From Frugal Innovation to Global Standards: India's Science Diplomacy in Low-Cost Technologies

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Introduction

India has earned global recognition for its ability to deliver cost-effective solutions without compromising on quality. From the Mars Orbiter Mission, achieved at a fraction of international costs, to the rapid distribution of vaccines during the COVID-19 pandemic, India has demonstrated that scientific ingenuity coupled with frugality can achieve scale and impact. Such innovations, born out of necessity, are now emerging as diplomatic assets.

Frugal innovation, broadly understood as "doing more with less," has evolved in India into a framework of designing affordable, functional, and scalable solutions by optimising resources. For countries facing constraints of finance, infrastructure, or technical capacity, these solutions are not merely cheaper substitutes but lifelines that enable progress. Strategically deployed, frugal innovation is more than a domestic achievement—it is an instrument of science diplomacy, allowing India to project influence and build partnerships across the Global South while contributing to global goals such as the UN Sustainable Development Goals (SDGs).[1,2]

Frugal Innovation and its Diplomatic Value

The roots of India's frugal innovation lie in its history of resource limitations. For decades, Indian laboratories operated with modest infrastructure, industries invested relatively little in R&D, and public spending on science rarely matched global averages. These constraints cultivated a culture of efficiency, adaptability, and problem-solving under pressure. What began as a compulsion has become a distinctive national capability.

For partner countries, this model has wide appeal. Many African, Southeast Asian, and Latin American nations face similar challenges: limited public health budgets, dispersed rural populations, and urgent needs in water, agriculture, and energy. By sharing frugal innovations, India signals solidarity and positions itself as a partner that provides affordable, context-sensitive, and scalable solutions rather than high-cost

technologies ill-suited to local realities. This makes frugal innovation not just a scientific or economic asset but also a diplomatic tool.

Healthcare Diplomacy: Vaccines and Diagnostics

India's pharmaceutical and biotechnology sectors are central pillars of its low-cost technology diplomacy. The country accounts for roughly one-third of the global vaccine market by volume, with pharmaceutical exports valued at US$30.47 billion in 2024–25.[3,4] During the COVID-19 pandemic, the Vaccine Maitri programme supplied 94 million doses to 94 countries and two UN agencies, an act of solidarity that enhanced India's credibility as a reliable health partner.[5]

The promise of healthcare diplomacy extends beyond emergencies. Indian companies produce affordable medicines for HIV/AIDS, tuberculosis (TB), and malaria, which remain endemic in parts of Africa and Asia. In TB, Indian molecular diagnostic platforms such as Truenat—endorsed by the World Health Organisation (WHO)—have been deployed across multiple countries, enabling early and accurate diagnosis in settings where conventional laboratory infrastructure is absent.[6-8]

This diplomatic footprint is expanding. In Africa, countries such as Nigeria, Ethiopia, Kenya, and Ghana are actively engaging with India on vaccine access and diagnostic collaborations. In Asia, Bangladesh, Nepal, Sri Lanka, and Cambodia have also benefited from Indian supplies and technical cooperation. The Serum Institute's plans to scale the R21 malaria vaccine to 100 million doses annually at a price of ~US$4 per dose highlight how India can address diseases of the Global South at scale.[9]

Water as a Strategic Resource

Safe drinking water is another arena where India's innovations are gaining diplomatic relevance. Globally, 2.2 billion people lack safely managed drinking water.[10] South Asia and Sub-Saharan Africa bear the brunt, with arsenic, fluoride, and bacterial contamination posing chronic risks. Indian scientists and entrepreneurs have developed low-cost arsenic removal plants, rapid testing kits, and nanobubble-based water rejuvenation technologies that are already in use within the country and piloted abroad.[11]

For example, arsenic treatment units originating from Indian R&D have been introduced in Bangladesh and Nepal. Cambodia and Vietnam, grappling with arsenic belts in their groundwater, are potential partners for future deployments. In Africa, Ghana, Uganda, and Ethiopia represent opportunities where modular, community-level water treatment systems can be financed through Indian concessional Lines of Credit (LoCs). By exporting such solutions, India not only addresses health challenges but also builds long-term goodwill with governments and communities.

Agriculture and Energy Access

Food and energy security represent additional domains where frugal innovation intersects with diplomacy. In Sub-Saharan Africa, only 6% of cultivated land is irrigated.[12] This presents a significant opportunity for Indian micro-irrigation systems, solar-powered pumps, and drought-tolerant crop varieties. The International Solar Alliance (ISA), co-founded by India, now includes 107 member countries and has aggregated demand for over 276,000 solar water pumps.[13,14] Indian firms supplying such pumps can play a pivotal role in Africa (Ethiopia, Kenya, Tanzania, Zambia) and small island states (Fiji, Comoros, Vanuatu) while contributing to climate resilience.

The energy dimension is equally pressing. Around 600 million Africans lack electricity, and the International Energy Agency estimates that US$25 billion annually will be required to meet universal access goals by 2030.[15] India's decentralised solar lanterns, mini-grids, and cold-chain

systems for vaccines and agriculture are well-suited to these contexts. Partnerships with Nigeria, Malawi, and Madagascar, supported by LoCs and ISA platforms, can scale such solutions in a financially sustainable manner.

From Low-Cost to High-Value: The Standards Imperative

Despite their potential, frugal technologies face barriers in global markets. Many are designed to meet Indian regulatory norms but not international standards such as ISO, CE, or WHO prequalification. This limits their exportability and reduces partner confidence.

Science diplomacy provides a way forward. India can negotiate joint certification programmes with regulators in Africa and ASEAN, allowing for concurrent reviews and reliance mechanisms. Embedding design-for-compliance into early-stage product development can ensure smoother adoption abroad. Equally important is India's active participation in global standards bodies, where it can advocate for protocols that reflect the realities of developing nations.

By aligning frugal innovation with global certification, India can shift perceptions from "low-cost" to "high-value," positioning itself as a supplier of robust and reliable technologies.

Financing and Policy Instruments

Financing is critical to transforming innovations into diplomatic assets. India has already extended US$32 billion in Lines of Credit across 68 countries[16], with an additional US$3.73 billion approved between 2022 and 2025.[17] If directed strategically, these LoCs can serve as vehicles for deploying certified frugal technologies in partner countries.

Blended finance models, combining LoCs with multilateral funds, can derisk projects in water treatment, solar irrigation, and diagnostics. Outcome-based procurement—where payments are tied to health outcomes, litres of water delivered, or hours of irrigation—offers another way to build trust and accountability. Such approaches can ensure that frugal technologies are not only adopted but also sustained in the long term.

Markets and Projections

The potential impact of frugal innovation diplomacy is substantial. Pharmaceutical exports, already at US$30.47 billion, could expand by US$4–6 billion by 2030 if India strengthens its foothold in Africa and ASEAN.[3,18] WHO-endorsed TB diagnostics such as Truenat could grow five- to seven-fold with pooled procurement across 25–30 countries.[6-8] In solar irrigation, the global market is projected to reach US$5.42 billion by 2033, and Indian firms could capture 8–10% of this share, translating to annual revenues of US$430–540 million.[19] Water testing and treatment, targeting communities without safe supply, could generate US$0.5–1 billion annually in exports and services by 2030.[10,11]

These projections illustrate that frugal innovation is not marginal; it is an economic and diplomatic force multiplier when coupled with certification and finance.

Challenges Ahead

Despite the promise, challenges remain. The perception of frugal technologies as "cheap substitutes" must be countered with evidence of durability, certifications, and lifecycle cost savings. Regulatory barriers—such as lengthy approval processes—require harmonisation efforts and mutual recognition agreements. After-sales service is often a weak link, but partnerships with local firms and regionally

based service hubs can address this. Geopolitical risks, such as tariff pressures on generics in the United States, highlight the need for diversification of markets.[18]

Conclusion

Frugal innovation is not only a story of doing more with less; it is about designing for inclusion, sustainability, and scalability. In the coming decade, countries that provide affordable, reliable health, water, agriculture, and energy solutions will hold both economic and diplomatic advantages. India, with its track record and scientific ecosystem, is well placed to be one of these leaders.

By embedding international standards, leveraging concessional financing, and targeting partnerships with Africa, ASEAN, and small island states, India can transform its reputation from a supplier of low-cost technologies to a trusted provider of high-value, globally relevant solutions. In doing so, frugal innovation will serve not only as a hallmark of Indian science but also as a powerful instrument of science diplomacy.

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