficient social assessment. Many project appraisals included unrealistic timelines for recovering operation and maintenance (O&M) costs, in some cases targeting full recovery within the duration of a single project, typically under seven years. However, most lacked a clear strategy for the gradual

withdrawal of external support as user groups became more established (World Bank, 2006)

Only a few appraisal documents presented a clear strategy for improving water use efficiency, such as through volumetric pricing or controlled supply methods. Most focused, instead, on repairing delivery infrastructure, enhancing cost recovery, and encouraging participation through system handovers. Furthermore, many systems were built around top-down supply management, lacking the equipment and capacity needed to regulate water distribution based on demand through volumetric measurement (World Bank, 2006).

A major systemic weakness across many projects was the inability to effectively measure and report outcomes, which made accountability difficult. Most initiatives lacked rigorous evaluation tools such as clear indicators, strong baselines, and independent control groups, while many had no reliable means to verify project impacts at all. Baseline data were often delayed or never established, as weakly planned monitoring and evaluation (M&E) frameworks led to late or incomplete assessments. Reporting also tended to emphasize physical achievements rather than higher-level impacts on poverty, employment, or social outcomes, leaving important social dimensions under-explored. In addition, economic analyses frequently exclude factors, such as job creation, poverty reduction, environmental effects, and institutional development, often dismissing them as too difficult to quantify. As a result, significant developmental benefits were left unmeasured and under-reported (World Bank, 2006).

Pakistan's capacity to absorb and regulate new agricultural technologies has been limited by weak intellectual property protections and outdated legal frameworks. The country lacks robust mechanisms for formal technology transfer, leading to the informal adoption of innovations without proper oversight or licensing. Seed legislation has historically been slow to evolve, delaying the registration, certification, and regulation of modern biotechnologies. Additionally, restrictive corporate policies and insufficient access to patented materials have further constrained the diffusion of global advancements (Babar et al., 2019).

Literature Review

Defining Science Diplomacy

Science diplomacy is still a concept that is changing, but it can be

applied to science, innovation and technology (The Royal Society, 2010). According to Nina Federoff, science diplomacy is "the use of scientific interactions among nations to address the common problems facing humanity and to build constructive, knowledge based international partnerships" (The Royal Society, 2010, p. 2). Similarly, Ruffini describes science diplomacy as a set of actions at the junction of foreign policy and science. Building on these definitions, the concept is generally understood through three main dimensions: diplomacy for science, science in diplomacy and science for diplomacy (The Royal Society, 2010). For the agricultural sector, these three forms guide how countries collaborate on issues like food security, climate adaptation, plant health, and establishing international standards for trade and biosafety (Fähnrich, 2017).

The Three Dimensions of Science Diplomacy

Science in Diplomacy

It is the idea that international policies and diplomatic decisions should be informed by credible scientific evidence rather than political agendas or intuition. The main goal of science in diplomacy is to guarantee that policymakers effectively use reliable, high-quality scientific evidence in their decision-making processes. Many of the global issues are rooted in science which makes it important for policymakers to understand the underlying scientific principles to make more informed decisions (The Royal Society, 2010).

To achieve the goals of science in diplomacy, the scientific community must fulfill several duties. They should provide policymakers with the latest and most relevant information about the Earth's natural and socio-economic systems. Scientists should not only share what they know but also what they do not know, so that policymakers understand the limits of current evidence. Foreign ministers should draw greater attention to scientific findings and use them when forming policies and strategies. Diplomats need training in how to interpret and apply scientific evidence in policymaking, while scientists need to understand the policy context and communicate their findings in ways that policymakers can use. Lastly, science is positioned as a key tool for addressing interconnected global challenges that no single country can solve alone (The Royal Society, 2010).

The effectiveness of this approach depends on the openness of diplomats to scientific information and the extent to which scientific

evidence helps with policy making.

Diplomacy for Science

Diplomacy for Science is one of the three core dimensions of science diplomacy, focusing on using diplomatic efforts and foreign policy resources to facilitate and support international scientific cooperation and enhance a nation's own scientific, technological, and innovation capabilities (Ruffini, 2020). The concept centers on mutual gain, fostering partnerships that benefit all parties rather than one-sided relationships (Flink & Schreiterer, 2010).

Diplomacy for Science is primarily motivated by national interests related to competitiveness, and often aligns with two strategic goals: Access and Promotion. The thrust of access is to improve a nation's competitiveness and enhance its national innovation capacity. Diplomacy is used to secure access for national researchers to critical international resources, including research findings, researchers, and research facilities. This also includes attracting foreign talent and investment, sometimes referred to as a "brain gain." It further involves identifying and securing new technologies, exploring potential research and scientific discoveries, and seizing new markets and key technologies. In addition, countries aim to stay current by benchmarking international R&D trends and policies (Flink & Schreiterer, 2010).

Promotion is fundamentally about marketing a country's scientific, technological, and innovation capabilities globally to attract partners and investments. It involves promoting a country's achievements in R&D as part of its broader global marketing efforts and engaging in science and technology (S&T) collaborations to attract the world's best researchers, students, and companies. Through these initiatives, nations can lay the groundwork for sustainable international partnerships that yield mutual benefits. This approach helps raise a country's academic capacity, strengthen its reputation and performance, and stimulate or enhance its innovative potential (Flink & Schreiterer, 2010).

Science for Diplomacy

Science for Diplomacy refers to using scientific collaboration as a means to improve relationships between nations, build trust and exert soft power influence. The concept rests on the idea that science, with its global credibility, neutrality, and universal values, can foster dialogue and

cooperation even when political channels are closed.

The goals of Science for Diplomacy include exerting soft power, improving relations between nations, practicing ersatz diplomacy, and strengthening international favor. Countries use the positive reputation of science to exert soft power, which is achieved through persuasion, mutual attraction, and influence rather than military coercion. Beyond this, nations seek to use scientific collaboration to improve relations, sometimes even during periods of heightened tension. Moreover, even when foreign relations between countries break down, scientists can still maintain contact through academic conferences, student and researcher exchanges, joint research projects, and collaborative publications. This form of cooperation continues to serve as ersatz diplomacy; even when official relations are suspended, scientific networks help ensure that specific channels of communication remain open. Additionally, many countries strategically use their scientific institutions to attract international students and talent, positioning themselves as innovation hubs and enhancing their global competitiveness (Flink, 2021).

Agriculture Intersection with Science Diplomacy

The relationship between science diplomacy and agriculture is crucial, as creating a sustainable food future requires tackling complicated issues related to multiple United Nations Sustainable Development Goals (SDGs), including ending hunger (SDG 2), addressing climate change (SDG 13), and fostering global partnerships (SDG 17). Science diplomacy acts as a catalyst for developing future food systems by connecting scientific knowledge, technology, and international collaboration. Through this integration, it promotes worldwide cooperation in research, innovation, and policy development to build stronger food systems and advance peace, prosperity, and sustainable development (Fung & Gonçalves, 2025).

Food security is highly sensitive to critical factors like population growth, socioeconomic disparities and climate change, necessitating cooperation at the international level. Similarly, food production is vulnerable to climate events which globally disrupt crop yields. Through science diplomacy, nations collaborate on developing crucial solutions to food shortage, such as drought-resistant plant varieties and alternative proteins. This joint research is a key strategy for achieving the Zero Hunger (SDG 2) and Climate Action (SDG 13) clauses of the United Nations SDGs.

International partnerships and knowledge-sharing platforms accelerated by science diplomacy ensure the adoption of resilient food system strategies, particularly in vulnerable regions.

Science diplomacy works to reduce the disparities in agricultural research capabilities and access to technology between developing and developed countries. Science diplomacy enables countries to collaborate through joint research and open platforms. This allows them to share effective methods for water-efficient irrigation, climate-resistant crops and sustainable farming. These efforts give developing nations access to innovative tools like smart materials for urban farming. Such technologies strengthen their ability to handle climate challenges. This reduces food insecurity and supports the zero-hunger goal.

Science Diplomacy and the Global South

Agriculture in the Global South is highly sensitive to climate events, and Science Diplomacy is critical for building resilience. Across the region, food production is particularly vulnerable to extreme weather patterns such as floods and droughts, which disrupt crop yields globally. With the intensifying effects of climate change, these climatic events have become increasingly frequent and severe. Science Diplomacy promotes joint research aimed at creating drought-resistant crops and developing data-driven solutions to address the impact of these events on food production. To effectively respond to these challenges, coordinated global efforts and innovative agricultural practices are essential. The growing pressure of climate change necessitates transforming food systems in the Global South, and calls for the adoption of Climate-Smart Agriculture. Science diplomacy facilitates necessary international partnerships and knowledge-sharing platforms that enable countries to share expertise, align priorities, and accelerate the adoption of resilient food system strategies (Fung & Gonçalves, 2025).

A fundamental challenge faced by developing countries is the gap in scientific expertise and technology access, which science diplomacy seeks to bridge. This disparity limits their ability to innovate and respond effectively to pressing global issues such as climate change and food insecurity. Science diplomacy supports technology transfer agreements, open-source platforms, and collaborative research programs to share expertise in areas such as sustainable farming, climate-resilient crops, and

efficient irrigation. Through these collaborative mechanisms, developing nations gain greater access to knowledge networks and scientific infrastructure. Countries from the Global South have pursued Science Diplomacy objectives, like S&T capacities, which enable them to move beyond being junior partners in research. In doing so, they become active contributors to global innovation and policy dialogue. For instance, in the context of food security, Science Diplomacy ensures that developing nations have access to innovative tools, enhancing self-reliance and reducing food insecurity (Rüland et al., 2023).

Financing sustainable food research and ensuring that policies incorporate local knowledge are significant diplomatic challenges. These issues often arise from limited funding coordination, competing national priorities, and insufficient recognition of community-based insights. Science diplomacy helps bring together resources by creating partnerships between governments, private companies, and philanthropic organizations. These collaborations allow different groups to work toward common sustainability goals through innovative funding models such as public–private partnerships and impact investing, which help expand financial support for sustainable food systems and ensure fair distribution of resources. At the same time, science diplomacy encourages inclusivity in policy making by using qualitative methods like ethnographic research and participatory evaluations. This approach values cultural and indigenous knowledge, supports evidence-based decision-making, and promotes greater policy coordination across countries.

Methodology

This paper employs a qualitative, document-analysis methodology to examine the role and impact of science diplomacy on agricultural development with special reference to Pakistan. The primary sources consist of official reports and publications from international organizations, particularly Food and Agriculture Organization - FAO of the United Nations and the World Bank. Secondary sources include academic literature, journal articles, and comparative case studies from the Global South. The collected material was analyzed using thematic analysis to identify key pattern in science diplomacy and its impacts on agricultural development. Pakistan was selected as the central case study to illustrate how global science diplomacy frameworks are interpreted and applied within a developing country context. The literature is reviewed from the

Global Governance theory and soft power lens which together provide a conceptual lens to assess how non coercive tools such as scientific collaboration, institutional partnerships and policy dialogue shape development outcomes across national borders.

Global Governance

According to Michael Zürn, Global Governance is "the exercise of authority across national borders as well as consented norms and rules beyond the nation state" (Fioretos & Tallberg, 2021, p. 100). Global Governance is a unique system of politics that makes the contemporary system of politics "qualitatively different from the past ones" (Fioretos & Tallberg, 2021, p. 100). The relationships among states, global civil society, and international organizations are now more structured and interconnected than ever before, influencing almost every aspect of international and cross-border politics. Global governance theory is part of the broader institutionalist approach, which examines how informal and formal rules influence global politics. These institutions vary widely, from major intergovernmental bodies such as the United Nations to private organizations like Standard & Poor's that hold influence beyond national boundaries (Fioretos & Tallberg, 2021).

Soft Power

Soft Power refers to "the ability to get what you want through attraction rather than coercion or payments" (De Martino, 2020, p. 15-16). Soft Power is defined as co-optive power where one country does what the other country wants it to do. It is about setting the agenda of a country without forcing them to set the agenda. According to Joseph Nye Jr., the soft power of a country is typically generated by three primary resources: Culture, Political Values and Foreign Policies. Culture includes both high culture and popular culture, while political values mean the ideology or the policies of a country. Lastly, foreign policies can generate attraction if other countries also believe it to be legitimate (De Martino, 2020).

Comparative Insights from the Global South

India

Agricultural science diplomacy holds significant importance in India. Around 56.6% of the population is engaged in agriculture and related sectors, which contribute 17.4% to the country's Gross Value Added. The

Millets and OtHer Ancient GRains International ReSearcH Initiative (MAHARISHI) is a specific agricultural science diplomacy initiative that was launched under India's G20 Presidency in 2023. The primary goal was to facilitate research collaboration on climate-resilient and nutritious grains. The initiative centers on millets and other lesser-used grains as part of a broader effort to advance research on locally adapted crops and promote inclusive strategies that support climate-resilient, nutritious, and indigenous grain varieties. The MAHARISHI initiative plays an important role in advancing science diplomacy aligned with India's agricultural development goals. It promotes international collaboration in agricultural research, creating opportunities for shared innovation and knowledge exchange. By leveraging India's experience as a major agricultural producer with diverse agroclimatic zones, the initiative focuses on climate-resilient and locally adapted crops that address the needs of many Global South countries. Additionally, through its engagement with the G20 MACS platform, the initiative strengthens multilateral cooperation and coordination in agricultural research, positioning India as a key contributor to global efforts in sustainable and climate-smart agriculture (Kumar, 2023).

The collaboration between India and the Consultative Group on International Agricultural Research (CGIAR) is a key part of India's multilateral science diplomacy strategy in agricultural research and development. CGIAR is a global research partnership that connects international organizations and research centers working toward a food-secure future. India participates as a donor and voting member, contributing significantly through the CGIAR System Council. The Department of Agricultural Research and Education (DARE) serves as the main liaison for this partnership, while the Indian Council of Agricultural Research (ICAR) works closely with CGIAR on joint initiatives. The collaboration focuses on enhancing agricultural productivity and sustainability through germplasm and technology development, aiming to improve crop and animal performance (Kumar, 2023).

India's key bilateral agricultural research collaborations through the Department of Agricultural Research and Education (DARE) and the Indian Council of Agricultural Research (ICAR) focus on partnerships that advance innovation, technology transfer, and food security. Major collaborations include those with Kansas State University and Cornell University in the United States, which emphasize crop improvement and

biotechnology; EMBRAPA in Brazil, focusing on tropical agriculture and sustainable farming systems; and the Chinese Academy of Agricultural Sciences (CAAS) in China, which promotes joint research in crop genetics and agricultural technology. In Africa, notable partnerships include work with the Ethiopian Institute of Agricultural Research (EIAR) and the Agricultural Research Council (ARC) in South Africa, aimed at enhancing agricultural productivity and capacity building. These strategic collaborations demonstrate India's active role in agricultural science diplomacy, fostering research exchange and innovation across diverse agroecological regions (Kumar, 2023).

Brazil

Brazil's cooperation in agricultural science with India represents a key example of bilateral collaboration through their leading research institutions, the Indian Council of Agricultural Research (ICAR) and the Brazilian Agricultural Research Corporation (EMBRAPA). This partnership, established under the broader framework of DARE/ICAR's bilateral collaborations with the Americas, aims to strengthen joint research and education in agriculture and related disciplines. Cooperation is formalized through Memoranda of Understanding (MoUs) and Work Plans that promote scientific exchange and capacity development. Typical areas of collaboration include the exchange of scientists for training and research, sharing of agricultural knowledge and literature, transfer of germplasm, and capacity-building initiatives in emerging fields of agricultural science (Moore & Donaldson, 2016).

Beyond bilateral partnerships, Brazil also plays an active role in multilateral agricultural research cooperation, particularly through G20 platforms. As a member of the G20 Agriculture Chief Scientists (MACS) group, Brazil contributes to global discussions on strengthening research collaboration in sustainable agriculture (Moore & Donaldson, 2016).

Findings

Science diplomacy has become progressively important for promoting agricultural progress in developing nations. It enables the essential transfer of expertise, technological innovations, and scholarly inquiry needed to address significant global challenges including climate change, inadequate food supplies, and water resource limitations. For countries like Pakistan, this diplomatic strategy serves as a critical mechanism for accessing global

scientific knowledge and strengthening their limited national research capacity (Gluckman et al., 2017).

Science diplomacy serves as a bridge between scientific research and international cooperation. In agriculture, this bridge allows countries to work together on climate-smart farming, biotechnology, and water management projects. Cantillo et al. (2021) under the Food and Agriculture Organization, and Pardey et al. (2016) explain, modern agriculture increasingly depends on scientific collaboration to manage soil degradation, pests, and changing weather patterns. Without shared scientific knowledge, many developing nations struggle to modernize their agricultural systems.

Science diplomacy acts as a link between scientific research and international collaboration. In the agricultural sector, it enables countries to cooperate on areas such as climate-smart practices, biotechnology, and water management. According to the Food and Agriculture Organization (Cantillo et al., 2021) and Pardey et al. (2016), the advancement of modern agriculture relies heavily on collaborative research to address challenges like soil degradation, pest management, and shifting climate conditions. Without access to shared scientific expertise, many developing countries face difficulties in modernizing their agricultural systems because the developed countries will go far ahead of the developing countries.

In Pakistan's case, various projects, such as the World Bank supported Sindh Water and Agriculture Transformation Project (World Bank, 2022) and partnerships with international research centers like CIMMYT's Global Wheat Program (Crespo-Herrera et al., 2017), show how global collaboration improves agricultural productivity and resilience. These partnerships have allowed Pakistan to access better crop varieties, efficient irrigation methods, and scientific training for farmers. This is reflected in the diplomacy for science model, where diplomatic ties help attract external expertise and resources to strengthen local agricultural innovation (Flink & Schreiterer, 2010).

Discussion

Challenges in Applying Science Diplomacy

Despite these positive developments, Pakistan still faces several obstacles that limit the full benefits of science diplomacy. One major issue is institutional fragmentation, there is no dedicated structure to coordinate between the Ministry of Foreign Affairs, agricultural research institutions,

and international partners (Rind, 2025). As a result, projects often work in isolation rather than as part of a national science diplomacy strategy.

Moreover, capacity gaps remain a major barrier in implementing science diplomacy. Many Global South countries lack sufficient scientists, laboratories, and funding to engage fully in global research networks (Fung & Gonçalves, 2025). Pakistan depends heavily on foreign research and imported technologies rather than developing its own innovations. Without investment in local science education and research infrastructure, science diplomacy cannot deliver sustainable long-term benefits.

Comparative Lessons from Other Countries

The experiences of India and Brazil show how countries can successfully use science diplomacy to strengthen agriculture. India's partnerships through the ICAR, and its leadership in global platforms, such as the MAHARISHI initiative under the G20 Presidency, demonstrate how agricultural science can become a tool of soft power and regional leadership (Kumar, 2023). Similarly, Brazil's cooperation with India through EMBRAPA shows how mutual exchange of scientists, germplasm, and research knowledge can strengthen tropical agriculture (Moore & Donaldson, 2016).

Both India and Brazil have established institutional systems that link foreign policy with agricultural research. In contrast, Pakistan's collaborations are often project-based and temporary, lacking a consistent diplomatic framework. To move forward, Pakistan can learn from these examples by creating a diplomacy unit that coordinates research partnerships and funding.

Policy Implications for Pakistan and the Global South

For countries in the Global South, science diplomacy can promote self-reliance and resilience. Through shared research and South–South cooperation, developing countries can co-develop technologies suited to their local conditions rather than relying on the Global North (Fung & Gonçalves, 2025). This reduces dependency on developed countries and strengthens regional solidarity.

In Pakistan, institutionalizing science diplomacy can help integrate climate-smart agriculture into national policies, ensuring that farmers benefit from these innovations. Additionally, involving local communities

and valuing indigenous knowledge can make science-based interventions more inclusive and sustainable (Cantillo et al., 2021).

Theoretical Implications

Using the lenses of Global Governance and Soft Power, Pakistan's case shows how agriculture has become a diplomatic tool that shapes international relationships. Global Governance theory explains how non-state actors and institutions influence policy beyond national borders (Fioretos & Tallberg, 2021). Science diplomacy fits within this system by linking researchers, governments, and organizations in shared efforts to solve food and climate challenges.

At the same time, soft power theory shows that countries can gain influence not only through economic or military strength but through cooperation and knowledge sharing (De Martino, 2020). By engaging in agricultural science diplomacy, Pakistan and similar nations can strengthen their international image as responsible and collaborative partners.

Conclusion

For Pakistan and other countries in the Global South, science diplomacy has become a necessity rather than an option. Since agriculture is fundamental to survival, economic growth, and global trade, it demands innovations that cannot be achieved by any nation working alone. Integrating science diplomacy into Pakistan's agricultural and foreign policy can help the country access new technologies, build resilience, and contribute more actively to global food security. Lessons from India and Brazil demonstrate that with adequate investment and strong institutional frameworks, developing countries can transition from aid dependency to leadership in innovation. Ultimately, science diplomacy provides Pakistan with a pathway not only to modernize its agriculture but also to enhance its role as a constructive and responsible player in the global community.

Strategic Recommendations

For science diplomacy to make a meaningful impact on Pakistan's agricultural sector, it must shift from isolated projects toward a coordinated national strategy. This requires institutional, policy, and capacity-building reforms that align scientific cooperation with agricultural and foreign policy goals. Firstly, capacity building should be prioritized to enhance both scientific and diplomatic skills. Training programs can help diplomats

understand scientific data, while equipping researchers with policy and communication skills to engage effectively in global forums The Royal Society, 2010). Strengthening domestic research institutions such as the Pakistan Agricultural Research Council (PARC) and encouraging collaboration with universities can create a sustainable base of expertise that reduces dependence on foreign consultants (Fung & Gonçalves, 2025).

Secondly, Pakistan must invest in modernizing legal and regulatory frameworks to manage biotechnology, seed certification, and intellectual property rights. Outdated biosafety and patent systems slow the adoption of innovations (Babar et al., 2019). Updating these laws would attract responsible private-sector partnerships while ensuring safe technology transfer.

Thirdly, Pakistan should expand South–South and triangular cooperation through platforms such as COMSATS and the South Asian Association for Regional Cooperation (SAARC). Partnerships with countries experienced in agricultural science diplomacy, can help Pakistan share lessons, co-develop regional innovations, and strengthen collective food security (Kumar, 2023; Moore & Donaldson, 2016). This approach aligns with the idea of mutual learning rather than one-sided technology dependence (Rüland et al., 2023).

Fourthly, improved M&E mechanisms are essential. Many past agricultural collaborations lacked clear indicators to measure their social and economic impacts (World Bank, 2006). Developing robust M&E systems that track outcomes would improve accountability and inform future strategies.

Finally, science diplomacy should be integrated with Pakistan's climate and sustainability goals. Coordinated action between the Ministry of Climate Change and agricultural research institutions can promote climate-smart agriculture and build resilience against droughts and floods (Cantillo et al., 2021). This integration not only strengthens food security but also enhances Pakistan's soft power by positioning it as a cooperative and responsible actor in global climate negotiations (De Martino, 2020).

In summary, Pakistan's success in agricultural science diplomacy depends on building institutional linkages, upgrading legal frameworks, and fostering regional partnerships. It can transform science diplomacy into a strategic tool for sustainable agricultural growth and long-term food

security.

Author Contribution

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Conflict of Interest

The author of the manuscript has no financial or non-financial conflict of interest in the subject matter or materials discussed in this manuscript.

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