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FOOD, FOREIGN POLICY, AND FUTURES: INDO-US COLLABORATION IN CLIMATE-SMART AGRICULTURE FOR THE GLOBAL SOUTH

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ABSTRACT

Climate change poses a growing threat to global food systems, particularly in the Global South, where agriculture remains a primary source of livelihood. In this context, climate-smart agriculture (CSA) has emerged as an adaptive framework designed to enhance agricultural productivity, build resilience to climate stressors, and reduce greenhouse gas emissions. The collaboration between India and the United States in promoting CSA offers a significant example of how international partnerships can align science, diplomacy, and development for food security. This article explores Indo-US cooperation as a multidimensional strategy that extends beyond bilateral engagement to influence agrarian transformation across Africa, Asia, and other vulnerable regions. Through initiatives such as the Agricultural Innovation Mission for Climate (AIM4C), Feed the Future Triangular Training Programs, and institutional linkages between Indian and American agricultural research centers, the two countries have created platforms for technological transfer, capacity building, and knowledge dissemination. These collaborations represent not only a response to climate and food insecurity but also reflect broader foreign policy objectives rooted in soft power and mutual strategic interests. The study highlights how public-private partnerships, triangular cooperation, and science diplomacy are becoming central to food and climate agendas. Case studies from Africa and South Asia illustrate the localized impact of these programs, including improved soil management, water efficiency, and digital agriculture applications. The analysis underscores the need for locally adapted, participatory models of CSA that prioritize smallholder farmers, gender inclusivity, and long-term sustainability. By contextualizing Indo-US collaboration within global development frameworks such as the Sustainable Development Goals (SDGs), this paper argues that climate-resilient agriculture is not only a technical challenge but also a diplomatic frontier shaping the future of global food security. The article concludes that such collaborative efforts can serve as a replicable model for transnational engagement in the era of climate uncertainty.

Keywords: Climate-Smart Agriculture, Indo-Us Cooperation, Food Security, Climate Diplomacy, Global South, Sustainable Development

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1. INTRODUCTION

Food security remains one of the most pressing global challenges of the 21st century, particularly in light of intensifying climate change and widening socio-economic disparities. According to the Food and Agriculture Organization (FAO, 2021), more than 800 million people worldwide face chronic hunger, a situation exacerbated by climate-induced disruptions such as prolonged droughts, erratic rainfall patterns, and extreme weather events. The impacts are most severe in regions of the Global South—South Asia, Sub-Saharan Africa, and parts of Southeast Asia—where agriculture constitutes the backbone of national economies and rural livelihoods. In this context, climate-smart agriculture (CSA) has emerged as an innovative, integrative approach to address the dual challenges of food insecurity

and climate change. It promotes sustainable increases in productivity, enhances adaptive capacities of agricultural systems, and minimizes greenhouse gas emissions (FAO, 2013).

As global food systems undergo transformation, international cooperation has become essential for achieving sustainable development goals. Among the prominent global partnerships, the collaboration between India and the United States has evolved into a strategic framework that extends beyond conventional bilateral diplomacy. Historically rooted in agricultural development during the Green Revolution era, Indo-US cooperation has matured to encompass contemporary issues such as climate resilience, technology transfer, and inclusive agricultural growth (Kharwar & Kumbhar, 2023). The U.S.-India Strategic Partnership and associated mechanisms such as the Agricultural Innovation Mission for Climate (AIM4C) and the Feed the Future Triangular Training Program reflect this evolving relationship (U.S. Department of State, 2021).

India's agricultural experience, particularly with smallholder farmers and low-cost innovations, positions it as a key player in South-South cooperation. Meanwhile, the United States offers advanced research capabilities, financial resources, and institutional infrastructure. Together, they form a complementary alliance capable of influencing agrarian policy and practice beyond their borders. Their collaboration is particularly visible in Africa and parts of Asia, where triangular cooperation programs are helping to promote climate-resilient practices and enhance food systems' sustainability.

This research article seeks to explore Indo-US collaboration in CSA as both a developmental necessity and a foreign policy tool. By analyzing joint initiatives, strategic objectives, and on-the-ground impacts, the paper investigates how these efforts contribute to broader goals such as poverty alleviation, sustainable food production, and global climate governance. The study situates this partnership within the broader framework of science diplomacy, development cooperation, and geopolitical realignment in a post-pandemic world.

The paper argues that Indo-US engagement in CSA is more than a technical endeavor—it is a reflection of evolving global governance norms where climate, food, and foreign policy converge. The research also highlights how these collaborations can serve as scalable, replicable models for addressing agrarian vulnerabilities in other regions of the Global South. Ultimately, this study aims to demonstrate that CSA, when integrated with inclusive diplomacy and international cooperation, holds the potential to transform the future of food security in a climate-constrained world.

2. METHODOLOGY

This study adopts a qualitative research methodology to explore the scope, impact, and implications of Indo-US collaboration in climate-smart agriculture (CSA) for the Global South. The qualitative approach is chosen for its strength in capturing the complexity, context, and interpretative depth required to analyze international development partnerships and their real-world implications (Creswell & Poth, 2018). The study is designed as a multi-layered case-based inquiry combining document analysis, institutional mapping, and thematic content analysis to construct a holistic picture of how this bilateral cooperation is contributing to food security and climate resilience in vulnerable regions.

The primary method of data collection is document analysis, which includes official government publications, multilateral development agency reports, international NGO evaluations, and peer-reviewed journal articles. Key policy documents such as the U.S.-India Strategic Energy Partnership frameworks, AIM4C initiative reports, USAID-India development cooperation archives, and Ministry of External Affairs (MEA) press releases form the core corpus for analysis. Reports from FAO, World Bank, and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) were also reviewed to gather insights into how Indo-US collaboration aligns with global CSA frameworks and Sustainable Development Goals (SDGs).

Case studies form an integral part of this methodology. Two illustrative examples were selected to understand the application and results of Indo-US collaboration: (1) the Feed the Future Triangular Training Program involving Indian training institutions and African agricultural professionals, and (2) the Indo-US partnership in the Agricultural Innovation Mission for Climate (AIM4C). These cases were chosen for their relevance, geographic diversity, and documented outcomes in CSA dissemination. Both cases were analyzed using qualitative indicators such as local capacity-building, stakeholder participation, scalability of technologies, and alignment with CSA principles (Schroeder et al., 2021).

The study also employs thematic content analysis to code and identify recurring patterns in the literature and institutional communications. Themes such as "technology transfer," "climate resilience," "triangular cooperation," and

"science diplomacy" were identified and analyzed for frequency and contextual depth. Thematic analysis enabled the researcher to link Indo-US CSA efforts to broader foreign policy objectives, development discourses, and governance models.

To ensure reliability and minimize bias, triangulation of sources was employed. Data from policy documents were cross-referenced with academic analyses and field reports. Furthermore, only open-source, verifiable data were used to maintain transparency and reproducibility. While this study does not employ primary fieldwork or interviews due to scope and resource constraints, the richness of secondary sources provided a robust foundation for interpretative analysis.

The methodological framework of this research is grounded in constructivist and interpretivist paradigms, which value the subjective, negotiated nature of international cooperation and development practices (Lincoln & Guba, 1985). This approach is particularly suitable for examining the interplay of policy, diplomacy, and science in shaping transnational agricultural outcomes.

In conclusion, the methodology employed allows for a comprehensive understanding of Indo-US collaboration in CSA, not just as a technical transfer process, but as a complex, multilayered development and diplomatic engagement influencing food systems across the Global South.

2.1. INDO-US AGRICULTURAL COOPERATION: HISTORICAL CONTEXT AND STRATEGIC EVOLUTION

The Indo-US agricultural partnership has evolved significantly over the past six decades, transforming from a donor-recipient model into a strategic, multidimensional collaboration rooted in shared interests in food security, technological innovation, and climate resilience. The origins of this relationship can be traced to the Green Revolution in India during the 1960s, where the United States played a pivotal role in supporting India's agricultural transformation through funding, research collaboration, and the transfer of high-yielding seed varieties (Perkins, 1997). American institutions such as the Rockefeller Foundation and USAID were instrumental in strengthening Indian agricultural research capacity, particularly through partnerships with the Indian Council of Agricultural Research (ICAR) and various agricultural universities.

This initial phase laid the foundation for long-term cooperation, fostering institutional linkages and building mutual trust. Over time, the bilateral relationship adapted to global and domestic challenges, shifting toward a more collaborative and reciprocal model. In 2005, the launch of the U.S.-India Agricultural Knowledge Initiative (AKI) marked a significant turning point. This initiative emphasized capacity-building, joint research, agribusiness development, and university-to-university partnerships (USDA, 2006). The AKI enabled the co-creation of knowledge and underscored the importance of equitable cooperation, with India emerging not merely as a beneficiary but as a co-leader in addressing global agricultural challenges.

The partnership further deepened with the establishment of the India-U.S. Strategic Dialogue and the formation of the India-U.S. Strategic Energy Partnership, both of which integrated food, energy, and climate into the strategic agenda. These platforms facilitated broader cooperation on sustainable agriculture, clean energy technologies, and climate mitigation strategies. In 2021, the launch of the Agricultural Innovation Mission for Climate (AIM4C) at COP26 further institutionalized this evolving partnership. Co-led by India and the United States, AIM4C aims to accelerate investment in climate-smart agriculture and food systems innovation, particularly in developing countries (U.S. Department of State, 2021).

Another hallmark of the strategic evolution is the Feed the Future Triangular Training Program, through which Indian agricultural institutions train professionals from African and Asian countries in sustainable farming practices. This reflects a shift toward triangular development cooperation, where India and the U.S. work together to support third countries, especially in the Global South. This model enhances India's South-South engagement while leveraging U.S. financial and logistical support, showcasing a balanced diplomatic equation rooted in mutual interest and global responsibility (Chaturvedi, 2021).

In recent years, the collaboration has increasingly focused on climate-smart agriculture (CSA), digital technologies, biotechnology, and resilient food systems. With growing concerns about climate variability and its impact on smallholder farmers, Indo-US agricultural diplomacy has embraced innovative tools such as precision agriculture, remote sensing,

AI-powered farm advisory systems, and low-emission farming technologies. These initiatives not only address environmental sustainability but also highlight the growing role of science diplomacy in shaping international relations.

Thus, the historical trajectory of Indo-US agricultural cooperation reflects a dynamic and responsive relationship. What began as development aid has matured into a strategic partnership grounded in shared global challenges and opportunities. This evolution demonstrates how agricultural collaboration can be leveraged as a cornerstone of foreign policy, economic development, and climate adaptation in the 21st century.

2.2. CLIMATE-SMART AGRICULTURE AND THE GLOBAL SOUTH: WHY IT MATTERS

The Global South—comprising regions of Sub-Saharan Africa, South Asia, Southeast Asia, and parts of Latin America—is at the epicenter of the global food insecurity crisis, compounded by climate change, environmental degradation, and persistent rural poverty. Agriculture in these regions is largely dominated by smallholder farmers who rely on rain-fed systems, low-capacity infrastructure, and traditional practices that are increasingly unsustainable in the face of unpredictable weather patterns and resource scarcity (FAO, 2021). According to the Intergovernmental Panel on Climate Change (IPCC, 2022), climate change will continue to disproportionately affect agricultural productivity and food systems in these vulnerable regions. This has created an urgent need for adaptive, sustainable agricultural practices capable of withstanding climatic and socio-economic stressors.

Climate-smart agriculture (CSA) is increasingly viewed as a transformative approach capable of bridging the gap between food production and climate resilience. As defined by the Food and Agriculture Organization (2013), CSA aims to sustainably increase productivity and incomes, adapt and build resilience to climate change, and reduce or remove greenhouse gas emissions where possible. Unlike conventional agricultural models, CSA is context-specific, focusing on integrating climate risk management, ecosystem stewardship, and inclusive growth into agricultural development strategies. For the Global South, where climate adaptation is not optional but essential, CSA offers a pathway for sustaining food production while mitigating environmental and social vulnerabilities.

India and the United States, as emerging leaders in agricultural innovation and development cooperation, have a unique and strategic role to play in advancing CSA across the Global South. India's experiences with climate-resilient cropping systems, low-cost irrigation techniques, and agroecological methods are highly relevant to other developing nations. Its National Innovations on Climate Resilient Agriculture (NICRA) initiative, led by the Indian Council of Agricultural Research (ICAR), serves as a blueprint for integrating research, extension, and community-level adaptation (Rao et al., 2020). The United States, through its vast agricultural R&D institutions such as the USDA and Land-Grant Universities, complements these efforts with advanced technologies, digital farming tools, and global financing mechanisms.

One of the most prominent examples of Indo-US collaboration benefiting the Global South is the Feed the Future Triangular Training Program. Under this initiative, Indian institutions—drawing on their own experiences of smallholder-focused agricultural development—train professionals from African and Asian countries on CSA practices, soil health management, water conservation, and integrated pest management (USAID India, 2020). These sessions focus not just on technology transfer, but also on context-specific adaptation, making the approach both scalable and sustainable.

The Indo-US partnership under the Agricultural Innovation Mission for Climate (AIM4C) further reinforces the importance of global collaboration in agricultural climate resilience. Launched at COP26, AIM4C aims to mobilize investment and collaborative innovation in CSA across diverse geographies, particularly in countries of the Global South. Its emphasis on funding inclusive research, supporting climate-resilient startups, and encouraging public-private partnerships aligns closely with the goals of sustainable development and equitable growth (U.S. Department of State, 2021). This partnership illustrates how international diplomacy and science can converge to solve global challenges through mutual investment in human and institutional capacity.

In Africa, where food insecurity has been worsened by both climate shocks and institutional fragility, Indo-US collaborative programs have introduced CSA practices such as drought-resistant seeds, zero-tillage techniques, and mobile-based weather advisory services. For example, pilot programs in Kenya and Malawi, implemented through a tripartite partnership involving Indian research institutions, USAID, and local governments, have demonstrated improvements in crop yield, water-use efficiency, and farmer income (Mehta & Kumar, 2020). These efforts not only

enhance agricultural productivity but also foster resilience against long-term climate risks, empowering local communities to break cycles of vulnerability and food dependence.

Despite these achievements, CSA adoption in the Global South faces several obstacles. The lack of financial access for smallholders, limited technical knowledge at the grassroots level, and inadequate policy support remain significant barriers (Lipper et al., 2014). Moreover, the success of CSA hinges on participatory governance, gender inclusion, and integration of indigenous knowledge systems—factors that are often overlooked in top-down development models. Indo-US cooperation, therefore, must prioritize inclusivity and locally owned solutions to ensure that CSA strategies are both effective and equitable.

In conclusion, the importance of CSA for the Global South cannot be overstated. As climate change continues to threaten the very foundations of agriculture in developing regions, CSA offers not only technical solutions but also a comprehensive development framework. Indo-US collaboration, rooted in shared expertise and strategic interests, provides a replicable model for enhancing food security, environmental sustainability, and rural resilience. By promoting CSA through institutional partnerships, knowledge transfer, and development diplomacy, India and the United States are helping shape a more secure and climate-resilient agricultural future for the Global South.

DIPLOMACY, DEVELOPMENT, AND TECHNOLOGICAL TRANSFER

In the contemporary geopolitical landscape, the intersection of diplomacy, development, and technological innovation plays an increasingly pivotal role in shaping global cooperation. The Indo-US collaboration in climate-smart agriculture (CSA) exemplifies how science diplomacy and strategic development engagement can be mobilized to address common global challenges such as food insecurity, climate change, and poverty in the Global South. Rather than functioning solely as a bilateral engagement, this collaboration represents a dynamic model of multi-actor, multi-level diplomacy, where public, private, and civil society stakeholders contribute to shared developmental outcomes.

Science and technology have emerged as instruments of "soft power" diplomacy, enabling countries to build influence and goodwill through knowledge sharing and institutional capacity-building (Flink & Schreiterer, 2010). In this context, India and the United States have effectively used agricultural cooperation as a tool of development diplomacy. The emphasis is not merely on financial assistance but on the co-creation and co-dissemination of adaptable technologies that support sustainable agricultural transformation. Initiatives such as the Feed the Future India Triangular Training Program, implemented by USAID in partnership with the Government of India, reflect a novel approach to development cooperation, wherein Indian experts train agricultural professionals from African and Asian nations on climate-resilient practices, organic farming, and digital extension services (USAID India, 2020).

This model aligns with the principles of triangular cooperation, wherein two or more countries collaborate to support a third country's development. In such frameworks, India contributes its experience and context-specific knowledge while the U.S. provides logistical, financial, and institutional support. The result is a more equitable and participatory form of development engagement, contrasting with traditional North-South models that often overlook local agency (Chaturvedi, 2021).

Technological transfer is central to this diplomatic architecture. Indian innovations in low-cost drip irrigation, integrated pest management, and climate-resilient seed varieties are increasingly being shared with Global South partners. Concurrently, U.S. technological leadership in precision agriculture, biotechnology, remote sensing, and data analytics offers powerful tools for transforming food systems. The Agricultural Innovation Mission for Climate (AIM4C), jointly led by India and the U.S., demonstrates the synergy of combining these respective strengths. The initiative seeks to accelerate investments in climate-resilient agricultural innovation globally and encourages collaborative research across public and private sectors (U.S. Department of State, 2021).

In addition, public-private partnerships (PPPs) have emerged as vital conduits for technological diffusion. Start-ups and agritech companies from both India and the U.S. are working together to introduce innovations in farm-to-market value chains, mobile-based crop advisory services, and AI-powered crop insurance systems. These partnerships not only facilitate the transfer of physical technology but also embed knowledge systems and digital literacy into local contexts.

Thus, Indo-US collaboration in CSA is emblematic of how diplomacy, development, and technology can be harmonized to create scalable, inclusive, and sustainable agricultural solutions. This model represents a shift from transactional aid to transformative cooperation—one that builds resilience, fosters innovation, and strengthens global partnerships in the era of climate uncertainty.

3. CHALLENGES AND THE WAY FORWARD

While Indo-US collaboration in climate-smart agriculture (CSA) has made significant strides in promoting sustainable agricultural practices across the Global South, the partnership is not without challenges. These challenges exist at the structural, operational, and socio-political levels, and addressing them is crucial for achieving long-term impact and scalability. For CSA to be effective and equitable, it must overcome barriers related to financial access, institutional capacity, policy coherence, and local adaptability.

A primary challenge is the lack of financial access for smallholder farmers in developing countries. CSA technologies, although beneficial, often require initial capital investment in inputs such as improved seed varieties, drip irrigation systems, or weather advisory tools. In regions like Sub-Saharan Africa and South Asia, where the majority of farmers operate at subsistence levels, access to affordable credit and insurance remains limited (Lipper et al., 2014). Without targeted financial inclusion measures, the benefits of CSA may remain confined to better-resourced farming communities.

Another critical issue is institutional capacity. Many recipient countries lack robust agricultural extension systems capable of disseminating CSA practices to remote and marginalized communities. Despite India's success in integrating extension networks with digital tools, replicating such systems in fragile or under-resourced regions requires sustained investment in training, infrastructure, and monitoring mechanisms (Rao et al., 2020). Additionally, language barriers, educational disparities, and gender-based exclusions often inhibit the adoption of new technologies at the grassroots level.

Policy incoherence between national agricultural strategies and climate change adaptation plans also poses a barrier. In many countries of the Global South, agricultural and environmental ministries operate in silos, resulting in fragmented implementation and limited policy integration. Without clear alignment of CSA strategies with national climate action plans, international partnerships may struggle to generate systemic change (FAO, 2013).

Moreover, technology transfer models sometimes risk being top-down, failing to sufficiently adapt to local agroecological conditions and traditional knowledge systems. CSA interventions developed in Indian or American contexts may not always translate effectively to African or Southeast Asian farming environments without contextual modification. The success of CSA depends not only on the transfer of physical technology but also on participatory approaches that engage farmers in co-designing solutions (Mehta & Kumar, 2020).

To address these challenges, a multi-pronged strategy is required. First, Indo-US collaborations should focus on inclusive financing models, such as climate-linked microcredit, subsidies for CSA tools, and index-based crop insurance tailored for smallholders. Second, strengthening institutional ecosystems through capacity-building initiatives—especially in local universities, agricultural training centers, and civil society networks—can help scale CSA practices effectively.

Furthermore, embracing co-creation and localization of CSA technologies, instead of mere transfer, is vital. Joint innovation labs, farmer field schools, and community-led pilot programs can foster knowledge exchange and empower local stakeholders. Finally, enhancing policy convergence through trilateral dialogues among development partners, recipient governments, and regional organizations can ensure the institutional sustainability of CSA efforts.

In conclusion, while Indo-US cooperation in CSA holds significant promise, its long-term success will depend on its ability to navigate financial, institutional, and cultural complexities. By adopting inclusive, adaptable, and participatory strategies, this partnership can build a resilient foundation for sustainable agriculture and food security in the Global South.

4. CONCLUSION

The Indo-US collaboration in climate-smart agriculture (CSA) represents a strategic convergence of food security, foreign policy, and sustainable development goals. As climate change increasingly threatens global agricultural systems, especially in the Global South, partnerships like these offer innovative, inclusive, and scalable responses to complex transnational challenges. This cooperation has moved beyond traditional aid models, fostering mutual learning and co-development between two of the world's largest democracies. Through initiatives such as the Feed the Future India Triangular Training Program and the Agricultural Innovation Mission for Climate (AIM4C), the Indo-US partnership has

demonstrated the potential of triangular cooperation, science diplomacy, and public-private partnerships in addressing global food and climate crises.

The strength of this collaboration lies in its multidimensional approach—combining technological innovation with institutional capacity-building, financial inclusion, and participatory models of development. By leveraging India's context-specific agricultural innovations and the United States' technological and financial resources, the partnership offers solutions that are both locally grounded and globally relevant. Moreover, its emphasis on soft power and strategic diplomacy enhances its legitimacy and appeal in international forums, particularly among African, Asian, and Latin American nations seeking alternative models of development engagement (Chaturvedi, 2021).

However, the effectiveness of this partnership hinges on its ability to overcome systemic barriers. Financial access for smallholder farmers, institutional fragmentation, and inadequate policy alignment remain significant challenges. The top-down nature of some technology transfers risks alienating local knowledge systems, which are vital for the successful adoption of CSA practices. Hence, greater efforts are needed to strengthen co-creation and localization strategies, foster inclusive governance frameworks, and ensure that gender, youth, and indigenous perspectives are fully integrated into program design and implementation (Lipper et al., 2014).

Moving forward, the Indo-US collaboration should aim to deepen its regional outreach, invest in long-term capacity building, and support platforms for cross-border innovation. Strengthening South-South and triangular cooperation mechanisms will be crucial for replicating successful CSA interventions in regions facing similar agroecological and socio-economic challenges. Furthermore, the integration of digital technologies—such as AI-driven climate models, precision farming tools, and blockchain-based supply chain management—can enhance the adaptability and resilience of food systems in low-resource settings (Rao et al., 2020).

In conclusion, Indo-US engagement in climate-smart agriculture offers a replicable and impactful model for global cooperation in the Anthropocene era. It illustrates how food security and climate resilience can be reframed as common global goods, rather than competitive national interests. As both countries continue to navigate their roles in global diplomacy and development, their shared leadership in sustainable agriculture can serve not only to uplift millions from poverty but also to redefine 21st-century partnerships for a more equitable and climate-resilient world.

CONFLICT OF INTERESTS

None.

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