SHAPING U.S.-INDIA AI COOPERATION

INSIGHTS FROM THE INAUGURAL U.S.-INDIA AI FELLOWSHIP PROGRAM

Edited by **ANDREAS KUEHN** *and* **ANULEKHA NANDI**

SHAPING U.S.-INDIA AI COOPERATION

INSIGHTS FROM THE INAUGURAL U.S.-INDIA AI FELLOWSHIP PROGRAM

Attribution: Andreas Kuehn and Anulekha Nandi, Eds., *Shaping U.S.-India A.I. Cooperation: Insights from the Inaugural U.S.-India A.I. Fellowship Program*, Observer Research Foundation, September 2025.

Editorial and Production Team: Vinia Mukherjee, *Editor and Producer*; Monika Ahlawat and Meryl Mammen, *Assistant Editors*; Rahil Miya Shaikh, *Design and Layout;* Ishani Chettri, *Cover Design.*

Contents

Foreword

The U.S.–India AI Fellowship Program was established with the vision to expand the trusted partnership of the two countries on Artificial Intelligence (AI). In a world where technology has become a fulcrum of geostrategic decisions, and large language models, algorithms, semiconductors and data centres are shaping the contours of power and prosperity, deepening this alliance between two of the world's biggest democracies is imperative. The two nations must not simply keep pace with innovation; they must define its course.

This was the remit around which the U.S.–India AI Fellowship Program was designed. The Fellowship invited 20 early- to mid-career leaders and thinkers, 10 from each country, to share their vision for this new relationship and develop a cohesive path towards effective AI innovation and optimisation.

Over the course of the past year, the Fellows met, discussed, and debated their vision of a U.S.–India AI partnership, not only with each other but also with an array of carefully curated global experts and audiences. These interactions led to new research, on topics as wide ranging as compute, training models, and extreme weather conditions to strategic bilateral and multilateral partnerships. Through this exercise, what became evident was the immense potential of what can be achieved by bringing together some of the best and brightest minds on AI and tech from the two countries. With diverse representation from across government, academia, and the private sector, the Fellowship birthed a new network of leaders with a clearly defined and closely aligned vision of strengthening cooperation between India and the US.

This edited volume, a proud outcome of the Fellowship, showcases the scope of ideas that the Fellows deliberated on. It addresses topics such as defence, space, health, and open commerce; cross-cutting issues of governance, risk, safety, and sustainability; and foundational issues of compute, the future of work, and the role of strategic public-private and multilateral partnerships. It captures the essence of building a new partnership—built upon, at times, a consensus, but rather often, a constellation of insights, provocations, and proposals.

As we conclude the first iteration of this Fellowship, our two organisations—ORF and ORF America—look, with hope, to a future where the US and India come together to define the advancement of humanity through technology. If the inaugural cohort was any indication, the future of this bilateral technological cooperation is in good hands.

Dr. Samir Saran
President
Observer Research Foundation

Introduction

Andreas Kuehn and Anulekha Nandi

Artificial Intelligence (AI) is promising a profound technological transformation and relentless innovation that will have wide-ranging benefits to society. Nowhere does this hold greater potential than in the burgeoning relationship between the United States (US) and India—two powerhouse democracies with complementary strengths: on one side stands the United States with its leading technology, unmatched innovation capacity, and vast financial capital; and on the other is India, with its large talent pool in the STEM (science, technology, engineering, and mathematics) fields, and immense data resources. To unlock AI's full potential, the governments, businesses, and academic and research institutions of both countries must work together. This publication seeks to offer some of the viable ways by which US-India cooperation in AI can be done.

As AI and technology is emerging as a pillar of the bilateral relationship, India and the US are heightening cooperation in the technology domain, driven by a blend of strategic and commercial incentives anchored in their respective national interests. This kind of technology partnership, however, is not new and can be traced back to the 2005 landmark US-India Civil Nuclear Initiative, which catalysed broader cooperation in science, technology, and defence.

Overall, economic and security relations between the two countries have deepened over the past two decades. In February 2025, President Donald Trump and Prime Minister Narendra Modi reaffirmed the US-India Comprehensive Global Strategic Partnership, a designation that was formalised in 2020 during President Trump's state visit to India in his first tenure.[1]

The US leads the world in innovation through its research and development capabilities, advanced technologies, and robust private investment ecosystem; India, meanwhile, offers skilled talent and extensive data resources generated by its billion-plus population through daily online and offline interactions. These complementary strengths present unique opportunities for AI collaboration. First, under the US-India Initiative on Critical and Emerging Technology (iCET), and continuing under the Transforming the Relationship Utilizing Strategic Technology (TRUST) initiative, the two countries are aiming to foster cooperation in domains such as academic research, agricultural and defence applications, and technology commercialisation, while encouraging sustained commitment and implementation by industry leaders and academic institutions.

It was against this dynamic backdrop that Observer Research Foundation (ORF) and ORF America launched the US-India AI Fellowship Program in September 2024. The programme brought together 20 early- to mid-career professionals from both countries belonging to industry, government, academia, and civil society to catalyse ideas, build professional networks, and contribute to a common vision for responsible and innovative AI. The Fellowship has been more than a leadership exercise; it is an attempt to build a bridge between the two nations to develop and sustain US-India cooperation in AI and technology.

Throughout the one-year programme—from October 2024 to September 2025—our Fellows conducted a series of in-person meetings. Some of these meetings were held in the run-up to the Raisina Dialogue in March, starting with Abu Dhabi in January 2025, followed by New Delhi in March, and finally in Washington, DC in September of 2025 for their concluding meeting and the launch of this volume. Interspersed with these convenings were regular, virtual guest lectures and workshops. A subset of Fellows also participated in ORF's Yerevan Dialogue in Armenia in May 2025 and Raisina Mediterranean in Marseilles in June, while others joined ORF America's Track 1.5 Dialogue on US-India AI and Technology Cooperation at the SCSP AI Expo in Washington, DC, also in June 2025. Engaging and building networks with AI experts, entrepreneurs, policymakers, and industry leaders from both the United States and India, the fellowship programme offered a rare opportunity to blend practical insight with rigorous in-depth research and cross-cultural exchange. Building on this, the Fellows contributed to this edited volume as well as a series of thought pieces that have previously been published by ORF and ORF America.[2]

This volume, "Shaping U.S.-India A.I. Cooperation: Insights from the Inaugural U.S.-India A.I. Fellowship Program", is a compendium of our Fellows' ideas and perspectives on different but interrelated subjects around the theme of AI. It offers a pioneering glimpse into how the next generation of thinkers and doers from both India and the US view the promise and perils of AI, and the future pathways that both nations can take. The articles identify the various ways by which the United States and India can cooperate for the benefit of their societies and citizens.

The articles contained in this volume offer varied opinions and prescriptions, and are not limited to the contours of specific policy priorities. Instead, they span a wide terrain: from the governance of AI and export controls on GPUs to workforce development and training, from the importance of creating responsible, fair AI to benefit all of society to the need for cutting-edge research and innovation to ensure AI leadership for industry, the economy, and national security. They also delve into the role that AI plays in leading democracies to the political alignment of like-minded countries in forums such as the Quad and TRUST.

Some contributions use a macro lens, exploring what a US-India AI cooperation could and should look like against the backdrop of increased global uncertainty; others dive into sector-specific issues and challenges, such as healthcare, extreme weather risks, and defence and space applications, as well as AI safety. Certain authors reflect on the implications of AI and digital public infrastructure for the Global South, as well as creative visions for joint R&D, capacity-building, and AI infrastructure development. These articles are threaded by a shared ambition: to imagine and help build a future in which AI serves society while addressing the risks and dangers that are an inevitable part of any widespread application of an emerging technology.

As the global AI landscape rapidly evolves, India and the United States have a historic opportunity to shape its trajectory. Their cooperation will not only matter for their own citizens, companies and governments, but will likely influence how AI is governed, developed, and deployed around the world.

We express our heartfelt gratitude to the following organisations and individuals for making this unique fellowship possible. We are especially grateful to Dr. Samir Saran for his overarching vision and leadership; to Dhruva Jaishankar and Sharon Stirling for their guidance and steadfast support in enabling ORF America's participation in the programme; and to Anirban Sarma, Jeffrey D. Bean, Natalie Boyse, and Ishani Chettri for their unwavering commitment and programme support throughout the duration of the project. Our sincere thanks also go to Shubh Soni, Tanoubi Ngangom, Pulkit Mohan, Sanjith Srikanth, Sukhmani Sharma, Sarah Sawhney, and the entire ORF Raisina Dialogue team for their exceptional efforts in coordinating events, meetings, and travel for all Fellows and staff. We thank Stelin Paul, and again Jeffrey D. Bean for their invaluable editorial guidance.

The chapters in this book have greatly benefited from the insightful critiques from our external reviewers and ORF experts, including, Amoha Basrur, Anirban Sarma, Aparna Roy, Basu Chandola, Chaitanya Giri, Oommen C. Kurian, Sameer Patil, Shravishtha Ajaykumar, K. S. Uplabdh Gopal, and Vivek Mishra. We thank Vinia Mukherjee, Monika Ahlawat, Meryl Mammen, and Rahil Shaikh for the dogged editorial and production work that put together our Fellows' articles into this one impressive volume. Finally, we thank all members of the ORF AI Task Force, as well as every guest lecturer and speaker who joined us for our convenings—their generosity with their time and knowledge enriched our discussions manifold.

This volume, like the fellowship programme it emerged from, is just a first step in helping craft an enduring US-India AI partnership. As the broader bilateral relationship continues to evolve, the structural nature of these relationships provides confidence in finding common ground for strategic technology partnerships between the two countries.

Endnotes

1 Ministry of External Affairs, Government of India, https://www.mea.gov.in/bilateral-documents.htm?dtl/32421/Joint_Statement_Vision_and_Principles_for_IndiaUS_Comprehensive_Global_Strategic_Partnership, 2020.

2 Shorter versions of these chapters have previously been published as commentaries by ORF at: https://www.orfonline.org/series/u-s-india-ai-fellowship-program and ORF America at: https://orfamerica.org/us-india-ai-fellowship.

I

U.S.-INDIA COOPERATION and STRATEGIC CONTEXT

Innovate Together: U.S.-India Collaboration on AI and Emerging Technologies

Elie Alhajjar

Abstract

Indian Prime Minister Narendra Modi's 2025 visit to Washington, DC, marked a pivotal moment for United States (US)-India cooperation in Artificial Intelligence (AI) and emerging technologies. The meeting with President Donald Trump produced an ambitious agenda aimed at elevating the strategic tech partnership to new heights. This article provides an overview of some of the US and India's joint AI initiatives and broader bilateral collaboration in the domain of tech. It examines the strategic context driving closer ties, including shared democratic values and mutual concerns over supply chain resilience and global tech

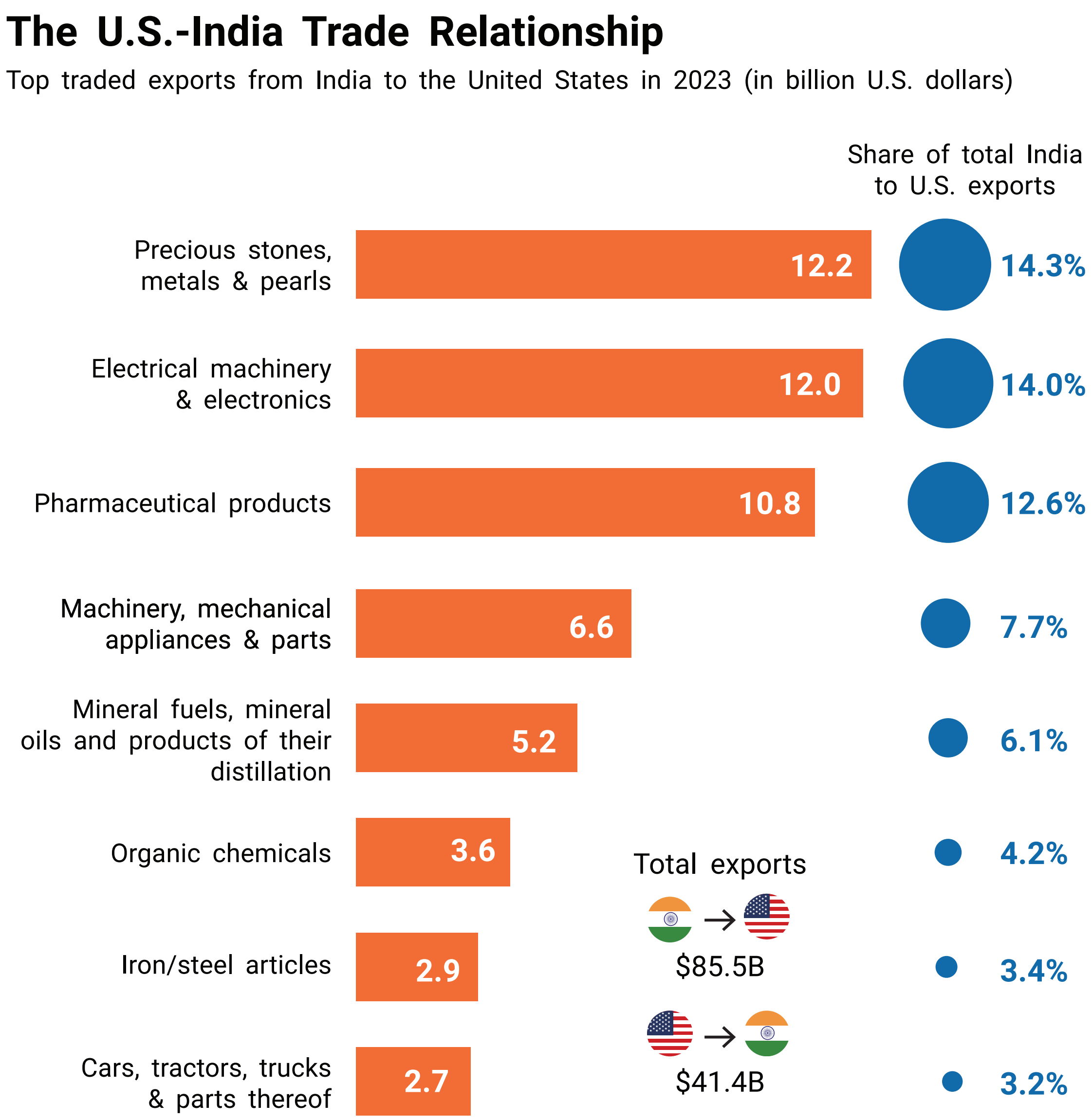
norms. It also analyses the scope and significance of each new framework. The article then addresses key barriers and implementation gaps—such as regulatory hurdles and capacity constraints—which could hinder progress. Finally, it offers actionable policy recommendations for both Washington and New Delhi to ensure that the promises of 'Innovate Together' are realised.

Strategic Context: A Convergence of Interests in Tech Collaboration

The world's two largest democracies, the United States (US) and India, are forging a techno-strategic partnership underpinned by shared democratic values and commitment to a rules-based order.[1] At the same time, geopolitical shifts are compelling greater alignment. Both nations recognise the rise of China's technological and military power as a long-term strategic challenge, necessitating efforts to align on critical and emerging technologies to maintain a competitive edge.[2] By pooling their strengths, the US and India seek to counterbalance China's dominance in sectors like 5G, AI, and critical minerals supply chains. It is worth mentioning that on both sides, the domestic political support for the engagement is bipartisan and/or multipartisan.

Economic synergy also underpins the partnership. The US is now India's largest trading partner, and the latter's booming digital economy and startup ecosystem present vast opportunities for American investors and companies. Bilateral trade has surged in recent years, reaching roughly US$129 billion in goods in 2024 (see Figure 1); the leaders have set an ambitious goal to more than double it to US$500 billion by 2030.[3] This reflects a shared interest in economic growth, job creation, and innovation. New Delhi and Washington both see technology collaboration as a driver of prosperity, whether through e-commerce, advanced manufacturing, or digital services, as well as a means to make supply chains more resilient and diversified to avoid single points of failure.

Figure 1. US-India Bilateral Trade in Goods (2023)



Source: UN Comtrade/BACI International[4]

Security considerations are equally important. Over the past two decades, US-India defence ties have evolved from estrangement to entente. India's desire to modernise its military and reduce reliance on Russian hardware dovetails with America's interest in finding a strong regional partner capable of deterring aggression in the Indo-Pacific. The result is a deepening defence-tech relationship that treats India as a key defence partner of the United States. This status, along with India's designation in Strategic Trade Authorization Tier-1,[5] facilitates smoother technology transfer and licencing for defence items. Both nations perceive that future warfare will be defined by AI, autonomous systems, as well as cyber and space capabilities, and they are determined to develop these jointly wherever possible.[6] The broader Indo-Pacific strategy, including cooperation through the Quad (US, India, Japan, Australia), has further cemented tech and innovation as pillars of the partnership.

Most importantly, the two nations have also moved past historical trust deficits. Legacy hurdles (e.g., India's Cold War non-alignment and the US sanctions after India's 1998 nuclear tests) have gradually given way to mutual trust built on successive agreements like the 2006 Civil Nuclear Agreement.[a] Additionally, an influential Indian diaspora in Silicon Valley, and a history of scientific cooperation (e.g., NASA-ISRO space projects) have fostered people-to-people linkages and understanding. All these had created a ripe environment for Prime Minister Modi's 2025 US visit to facilitate a new wave of initiatives focusing on AI and emerging technologies as core areas of cooperation.

New Frameworks from the 2025 Summit

The February 2025 Modi-Trump meetings culminated in the launch of several high-profile initiatives that include COMPACT, TRUST, INDUS Innovation, and ASIA, each addressing different facets of the partnership. These frameworks aim to institutionalise collaboration across defence, commerce, and technology for the 21st century. Table 1 provides an overview of these key initiatives; more details can be found in a White House Joint Leaders' Statement.[7]

---

[a] Other key agreements include the 2012 Defence Technology and Trade Initiative (DTTI), which promoted co-development of defence technologies, and the 2018 Communications Compatibility and Security Agreement (COMCASA), which enhanced secure interoperability between the two militaries.

Table 1: Key US-India Technology Initiatives (2025)

Initiative	Name	Focus Areas
COMPACT	Catalysing Opportunities for Military Partnership, Accelerated Commerce & Technology	Defence, trade, and technology integration; bilateral trade goals; regulatory alignment
TRUST	Transforming the Relationship Utilizing Strategic Technology	Critical and emerging technologies, AI, semiconductors, quantum, biotech, and supply chains
INDUS Innovation	India-US Innovation Bridge	Industry-academia collaboration; civilian innovation in space, energy, and R&D
ASIA	Autonomous Systems Industry Alliance	Joint development of unmanned and AI-enabled defence systems, drones, and maritime autonomy

COMPACT: An Umbrella Strategic Partnership

Launched during Prime Minister Modi's 2025 visit to Washington, COMPACT is a framework for deepening US-India cooperation across defence, trade, and innovation. It envisions a new 10-year defence partnership agreement, joint production of systems like Javelin missiles and P-8I aircraft, and a roadmap to double bilateral trade to US$500 billion by 2030. COMPACT also integrates the critical tech areas of space, semiconductors, and AI by anchoring them alongside strategic and commercial priorities.

The TRUST Initiative: Transforming Tech Cooperation

The TRUST initiative institutionalises public-private partnerships across AI, semiconductors, quantum, biotech, and critical minerals. It emphasises both innovation and ecosystem security, pledging to reduce regulatory barriers and align export controls. A key deliverable is the US-India AI Infrastructure Roadmap, designed to expand India's compute capacity through data centres and advanced processors, with shared safeguards and interoperability. TRUST also targets the resilience of pharmaceutical and critical mineral supply chains, framing India as a long-term co-developer in areas essential to global tech sovereignty.

While the US-India Initiative on Critical and Emerging Technology (iCET), launched in 2023, marked a leap in US-India tech cooperation, TRUST builds on that foundation with a more institutional and trade-focused lens. Designed to streamline export controls, enhance supply chain security, and align governance across domains such as AI, biotechnology, and advanced manufacturing, TRUST offers a more comprehensive regulatory and commercial framework than iCET, which is primarily a strategic initiative oriented around national security and innovation. Under the second Trump administration, TRUST has taken on new strategic and transactional twists, with an emphasis on bilateral trade reciprocity and stricter vetting of technology transfers in line with an "America First" approach. This has introduced a more conditional tone to cooperation (especially on dual-use technologies) while still recognising India's strategic value in countering Chinese influence and building resilient, trusted tech ecosystems.

INDUS Innovation: Bridging Industry and Academia

INDUS Innovation, modelled after the defence-focused INDUS-X platform, connects startups, universities, and industry across space, clean energy, and digital health. It aims to institutionalise cross-border innovation ecosystems by seeding joint R&D projects, co-funding public-private ventures, and attracting long-term investment. The initiative builds on India's growing R&D footprint and US innovation leadership to co-create technologies that help overcome shared societal challenges. With many US firms already operating research centres in India, INDUS Innovation scales these links for systematic collaboration beyond bilateral pilot programmes.

ASIA: Autonomous Systems Industry Alliance

The Autonomous Systems Industry Alliance (ASIA) represents a shift from defence procurement to co-development. Its initial focus is maritime drones and counter-drone systems, with partnerships like Anduril (US) and Mahindra (India) exemplifying this new model. ASIA enhances India's defence capabilities while giving US firms access to manufacturing capacity and Indo-Pacific deployment pathways. It deepens military-tech interoperability and positions both countries to lead in AI-enabled autonomous defence systems amid intensifying regional security challenges.

One notable area is the development of autonomous underwater systems, which are critical for enhancing maritime domain awareness and underwater deterrence in the Indo-Pacific, a region where both India and the US face increasing strategic challenges from China. These systems can support anti-submarine warfare, seabed surveillance, and protection of undersea cables, aligning closely with both countries' efforts to secure vital maritime infrastructure. The partnership not only reflects ASIA's ambition to accelerate co-development and fielding of cutting-edge capabilities but also signals a shift toward more operationally meaningful joint innovation in contested domains.

Implementation Challenges

The lofty vision for US-India collaboration on AI and emerging tech faces various obstacles and gaps that both sides must navigate. Historical mistrust may have largely faded, but practical hurdles such as policy frictions and capacity issues could slow progress if left unaddressed. Recognising these challenges is the first step toward overcoming them. Key barriers include the following:

Regulatory and Policy Misalignments

Despite efforts like TRUST to bridge these gaps, differences in laws, regulations, and institutional processes continue to impede effective US-India technology collaboration. The US export control regime still classifies certain high-end technologies as restricted for non-allies. Although India has been granted Strategic Trade Authorization-1 (STA-1) status, it does not receive the same treatment as treaty allies like Japan or NATO members. Complex US licencing procedures can deter agile technology sharing, just as India's high import tariffs (averaging around 17 percent) and local content requirements complicate access to advanced equipment. During PM Modi's 2025 visit, President Trump raised concerns about these barriers, and while India expressed willingness to increase the purchase of US goods, a broader resolution remains elusive.

India's evolving data localisation policies also risk clashing with the US emphasis on cross-border data flows. These regulatory differences are compounded by bureaucratic and institutional hurdles in both countries. For COMPACT and related frameworks to succeed, agencies spanning defence, commerce, and technology must coordinate effectively, yet inter-agency processes are often slow or fragmented. In India, implementation may be hindered by procurement complexities or limited ministerial capacity. While in the US, shifting political priorities and internal policy debates, such as those over export reforms, can create inconsistencies. Without strong oversight and dedicated monitoring mechanisms, these factors collectively threaten to delay or dilute the ambitious outcomes envisioned under the new bilateral frameworks.

Regulatory and policy misalignments continue to pose barriers to US-India tech cooperation, particularly where high-end technologies are subject to restrictive export controls. US ITAR regulations, in particular, have often complicated or delayed transfers of sensitive defence and dual-use technologies to India, even as strategic ties have deepened.

Slow Pace of Trade Negotiations

The plan for a bilateral trade agreement by the end of 2025 is ambitious. In the past, US-India trade talks have repeatedly stalled over agriculture, intellectual property (IP), and market access issues. There is a risk that entrenched interests and political pressures on both sides could delay or dilute the agreement, which, in turn, might limit the scope of tech collaboration (since trade rules on services and digital trade are integral to it). For example, issues like patent protections for pharmaceuticals have historically derailed talks. If these areas are not managed carefully, they could act as speed bumps. Without a modern trade framework, things like seamless e-commerce or digital services trade between the countries might not reach their full potential.

Resource Constraints and R&D Investment Gap

Achieving the goals will require considerable resources. India's R&D spending, at <1 percent of gross domestic product (GDP), is far below that of the US (over 3 percent).[8] Without ramping that up, India may struggle to match US contributions in joint research, and its institutions could be overwhelmed or underfunded in collaborations. The private sector in India also underinvests in R&D relative to its global peers. On the US side, funding dedicated to bilateral efforts (e.g., grants for joint projects, or financing for initiatives like INDUS-X) needs to be maintained or increased, which is not guaranteed given budgetary politics. Likewise, building hardware infrastructure (e.g., fabs or power plants) is capital-intensive. Global economic conditions and risk perceptions will affect the flow of private capital into these envisioned projects.

Divergent Perspectives and Strategic Autonomy

Despite converging interests, the US and India do have different worldviews in some respects. India cherishes its strategic autonomy—meaning that it often avoids being seen as too closely aligned with any one power. This could limit how far it goes with the US on certain issues. For instance, India may hesitate to fully integrate weapons systems if it fears over-dependence, or it might be cautious in intelligence-sharing. Similarly, India's historical ties with Russia present a delicate balancing act; even as it diversifies arms sources, it has not joined Western sanctions on Russia. On the US side, there is always the risk of policy shifts with changes in leadership. A future US administration might prioritise other regions or take issue with aspects of India's policies (e.g., on human rights or trade protectionism), which could spill over into tech cooperation. Maintaining a purely neutral, transactional tone may be difficult if geopolitical crises force choices (e.g., the Taiwan conflict or Iran issues, where India and the US might not align perfectly). Nonetheless, recent agreements including LEMOA, COMCASA, BECA, and GISMOA, have advanced interoperability and created formal mechanisms for secure exchange of geospatial, maritime, and communications intelligence, marking a shift toward deeper strategic alignment.

Policy Recommendations

To realise the full potential of the 'Innovate Together' agenda, both governments must take proactive steps to address hurdles and institutionalise cooperation. The following paragraphs outline actionable recommendations for the US and India to strengthen their AI and emerging tech partnership. These recommendations aim to translate strategic intent into operational reality, ensuring that the lofty goals set by COMPACT and related initiatives lead to tangible outcomes.

For the United States Government

- **Support Joint R&D and Innovation Funding:** Congress and the Administration should dedicate funding to sustain initiatives like TRUST and INDUS Innovation. For instance, create a US-India Innovation Fund (perhaps a public-private endowment) that gives grants to joint research teams in AI, quantum, and green tech. Even a relatively modest fund (say, US$50-100 million) could seed dozens of collaborations. The US should also increase funding for the US-India Science & Technology Endowment Fund,[9] which has a track record of supporting joint projects, and steer it towards emerging-tech applications. Moreover, provide support for establishing joint centres of excellence, such as an Indo-US Center for AI Research, at leading universities.

- **Facilitate Talent Mobility and Exchange:** Easing the movement of Indian professionals and students will directly feed the innovation ecosystem. The US should consider expanding the H-1B visa cap or creating a US-India Innovation Visa—a new category for professionals engaged in bilateral strategic projects. Streamlining visa processing for Science, Technology, Engineering, and Mathematics (STEM) students and researchers by offering expedited interviews or special scholarships for top Indian talent will attract the best to American institutions. Such talent will also be instrumental in nurturing the Indian technology landscape through knowledge and innovation exchanges. Also, fund short-term exchange programmes for US scientists to spend time in Indian labs and vice versa, possibly under the Fulbright or a new fellowship tailored to tech collaboration.

- **Encourage Private Sector Partnerships with Incentives:** The US government can use tax breaks or financing support to nudge American companies into partnering with Indian counterparts. For example, the Development Finance Corporation (DFC)[10] can be utilised for risk insurance or co-investment for US firms setting up R&D centres or manufacturing plants in India for semiconductors (long-term) and electric vehicle (EV) batteries (short-term). Similarly, incentives for US defence companies to engage in co-development with India (like fast-tracking licences or cost-sharing of demo projects under the Department of Defense's comparative technology offices) can be rolled out. These measures will mitigate corporate hesitation and align business incentives with strategic goals.

- **Align International Strategy to US-India Collaboration:** Washington should leverage its international engagements to bolster the partnership. This means advocating for India's inclusion in elite multilateral tech groupings to normalise high-tech trade and supporting its eventual accession to agreements like the Information Technology Agreement (ITA-2)—from which India opted out in 2015. This can be utilised to align tariff regimes and facilitate smoother trade in Information and Communication Technology (ICT) products. By visibly coordinating in forums like the Quad's tech working group or the G20 Digital Economy track, the US can help elevate India's role as a shaper of tech governance. This international validation, in turn, empowers reformers within India to continue aligning with global standards.

For the Government of India

- **Undertake Regulatory Reforms to Attract Tech Trade and Investment:** India should continue reducing barriers that have historically deterred US businesses. This includes lowering tariffs on electronics, IT equipment, and medical devices. The average tariff of 17 percent needs a downward trajectory—even incremental cuts in the upcoming budgets would send a positive signal. Simplifying compliance under local sourcing rules or licenses, especially for defence and sensitive tech projects, is vital. For example, a single-window clearance mechanism for all US-India joint projects could be instituted to cut bureaucratic red tape. India can embed data governance provisions for trusted partners, allowing data flow to the US under adequacy if companies adhere to certain standards. This could effectively address US firms' concerns about data localisation.

- **Boost R&D Spending and Incentivise Innovation:** New Delhi must ramp up its R&D investment to at least 1-2 percent of GDP in the immediate future. This means allocating more funds to national missions (AI, quantum, semiconductor mission) and ensuring they are well-utilised. Public research institutions should receive targeted funding specifically earmarked for collaborative projects with US counterparts. Simultaneously, the government could incentivise private R&D by expanding tax breaks for in-house research and venture capital in deep-tech startups as well as consider matching grants for companies that partner with US firms or labs on R&D. Encouragingly, some steps have already been taken such as the recent Cabinet approval for long-term, low-interest research funding, aimed at supporting innovation through a credit guarantee mechanism for both public and private institutions.[11] Such actions will close the resource gap and make India a more equal partner in joint innovation endeavours.

- **Strengthen Intellectual Property Regimes and Trust:** To reassure foreign partners, India should continue improving its IP protection environment. Although India has updated its IP policy, patent processing time and enforcement remain issues. India can also explore joint IP frameworks for co-developed technology with the US to pre-empt disputes. For example, agreements on IP-sharing in projects under INDUS-X or INDUS Innovation can be drawn in the form of a clear template for Indian and American entities co-inventing solutions. Through this template, both companies can get licensing rights in each other's markets, royalty-free for government use. Moreover, India must maintain its record of protecting sensitive information. Expanding personnel vetting and cyber-hygiene in Indian organisations involved in joint work will assure US partners that technology will not leak or be transferred onward without consent.

- **Expand Education and Skilling Initiatives in Emerging Tech:** Domestically, India should invest in its human capital to support the collaboration. This means updating curricula in universities to include more AI, data science, robotics, and interdisciplinary tech programmes, as industry leaders have emphasised. Launch a 'National Digital Talent Corps'—a programme to train youth in high-end tech skills (AI, chip design, cybersecurity), potentially with US companies like Google, IBM, or NVIDIA contributing to course design or providing trainers. Additionally, ease rules for foreign universities to partner or set up campuses in India to produce more skilled graduates and researchers.

- **Preserve Strategic Autonomy while Deepening Trust:** India should continue its diplomacy of engaging deeply with the US while maintaining independent relationships elsewhere, but it can take steps to signal reliability as a US partner. For example, diversifying defence imports away from Russia (which is ongoing, given recent US deals) should continue, and India could align more with US positions in multilateral tech standards bodies. By transparently addressing any US concerns on market access or human rights in tech (like ensuring internet freedom), India can build a reservoir of goodwill that helps insulate the tech partnership from political swings.

Joint and Collaborative Actions

- **Establish a High-Level US-India Technology Partnership Council:** Create a standing bilateral council chaired by senior officials from the US's and India's National Security circles or respective Science and Technology heads, specifically to track and drive the COMPACT and TRUST outcomes. This council would meet semi-annually and include leaders from the defence, commerce, energy, and science ministries of both sides. Its mandate would include troubleshooting bottlenecks, reviewing progress on each initiative, and setting targets for the next period. The council can publish an annual US-India Tech Partnership Report documenting achievements (such as the number of joint projects started, value of co-investments made) to keep momentum and public accountability.

- **Develop Joint Standards and Certification Bodies:** Setting up bilateral working groups to align standards in critical tech domains would be a practical step. For example, a Joint Task Force on AI Ethics and Standards could bring the US's National Institute of Standards and Technology (NIST) and the Bureau of Indian Standards (BIS) together with industry representatives to develop common principles for AI development and maybe certify products or datasets that meet those standards. Similarly, collaborate on cybersecurity standards to ensure that devices or software developed in either country meet common security criteria. Over time, this could lead to mutual recognition agreements: a product tested in an Indian lab could be automatically approved for use in the US and vice versa, speeding up the deployment of new tech. It would also set a de facto standard that others might adopt.

- **Launch Pilot Projects for Societal Impact:** To demonstrate the value of the tech partnership to citizens and build broad support, the two governments should sponsor a few flagship pilot projects. For instance, a Smart Agriculture Initiative where US satellite imagery and AI analytics are used with Indian farm advisories to improve crop yields in different regions could be considered. Or a joint clean city project where an Indian city and an American city become testbeds for air quality sensors and traffic management deployed by a consortium of both countries' firms. These pilots, conducted under an Indo-US banner, will show how collaboration can tangibly improve lives, creating a constituency for sustained partnership beyond strategic circles.

- **Secure Supply Chain Agreements:** Building on TRUST's supply chain focus, sign specific agreements or MoUs that cement cooperation in critical supply chains. For semiconductors, the countries could ink a Semiconductor Supply Chain MoU that outlines how the US will involve India in its discussions with Japan, South

Korea, and Taiwan. It could also contain details on how India will consult the US on its semiconductor incentive schemes so they complement each other. In the pharmaceutical space, this could be in the form of a joint pledge to avoid export bans on critical medicines to each other and coordinate reserves of key drugs (as highlighted during the COVID-19 pandemic).

By undertaking these recommendations, the US and India can cement the frameworks established in 2025 into lasting pillars of cooperation. This will ensure that COMPACT, TRUST, INDUS Innovation, and ASIA are not just one-off headlines, but continually evolving programmes delivering results year after year. The investments made in aligning policies and resources will pay off in the form of strategic advantages, economic gains, and a stronger position for both nations in the global technology order.

Conclusion

Prime Minister Modi's February 2025 meeting with President Trump marked a turning point in India-US relations, launching initiatives that could reshape the partnership into a global force in technology leadership. Through frameworks like COMPACT and TRUST, both nations are signalling that cooperation in AI, defence innovation, and critical infrastructure are now central to their strategic alignment. This collaboration is rooted in shared democratic values and mutual concerns over economic resilience and supply chain security. The potential benefits are vast: accelerating digital economies, enhancing defence capabilities, and shaping global norms for emerging technologies. By linking innovation ecosystems and investing in joint research, the two countries can set a standard for inclusive, secure, and values-driven tech development.

However, realising this vision will require overcoming regulatory misalignments, bureaucratic inertia, and capacity constraints. Policymakers must sustain momentum through coordinated implementation, strategic investments in R&D and talent, and continuous engagement across government, industry, and academia. The 2025 initiatives are not an endpoint but a beginning. If matched by action and follow-through, they can establish the India-US partnership as a cornerstone of a democratic technology order: one that advances prosperity, resilience, and responsible innovation in an era of global uncertainty.

Endnotes

1 “United States-India Joint Leaders’ Statement,” the White House, February 13, 2025, https://www.whitehouse.gov/briefings-statements/2025/02/united-states-india-joint-leaders-statement.

2 Aggam Walia, “The India-US TRUST Initiative: What is it, and How Will it Strengthen the Critical Minerals and Pharma Supply Chains,” February 16, 2025, https://indianexpress.com/article/explained/explained-economics/us-trust-initiative-9835961.

3 “Modi Says US and India Target $500 Billion Bilateral Trade by 2030,” Reuters, February 13, 2025, https://www.reuters.com/world/india/modi-says-us-india-target-500-billion-bilateral-trade-by-2030-2025-02-13/.

4 “United States/India Bilateral Trade,” https://oec.world/en/profile/bilateral-country/usa/partner/ind.

5 Ministry of External Affairs, Government of India, “India Moved to Tier-1 of Department of Commerce’s Strategic Trade Authorization licence exception,” July 31, 2018, https://www.mea.gov.in/press-releases.htm?dtl/30203/India_moved_to_Tier1_of_Department_of_Commerces_Strategic_Trade_Authorization_licence_exception.

6 Jon Harper, “Trump, Modi Announce New US-India Autonomous Systems Partnership,” February 14, 2025, https://defensescoop.com/2025/02/14/trump-modi-announce-us-india-autonomous-systems-industry-alliance.

7 “United States-India Joint Leaders’ Statement”.

8 “India’s R&D Investment Lags Behind Global Peers, Private Sector Involvement Low: Economic Survey,” The Economic Times, July 22, 2024, https://economictimes.indiatimes.com/news/science/indias-rd-investment-lags-behind-global-peers-private-sector-involvement-low-economic-survey/articleshow/111927926.cms?from=mdr.

9 “The Indo-U.S. Science and Technology Forum,” https://iusstf.org/u-s-india-science-technology-endowment-fund.

10 “U.S. International Development Finance Corporation,” https://www.dfc.gov.

11 Cabinet, Government of India, https://www.pib.gov.in/PressReleasePage.aspx?PRID=2141130.

Mutual Benefit and Global Good: India-U.S. Collaboration on AI

Raj Shekhar

Abstract

Globally, leaders, institutions, and multilateral groupings have been rallying around the crucial need to bridge the global Artificial Intelligence (AI) divide. Unfortunately, progress has been slow, which threatens to worsen economic disparities between countries, erode trust in the international order, and fragment it with far-reaching negative consequences for the world. Collaboration between the world's oldest and largest democracies—the United States and India—on AI development and governance offers a conceivably pragmatic and effective route to accelerate progress toward AI equity and safety. This article outlines key

priorities for cross-border collaboration, along with related opportunities, incentives, and potential pathways for it to flourish and benefit both countries.

Introduction

Artificial Intelligence (AI) is rapidly being recognised as an indispensable resource for countries seeking to enhance national productivity and global competitiveness, and address persistent challenges in critical sectors such as healthcare, education, and finance. Concurrently, it is increasingly being viewed as a powerful weapon for executing sophisticated cyberattacks, causing election interference, and accelerating bioweapons development that could trigger the next pandemic. Therefore, it is incumbent upon leaders globally to negotiate and enforce arrangements that could anchor the development and use of AI in equity and safety considerations. One could term this crucial imperative, implicating countries and stakeholders globally, as responsible AI governance.[1]

At present, the countries of the Global South continue to severely lag[2] in AI investment, innovation, and implementation, except for a few economic powers such as China and India. The core AI enablers, such as advanced high-performance compute and research and innovation talent, remain concentrated in a small group of Western countries, with the United States (US) at the forefront. This also invariably legitimises[3] the Western world's creation of AI safety rules and standards with minimal involvement from the Global South. This global AI divide, if not addressed urgently, could irreversibly deepen economic disparities between countries, erode trust in the international order, and fragment it—potentially resulting in far-reaching consequences for populations and industries worldwide.

Multilateral initiatives, such as the Global Digital Compact[4] of the United Nations and the International Network of AI Safety Institutes,[5] alongside declarations from geopolitical groupings like the G20 New Delhi's Leaders' Declaration of 2023[6] and the G7 Industry, Technology and Digital Ministerial Declaration of 2024,[7] have sought to unite the world around the imperative of responsible AI governance. However, these international cooperation efforts are yet to define concrete mechanisms and/or clear timelines for operationalising the different strands of AI equity and safety. Moreover, the success of these efforts largely depends on sustained consensus among a broad range of sovereign actors with diverse priorities; dilution or erosion of such a consensus[8] is not hard to fathom, especially given the growing multipolarity of the world.

Collaboration between the world's oldest and largest democracies—the US and India—offers a conceivably pragmatic and effective route to accelerate progress toward AI equity and safety. India has been steadily advancing its core capabilities[9] to adopt and scale AI to drive industrial growth and governance reform—while prioritising trust and safety[10]—to achieve its vision of *Viksit Bharat* (Developed India) by 2047. Given India's commitment to advancing equitable access to AI for the global good[11] and its strong alliances within the Global South, one could expect India's expanding AI capabilities to gradually diffuse into regions currently lagging in AI development and governance through focused bilateral or regional partnerships. A notable component of such partnerships could be leveraging India's Data Empowerment and Protection Architecture (DEPA)[12] to help developers in AI-lagging regions unlock and access high-value datasets in a secure, privacy-preserving manner. The US could catalyse this positive momentum toward bridging the global AI divide by leveraging its mature capabilities in AI technology. By strategically collaborating with India on AI development and governance, the US could help empower allies in the Global South to move up the AI ladder. In turn, the leading AI nation could reinforce its reputation as a reliable and trusted technology partner for the world, expand the addressable global market for American AI hardware and software, capitalise on cross-border AI innovation and trade, and reduce the risk of rival coalitions, especially those led by China,[13] in the global AI race. These are all priorities central to advancing the international diplomacy and security objectives outlined in America's AI Action Plan.[14]

Both countries have compelling reasons to collaborate on AI development and governance, which could accelerate progress toward AI equity and safety for a more prosperous, peaceful, and sustainable world. However, to effectively forge and sustain such collaboration, they must align their priorities, develop coordinated strategies, and lay out joint action plans with concrete institutional arrangements for execution.

India-US Collaboration on AI Development and Governance Priorities

India presents a highly lucrative market for American AI, driven by its large population with rising purchasing power, robust digital infrastructure, a vast pool of young, tech-savvy professionals, and a thriving startup ecosystem. The government's strong support for AI innovation and implementation, through national initiatives like the IndiaAI Mission, further enhances the country's appeal as a premier destination for AI investment and collaboration. A strategic collaboration between India and the US on AI development and governance could accelerate India's advancement in AI while enabling American AI to solidify and expand its presence in India and boost its global competitiveness. Pursuing this collaboration could help both countries strengthen their geopolitical and geoeconomic positioning in an AI-driven international order.

The collaboration could be institutionalised through a joint, empowered, and specialised committee, comprising leading Indian and American AI researchers and experts from the industry, academia, and civil society, and representatives from relevant government departments and agencies, such as the Emerging Technologies Division and Cyber Laws Division of the Ministry of Electronics and Information Technology, and the Department of Science and Technology in India—and the Department of Commerce, the Office of Science and Technology Policy and the National Institute of Standards and Technology in the US. This committee could be established under the US-India TRUST (Transforming the Relationship Utilizing Strategic Technology) initiative[15] formerly the Initiative on Critical and Emerging Technology or iCET) and entrusted with identifying the current and emergent AI development and governance priorities in both countries, along with the related opportunities, incentives, and potential pathways for cross-border collaboration.

The recommendation to establish such a committee draws from Chaudhuri and Bhandari's suggestion that bilateral cooperation between India and the US on AI "is a line of effort that needs a fillip".[16] Such a committee could complement the goals and pillars of existing technology partnership frameworks between the two countries, such as the US-India Information and Communications Technology Working Group.[17] To support the mandate of the proposed committee, the following paragraphs present foundational insights into AI development and governance priorities ripe for Indo-US collaboration. The insights have been developed through desk research and engagements with high-level experts and stakeholders from both countries.

Priority 1: High-Quality Datasets

India possesses troves of potentially high-value, publicly-owned data, including public sector records and historical archives covering a gamut of Indian languages, imbued with rich cultural references. However, much of this data is non-digitised and in non-machine-readable formats.[18] For the most part, public datasets that are available in digital format are siloed and unstructured.[19] Well-maintained, richly annotated, and feature-rich Indian datasets that could be leveraged for AI development and innovation remain largely proprietary and inaccessible to startups and researchers.[20]

High-quality, AI-ready Indian datasets will be integral to ensuring that AI models deployed in India cater to the unique linguistic and cultural needs of Indian users. The continuous and steady expansion of this dataset pool could empower AI developers, both in India and the US, to build models and applications tailored to the Indian market, while also fuelling the next wave of innovative AI solutions for the world. The imperative to address India's data gap holds strategic importance for the country and its allies, given that data will likely serve as a key competitive moat[21] for AI companies as models become commoditised, at least in the near to medium term. Recognising this imperative, the IndiaAI Mission has taken on the task of sourcing both public and proprietary datasets and making them available in machine-readable formats through the AIKosh platform.[22]

In parallel, private data marketplaces will remain vital in addressing any shortcomings of government-managed data platforms like AIKosh, as various experts have suggested.[23] The moment is opportune for India and the US to fast-track coordination on strategies for cross-border data sharing, enabling them to jointly advance and shape new frontiers in AI development and innovation. At the core of this effort must be the negotiation of secure technical architectures and protocols, underpinned by robust, interoperable rules to safeguard sensitive, personal, and proprietary data against unauthorised or illegitimate use, to support trusted, scalable, and efficient cross-border data sharing.

A focal point of such negotiations should be recognising the limits of classic command-and-control regulation—typified by the European Union's AI Act—in effectively mitigating AI harms.[24] This recognition could open doors for India and the US to explore techno-legal regulatory approaches that are responsive to AI's fast-moving, unpredictable nature, transformative potential, and rapidly evolving risk landscape. The DEPA Training Framework, for instance, is an emerging exemplar of India's techno-legal regulatory approach that could serve as a common standard for trusted and secure data sharing—supporting cross-border AI development and innovation between the two countries.[25]

Priority 2: High-Performance Compute

Access to advanced high-performance compute (HPC) has been a formidable challenge for AI developers in India, though recent efforts under the IndiaAI Mission are beginning to address this gap. Under the Mission, the Indian government intends to create a high-end common computing facility[26] with over 34,000 Graphics Processing Units (GPUs)[27] to service the AI computing demands of Indian startups and researchers. Additionally, Indian corporate giants like Reliance Industries have procured GPUs from Nvidia with plans to build a 3-gigawatt data centre in Jamnagar, Gujarat.[28] The Government of Telangana has also announced a partnership with NTT Data and Neysa Networks to build a 400-megawatt data centre in Hyderabad which will host 25,000 GPUs.[29]

Meanwhile, Indian innovation hubs like the Centre of AI Research, a joint venture of Ziroh Labs and IIT Madras, have pioneered a novel and cost-effective AI computing solution called Kompact AI that would allow large models like Meta's Llama 2 to run efficiently on standard CPUs, such as off-the-shelf Intel Xeon processors.[30] These advancements in India's AI computing capabilities are promising. Yet, industry experts caution, they are unlikely to suffice to support the country's ambitions for large-scale AI-driven transformations across its public and private sectors.[31] While the Indian government has revealed its intent to "develop its own GPU within the next three to five years" to reduce reliance on imports,[32] it is important to recognise that the Indian semiconductor industry is still nascent and is facing various geopolitical and geoeconomic challenges[33] that threaten to hinder its growth.

Even innovations like Kompact AI are designed to make AI inferencing cost-effective and accessible for organisations without deep pockets, not for training large models or for driving future breakthroughs in AI, which would still require high-end GPUs. The demand for advanced HPC to support India's AI ambitions will continue to outpace domestic supply, at least in the near to medium term. The gap could become even more pronounced as Indian firms dabble with agentic AI systems, where the demand for advanced HPC is expected to exceed all previous thresholds. This creates an opportunity for the American AI chip suppliers to continue the expansion of their presence in India. However, to effectively capitalise on this opportunity, both countries must negotiate balanced tariff structures for American AI exports to India and security safeguards against potential theft or diversion of American GPUs[34]—ensuring such transfers do not create vulnerabilities for US national or economic security.[35] Trump's rescission of Biden's AI Diffusion Rule has likely created a wider berth for negotiations that could yield beneficial outcomes for both countries.[36]

Priority 3: Workforce Development

The Indian government, through projects like the IndiaAI Future Skills Prime[37] and the AI Competency Framework for Public Sector Officials,[38] has been making strides toward building competencies across both public and private sector workforces to develop, deploy, and use AI technologies, while adapting to an AI-driven work environment. In parallel, industry bodies such as Nasscom,[39] along with American technology giants such as Microsoft[40] and Google,[41] have been driving programmes and initiatives to make the Indian workforce AI-ready and support Indian leaders in addressing the organisational change management challenge posed by AI adoption. It is critical that such workforce upskilling and reskilling initiatives not only continue but are routinely adapted and systematically scaled to match the breakneck pace of AI advancements—and to serve the complex needs of India's vast and profoundly diverse public and private sectors. This could help prevent potential contractions in the market for both Indian and American AI solutions, enable India to future-proof its workforce, and help the US optimise its technology labour costs by leveraging India's broad talent pipeline.

The US government and technology giants should, therefore, double down on advancing AI upskilling and reskilling initiatives in India while leveraging strategic partnerships with the Indian government, academic institutions, and industry stakeholders. This support could include faculty development programmes at Indian technical institutes focused on both fundamental and applied AI research, as well as industry training initiatives involving hands-on experience with cutting-edge AI technologies and collaborative projects with American technology companies. The industry training initiatives could also include economic adjustment schemes to support workers transitioning into AI-centric or AI-enabled roles.

Priority 4: Safety Standards

Globally, standard-setting bodies such as International Organization for Standardization/ International Electrotechnical Commission (ISO/IEC)[42] and Institute of Electrical and Electronics Engineers (IEEE),[43] inter-governmental entities such as United Nations Educational, Scientific and Cultural Organization (UNESCO)[44] and Organisation for Economic Co-operation and Development (OECD),[45] government agencies such as the Telecommunication Engineering Centre (TEC)[46] in India and the National Institute of Standards and Technology (NIST)[47] in the US, big technology companies such as IBM[48] and Microsoft,[49] and industry bodies like Nasscom[50] have been advancing efforts to define principles and standards for AI risk identification and mitigation. While these efforts are encouraging, the global AI safety regime remains fragmented, marked by a lack of scientific and regulatory consensus on AI capabilities, risks, and risk mitigation strategies.

This could potentially prevent both Indian and American AI from accessing or retaining their presence in each other's markets, as well as other key foreign markets, thwarting the innovation and growth potential of AI industries in both countries. The need to establish robust, interoperable principles and standards for safe AI remains central to building trust in the technology and promoting cross-border AI innovation and trade between the two nations. Both countries should therefore collaborate to create and operate test beds for evaluating the impact of emerging AI use cases and testing the effectiveness of novel AI safety measures. The results from these trials could be open-sourced, which could solidify the leadership of both nations in shaping and harmonising the global AI safety regime. The IndiaAI Safety Institute and the US Center for AI Standards and Innovation could serve as anchors in advancing such collaborative efforts. The success of these efforts, however, will largely hinge on the two countries aligning on AI risk perceptions and governance philosophies—an outcome that may prove challenging in the wake of Trump's Executive Order 14179 and its emphasis on deregulation and rapid AI development.[51] A structured, high-level bilateral dialogue could help bridge existing differences and foster mutual understanding of responsible AI governance.

Priority 5: Value Assessments

AI's transformative potential remains far from axiomatic, amid strong scepticism voiced by both technology pioneers[52] and cultural critics.[53] Even as the consistent hype around AI has caused AI deployments to steadily increase,[54] especially in the private sector, most organisations continue to struggle to generate tangible value[55] from these deployments. Meanwhile, pundits have suggested that business leaders will need to initiate substantial organisational changes to fully unlock AI's potential.[56]

While large organisations can afford to experiment with this proposition, small and medium-sized businesses simply cannot. Constrained by limited budgets and a low risk tolerance, it is incumbent on the heads of smaller organisations to exercise a high degree of prudence in identifying use cases for AI and redesigning organisational workflows and management structures to avoid critical failure. In government, AI integration would demand an even more cautious approach given the heightened standards of accountability associated with the use of public funds and the large-scale economic, political, and social consequences of potential failures. This underscores the need to generate compelling evidence on value creation from AI adoption and to identify best practices for organisations to extract and scale value from AI integrations across both the public and private sectors.

India and the US should therefore collaborate on joint pilot projects to assess the efficacy and impact of various AI technologies and applications while testing different adoption strategies across sectors of mutual interest. The findings from these pilot projects could be presented as case studies to help organisations effectively overcome existing inertia toward AI adoption and maximise value creation from it while minimising failure risks. This collaboration could ultimately stimulate the demand for AI solutions while mitigating potential market contractions in both India and the US.

Conclusion

As AI transforms the international order, the choices made today will determine whether it unites or divides the world. Strategic, coordinated action on shared priorities—such as unlocking high-quality datasets, expanding high-performance computing access, scaling workforce development, establishing interoperable safety standards, and conducting value assessments—could enable both India and the US to strengthen their geopolitical and geoeconomic positioning in an AI-driven international order, while demonstrating a pragmatic commitment to bridging the global AI divide for a more prosperous, peaceful, and sustainable world. Both countries must act with urgency, ambition, and resolve to set a compelling example of how AI diplomacy can advance national interests while upholding the global good.

Endnotes

1 Prime Minister's Office, Government of India, https://pib.gov.in/PressReleaseIframePage.aspx?PRID=2101740.

2 Tortoise Media, *The Global AI Index 2024*, September 19, 2024, https://www.tortoisemedia.com/data/global-ai#rankings.

3 Sumaya Nur Adan, "The Case for Including the Global South in AI Governance Discussions," *Centre for the Governance AI*, October 20, 2023, https://www.governance.ai/analysis/the-case-for-including-the-global-south-in-ai-governance-conversations.

4 United Nations General Assembly, *Global Digital Compact (A/79/L.2)*, September 2024, https://www.un.org/global-digital-compact/sites/default/files/2024-09/Global%20Digital%20Compact%20-%20English_0.pdf.

5 U.S. National Institute of Standards and Technology (NIST), *Mission Statement – International Network of AI Safety Institutes*, November 20, 2024, https://www.nist.gov/system/files/documents/2024/11/20/Mission%20Statement%20-%20International%20Network%20of%20AISIs.pdf.

6 Government of India, *G20 New Delhi Leaders' Declaration* (New Delhi: Ministry of External Affairs, 2023), https://www.mea.gov.in/Images/CPV/G20-New-Delhi-Leaders-Declaration.pdf.

7 G7 Industry, Technology and Digital Ministerial Meeting, *Ministerial Declaration* (Verona and Trento, March 14–15, 2024), https://assets.innovazione.gov.it/1710505409-final-version_declaration.pdf.

8 The White House, *Removing Barriers to American Leadership in Artificial Intelligence*, Executive Order 14179, January 23, 2025, https://www.whitehouse.gov/presidential-actions/2025/01/removing-barriers-to-american-leadership-in-artificial-intelligence/.

9 Ministry of Electronics and Information Technology, Government of India, https://pib.gov.in/PressReleasePage.aspx?PRID=2108810.

10 Ministry of Electronics and Information Technology, Government of India, https://pib.gov.in/PressReleasePage.aspx?PRID=2065579.

11 Prime Minister's Office, Government of India, https://pib.gov.in/PressReleaseIframePage.aspx?PRID=2101740.

12 "DEPA World: The Complete Reference for DEPA," https://depa.world/.

13 Adan, "The Case for Including the Global South in AI Governance Discussions"

14 The White House, *Winning the AI Race: America's AI Action Plan*, July 2025, https://www.whitehouse.gov/wp-content/uploads/2025/07/Americas-AI-Action-Plan.pdf.

15 The White House, *United States-India Joint Leaders' Statement*, February 13, 2025, https://www.whitehouse.gov/briefings-statements/2025/02/united-states-india-joint-leaders-statement/.

16 Rudra Chaudhuri and Konark Bhandari, *The U.S.–India Initiative on Critical and Emerging Technology (iCET) from 2022 to 2025: Assessment, Learnings, and the Way Forward*, Washington DC, Carnegie Endowment for International Peace, October 2024, https://carnegie-production-assets.s3.amazonaws.com/static/files/The%20U.S.%20India%20Initiative%20on%20Critical%20and%20Emerging%20Technology%20(iCET)%20from%202022%20to%202025%20Assessment,%20Learnings,%20and%20the%20Way%20Forward.pdf.

17 U.S. Department of State, *Joint Statement on the U.S.-India Information and Communications Technology Working Group*, January 17, 2025, https://2021-2025.state.gov/office-of-the-spokesperson/releases/2025/01/joint-statement-on-the-u-s-india-information-and-communications-technology-working-group.

18 Ministry of Culture, Government of India, *Digitization of Cultural Heritage in India*, March 17, 2025, https://www.pib.gov.in/PressReleasePage.aspx?PRID=2111884.

19 Anand Murali, "Data is India's Handicap in AI but Help Is at Hand," *FactorDaily*, February 5, 2019, https://archive.factordaily.com/indian-ai-has-a-dataset-problem/.

20 Anirudh Suri, *The Missing Pieces in India's AI Puzzle: Talent, Data, and R&D*, Washington DC, Carnegie Endowment for International Peace, February 24, 2025, https://carnegieendowment.org/research/2025/02/the-missing-pieces-in-indias-ai-puzzle-talent-data-and-randd?lang=en.

21 Matt Strain, "The AI Moat: Why Data is the Ultimate Competitive Advantage," LinkedIn article, January 30, 2025, https://www.linkedin.com/pulse/ai-moat-why-data-ultimate-competitive-advantage-matt-strain-9jjuc/.

22 Ministry of Electronics and Information Technology, Government of India, *AIKosha: IndiaAI Datasets Platform*, https://aikosha.indiaai.gov.in/home.

23 Anirudh Suri, *The Missing Pieces in India's AI Puzzle: Talent, Data, and R&D*, Washington DC, Carnegie Endowment for International Peace, February 24, 2025, https://carnegieendowment.org/research/2025/02/the-missing-pieces-in-indias-ai-puzzle-talent-data-and-randd?lang=en.

24 Jürgen Hill, "EU Guidelines on AI Use Met with Massive Criticism," *CIO*, July 16, 2025, https://www.cio.com/article/4022707/massive-criticism-of-eu-guidelines-on-the-use-of-ai.html.

25 "DEPA Training Framework," https://depa.world/training/depa_training_framework.

26 Ministry of Electronics and Information Technology, Government of India, "IndiaAI Compute Portal," https://compute.indiaai.gov.in/.

27 Ministry of Electronics and Information Technology, Government of India, https://www.pib.gov.in/PressReleasePage.aspx?PRID=2132817.

28 Aman Rashid, "Mukesh Ambani Buys Nvidia AI Chips, Plans to Build Largest Data Centre in India," *India Today*, January 24, 2025, https://www.indiatoday.in/technology/news/story/mukesh-ambani-buys-nvidia-ai-chips-plans-to-build-largest-data-centre-in-india-report-2669382-2025-01-24.

29 "Telangana Government Inks ₹10,500 Crore MoU with Japanese IT Firms During CM Revanth's Visit," *The New Indian Express*, April 18, 2025, https://www.newindianexpress.com/states/telangana/2025/Apr/18/telangana-government-inks-rs-10500-crore-mou-with-japanese-it-firms-during-cm-revanths-visit.

30 Soumyadeep Sarkar, "Kompact AI, Developed by Ziroh Labs and IIT Madras, Can Run AI Models Without Heavy Computing Chips," *The Tech Portal*, April 10, 2025, https://thetechportal.com/2025/04/10/kompact-ai-developed-by-ziroh-labs-and-iit-madras-can-run-ai-models-without-heavy-computing-chips/.

31 Aihik Sur and Bhavya Dilipkumar, "US AI Export Curbs Spark Concerns in India, Experts Flag Long-term Challenges," *Moneycontrol*, January 16, 2025, https://www.moneycontrol.com/technology/us-ai-export-curbs-spark-concerns-in-india-experts-flag-long-term-challenges-article-12911890.html.

32 Ministry of Electronics and Information Technology, Government of India, https://pib.gov.in/PressReleasePage.aspx?PRID=2108810.

33 Sandeep Bhardwaj, “Geopolitical Limits of India’s Semiconductor Ambitions,” *The India Forum*, October 29, 2024, https://www.theindiaforum.in/technology/geopolitical-limits-indias-semiconductor-ambitions.

34 “How a Mumbai Drugmaker is Helping Putin Get Nvidia AI Chips,” Bloomberg, October 28, 2024, https://www.bloomberg.com/news/features/2024-10-27/russia-is-getting-nvidia-ai-chips-from-an-indian-pharma-company.

35 The White House, *Winning the AI Race: America’s AI Action Plan,* https://www.whitehouse.gov/wp-content/uploads/2025/07/Americas-AI-Action-Plan.pdf

36 Bureau of Industry & Security, U.S. Department of Commerce, *Department of Commerce Announces Rescission of Biden-Era Artificial Intelligence Diffusion Rule, Strengthens Chip-Related Export Controls*, May 13, 2015, https://www.bis.gov/press-release/department-commerce-announces-recission-biden-era-artificial-intelligence-diffusion-rule-strengthens-chip.

37 Ministry of Electronics and Information Technology, Government of India, *FutureSkills Prime: India’s Technology Skilling Hub*, https://www.futureskillsprime.in/.

38 Ministry of Electronics and Information Technology, Government of India, *Empowering Public Sector Leadership: A Competency Framework for AI Integration in India*, March 2025, https://indiaai.s3.ap-south-1.amazonaws.com/docs/empowering-public-sector-leadership-a-competency-framework-for-ai-integration-in-india.pdf.

39 Nasscom, *Nasscom AI Community Program*, https://nasscom.in/ai/nasscom-ai-community/.

40 Microsoft, “Microsoft Launches AI Odyssey to Skill 100,000 Developers in India in Latest AI Technologies and Tools,” *Microsoft Stories India*, January 8, 2024, https://news.microsoft.com/en-in/microsoft-launches-ai-odyssey-to-skill-100000-developers-in-india-in-latest-ai-technologies-and-tools/.

41 Google, “Making Investments in Online Safety, Skill Development and Green Energy to Ensure Long-term growth with AI,” *Google India Blog*, October 3, 2024, https://blog.google/intl/en-in/company-news/outreach-initiatives/making-investments-in-online-safety-skill-development-and-green-energy-to-ensure-long-term-growth-with-ai/.

42 International Organization for Standardization (ISO) and International Electrotechnical Commission (IEC), *ISO/IEC 42001:2023—Information technology — Artificial intelligence — Management system*, December 2023, https://www.iso.org/standard/81230.html.

43 IEEE Standards Association, *P7018: Standard for Security and Trustworthiness Requirements in Generative Pretrained Artificial Intelligence (AI) Models*, June 29, 2023, https://standards.ieee.org/ieee/7018/11306/.

44 UNESCO, *Recommendation on the Ethics of Artificial Intelligence*, November 2021, https://www.unesco.org/en/articles/recommendation-ethics-artificial-intelligence.

45 Organisation for Economic Co-operation and Development (OECD), *AI Principles*, May 2024, https://oecd.ai/en/ai-principles.

46 Telecommunication Engineering Centre, Government of India, *Standard for Fairness Assessment and Rating of Artificial Intelligence Systems* (New Delhi: Department of Telecommunications, Ministry of Communications), https://tec.gov.in/ai-fairness.

47 National Institute of Standards and Technology (NIST), *AI Risk Management Framework*, January 26, 2023, https://www.nist.gov/itl/ai-risk-management-framework.

48 IBM, “AI Ethics,” *IBM Impact*, https://www.ibm.com/impact/ai-ethics.

49 Microsoft, “Responsible AI Principles and Approach,” https://www.microsoft.com/en-us/ai/principles-and-approach.

50 Nasscom, *The Developer's Playbook for Responsible AI in India*, November 2024, https://nasscom.in/ai/pdf/the-developers-playbook-for-responsible-ai-in-india.pdf.

51 The White House, *Removing Barriers to American Leadership in Artificial Intelligence,* https://www.whitehouse.gov/presidential-actions/2025/01/removing-barriers-to-american-leadership-in-artificial-intelligence/

52 Ron Miller, "MIT Robotics Pioneer Rodney Brooks Thinks People Are Vastly Overestimating Generative AI," *TechCrunch*, June 29, 2024, https://techcrunch.com/2024/06/29/mit-robotics-pioneer-rodney-brooks-thinks-people-are-vastly-overestimating-generative-ai/.

53 Freddie deBoer, "Some Say AI Is the Greatest Invention Ever. I Don't Get It," *The Free Press*, January 29, 2025, https://www.thefp.com/p/freddie-de-boer-is-ai-the-greatest-invention-or-overhyped.

54 Alex Singla et al., *The State of AI: How Organizations are Rewiring to Capture Value*, McKinsey & Company, March 12, 2025, https://www.mckinsey.com/capabilities/quantumblack/our-insights/the-state-of-ai.

55 Nicolas de Bellefonds et al., *Where's the Value in AI*, Boston Consulting Group, October 24, 2024, https://www.bcg.com/publications/2024/wheres-value-in-ai.

56 Singla et al., *The State of AI: How Organizations are Rewiring to Capture Value.*

The IMEC as a Foundation for Secure AI Infrastructure Deployment Across the Global South

Divyansh Kaushik

Abstract

The India-Middle East-Europe Economic Corridor (IMEC) provides an opportunity to reshape global connectivity and economic integration. Initially conceived as a transportation and energy logistics corridor, IMEC now stands at a critical juncture where its scope must evolve to address the emerging realities of digital geopolitics. This article proposes the integration of a Secure and Aligned AI Initiative (SAAII) as a foundational digital pillar within IMEC, designed to counter digital dependency, strengthen strategic partnerships, and safeguard national security in an increasingly contested technological landscape. SAAII

presents a bold vision for sovereign nations to reclaim technological independence in an era of expanding state-controlled digital systems. Its architecture combines robust physical infrastructure, transparent governance, and mechanisms for economic empowerment through the deployment of secure, value-aligned AI data centres across the IMEC region and the Global South. By leveraging the complementary strengths of US semiconductor leadership, diversified international capital sources, and India's talent ecosystem, SAAII can create a technology corridor for Global South nations while maintaining high security standards.

Introduction: The Evolving Digital Landscape

The Digital Transformation of Critical Infrastructure

Global power dynamics are increasingly defined not by traditional infrastructure alone, but by the digital architecture that underpins economic, political, and security systems. As nations navigate the fourth industrial revolution, control over digital infrastructure—including data centres, cloud computing platforms, submarine cables, 5G networks, and AI processing facilities—has become as strategically significant as historical investments in roads, railways, and canals during previous eras of development.[1]

The India-Middle East-Europe Corridor (IMEC), announced at the G20 Summit in New Delhi in September 2023, initially emphasised physical connectivity across regions representing over 35 percent of global gross domestic product (GDP).[2] The memorandum of understanding signed by India, the United States (US), Saudi Arabia, the United Arab Emirates (UAE), the European Union (EU), France, Germany, and Italy outlined plans for an integrated multimodal transportation network spanning railway systems, ports, digital cables, energy pipelines, and electricity networks connecting Asia, the Arabian Gulf, and Europe.[3] This ambitious initiative aims to increase trade while reducing logistics costs by up to 30 percent and transit time by up to 40 percent compared to existing routes.[4]

However, in an era where digital sovereignty has become fundamental to national security and economic resilience, IMEC must expand beyond physical infrastructure to include secure digital frameworks. The corridor's unique positioning across continents provides an unprecedented opportunity to establish a new model for digital connectivity—one that prioritises security, sovereignty, and shared prosperity. Unlike existing digital infrastructure models that create dependencies, IMEC can leverage its diverse membership to build resilient, distributed AI systems that serve as alternatives to single-source providers.

This approach aligns with IMEC members' shared goals of technological autonomy while addressing the specific digital transformation needs of Middle Eastern energy economies, and Europe and India's growing semiconductor and AI sectors.

The Challenge of Digital Dependency

The rapid deployment of digital technologies has introduced strategic vulnerabilities across the global landscape. Low-cost technologies, while accelerating connectivity, often present security risks. This is evident in debates surrounding equipment, including base stations and network infrastructure, from companies controlled by or under the influence of the People's Republic of China (PRC)—such as Huawei and ZTE—which have raised concerns about potential backdoors for espionage and data collection.[5]

Recent evidence reveals alarming trends in digital dependency. Over 70 percent of countries that have deployed Chinese AI surveillance systems have experienced a decline in digital privacy protections since 2020. Nearly 83 percent of technology agreements facilitated through properties like China's Belt and Road Initiative (BRI) include mandatory data-sharing provisions. Chinese firms control critical digital infrastructure in 37 out of 54 African nations—a steep rise from 21 in 2019.[6] Expanding Beijing's digital influence is the Digital Silk Road initiative, launched as part of the Belt and Road Initiative, with its investments in 5G networks, undersea cables, satellite systems, and smart city technologies across developing nations. This digital expansion has created new dependencies, with Chinese firms now controlling critical telecommunications infrastructure in over 100 countries.[7]

As AI becomes the central nervous system of modern economies, securing the infrastructure that processes, stores, and analyses enormous volumes of critical data has become a national security imperative. Data centres are the new nerve centres where sensitive information is housed, and without robust security measures, these facilities could become entry points for nations with authoritarian agendas to access proprietary algorithms and critical research.[8]

The Strategic Imperative for SAAII

This initiative is designed to be a critical response to both the challenges of the digital divide and emerging technological dependencies. SAAII embeds secure AI infrastructure within IMEC, providing wider access to advanced AI capabilities—specifically for Global South regions—while ensuring that technological progress advances development goals and helps maintain superior security standards.

SAAII's integration with IMEC leverages a number of unique advantages: the corridor's existing physical infrastructure provides ready pathways for digital cables and data centre locations; the diverse economic profiles of member states—from energy and capital-rich Gulf nations to technology hubs in India and Europe's advanced research and manufacturing ecosystem—create complementary capabilities; and the shared strategic interest in reducing dependency on Chinese digital infrastructure provides strong political alignment. Furthermore, IMEC's geographic span positions it as a digital bridge to Africa, Southeast Asia, and Latin America, addressing the Global South's AI infrastructure gap while maintaining security standards.

SAAII, therefore, creates a secure digital corridor that spans from India through the Middle East to Europe and extends to underserved regions across the Global South. It presents an opportunity to develop AI infrastructure that democratises access to cutting-edge technology for developing nations while maintaining the appropriate security and sovereignty protections.

IMEC's strategic geographic positioning, extending across key markets and technological hubs, provides an ideal platform for SAAII to flourish. The European Centre for Foreign Relations notes that despite geopolitical challenges in the region, the long-term strategic objectives of IMEC participants remain aligned, and initiatives like SAAII can help strengthen these relationships while addressing shared security concerns.[9]

Current State of the Global AI Infrastructure

The Geopolitics of AI Development

The global AI landscape is characterised by intense competition between global powers seeking technological dominance. The US and China have emerged as the primary contenders, with each investing hundreds of billions of dollars in AI research, development, and deployment.

The US approach emphasises private sector innovation catalysed by government investment. The CHIPS and Science Act of 2022 allocated approximately US$80 billion to boost domestic semiconductor manufacturing and research.[10] According to the Semiconductor Industry Association, US fab capacity is projected to increase by 203 percent by 2032, enabling the country to grow its share of global fabrication capacity from 10 percent today to 14 percent by 2032.[11]

China's approach combines state direction with commercial development, investing heavily in AI research and semiconductor manufacturing to reduce its dependency on foreign technology. The EU has adopted a regulation-focused approach that employs heavy-handed tactics to AI development through frameworks like the EU AI Act. India, meanwhile, has positioned itself as a hub for AI talent and research through initiatives like the National Strategy for Artificial Intelligence.[12]

AI Infrastructure Landscape and Vulnerabilities Along the IMEC Corridor

Current AI Diffusion in IMEC Countries

The IMEC corridor encompasses nations at varying stages of AI development and adoption:

- **India** has emerged as a global AI talent hub with over 400,000 AI professionals and growing investments in AI startups, though it lacks advanced semiconductor manufacturing capabilities.[13]
- **The UAE** leads the Middle East in AI adoption, with its National AI Strategy 2031, existing investments exceeding US$30 billion in AI infrastructure, and pledged investments exceeding hundreds of billions of dollars.[14]
- **Saudi Arabia** has planned US$100 billion towards AI development through NEOM and other initiatives, focusing on smart cities and energy sector applications.[15]
- **European Union** members bring world-class research institutions, advanced manufacturing capabilities in specialised semiconductors, and deep expertise in industrial AI applications for sectors like automotive, aerospace, and precision engineering.[16]

IMEC-Specific Vulnerabilities

The corridor faces unique challenges that SAAII must address:

1. **Technology Transfer and Dual-Use Concerns:** The UAE and Saudi Arabia's relationships with both Western and Chinese technology providers create complex security challenges. Both nations have been identified as potential conduits for sensitive technology reaching restricted entities, requiring robust export control mechanisms and end-use monitoring.[17]
2. **Cybersecurity and State-Sponsored Threats:** Gulf cyber risk is elevated by regional rivalries and state actors: the Shamoon wiper devastated Saudi Aramco (2012), Iran-

linked Dustman hit Bahrain's Bapco (2019), and 2025 US/ally advisories warn of continued Iranian targeting of critical infrastructure—risks salient for IMEC's digital corridor.

3. **Data Governance and Surveillance Concerns:** Several IMEC nations employ extensive domestic surveillance systems, raising questions about data protection and privacy standards. The UAE's ToTok messaging app controversy and Saudi Arabia's use of Pegasus spyware highlight the need for clear boundaries between legitimate security needs and privacy protection in SAAII's governance framework.[18]

Chinese Digital Penetration in IMEC Regions

Chinese technology firms have established their presence across the IMEC corridor:[19]

- Huawei has deployed 5G networks in the UAE, Saudi Arabia, and several European nations despite security concerns.
- Chinese surveillance systems are operational in cities across the Middle East, with Dubai and Riyadh utilising extensive Chinese-built smart city infrastructure.
- India has restricted Chinese apps and equipment but remains dependent on Chinese components in its electronics manufacturing sector.

The global AI infrastructure supply chain is characterised by vulnerabilities that can undermine national security and economic resilience. For example, semiconductor manufacturing is highly concentrated geographically, with approximately 75 percent of global production capacity located in East Asia.[20] Nearly all of the world's most advanced semiconductor manufacturing capacity (below 10 nanometres) is currently located in Taiwan and South Korea.[21]

More than 50 points across the semiconductor value chain have one region holding more than 65 percent of the global market share.[22] A RAND Corporation study estimated that a disruption in Taiwan's semiconductor production could cost the global economy up to US$1.6 trillion, highlighting the systemic risks associated with geographic concentration.[23]

Table 1: SAAII vs. Chinese Digital Infrastructure Models

Dimension	SAAII Model	Chinese Digital Silk Road Model
Core Priorities	Security, strategic autonomy, and economic growth	State control, surveillance, and data access
Data Policies	National sovereignty and strategic localisation	State access and mandatory sharing provisions
Governance	Multi-stakeholder coordination	State-directed and centralised control
Security Model	Defence-in-depth and trusted standards	Black-box security and potential backdoors
Economic Model	Market-based with strategic investments	State subsidies and predatory pricing
Value Proposition	Higher quality, strategic independence, and long-term security	Lower upfront cost and faster deployment
Technology Transfer	Capacity building and skill development	Dependence-creating and limited knowledge transfer
Impact on Sovereignty	Preserves national technological autonomy	Creates technological dependencies

The Rise of Authoritarian Digital Infrastructure

The digital landscape has seen an expansion of PRC-controlled infrastructure through initiatives like the Digital Silk Road. This digital component of the BRI has facilitated the export of Chinese surveillance technologies, telecommunications equipment, and digital governance models to participating countries.[24]

Chinese companies have played a central role in deploying critical infrastructure worldwide. Huawei has been instrumental in the global rollout of 5G networks, despite concerns about potential security vulnerabilities. The expansion includes not only hardware deployment but also digital governance models that prioritise state control, representing a challenge to open systems in cyberspace.

The establishment of SAAII within IMEC provides a critical opportunity to counter this trend by offering an alternative model for digital infrastructure development. By creating a corridor of secure and strategically aligned AI infrastructure, SAAII can help ensure that the future digital landscape supports national sovereignty and strategic autonomy.

A Comprehensive SAAII Framework

Building the Foundation for a Robust Technical Infrastructure

At the core of SAAII lies the need for a robust, jointly financed network of secure AI data centres strategically positioned across the IMEC corridor and partner regions. These facilities would serve as the backbone of a strategic AI ecosystem, providing the computational power, storage capacity, and networking infrastructure necessary for advanced AI applications while maintaining strict security standards.

The recent US$1-billion comprehensive digital ecosystem initiative announced by Microsoft and tech entity G42 in Kenya provides a compelling example of the SAAII approach. This landmark project includes the construction of a state-of-the-art green data centre in Olkaria, powered entirely by renewable geothermal energy, and demonstrating how collaborative financing can achieve both scale and security.[25]

The SAAII technical infrastructure would emphasise:

1. **Secure Hardware Supply Chains:** Ensuring that physical components come from trusted sources with transparent supply chains by leveraging the semiconductor manufacturing capabilities of the US and its allies.[26]
2. **Sovereign Computing Environments:** Developing computing frameworks that enable data processing while maintaining strict sovereignty requirements.[27]
3. **Resilient Network Architecture:** Creating redundant, highly available network connections between data centres to ensure operational continuity.[28]
4. **Advanced Cybersecurity Frameworks:** Implementing multiple layers of security controls to protect users against unauthorised access or attacks.[29]

Governance Framework: Ensuring Transparency and Accountability

A robust technical infrastructure must be complemented by a strong governance framework characterised by collaborative oversight. SAAII proposes a multi-layered approach that balances shared decision-making with security requirements.[30]

Key elements include:

1. **Multilateral Strategic Oversight:** Establishing governance structures with rotating leadership among key partners to ensure equitable participation in critical infrastructure operations and strategic planning.
2. **Security-Focused Data Governance:** Developing clear policies for data collection, storage, processing, and sharing that prioritise security and national interests while facilitating the necessary data flows for AI deployment across Africa, Southeast Asia, and South Asia.
3. **Collaborative Technical Standards:** Creating guidelines for secure development and deployment of AI applications, with emphasis on interoperability, security, and accessibility for emerging markets.
4. **Comprehensive Risk Assessment:** Implementing regular assessments of security risks and operational dependencies with mechanisms to ensure resilient and diversified infrastructure networks.
5. **Global South Priority Framework:** Establishing mechanisms to prioritise AI infrastructure deployment and capacity building specifically across Africa, Southeast Asia, and South Asia with dedicated resources and governance structures focused on the needs of developing nations.
6. **Export Controls and Compliance:** Ensuring compliance with relevant export control regimes while facilitating legitimate technology transfer for development purposes.

Economic Empowerment: Driving Growth and Innovation

Beyond security and governance, SAAII aims to deliver tangible economic benefits to Global South regions, like Africa, Southeast Asia, and South Asia, through various mechanisms designed to foster inclusive growth, innovation, and technological leapfrogging opportunities.

The components of economic empowerment include:

1. Multilateral Development Financing: Pooling resources from like-minded countries and development institutions (such as the Development Finance Corporation and the Asian Development Bank) to secure substantial capital investments in AI infrastructure that prioritises access and affordability.[31,32]
2. Global South Talent Development Networks: Facilitating cross-border sharing of technical expertise through centres of excellence that drive innovation while building local capacity in developing regions situated in Africa and Asia. This can be achieved by leveraging India's educational expertise and the US's research capabilities.

3. Measurable Development Impact: Investments in Information and Communication Technology (ICT) infrastructure have proven particularly impactful in developing economies. Studies show a positive correlation between ICT adoption and economic development at both national and commercial levels.[33] In the UAE, for example, the ICT spending multiplier on non-oil GDP is around 1.8, which is notably higher than the multiplier for non-ICT investments at 0.9.[34]
4. Innovation Ecosystems for Developing Nations: This involves creating environments that foster local entrepreneurship and research around AI applications relevant to challenges in the Global South, including agriculture optimisation, healthcare delivery, education access, and financial inclusion through targeted incubators and technology transfer programmes.[35]

Complementary Strengths: US Chips, International Capital, and Indian Talent

The US's AI and Semiconductor Leadership

The US maintains a dominant position in various segments of the global semiconductor value chain, particularly in chip design, electronic design automation (EDA) software, and core intellectual property. This leadership provides a foundation for secure AI infrastructure development within SAAII.[36]

American companies account for approximately 48 percent of the global semiconductor market revenue, with particular strength in logic chips, which are essential for AI applications.[37] American firms like Nvidia, Intel, AMD, and Qualcomm lead in the designing of advanced processors for various applications.

The CHIPS and Science Act has accelerated domestic semiconductor manufacturing capacity. The US is expected to secure some 28 percent of the global capital expenditures between 2024 and 2032, which amounts to an estimated US$646 billion.[38] This investment is projected to triple the US's fabrication capacity over the next decade.

Within SAAII, the US's semiconductor leadership can ensure secure chip designs specifically optimised for AI applications, trusted supply chains for critical components, advanced manufacturing capabilities, and technical standards that emphasise security and performance.

International Capital and Global Development Focus

The development of SAAII requires substantial international capital from diverse sources committed to expanding AI infrastructure globally, with particular emphasis on catering to underserved regions in the Global South. Multiple funding mechanisms and international partners can contribute to this development-focused initiative.

Financial Capabilities of the Gulf Region: Gulf states, particularly Saudi Arabia and the UAE, possess the financial resources and strategic positioning required for widespread AI infrastructure development. Their sovereign wealth funds have accumulated vast resources that are increasingly being directed toward advanced technology investments as part of broader economic diversification strategies.[39]

In 2024, *Bloomberg* reported on Saudi Arabia's plans for a new AI project, backed by close to US$100 billion, to develop a technological hub that is expected to rival that of the UAE.[40] The UAE has established MGX, a US$100-billion fund developed in partnership with BlackRock and Microsoft, aimed at investing in AI companies and infrastructure.[41]

Multilateral Development Framework

- **Development Banks:** The Asian Development Bank, World Bank, and regional development banks offer established frameworks for financing infrastructure in developing nations.
- **Blended Finance Mechanisms:** This model combines public and private capital to reduce risks and make projects viable in emerging markets.
- **Impact Investment Funds:** These comprise private capital specifically focused on generating positive social and economic impact in underserved regions.

US and Allied Government Support: The Development Finance Corporation, Export-Import Bank, and similar institutions from allied nations can provide strategic financing while promoting the export of secure AI technologies to markets across Africa, Latin America, and Asia.

Indian Technology Talent: The Human Capital Engine

India's position as a global technology talent hub provides a critical advantage for SAAII implementation. At a global level, India leads in AI skill penetration with a score of 2.8, surpassing the US (2.2) and Germany (1.9) as per the Stanford AI Index 2024.[42] The country's AI talent concentration has grown by 263 percent since 2016.

Currently, 20 percent of global semiconductor design talent comes from India, with over 35,000 engineers engaged in chip design. However, this talent is predominantly employed by established international fabless companies rather than Indian design firms, reflecting the current lack of indigenous agency in the semiconductor design space. Additionally, intellectual property protection frameworks in India require strengthening to support advanced technology development and ensure secure design environments.

Despite these challenges, India's vast engineering talent pool represents a significant opportunity for SAAII. The initiative can help develop indigenous design capabilities while leveraging existing expertise to support secure supply chain development. This approach would complement the US's manufacturing capabilities and create opportunities for more resilient end-to-end supply chains within the SAAII framework, while also building Indian institutional capacity in advanced semiconductor design.[43]

Conclusion

The Secure and Aligned AI Initiative within IMEC represents a transformative opportunity to democratise access to advanced AI infrastructure while addressing the urgent digital divide affecting billions of people across Africa, Latin America, Southeast Asia, and South Asia. As AI becomes increasingly central to economic development, education, healthcare, and social progress, ensuring equitable access to secure, trusted infrastructure for Global South nations is both a moral imperative and a strategic opportunity.

SAAII offers a collaborative framework that leverages the complementary strengths of all partners—the US's technological leadership, international capital and energy resources; and Indian technical talent—to deliver meaningful AI capabilities to underserved regions throughout the Global South. This approach transforms IMEC from a traditional corridor to a comprehensive platform for digital inclusion in the Global South.

Development Impact Priority: The initiative's success should be measured not only by infrastructure deployment but by tangible improvements in education, healthcare, economic opportunity, and governance capabilities across Africa, Southeast Asia, and South Asia. By prioritising these outcomes, SAAII can demonstrate the power of multilateral cooperation in addressing development challenges in the region.

Bridging the Digital Divide: As digital transformation accelerates, the gap between connected and unconnected populations across the Global South continues to widen. SAAII presents an opportunity to reverse this trend by making advanced AI capabilities accessible to emerging markets in Africa and Asia, enabling leapfrog development opportunities that can transform entire regions.

By pursuing this vision through collaborative action and shared commitment, SAAII can advance not only economic and security interests but also the development goals in the Global South. It is indeed a unique opportunity to demonstrate that international cooperation can deliver concrete benefits to developing nations while building more resilient and secure digital infrastructure specifically designed to address the requirements in the Global South.

Endnotes

1 James Lewis, "Digital Geoeconomics and National Security," Center for Strategic and International Studies, March 2022, https://www.csis.org/analysis/digital-geoeconomics-and-national-security.

2 World Bank, "GDP Statistics 2023," World Bank Data, 2024, https://data.worldbank.org/indicator/NY.GDP.MKTP.CD.

3 "Memorandum of Understanding on the Principles of an India – Middle East – Europe Economic Corridor," The White House, 2023, https://bidenwhitehouse.archives.gov/briefing-room/statements-releases/2023/09/09/memorandum-of-understanding-on-the-principles-of-an-india-middle-east-europe-economic-corridor/

4 Hannah Ellis-Petersen, "G20: EU and US Back Trade Corridor Linking Europe, Middle East and India," *The Guardian*, September 9, 2023, https://www.theguardian.com/world/2023/sep/09/g20-eu-and-us-back-trade-corridor-linking-europe-middle-east-and-india.

5 "China's Digital Silk Road: Strategic Technological Competition and Exporting Political Illiberalism," Council on Foreign Relations, September 26, 2022, https://www.cfr.org/china-digital-silk-road/.

6 Divyansh Kaushik, "Securing our Digital Future: The Case for a Secure and Aligned AI initiative Within IMEC," Observer Research Foundation, https://www.orfonline.org/index.php/expert-speak/securing-our-digital-future-the-case-for-a-secure-and-aligned-ai-initiative-within-imec.

7 Jonathan E. Hillman, "The Digital Silk Road: China's Quest to Wire the World and Win the Future," *Harper Business*, 2021.

8 Jon Bateman, "Securing the Digital Commons: U.S. Approaches to Countering Authoritarian Digital Threats," Carnegie Endowment for International Peace, July 2022, https://carnegieendowment.org/2022/07/13/securing-digital-commons-u.s.-approaches-to-countering-authoritarian-digital-threats-pub-87478.

9 Alberto Rizzi, "The Infinite Connection: How to Make the India-Middle East-Europe Economic Corridor Happen," European Council on Foreign Relations, June 11, 2024, https://ecfr.eu/publication/the-infinite-connection-how-to-make-the-india-middle-east-europe-economic-corridor-happen/.

10 Stephen Ezell, "CHIPS for America Act Essential to U.S. Semiconductor Competitiveness," Information Technology and Innovation Foundation, January 2021, https://itif.org/publications/2021/01/11/chips-america-act-essential-us-semiconductor-competitiveness/.

11 "Emerging Resilience in The Semiconductor Supply Chain," Semiconductor Industry Association, May 16, 2024, https://www.semiconductors.org/emerging-resilience-in-the-semiconductor-supply-chain/.

12 NITI Aayog, "National Strategy for Artificial Intelligence," June 2018, https://niti.gov.in/writereaddata/files/document_publication/NationalStrategy-for-AI-Discussion-Paper.pdf.

13 "Advancing India's AI Skills: Interventions and Programmes Needed," NASSCOM, August 2024, https://community.nasscom.in/communities/data-science-ai-community/advancing-indias-ai-skills-interventions-and-programmes.

14 "UAE National Strategy for Artificial Intelligence 2031," UAE Government, 2021, https://ai.gov.ae/wp-content/uploads/2021/07/UAE-National-Strategy-for-Artificial-Intelligence-2031.pdf.

15 Marissa Newman, Julia Love, Mark Bergen, and Christine Burke, "Saudis Plan $100 Billion AI Powerhouse to Rival UAE Tech Hub," *Bloomberg News*, November 11, 2024, https://www.bloomberg.com/news/articles/2024-11-06/saudis-plan-100-billion-ai-powerhouse-to-rival-uae-s-tech-hub.

16 European Commission, "Chips Act," 2024, https://digital-strategy.ec.europa.eu/en/factpages/chips-act.

17 "China and the Middle East," U.S.-China Economic and Security Review Commission, November 2024, https://www.uscc.gov/sites/default/files/2024-11/Chapter_5--China_and_the_Middle_East.pdf.

18 Freedom House, "United Arab Emirates," 2024, https://freedomhouse.org/country/united-arab-emirates/freedom-net/2024; Freedom House, "Saudi Arabia," https://freedomhouse.org/country/saudi-arabia/freedom-net/2024.

19 James Lynch, "Iron Net: Digital Repression in the Middle East and North Africa," European Council on Foreign Relations, 2022, https://ecfr.eu/publication/iron-net-digital-repression-in-the-middle-east-and-north-africa/; "China and the Middle East," U.S.-China Economic and Security Review Commission.

20 "Strengthening the Global Semiconductor Supply Chain in an Uncertain Era," Semiconductor Industry Association, May 11, 2021, https://www.semiconductors.org/strengthening-the-global-semiconductor-supply-chain-in-an-uncertain-era/.

21 "Strengthening the Global Semiconductor Supply Chain in an Uncertain Era."

22 "Strengthening the Global Semiconductor Supply Chain in an Uncertain Era."

23 Daniel Egel et al., "Economic Consequences of a Conflict Between China and Taiwan," RAND Corporation, 2023, https://www.rand.org/pubs/research_reports/RRA1288-1.html.

24 Samantha Hoffman and Elsa Kania, "Huawei and the Ambiguity of China's Intelligence and Counter-Espionage Laws," The Strategist, Australian Strategic Policy Institute, September 13, 2018, https://www.aspistrategist.org.au/huawei-and-the-ambiguity-of-chinas-intelligence-and-counter-espionage-laws/.

25 "Microsoft and G42 Announce $1 Billion Comprehensive Digital Ecosystem Initiative for Kenya," Microsoft News Center, May 22, 2024, https://news.microsoft.com/2024/05/22/microsoft-and-g42-announce-1-billion-comprehensive-digital-ecosystem-initiative-for-kenya/.

26 John Costello and Mikhail Grinberg, "Securing Semiconductor Supply Chains: An Evolving US Approach to Technology Competition," Carnegie Endowment for International Peace, March 2023, https://carnegieendowment.org/2023/03/14/securing-semiconductor-supply-chains-evolving-us-approach-to-technology-competition-pub-89112.

27 Anupam Chander and Haochen Sun, "Sovereignty 2.0," *Georgetown Law Journal* 110, 2021, https://georgetownlawjournal.org/articles/447/sovereignty-2-0.

28 Arvind Krishna et al., "Resilient Network Systems," Computing Community Consortium, 2020, https://cra.org/ccc/wp-content/uploads/sites/2/2020/11/Resilient-Network-Systems-2020.pdf.

29 National Institute of Standards and Technology, "Framework for Improving Critical Infrastructure Cybersecurity, Version 1.1," April 16, 2018, https://nvlpubs.nist.gov/nistpubs/CSWP/NIST.CSWP.04162018.pdf.

30 Mark MacCarthy and Kenneth Propp, "Machines and Trust: Developing Responsible AI Governance," Brookings Institution, May 2021, https://www.brookings.edu/articles/machines-and-trust-developing-responsible-ai-governance/.

31 "Microsoft's Investment in G42 will Enhance the UAE's Position as a Leading AI Hub," Microsoft, April 16, 2023, https://news.microsoft.com/en-xm/2023/04/16/microsofts-investment-in-g42-will-enhance-the-uaes-position-as-a-leading-ai-hub/.

32 Asian Development Bank, "Digital Development," 2023, https://www.adb.org/what-we-do/topics/digital-technology/overview.

33 World Bank, "World Development Report 2023: Data for Better Lives," 2023, https://documents1.worldbank.org/curated/en/099554003092330716/pdf/IDU0d9338f7201a08048bb088650a4f928761e4b.pdf.

34 International Monetary Fund, "Information and Communication Technologies and Productivity Growth in the UAE," 2023, https://www.elibrary.imf.org/view/journals/002/2023/224/article-A003-en.xml.

35 Martina Ferracane and Erik van der Marel, "The Importance of Cross-Border Data Flows for AI Development and Diffusion," ECIPE Policy Brief, January 2023, https://ecipe.org/publications/importance-of-cross-border-data-flows-for-ai/.

36 "Mapping the Semiconductor Supply Chain: The Critical Role of the Indo-Pacific Region," Center for Strategic and International Studies, October 15, 2024, https://www.csis.org/analysis/mapping-semiconductor-supply-chain-critical-role-indo-pacific-region.

37 "Mapping the Semiconductor Supply Chain: The Critical Role of the Indo-Pacific Region"

38 "Emerging Resilience in The Semiconductor Supply Chain"

39 "Strategic Technology in the Middle East: Gulf States' Place in the AI Race," Italian Institute for International Political Studies, January 29, 2025, https://www.ispionline.it/en/publication/strategic-technology-in-the-middle-east-gulf-states-place-in-the-ai-race-198131.

40 Newman, Love, Bergen, and Burke, "Saudis Plan $100 Billion AI Powerhouse to Rival UAE Tech Hub."

41 "The UAE and US: Forging the Future of AI and Advanced Tech," UAE Embassy, https://www.uae-embassy.org/uae-us-cooperation/economic/artificial-intelligence.

42 "India Leads Global AI Talent and Skill Penetration," India AI, https://indiaai.gov.in/article/india-leads-global-ai-talent-and-skill-penetration.

43 "India's AI Talent Pool to Grow to 1.25 Million by 2027: Nasscom-Deloitte India Report," India AI, https://indiaai.gov.in/article/india-s-ai-talent-pool-to-grow-to-1-25-million-by-2027-nasscom-deloitte-india-report.

Artificial Intelligence: The Infinite Game of the 21st Century

Honson Tran

Abstract

Artificial Intelligence (AI) is often framed as a finite "race" between the United States (US) and China, yet such framing obscures the technology's complexity and long-term significance. AI should instead be understood as an infinite game—a contest without winners or losers, where the objective is to persist, adapt, and evolve. Current leadership across the AI technology stack reveals critical asymmetries: the US dominates infrastructure and foundational research but struggles with public adoption, while China excels in efficient resource utilisation despite hardware constraints. India emerges as a pivotal third player, leading globally in AI

skills penetration and application deployment through robust digital public infrastructure. These complementary strengths become crucial as AI moves beyond centralised cloud computing toward the Edge Continuum—distributed intelligence that will determine AI's true pervasiveness and sustainability. Enduring partnerships, particularly between the US and India, are essential to shaping AI as a resilient, inclusive, and human-centred force for the 21st century.

Introduction

Artificial Intelligence (AI) is one of the most significant technological advancements of our time. As the 21st century progresses, AI will become a more powerful force and catalyst for sectors and industries across the board. Both private and public sectors are shifting towards harnessing AI, trying to capture the so-called "lightning in a bottle".[1]

Yet, one of the main concerns surrounding AI is its strong nature as a dual-use technology. Global powers are rushing to establish dominance and mastery of the technology in what is being popularly referred to as the "AI arms race".[2] However, AI is not merely about technological advancement; it is about securing a nation's future in terms of national security and economic prosperity, and upholding core values in an increasingly interconnected world.

This dual-use technology raises an important question: Is the "AI race" truly a race, or an infinite game? Policymakers and analysts typically frame this as a binary competition—the United States (US) versus China—with clear winners and losers. Such framing, determined by who builds the most powerful models or accumulates the most compute, misses a critical element. One singular metric never defined AI leadership. Today's frontrunners may dominate model training, but tomorrow's leaders could set the standard in data privacy, compute sustainability, or international cooperation. It is a constantly shifting game that involves a multitude of variables.

Describing the intent to achieve AI dominance as a "race" would imply that there are winners and losers, determined by geopolitical and strategic outcomes like negotiation leverage, intelligence advantages, and economic dominance. However, there is no such thing as winners and losers in the AI domain; there are simply remaining players left in the game. The entire goal of the infinite game is not to win or lose, but to persist and constantly evolve within the game. Those who understand the infinite game understand that it is not about the battle; it is about the war. Here is where the conventional US-versus-China narrative becomes strategically limiting. While Washington fixates on outcompeting Beijing,[3] it overlooks a nation that brings the exact complementary strengths needed to excel in this infinite game: India.

For example, with regard to data centres, the US has the largest number in the world,[4,5] the highest energy use,[6] biggest amounts of investment capital,[7] and the highest model scores.[8] Despite all these advantages, however, China is achieving almost on-par model capability[9] and producing more AI publications than any other country.[10] Meanwhile, India ranks first globally in AI skills penetration[11] and leads in technology adoption rates that American companies can only dream of achieving.

The infinite game framework reveals why this matters strategically. Success requires sustained excellence across the entire AI technology stack: infrastructure, technology, and applications. The US excels in the first two layers but struggles with the third, where public scepticism runs high[12,13] and regulatory uncertainty creates deployment friction.[14] India dominates precisely where America falters—the application layer, where AI interfaces with users and generates the data needed to drive continuous improvement.

Establishing AI leadership feels like a tactical race, especially for those in the government, defence, and industrial sectors. However, at a strategic and humanistic level, it is an ongoing, indefinite game to shape AI in ways that benefit humanity in the long run. The question is not whether the US can beat China in a traditional competition, but whether America can build the partnerships needed to remain a leading player in an infinite game that will define the next century.

The Components of an Infinite Game

In an infinite game, the only competition is oneself. The idea is not to beat another player once and for all—one seeks to outlearn, outlast, and out-adapt your past performance.

According to Simon Sinek, author of The Infinite Game, five interdependent components will help one succeed in this game:[15]

- **A just cause** – A vivid, long-term vision that aligns every policy, research, and investment decision toward a shared purpose, rather than a one-off victory or comparison of resources and metrics. In other words, strong guiding tenets must be embedded in decision-making.

- **Trusting teams** – A culture where engineers, ethicists, and regulators can freely admit mistakes and raise concerns. Establishing a “fail fast” culture—where experiments and ideas are tested quickly, failures are recognised early, and teams can rapidly iterate—and extensive sandbox will allow for fast-paced AI development and incentivise immediate pauses and pivots along development for assessment and reflection.

- **Worthy rivals** – The presence of worthy opponents points out one's weaknesses. These moments can provide opportunities to gain strength. In the context of AI, this can range anywhere from improving infrastructure, finding creative solutions with limited compute, or improving research funding to promote discoveries.

- **Existential flexibility** – The willingness and capability to pivot dramatically if current strategies and approaches do not serve the long-term vision or just cause. Pivoting could entail, but is not limited to, redefining metrics of success, rapid adaptation of organisational structures and culture, and changes in core missions and business models.

To establish leadership in the AI space, it is crucial to understand the strengths, weaknesses, and areas of opportunity for growth. Success and leadership demand humility in recognising that one's position on the leaderboard can fluctuate over time across many areas of the technology stack. Identifying and partnering with other countries to achieve these goals as AI advancements accelerate is more critical than ever.

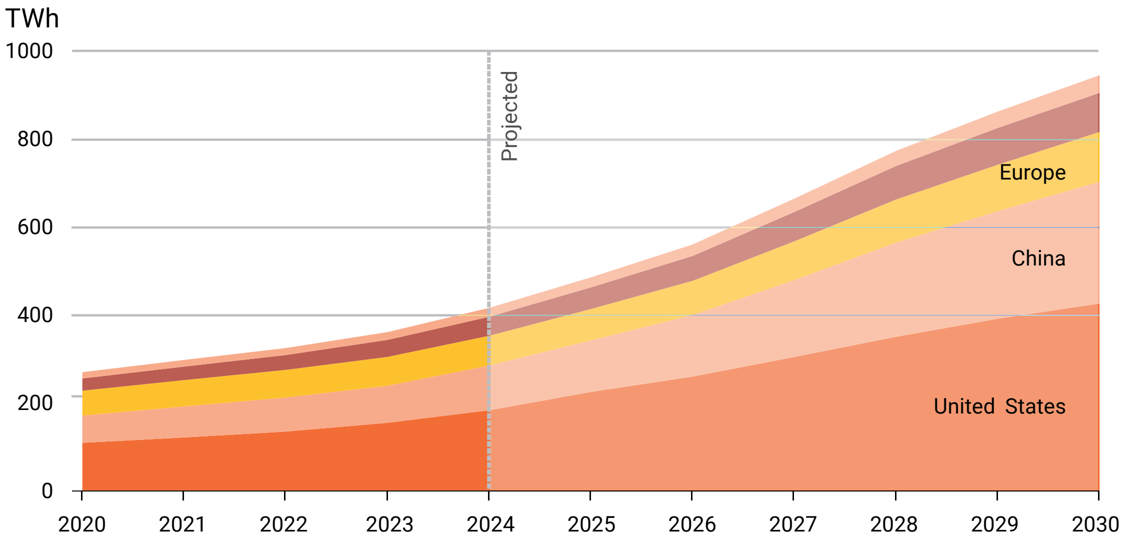
The AI Tech Stack

AI leadership is not just about having the best model; it involves many additional factors and well-defined goals across the complete technology stack, which comprises infrastructure, technology, and application. For example, leadership in model capabilities can only be helpful to others if successfully diffused into society. Diffusion will allow for continuous improvements to these systems over time.

Infrastructure

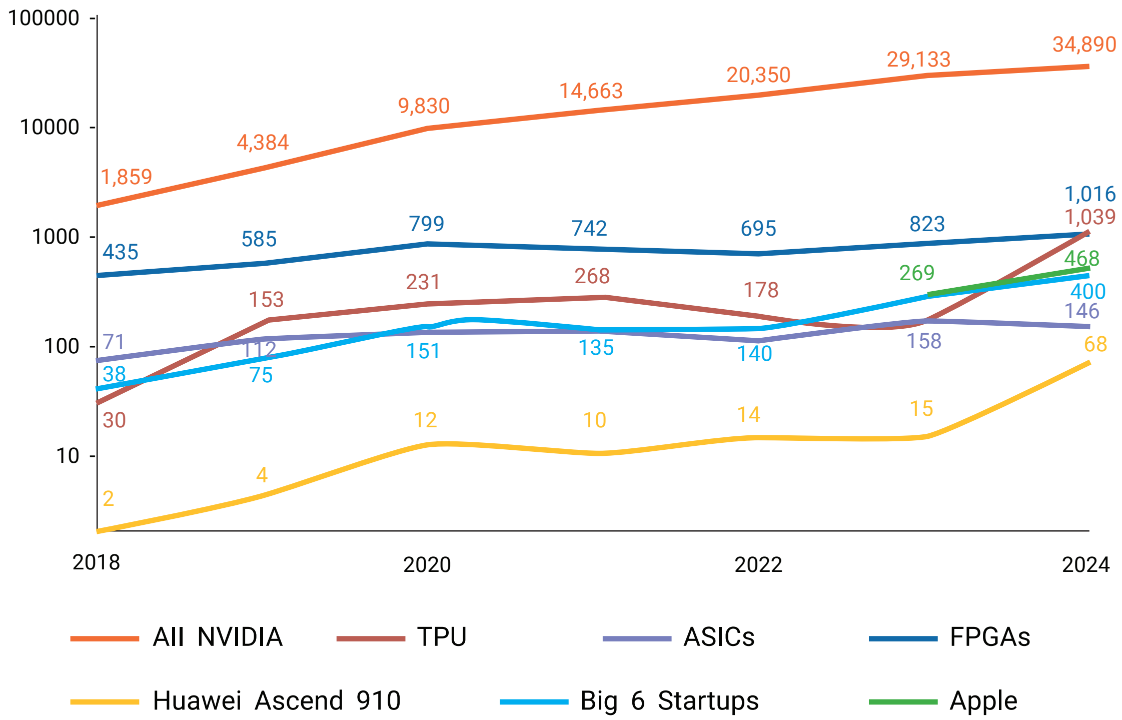
Infrastructure can be seen as the bedrock of the technology stack. The term 'infrastructure' is broad and covers an array, from semiconductor fabrication facilities to highly interconnected GPU (Graphics Processing Unit) data centres. Data centres accounted for 1.5 percent of the world's electricity consumption in 2024. Of all data centres, those in the US had the highest energy usage, accounting for 45 percent, followed by China with 25 percent[17] (see Figure 1).

Figure 1: Data Centre Electricity Consumption by Region (Base Case, 2020-2030)



Source: IEA[16]

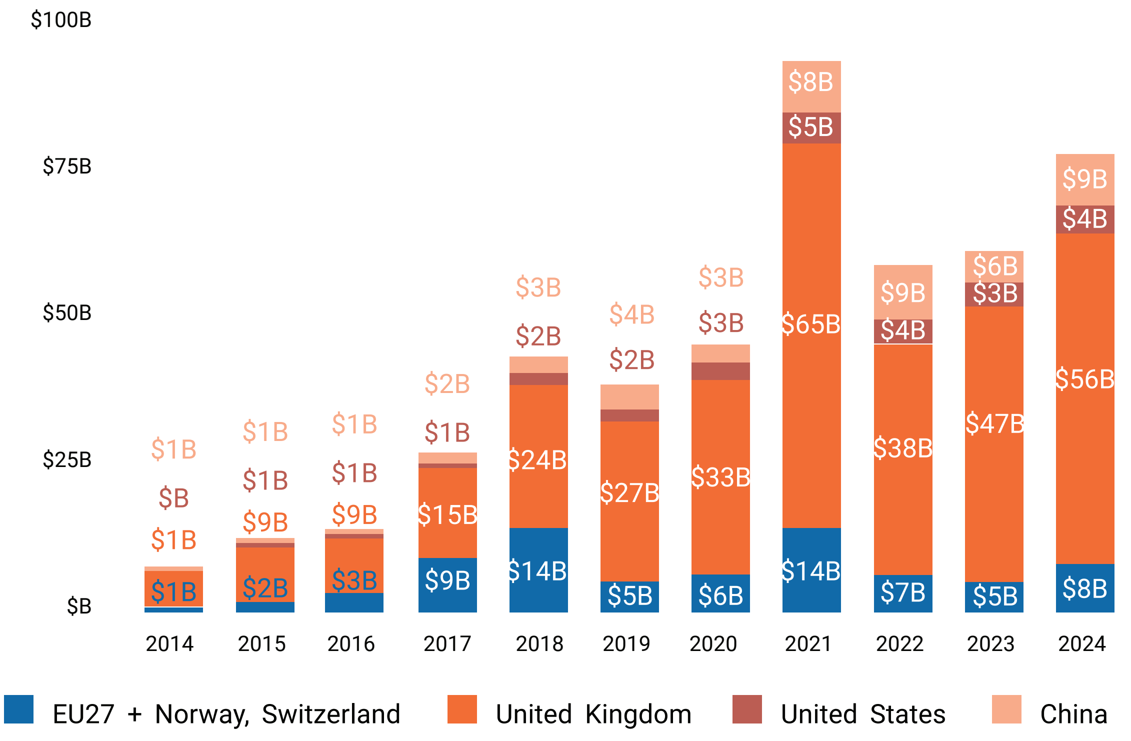
Figure 2: Cited Hardware Usage in AI Research Papers



Source: State of AI Report[18]

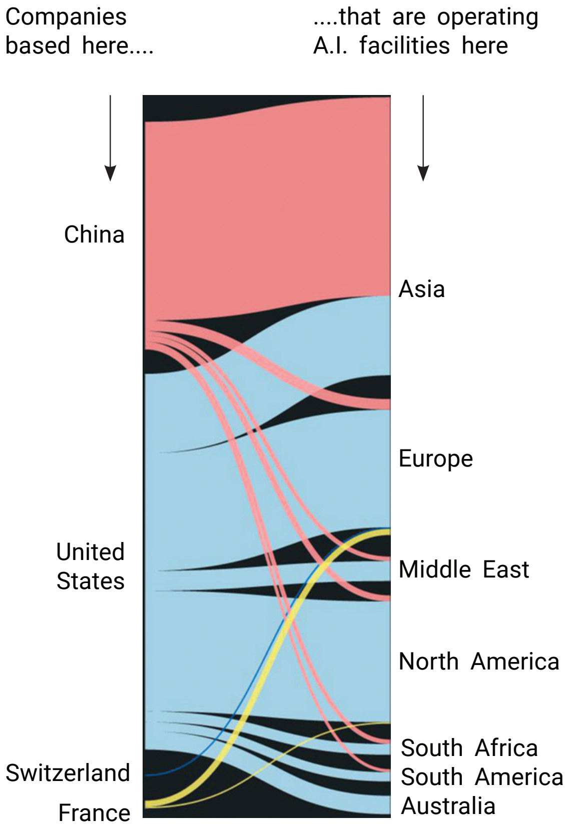
Furthermore, as Figure 2 shows, American companies lead in defining the infrastructure and tooling ecosystem required for AI development. The most notable company is NVIDIA, whose GPUs are still the hardware accelerator of choice for academia and industry worldwide.[19] Security in infrastructure leadership remains strong, as policies such as the US CHIPS Act show signs of success, with companies such as Apple manufacturing with TSMC on their 4nm process for the next iPhones.[20,21]

Figure 3: AI Investment by Geography (2014-2024)



Source: State of AI Report[22]

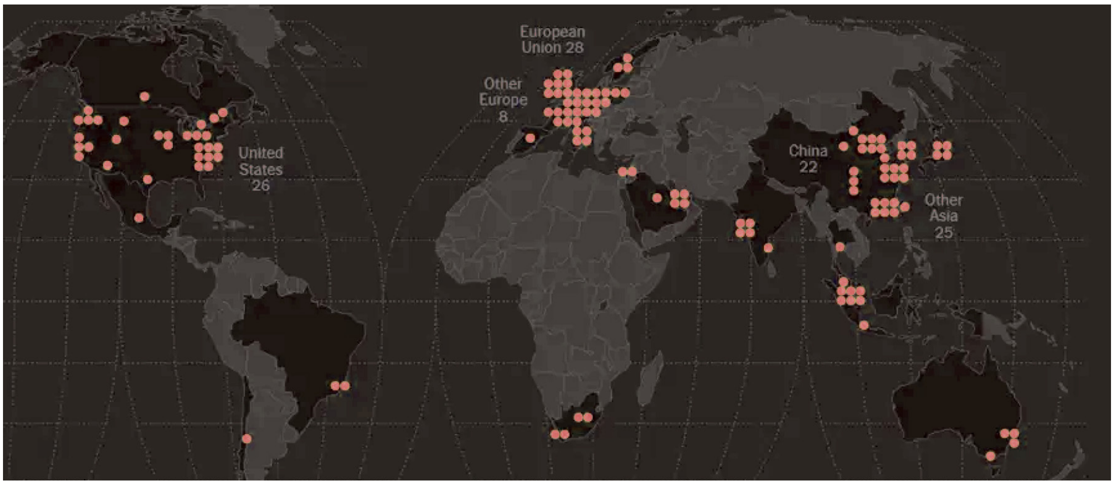
Figure 4: Global Flow: AI Companies and Their Operational Centers



Source: New York Times[23]

Maintaining leadership in this sector involves multiple variables. Clearly, the US's data centre infrastructure and hardware capabilities are world-leading, though securing domestic chip manufacturing is still in its early stages. As shown in Figure 3, US investments in AI exceed those of China and Europe combined,[24] and Figure 4 shows that most global companies rely on US-operated AI facilities.[25] However, despite strong US-operated infrastructure adoption, continuing leadership in infrastructure is also an energy problem.

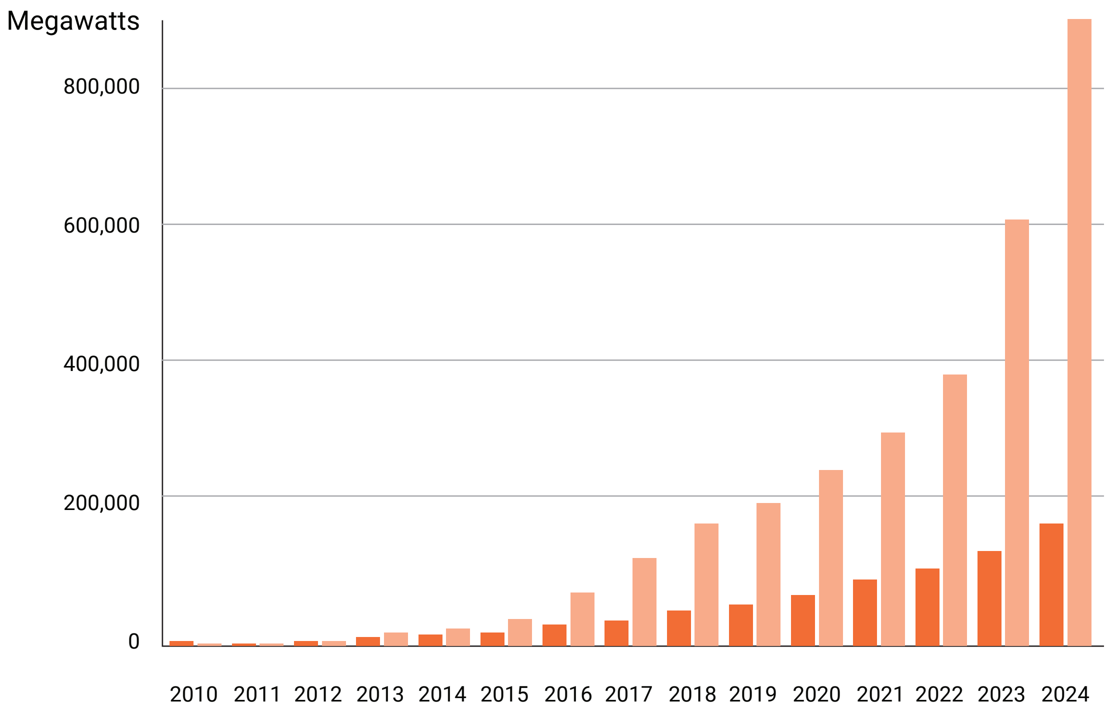
Figure 5: Number of Data Centres Worldwide and China



Source: New York Times[26]
Note: 'China' does not include Hong Kong and Taiwan.

The US currently leads in infrastructure and global adoption, operating 26 AI-specialised data centres powered predominantly by NVIDIA hardware.[27] However, with half of the US compute clusters concentrated in just five regions, energy generation has become the primary constraint on expansion.[28]

Figure 6: US and China Solar Capacity (2010-2024)



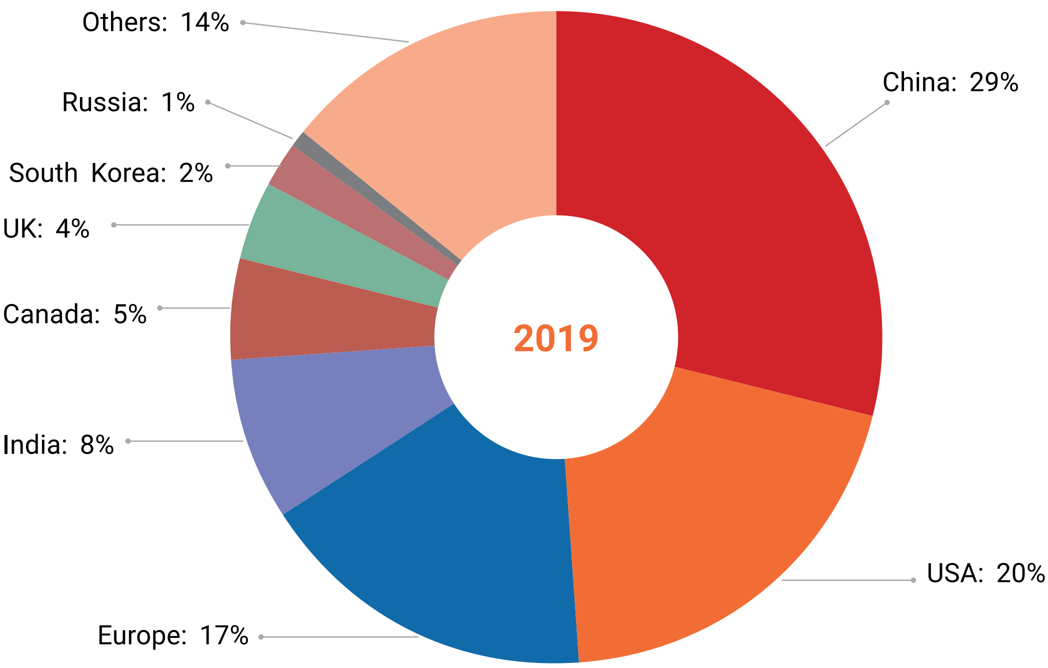
Source: Crownhart[29]

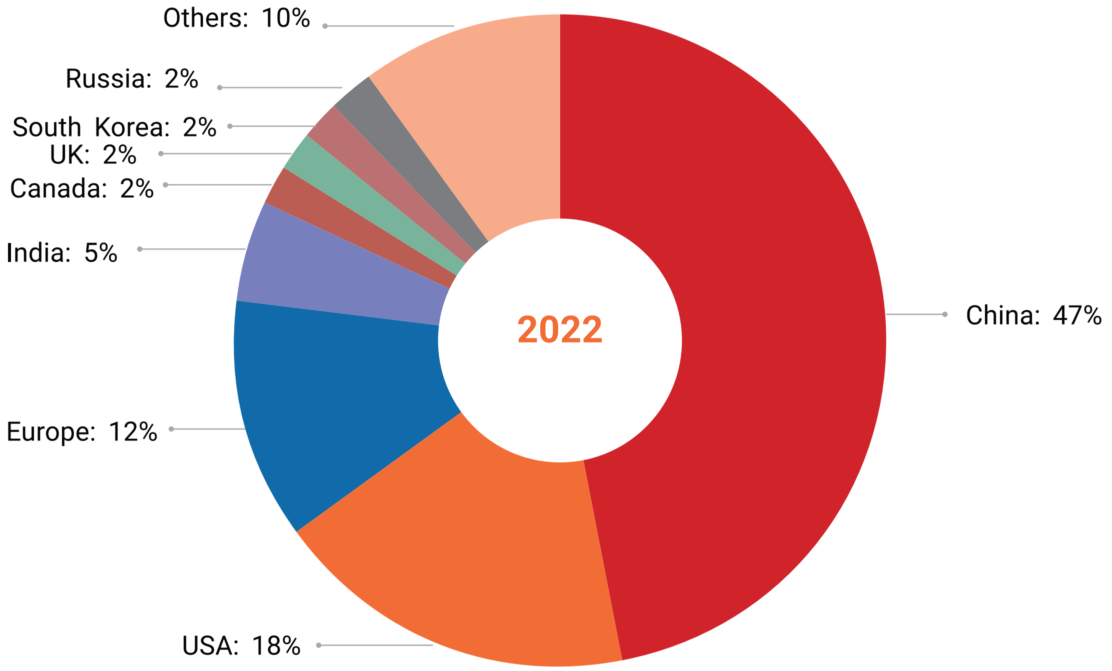
China faces the opposite challenge: it has abundant energy capacity but limitations in hardware. While China has installed 7.56 times more (800,000+ megawatts) solar capacity than the US by the end of 2024,[30] China operates a similar number of AI data centres as the US. However, the country faces challenges with hardware adoption. All but three of its data centres run on Chinese-native hardware,[31] and those that run on NVIDIA-enabled hardware are limited in compute power due to US export controls.[32] This creates a fundamental asymmetry: the US has superior computing infrastructure but lacks the energy capacity to scale, while China has the renewable energy foundation to expand rapidly, but is constrained by access to cutting-edge AI hardware.

Infrastructure developments in hybrid computing and on-premise solutions—computing systems hosted and managed within an organisation's own facilities rather than by external cloud providers—can help the US decentralise computing loads and reduce grid strain, but unless energy generation can keep pace with data centre consumption, the International Energy Agency (IEA) predicts that 20 percent of planned US data centre projects could face delays.[33] Meanwhile, China's energy advantage positions it to rapidly scale AI infrastructure once hardware constraints are resolved, creating an urgency for the US to address its energy bottleneck before losing its technological edge.

Technology

Figure 7: Countries of Origin of Top-tier AI Researchers



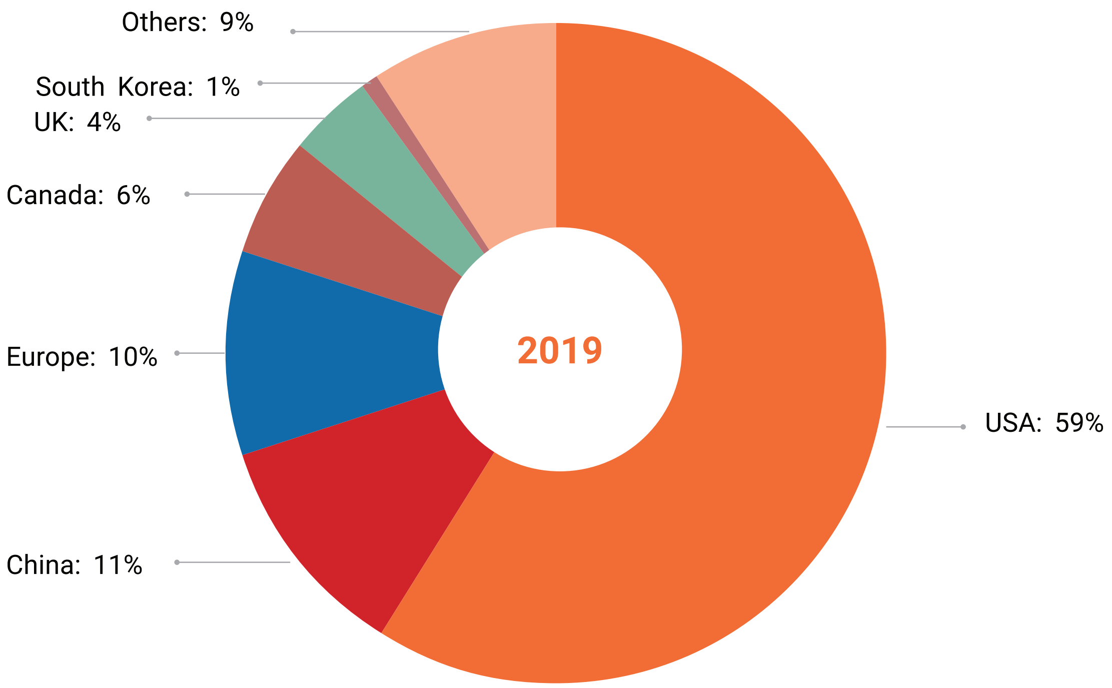


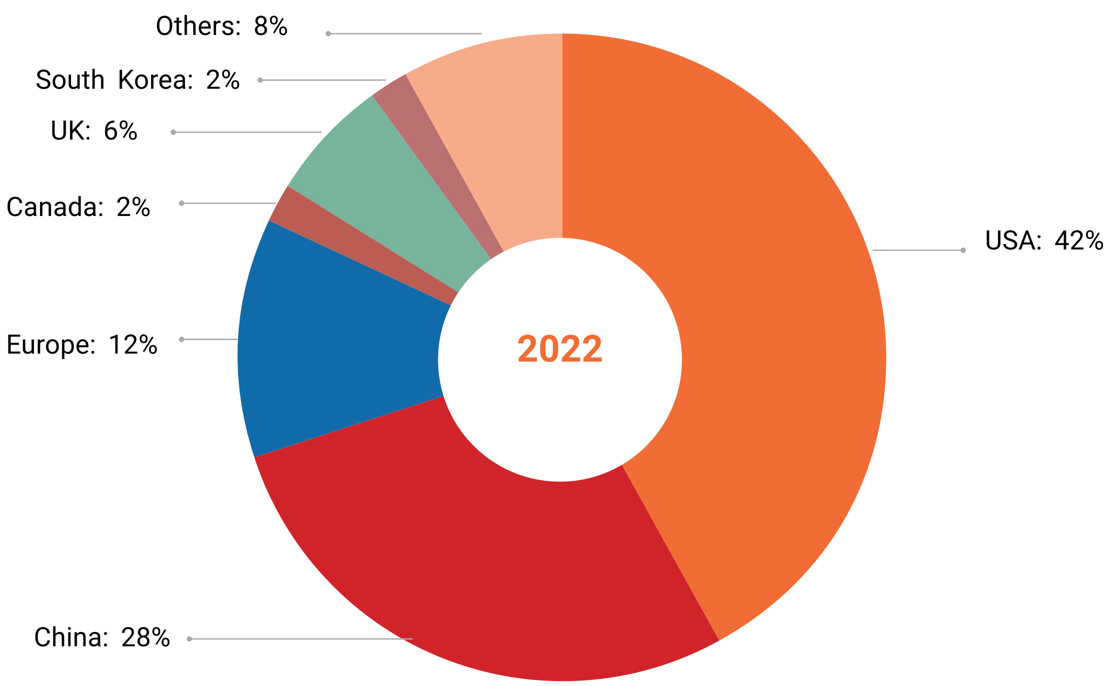
Source: Macro Polo[34]

Note: Top ~20 percent: based on undergraduate degrees.

'Technology' refers to intellectual capital. To succeed in this layer, countries must promote deep research and education while maintaining high stickiness—a magnetic pull—in talent retention. Infrastructure utilisation will not be able to reach its full potential without intellectual capital and a culture encouraging innovation and cutting-edge research. Regarding the sheer volume of intellectual capital, nearly half of the world's AI researchers are Chinese (see Figure 7), growing from 29 percent to 47 percent in only two years.[35,36]

Figure 8: Leading Countries Where Top-tier AI Researchers Work



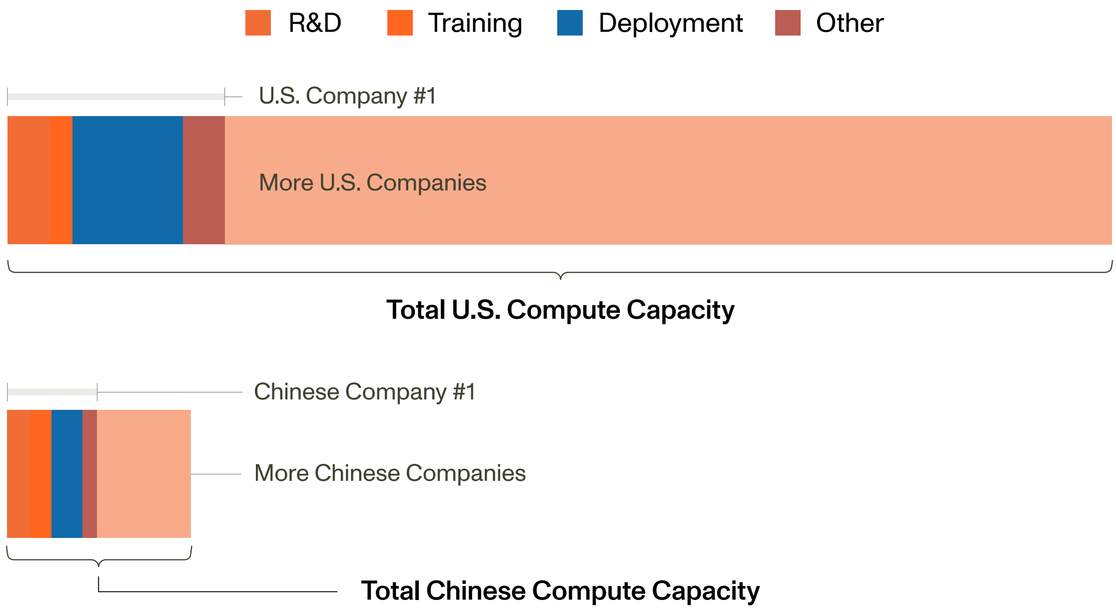


Source: Macro Polo[37]

Note: Top ~20 percent

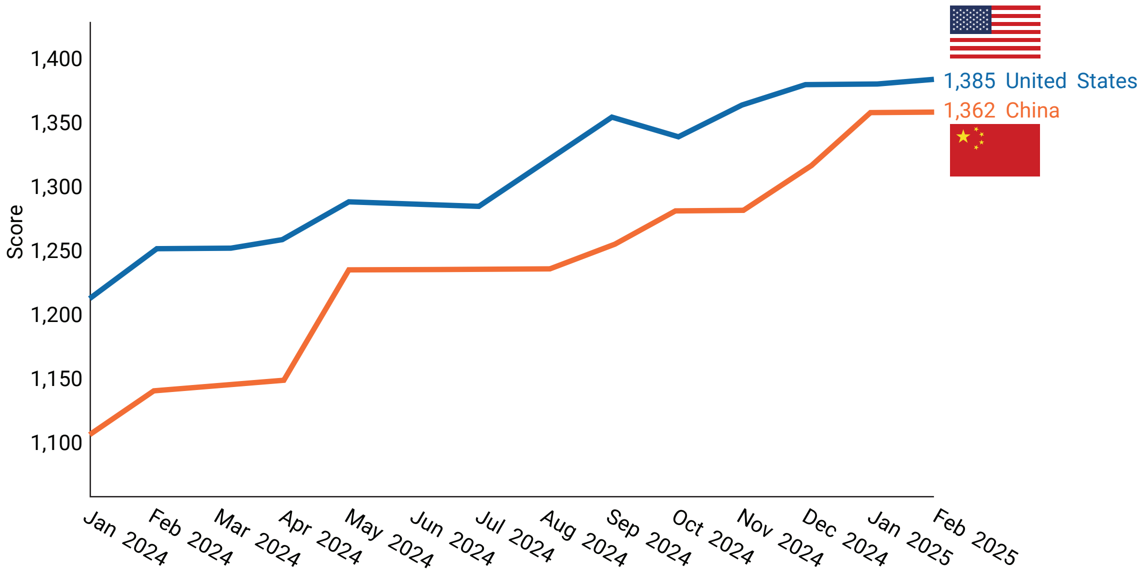
Although the US is widely considered a global AI leader, the country's intellectual capital pool is shrinking. Regarding its position as primary destination country for AI researchers, more researchers opt to stay in their country of origin rather than working in another.[38] As seen in Figure 8, countries like Switzerland, South Korea, and China have a higher percentage of foreign talent in their population than the US, suggesting that other countries may have much more favourable AI incentives and immigration policies to attract global talent.[39] For example, the roadmap and sentiment of the Chinese government are focused on developing AI to power all sectors of its economy, where all government members share this same focus.[40]

Figure 9: Total Compute of the US vs. China



Source: Heim[41]

Figure 10: Performance of Top US vs. Chinese Models on LMSYS Chatbot Arena



Source: The 2025 AI Index Report[42]

Despite a shrinking population of global talent in the US over the years, the country remains a leader in developing cutting-edge foundation models. These models include OpenAI's GPT-5, Meta's Llama 4, and Google's Gemini 2.5 Pro. Maintaining leadership in foundation models is critical to driving the wave of applications that rely on generative AI, especially given its increase in usage. However, when comparing computing resources to model capability, China's effective use of its talent pool and ability to innovate under resource constraints remains undisputed (see Figures 9 and 10). In contrast, the US's advantage in infrastructure allows more companies to emerge and access abundant compute resources for development. However, this is not simply a matter of scale. As the saying goes: "It's not about the size of the dog in the fight, but the size of the fight in the dog." In other words, determination and technical aptitude matter more than physical size and outward power.

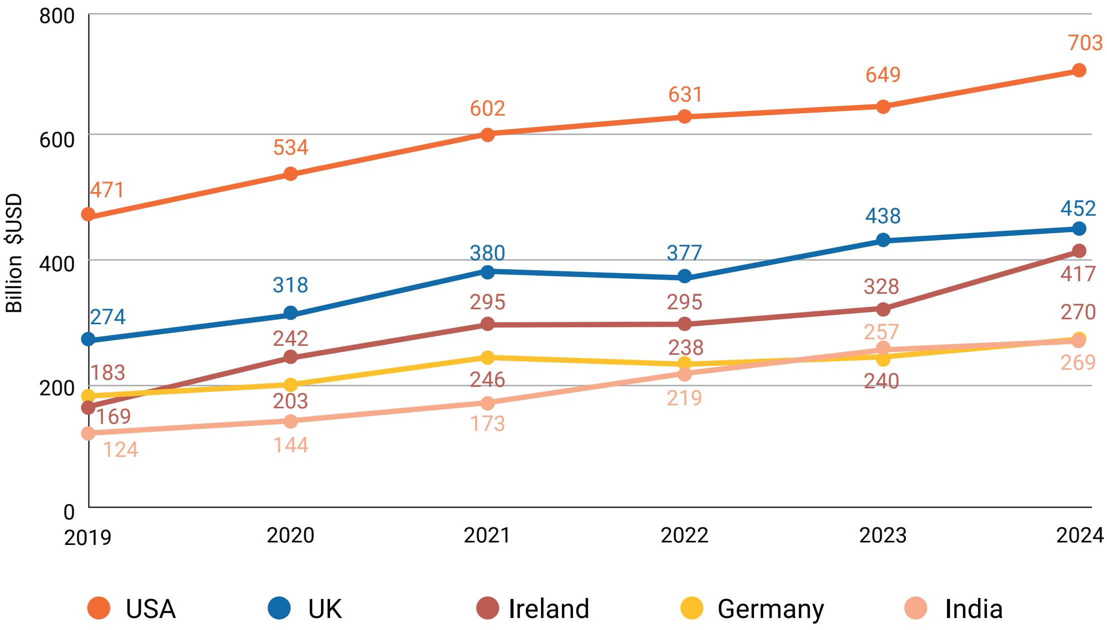
Ultimately, leadership in the technology layer relies on retaining talent, funding for deep research, and progressive AI policies. Infrastructure is merely a force multiplier to magnify the output from a country's intellectual capital. Without these elements, even the best infrastructure will remain underutilised and fail to translate into sustained AI leadership.

Application

As discussed above, even with all the progress made in infrastructure and research, the application layer is arguably the most essential in the AI technology stack for achieving leadership. This layer consists of domain-specific applications and solutions built on the infrastructure and technology behind it. These applications could range from visual inspection at manufacturing facilities, autonomous vehicles in transportation, personalised diagnostics and medical imaging in healthcare, to sophisticated recommendation engines in e-commerce and content delivery platforms.

However, creating new products and solutions is not the only thing that matters. The willingness of the population to engage and use AI is just as important. Growing and nurturing this layer of the AI stack is critical because this is the layer that interfaces with users. It is about tech pervasiveness and accessibility. Given that AI systems require enormous amounts of data to excel, more applications and solutions mean more data. More data will help drive the AI flywheel effect needed for systems to continue improving.

Figure 11: Top 5 Countries for Digital Services Exports (2019-2024, US$ Billions)

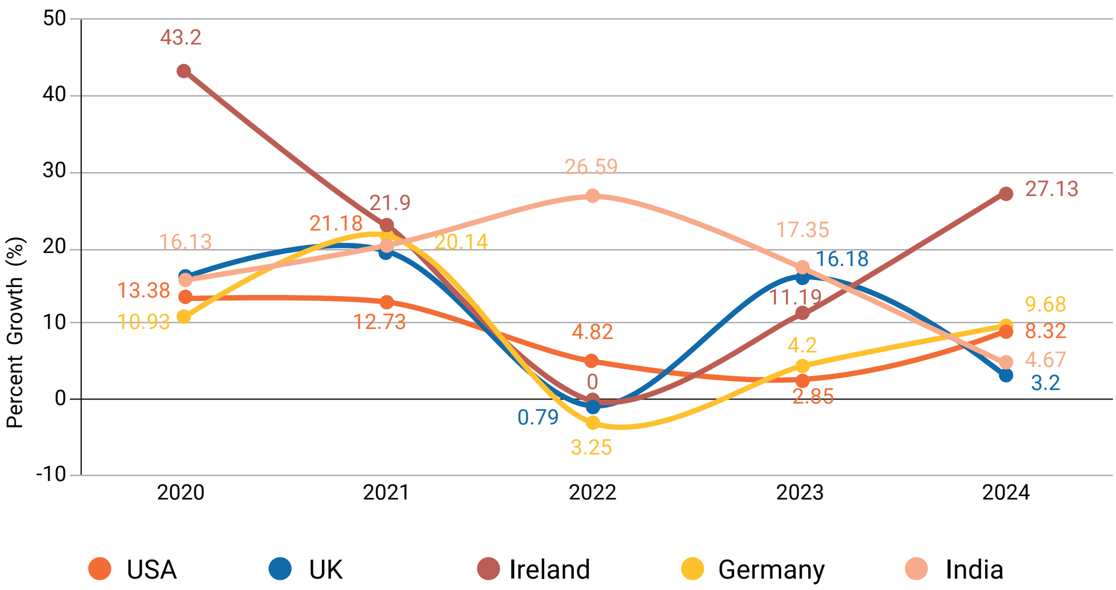


Sources: WTO (2025);[43] WTO (2024)[44]

As the most populous country in the world with over 1.46 billion people,[45] India is in a highly competitive position to execute at the application layer, especially being one of the world's primary technology and systems integration centres. Despite being classified as a developing country, India ranks among the top five global exporters of digital services at 5.8 percent of global market share—standing shoulder-to-shoulder with advanced economies like the US, the United Kingdom (UK), Ireland, and Germany (see Figure 11). This underscores how strategic investment in talent, infrastructure, and digital public goods allows emerging economies to leapfrog into high-value sectors.

Additionally, India has had success in developing and adapting new technologies. Providing Digital Public Infrastructure (DPI), with components such as Unified Payment Interfaces (UPI) and offerings like Digilocker, has helped its population become more accepting of using new technologies to benefit their daily lives. As such, the conduit and positive sentiment to use new technologies is already present. India has a strong environment to be an AI application sandbox, allowing for faster development of AI applications and data collection from these applications.

Figure 12: Top 5 Countries for Digital Services Exports (2019-2024, Year-over-Year % Change)



Sources: WTO (2025);[46] WTO (2024)[47]

India's willingness to accept new technologies is extraordinary, despite all headwinds. As per Figure 12, India's digital services export growth has dropped over the years. After accelerating from 16.13 percent (2020) to 26.59 percent (2022), growth decelerated sharply to 17.35 percent in 2023 and plummeted to just 4.67 percent in 2024. While correlation does not imply causation, the timing is notable: India's growth rate peaked at 26.59 percent in 2022—the year of ChatGPT's launch—before declining sharply.

Figure 11 shows a steady upward trend of global digital services exports, but the trend is decelerating. This deceleration coincides with workforce restructuring in India's IT sector. Leading firms like Tata Consulting Services (TCS) reduced hiring by 96 percent (from 20,000+ employees in Q1 FY23 to just 523 in Q1 FY24),[48] while simultaneously launching massive AI reskilling programmes—training more than 100,000 workers in AI expertise in Q4 FY23.[49] As stated by TCS, the layoffs are a strategic shift towards building a "future-ready generation" through upskilling and redeployment, reflecting a broader cost-cutting trend amid weakening demand and client project delays.[50] These layoffs suggest the Indian technology sector is adapting to a new reality where the volume of labour to value ratio is completely disrupted. Indeed, clients are discovering the potential for AI to cut costs, automate routine tasks, and draft initial deliverables before considering outsourcing.

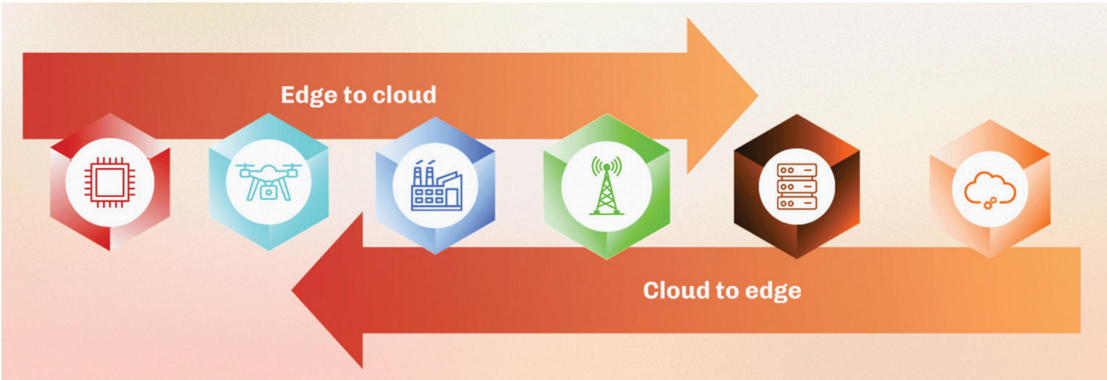
Yet, this adverse disruption paradoxically positions India as an ideal sandbox for AI innovation. Compared to countries not yet severely impacted by AI's impact on their people or workforce, India is living through the AI transition in real-time. More importantly, this disruption creates an urgency to innovate and understand the new customer base. Despite the adverse effects of India's AI transition, India is motivated to work with AI rather than against it. In 2024, Stanford's AI Index ranked India #1 globally in AI skills penetration, with a score of 2.8 (higher than the US at 2.2).[51] India's AI talent pool has grown by 263 percent since 2016. This strength extends to diversity: India also leads in female AI skills penetration (with a score of 1.7 vs. 1.2 for the US).[52] Top institutes (IITs and NITs) and a large IT professional workforce create a steady stream of graduates comfortable with AI. Surveys note that Indians focus on AI benefits in education, work efficiency, and services (e.g., >60 percent use AI for work productivity or helping students) rather than fixating on risks.[53] India's ongoing acceptance of AI, its perseverance during its AI transition, and the willingness to try new technologies position India as an ideal sandbox for the AI frontier.

In contrast, US surveys show, Americans are wary of AI. In late 2023, 52 percent of adults said they were more concerned about AI in their daily lives, versus only 10 percent who were excited.[54] A 2025 Pew Research Center study also found that 52 percent of American workers worry about AI's future workplace impact, and 32 percent expect AI will reduce job opportunities.[55] Furthermore, this hesitant and fearful sentiment from the US carries over to a patchwork of statutes and regulations, most notably former President Biden's 2023 AI safeguards that were rescinded in 2025. This fragmented approach also means that developers will operate under a variety of state and local laws, which can slow development due to compliance complexity.[56]

Addressing the AI Stack with the Edge Continuum

To show AI leadership, countries should address strengthening their capabilities across the entire AI stack. Most importantly, the components of the AI stack are interdependent. To increase AI pervasiveness, nations must consider how manufacturing AI solutions and intelligence should be distributed across cloud to edge, otherwise known as the Edge Continuum.

Figure 13: The Edge Continuum



Source: Latent AI[57]

The Edge Continuum is the range of devices and environments where AI can live and operate—from massive cloud data centres, on-premise workstations, everyday devices like phones, factory sensors, and delivery robots, to microcontrollers in deserts. Instead of relying entirely on the cloud, AI workloads can be distributed based on what makes sense: run complex training in the cloud, but push lightweight, fast, or sensitive tasks closer to the data's location. Such hybrid approaches can help systems respond faster, use less bandwidth, and keep sensitive data local—making AI more practical and adaptable in the real world.

Utilising all compute across the entire Edge Continuum will also help in pervasiveness. Pervasiveness is not just a function of access to large models, but of making operable and capable systems in diverse environments. As models grow and compute demand increases, latency, bandwidth, and data privacy limit the practicality of sending data to centralised platforms. Distributing AI workloads will address the demand for infrastructure, which will help free up compute for more intensive AI research and workloads. Enabling AI capabilities on the edge can also open access to the larger demographic of people who do not have access to larger forms of compute.

Additionally, distributed AI workloads will increase accessibility in areas where connectivity or access to centralised systems is limited. This approach bridges the digital divide and creates new opportunities for innovation by allowing local actors—such as small businesses, regional governments, and community-level organisations—to participate in and benefit from AI advancements. When intelligence can be deployed and refined locally, it becomes more relevant, responsive, and resilient.

Winning the AI "arms race" also means enabling a larger pool of contributors to the AI flywheel. These contributions consist not only of elite researchers, but data collectors, edge device operators, and domain experts. The future of AI lies in systems that learn from the edge, continuously improve from real-world data, and adapt locally while sharing insights globally. This model requires a shift in how distributed intelligence is valued and orchestrated—recognising that AI is only as good as its data, and the best data often originates at the location of the event itself.

Challenges on the Edge

A barrier to realising the edge continuum vision is that only 10 percent of AI models make it to production, due to persistent challenges in deployment, data integration, and operational scalability.[58] These obstacles are even more pronounced at the edge, where hardware heterogeneity—from smartphones and embedded systems to industrial sensors and IoT devices—complicates model optimisation, compatibility, and performance tuning.[59,60] Unlike standardised cloud environments, edge deployments must accommodate various configurations, compute capabilities, and use cases. For edge AI to be a viable option, modularity is critical to allow developers to focus on value propositions instead of debugging bespoke vendor software.[61,62]

In addition, computational restraints remain a critical limitation. Many edge devices operate with limited memory, processing power, and energy availability. Supporting AI inference in these environments demands aggressive optimisation—model compression, quantisation, and power-efficient chip design—yet even these approaches have latency, accuracy, and cost trade-offs.[63] Maintenance and lifecycle management of edge AI systems further add to the complexity, especially in remote or security-sensitive environments where over-the-air updates or centralised monitoring may not be feasible.[64]

More importantly, the opportunity for improvement at the edge far exceeds what can be gained by improving the top 1 percent of AI models or researchers. While breakthrough models dominate headlines, they represent only a narrow slice of the stack. The broader challenge—and opportunity—lies in enabling the other 99 percent: the infrastructure, tooling, and workflows needed to deploy, maintain, and evolve AI systems in real-world environments. This shift from model-centric to system-centric thinking is critical for nations looking to establish leadership in AI.

By designing systems that consider hybrid computing from the beginning, countries can increase the likelihood of successful large-scale AI deployments. This includes support for federated learning, on-device inference, and real-time data feedback loops, allowing models to adapt in context while respecting privacy and bandwidth constraints.

Furthermore, AI leadership must include future AI operators, data collectors, and edge participants, not just model developers. In this co-creation model, intelligence is distributed and shaped continuously by the environments in which it operates. As mentioned, AI is only as good as its data, and the best data often originates at the edge, where people live, decisions are made, and changes happen in real time.

Finally, these edge systems must be powered by sustainable energy strategies. As AI becomes more pervasive, the energy cost of inference, especially in distributed systems, can quickly become unsustainable. To reduce costs and environmental impact, nations must invest in power-efficient hardware, renewable energy infrastructure, and intelligent workload scheduling. Efficiency at the edge is not just a technical challenge—it is a strategic necessity.

Conclusion

Reframing AI leadership as an infinite game stresses the need for enduring partnerships and long-term roadmaps rather than fleeting victories. The US and India, each with complementary strengths, are uniquely positioned to co-author this next chapter. America's world-class compute infrastructure, venture capital ecosystems, and foundational-model expertise pair naturally with India's expansive digital public infrastructure, surging AI skills penetration, and massive, tech-savvy population. By aligning behind a shared vision—one that prizes continuous innovation, ethical safeguards, and societal benefit—both countries can outlearn and outlast any single challenger.

A formal US–India AI alliance could take shape through joint research centres focused on energy-efficient, edge-ready hardware; regulatory sandboxes that harmonise safety standards; and talent-exchange programmes that accelerate cross-cultural knowledge transfer. Indian engineers can validate models in real-world, high-volume application environments while American labs push the frontier of model research. In turn, US policymakers can learn from India's bold digital-governance experiments, and Indian regulators can benefit from American innovation.

By weaving together infrastructure, intellectual capital, applications, and the edge continuum under a collaborative framework, the US and India can ensure that AI's evolution remains both visionary and inclusive. This enduring partnership will keep both countries at the forefront of technological progress and demonstrate how strategic cooperation rooted in mutual learning and shared purpose can amplify AI's promise for societies around the globe.

Endnotes

1 JD Vance, "Remarks by Vice President Vance at the Artificial Intelligence Action Summit" (speech, Paris, February 11, 2025), The American Presidency Project, https://www.presidency.ucsb.edu/documents/remarks-the-vice-president-the-artificial-intelligence-action-summit-paris-france.

2 Drew Bernstein, "Who Is Winning the AI Arms Race?," Forbes, August 28, 2024,
https://www.forbes.com/sites/drewbernstein/2024/08/28/who-is-winning-the-ai-arms-race/.

3 National Security Commission on Artificial Intelligence, "Letter from the Chair and Vice Chair," National Security Commission on Artificial Intelligence, https://reports.nscai.gov/final-report/chair-and-vice-chair-letter.

4 John Minnix, "215 Data Center Stats (June-2025)," *Brightlio,* April 10, 2025, https://brightlio.com/data-center-stats.

5 Adam Satariano and Paul Mozur, "The Global A.I. Divide," *New York Times,* June 23, 2025.

6 International Energy Agency, "Energy and AI – Analysis," https://www.iea.org/reports/energy-and-ai/energy-demand-from-ai.

7 Nathan Benaich and Alex Chalmers, "AI Investment Surges in Every Region" in *State of AI Report 2024*, Air Street Capital, pp. 148. https://www.stateof.ai/.

8 Stanford University Human-Centered Artificial Intelligence, "Chapter 2: Technical Performance" in *The 2025 AI Index Report*, Stanford University Human-Centered Artificial Intelligence, 2025, pp. 97. https://hai.stanford.edu/ai-index/2025-ai-index-report.

9 "Chapter 2: Technical Performance," 97.

10 Stanford University Human-Centered Artificial Intelligence, "Chapter 1: Research and Development" in *The 2025 AI Index Report*, Stanford University Human-Centered Artificial Intelligence, 2025, pp. 34-37. https://hai.stanford.edu/ai-index/2025-ai-index-report.

11 Nivash Jeevanandam, "India Leads Global AI Talent and Skill Penetration," *IndiaAI,* December 17, 2024, https://indiaai.gov.in/article/india-leads-global-ai-talent-and-skill-penetration.

12 Michelle Faverio and Alec Tyson "Americans' Views of Artificial Intelligence in 2023," Pew Research Center, November 21, 2023, https://www.pewresearch.org/short-reads/2023/11/21/what-the-data-says-about-americans-views-of-artificial-intelligence/.

13 Luona Lin and Kim Parker, "U.S. Workers Are More Worried Than Hopeful About Future AI Use in the Workplace," Pew Research Center, February 25, 2025, https://www.pewresearch.org/social-trends/2025/02/25/u-s-workers-are-more-worried-than-hopeful-about-future-ai-use-in-the-workplace.

14 Hope Anderson, Earl Comstock, and Erin Hanson, "AI Watch: Global Regulatory Tracker - United States," White & Case LLP, July 21, 2025, https://www.whitecase.com/insight-our-thinking/ai-watch-global-regulatory-tracker-united-states.

15 Simon Sinek, *The Infinite Game* (Penguin Business, 2019).

16 International Energy Agency, "Data Centre Electricity Consumption by Region, Base Case, 2020-2030," International Energy Agency, https://www.iea.org/data-and-statistics/charts/data-centre-electricity-consumption-by-region-base-case-2020-2030.

17 International Energy Agency, *Energy and AI,* International Energy Agency, 2025, pp.14, https://iea.blob.core.windows.net/assets/34eac603-ecf1-464f-b813-2ecceb8f81c2/EnergyandAI.pdf.

18 "AI Investment Surges in Every Region," 94.

19 "AI Investment Surges in Every Region", 92-95.

20 "AI Investment Surges in Every Region," 94.

21 Katie Tarasov, "Inside TSMC's New Chip Fab Where Apple Will Make Chips in the U.S.," *CNBC,* December 13, 2024, https://www.cnbc.com/2024/12/13/inside-tsmcs-new-chip-fab-where-apple-will-make-chips-in-the-us-.html.

22 "AI Investment Surges in Every Region," 92-95.

23 Satariano and Mozur, "The Global A.I. Divide."

24 "AI Investment Surges in Every Region," 92-95.

25 Satariano and Mozur, "The Global A.I. Divide."

26 Satariano and Mozur, "The Global A.I. Divide."

27 Satariano and Mozur, "The Global A.I. Divide."

28 "Energy and AI, 2025."

29 Casey Crownhart, "China's Energy Dominance in Three Charts," *MIT Technology Review,* July 10, 2025. https://www.technologyreview.com/2025/07/10/1119941/china-energy-dominance-three-charts/.

30 Crownhart, "China's Energy Dominance in Three Charts."

31 Satariano and Mozur, "The Global A.I. Divide."

32 Liam Mo and Brenda Goh. "Nvidia Modifies H20 Chip for China to Overcome US Export Controls, Sources Say," *Reuters,* May 9, 2025, https://www.reuters.com/world/china/nvidia-modifies-h20-chip-china-overcome-us-export-controls-sources-say-2025-05-09/.

33 "Energy and AI, 2025."

34 Macro Polo, "The Global AI Talent Tracker 2.0," Macro Polo, https://archivemacropolo.org/interactive/digital-projects/the-global-ai-talent-tracker/.

35 Macro Polo, "The Global AI Talent Tracker 2.0."

36 Siddhi Pal et al., "Technical Tiers: A New Classification Framework for Global AI Workforce Analysis," *Interface,* April 29, 2025, https://www.interface-eu.org/publications/technical-tiers-in-ai-talent.

37 Macro Polo, "The Global AI Talent Tracker 2.0."

38 Macro Polo, "The Global AI Talent Tracker 2.0."

39 Pal et al., "Technical Tiers: A New Classification Framework for Global AI Workforce Analysis."

40 "Xi Urges Promoting Healthy, Orderly Development of AI," The National Committee of the Chinese People's Political Consultative Conference, April 27, 2024, http://en.cppcc.gov.cn/2025-04/27/c_1088876.htm.

41 Lennart Heim, "China's AI Models Are Closing the Gap—but America's Real Advantage Lies Elsewhere," Rand, May 2, 2025, https://www.rand.org/pubs/commentary/2025/05/chinas-ai-models-are-closing-the-gap-but-americas-real.html.

42 "Chapter 2: Technical Performance," 97.

43 World Trade Organization, *Global Trade Outlook and Statistics,* April 2025, World Trade Organization, 2025, https://www.wto.org/english/res_e/booksp_e/trade_outlook25_e.pdf.

44 "Global Trade Outlook and Statistics, April 2024."

45 Worldometer, "India Population (2025), " Worldometer, https://www.worldometers.info/world-population/india-population/.

46 "Global Trade Outlook and Statistics, April 2024."

47 "Global Trade Outlook and Statistics, April 2024."

48 “TCS Layoffs Reflect Growing Pressure on Indian IT Sector as AI Is Drastically Reshaping Job Opportunities,” *The Financial Express,* August 4, 2025, https://www.financialexpress.com/life/technology-tcs-layoffs-reflect-growing-pressure-on-indian-it-sector-as-ai-is-drastically-reshaping-job-opportunities-3935793/.

49 Tata Consultancy Services.

50 “TCS Layoffs Reflect Growing Pressure on Indian IT Sector as AI Is Drastically Reshaping Job Opportunities.”

51 Jeevanandam, “India Leads Global AI Talent and Skill Penetration.”

52 Jeevanandam, “India Leads Global AI Talent and Skill Penetration.”

53 “Microsoft Report Reveals 65% of Indians Used Gen AI in 2024, Parents More Aware of AI Risks,” *The Indian Express,* February 11, 2025, https://indianexpress.com/article/technology/artificial-intelligence/microsoft-report-reveals-64-of-indians-used-gen-ai-in-2024-parents-more-aware-of-ai-risks-9830216/.

54 Faverio and Tyson, “Americans’ Views of Artificial Intelligence in 2023.”

55 Lin and Parker, “U.S. Workers Are More Worried Than Hopeful About Future AI Use in the Workplace.”

56 Anderson, Comstock, and Hanson, “AI Watch: Global Regulatory Tracker - United States.”

57 “AI Edge Continuum,” Latent AI, July 04, 2025, https://latentai.com/white-paper/ai-edge-continuum/.

58 “Why Do 87% of Data Science Projects Never Make It into Production?,” VentureBeat, 2019.

59 Roberto Morabito et al., “Edge AI Inference in Heterogeneous Constrained Computing: Feasibility and Opportunities” in *Proceedings of the IEEE International Workshop on Computer Aided Modeling and Design of Communication Links and Networks.*

60 “2023 Edge AI Technology Report. Chapter IX: Challenges of Edge AI,” *Wevolver,* 2023, https://www.wevolver.com/article/2023-edge-ai-technology-report-chapter-ix-challenges-of-edge-ai.

61 David Maidment, “How Evolving Edge Computing Will Define and Secure an AI-enabled Future,” *Arm Newsroom,* April 8, 2024, https://newsroom.arm.com/blog/evolving-edge-computing.

62 “2023 Edge AI Technology Report. Chapter IX: Challenges of Edge AI, 2023.”

63 “2023 Edge AI Technology Report. Chapter IX: Challenges of Edge AI, 2023.”

64 Marco Madrigal, “Moving AI from Cloud to Edge: Challenges, Pros & Cons, and Optimization,” RidgeRun.ai, April 1, 2024, https://www.ridgerun.ai/post/moving-ai-from-cloud-to-edge-challenges-pros-cons-and-optimization.

II

ECONOMIC, INDUSTRIAL, and TECHNOLOGICAL CONDITIONS

Charting Pathways for India-U.S. Cooperation in AI Compute

Megha Shrivastava

Abstract

The engine of the ongoing Artificial Intelligence (AI) revolution is efficient computational power (or 'compute', for short). As the demand for AI compute grows, governments worldwide are streamlining policies to scale operations and enhance the efficiency of the overall AI compute ecosystem. As India's nascent AI market grows, the United States (US) is seen as a potential partner in augmenting India's current capabilities in the AI compute ecosystem. This article examines the current state of India's compute infrastructure and identifies the untapped potential of its data centre industry as a catalyst for deeper India–US cooperation in emerging technologies.

Introduction

The launch of OpenAI's ChatGPT in 2022, which uses Large Language Models (LLMs) called generative pre-trained transformers (or GPT),[1] heralded the era of AI chatbots, with Google's Gemini, Meta's Llama, and Deepseek's R1 soon following. A particular set of resources is essential to create a successful AI model: data, algorithms, and computational hardware.[2] Extensive data is used to generate algorithms that are trained using high-performance semiconductor chips. Compute—comprising a set of layers, hardware, software, and infrastructure—makes data and algorithms work.

In general terms, 'compute' refers to the number of computations needed to perform a task, such as training an AI model. More specifically, the term refers to a tech stack comprising hardware such as Graphics Processing Unit (GPU) chips, infrastructure such as data centres, and software that enables the functioning of chips and manages data. Various tech firms have monopolised one or more parts of the compute supply chain, consisting of: (i) companies that design, fabricate, and market GPUs; (ii) firms that deploy the chips to provide compute; (iii) enterprises that provide cloud infrastructure to run AI systems; and (iv) companies that use compute to deploy AI systems.[3]

Acquiring and securitising this resource has become part of national policies in recent years. Notably, in addition to the geopolitical competition between the US and China, the securitisation of compute is also exacerbated by its diminishing prospects of scalability in the future.[4] Balancing the ballooning GPU fleet and smarter algorithms is becoming a bigger challenge. Countries that can maintain this balance will become global digital hubs. Indeed, enhanced compute capability will determine a country's digital and geopolitical standing. Consequently, a number of countries have sought to indigenise supply chains through supportive industrial policies,[5] export controls, and investment screening to constrain the availability of compute,[6] especially since many countries are now running out of compute capabilities.

While the upstream segment of the supply chain is being securitised, the downstream segment (i.e., the infrastructure layer) remains crucial to future innovation. Smarter algorithms need valuable, high-quality data to be streamlined with efficient data centre processing and deployed in multiple use cases. India produces large volumes of high-quality data and talent, and its data centre industry remains one of the fastest-growing worldwide. Additionally, India's vast user base makes it ideal for AI inference workloads and use-case deployment.

A strong compute infrastructure will not only determine scalability, but also influence who can build powerful AI, how it is built, and who benefits the most. Current trends suggest that capital, resources, and talent are increasingly expected to be concentrated in fewer countries. The risk of India being sidelined in this massive AI-led transformation is a matter of concern, especially as access to hardware and infrastructure is increasingly restricted. While India's AI Mission seeks to deploy compute facilities from AMD, Nvidia, and Intel,[7] there is scope for exploring how India can leverage its potential in the infrastructure layer of the data centre industry to enable a sovereign, scalable, and strategically aligned AI compute base. This is especially valuable to the US and its allies who are seeking to derisk digital infrastructure from authoritarian control. This article examines India's capabilities in AI compute infrastructure and argues that the country must strengthen its current computing infrastructure, which includes the need to bolster its data centre capabilities, if it is to realise its goal of becoming a key global AI player.

India's Focus on AI Compute and the Partnership with the United States

India's semiconductor dream is long due. One of the early attempts to incentivise India's electronics manufacturing capacity was initiated through a revision of the Electronics Policy of 2012.[8] Due to a lack of financial closure, none of the proposals could be materialised. In recent years, amid speculations of US-China decoupling and rising pressure to reduce dependence on Chinese imports, India's industrial policy has taken a more concentrated approach. India's National Strategy for Artificial Intelligence, released in 2018, set the roadmap for AI adoption in the country.[9] One of the most important initiatives providing direct support includes India's flagship Production Linked Incentive (PLI) (2020) Scheme that aims to support the development of fabs for compound semiconductors and silicon photonics.[10] In 2021, the India Semiconductor Mission—a central coordinating body for semiconductor policy—was set up, showcasing a renewed semiconductor push.[11]

India's focus on building scalable and safe compute is specifically marked by the launch of the India AI Mission in 2024.[12] The mission is a multi-year, multi-stakeholder initiative, with an outlay of US$1.3 billion, aiming to build GPU/TPU supercomputing clusters across India, providing affordable compute for startups, researchers, and government use.[13] It stems directly from the 2023 Working Group Report on Artificial Intelligence, comprising over 80 members from government, industry, academia, and civil society and convened under India's Ministry of Electronics and Information Technology (MeitY) to chart a comprehensive roadmap for AI development and deployment in India.[14] In addition to recommending the National AI Mission, the 2023 Working Group also proposed establishing a National Data Management Office, scaling up AI compute infrastructure, supporting public-sector AI use cases in health, agriculture, and education, and promoting the development of multilingual Indian LLMs to ensure inclusive digital transformation.[15]

In 2025, India's policy focus will be on procuring AI compute infrastructure, including GPUs that remain relevant to AI modelling and training, amid a rapid rise of generative AI models, especially in the US and China. In February 2025, India announced it would make 18,000 GPUs available to AI-focused research and startups.[16] Through the National Supercomputing Mission, India aims to scale up the current compute capacity of 24.83 petaflops to 66 petaflops by 2025.[17] This will help address bottlenecks in the hardware segment. In March, India also launched its AI compute portal, AI Kosha,[18] a secured repository of datasets, models, and use cases to enable AI innovation.

While India's compute ambitions grow, its partnership with the US stands at a critical juncture. Under the Biden administration, the India–US partnership in emerging technologies gained momentum with the launch of the US–India Initiative on Critical and Emerging Technology (iCET) in 2023—a framework to enhance cooperation in semiconductors, AI, quantum computing, and cybersecurity.[19] An outcome of the initiative was Micron's commitment to invest US$2.75 billion in an ATMP (Assembly, Testing, Marking and Packaging) facility in Sanand, Gujarat.[20] The two countries have also established a Joint Semiconductor Workforce Development Initiative to train engineers and boost domestic chip design capabilities.[21] In 2025, Indian Prime Minister Narendra Modi's visit to the US resulted in the launch of the India-US TRUST (Transforming the Relationship Utilizing Strategic Technology) initiative, which aims to deepen bilateral relations through academia-to-academia and academia-to-industry partnerships. The two sides committed to push for a "US-India Framework on Accelerating AI Infrastructure", raising the prospects of leveraging India's AI ecosystem for building secure and sustainable AI infrastructure.

While such emerging strands in the partnership bolster the opportunities for future cooperation, Washington's inward-looking approach under Trump 2.0 could pose a test for the durability and depth of the India–US tech partnership. Though the current administration has signalled the need for innovation, political, ideological and techno-industrial asymmetries continue to challenge their partnership in long-term collaborative tech diplomacy. The strength of growing mutual willingness hinges on their ability to coordinate on domestic industrial policies and geopolitical priorities.

Amid growing volatility and infrastructure constraints on both sides, deepening cooperation on AI compute is both a geopolitical necessity and an imperative to boost bilateral ties. India's partnership with the US is key to resolving mutual constraints in AI development. India's strength lies in political reliability, engineering depth, and market scale—criteria that converge with Washington's need to secure a trusted node in its strategy to reduce dependence on China.

New Delhi must focus on gaining traction in the global AI race by leveraging its strengths in AI and the digital technology ecosystem. In addition to revolutionising the domestic AI development policy sphere, India must enhance diplomatic and industrial cooperation with the US to address its compute limitations. However, even as it strives to strengthen its compute capabilities, wider challenges—mainly, the lack of skill, talent, data, and research and development—remain.[22]

Locating India's Data Centre Industry in India-US Compute Cooperation

The infrastructure layer of the AI compute stack comprises (i) data centres (also requiring cloud storage and edge technologies); (ii) compute capacity (high-performance compute (HPC) clusters and GPU clusters); (iii) networking (fibre connectivity and submarine cables); and (iv) power supply (green energy, electricity, and cooling systems). This infrastructure layer is crucial to enabling the functions of downstream layers: the platform, model, and application layers. The availability and efficiency of infrastructure influence the cost of running AI models.

Data centres, which include several connected chips, provide the infrastructure to support the training of large AI models using massive datasets, enable running complex inferencing tasks, and support distributed training and parallel processing. Of the approximately 30,000 data centres worldwide, anywhere between 335 and 1,325 host a supercomputer.[23] This physical infrastructure also enables cloud computing—a service delivery model that allows users to access computing resources, such as servers, storage, databases, networking, software, and analytics, over the internet on an on-demand basis.

Various factors, such as high-quality data, high-end hardware and processors, and skilled talent, contribute to building quality data centres, and there are certain ways for India and the US to enhance them. The first challenge is to reduce the cost of computing. As model sizes grow exponentially, compute costs are expected to exceed 2.2 percent of US GDP by 2032.[24] In a general context, there are two ways of reducing the cost of computing: by improving the hardware and by making smart algorithms that produce optimum output with less computing power.[25] If good-quality data is used, even smaller models can perform better than LLMs built on poor-quality data.[26] Since restrictions on the free use of available data are increasing, acquiring quality data is an emerging challenge even for American hyperscalers.[a] As such, companies like Nvidia are increasingly investing in

---

[a] 'Hyperscalers' is a term used to refer to large US-based technology companies that operate vast cloud infrastructure and computing resources to support services such as cloud computing, AI, data storage, and content delivery.

startups that focus on algorithmic progress.[27] If the US aims to compete in the global market against rising Chinese capabilities in the generative AI domain, it must rely on LLMs with high-quality data.

Focusing on compute-relevant data is crucial for India as well. India relies on hyperscaler firms to provide access to application programming interfaces and host certain models on their servers. While India produces large data sets, it has so far failed to leverage its potential; India accounts for 20 percent of the global data production, but has only 3 percent of its data centre capacity.[28] Further, data production in India could triple due to the adoption of 5G, Internet of Things, and AI technologies. Capacity is expected to double by 2026 to approximately 2,000 MW, leading to inclusive investment opportunities, with a projected capital expenditure of US$6 billion.[29] India's public cloud service market is expected to grow at a compound annual growth rate of 24 percent by 2027.[30]

Additionally, enhanced data centre capabilities will enable India's smaller firms to strengthen their services by producing small models dedicated to domestic use cases. Industry leaders have also noted that building small models by leveraging the potential of the Indian IT space can make the country the "use-case capital of the world," particularly if it focuses on creating synthetic data and utilising this to build application-specific use cases.[31] This is relevant for the long-term goal of building LLMs, as capability improvements can be achieved by training small models.[32] It also aligns with the US's needs, as it serves as a market to train their AI system to be compatible with various use-cases.

India and the US must also focus on cross-country private-to-private collaboration to enhance data centre efficiencies. Indeed, strengthening cooperation with American firms to build its data centre capabilities is key for India to resolve its compute conundrum, i.e., having vast data availability but lacking training, hardware, and cloud availability. India's IT sector is key on this front. IT firms' Global Capability Centres (GCCs)[b] design, manage, and optimise cloud infrastructure, including HPC clusters, distributed storage systems, and GPU virtualisation platforms, for their parent companies. For example, Microsoft's India GCC contributes to Azure's AI infrastructure design and optimisation for global users. Indeed, India has emerged as a GCC hub, evolving from a global outsourcing services centre to hosting centres of excellence (CoE) involved in innovation, product development, and strategic decision-making.[33]

---

[b] A Global Capability Center (GCC) is a strategic unit that supports an organisation's global operations through technology, talent, and innovation.

Given its growth potential, the Indian AI market is lucrative for American firms. India can become a hub of compute-serving GCCs due to its cost efficiency, technical talent, controlled inflation rates, and engineering Research and Development (R&D) record.[34] Notably, GCCs focusing on engineering R&D have grown, showcasing India's progress in AI, product engineering, and software development.[35] In recent years, India has become home to over 1,700 GCCs, contributing US$64.6 billion to the national economy and employing nearly two million individuals.[36] Additionally, 58 percent of Fortune 500 companies with GCCs in India record higher than expected returns on their digital investments.[37] As such, India's accelerated policy focus on facilitating AI development should incentivise American firms to invest in long-term projects.

India accounts for over 34 percent of the world's STEM (science, technology, engineering, and mathematics) graduates annually, and this vast talent can be leveraged to support the expanding data centre industry.[38] Additionally, the rapid expansion of GCCs in India has catalysed the creation of a large specialised talent pool in AI, cloud architecture, and data infrastructure; India's AI and analytics talent pool is projected to exceed one million professionals by 2026, driven mainly by GCC-led skilling programmes and partnerships with academic institutions.[39] India already has over 120,000 AI specialists and has set up 185 AI/ML CoEs to further enhance skilling.[40] A low-cost and abundant talent pool will support the US's aim of reducing computing costs.

This concentration of expertise presents a unique opportunity for strategic cooperation, especially in areas like joint compute infrastructure development, public-private AI training clusters, and cross-border AI R&D initiatives. Therefore, there is a need to recognise GCCs not merely as operational units, but as talent hubs and infrastructure bridges that can support bilateral and multilateral AI cooperation. Aligning their growth with national AI strategies can ensure that India's compute ecosystem becomes both globally competitive and geopolitically trusted.

Existing partnerships have already demonstrated positive developments in democratising access to cheaper computing resources. For instance, an Nvidia-initiated model ('GPU-as-a-service') is gaining popularity by providing data centre facilities with a pay-as-you-go approach, making compute more easily accessible to even minor players.[41] This approach is also feasible in the Indian AI market, as small AI outfits are looking for cheaper and more efficient access to compute. India's Sify Technologies has partnered with Nvidia to integrate Nvidia's DGX-Ready liquid cooling system with its data centre services, enabling Sify to accelerate the potential of AI applications.[42] An Indian cloud service provider, Yotta, also hosts Nvidia's H100 GPU cluster.[43]

Additionally, Indian IT firms are increasingly pivoting toward the software-as-a-service (SaaS) model. This trend grows towards developing a vertical integration strategy, often through strategic partnerships with hardware providers like Nvidia, enabling Indian tech firms to position themselves for the emerging 'AI-as-a-Service' market. As SaaS applications evolve to embed more AI capabilities,[44] the ability to integrate hardware and software stacks becomes commercially and strategically significant.

Finally, while hyperscalers such as Microsoft Azure and Amazon Web Services present stiff competition to local cloud service providers, they have also helped democratise access to compute resources. Programmes like Microsoft's BizSpark Plus and Amazon's ML Elevate have supported Indian AI startups by offering cloud credits, development tools, and infrastructure support.[45] These initiatives have lowered the entry barriers for innovation and experimentation in AI.

Together, these trends point to the growing maturity of India's AI ecosystem, where large IT firms, global hyperscalers, and startups are converging around scalable compute infrastructure. This convergence strengthens India's position in the global AI value chain and offers a foundation for future cooperation in AI innovation, particularly with trusted partners.

Conclusion

AI compute is rapidly becoming a strategic resource. Amid this development, India and the US have a critical opportunity and responsibility to shape an AI-led transformation through closer cooperation and a shared strategic vision. Realising this goal requires policy alignment, especially in areas involving AI infrastructure deployment.

To offer a democratic and transparent alternative to China's technology, India and the US, in future talks to operationalise the TRUST initiative, should focus on tackling hindrances that inhibit cross-country collaboration. Ensuring alignment in political willingness and policy coordination is crucial to achieving such objectives. Clear and consistent efforts are also required to coordinate technology diffusion strategies.

To strengthen India's AI compute infrastructure and leverage its IT service talent, more private-to-private collaborations should be promoted to enhance the potential of India's data centre industry. India's diplomatic channels should focus on strengthening industry collaborations, rationalising export restriction caps, and simplifying regulatory procedures. As future negotiations unfold under the TRUST initiative, they will not only shape the contours of bilateral tech ties but also serve as a testing ground to see how India and the United States deepen, diversify, and future-proof their strategic partnership amid an increasingly complex geopolitical environment.

Endnotes

1 Yura Sosnovsky et al., "The Carbon Footprint of Machine Learning Training Will Plateau, Then Shrink," arXiv, March 2022, https://arxiv.org/pdf/2203.15556.

2 Jai Vipra and Sarah Myers West, "Computational Power and AI," AI Now Institute, 2023, https://ainowinstitute.org/publications/compute-and-ai.

3 OECD, *A Blueprint for Building National Compute Capacity for Artificial Intelligence*, Organisation for Economic Co-operation and Development, 2023, https://doi.org/10.1787/876367e3-en.

4 Chieng Ping Lu, "The Race to Efficiency: A New Perspective on AI Scaling Laws," arXiv, January 4, 2025, https://arxiv.org/html/2501.02156v3.

5 Guido Appenzeller, Matt Bornstein, and Martin Casado, "Navigating the High Cost of AI Compute, Andreessen Horowitz," April 27, 2023, https://a16z.com/navigating-the-high-cost-of-ai-compute.

6 James Fahey, "Tariffs, Trade Wars, and the Future of AI: Is the Era of Open Source at Risk?," *Medium*, https://medium.com/@fahey_james/tariffs-trade-wars-and-the-future-of-ai-is-the-era-of-open-source-at-risk-0e1ec3d704a2.

7 Siddharth Jindal, "India Will Provide the Cheapest Compute Facilities in the World at ₹67 Per GPU Hour: IT Minister Ashwini Vaishnaw," *Analytics India Magazine*, March 6, 2025, https://analyticsindiamag.com/ai-news-updates/india-will-provide-the-cheapest-compute-facilities-in-the-world-at-%E2%82%B967-per-gpu-hour-it-minister-ashwini-vaishnaw/.

8 Ministry of electronics and Information Technology, Government of India, *National Policy on Electronics 2012* (New Delhi: Ministry of Electronics & Information Technology, 2012), https://www.indiascienceandtechnology.gov.in/sites/default/files/file-uploads/sciencetechnologypolicies/1527506800_NPE_Notification.pdf.

9 Office of the Principal Scientific Adviser to the Government of India, *Artificial Intelligence Mission*, https://www.psa.gov.in/mission/artificial-intelligence/34.

10 Invest India, "PLI Scheme: A Game-Changer for India's Manufacturing Sector," 2020, https://www.investindia.gov.in/team-india-blogs/pli-scheme-game-changer-indias-manufacturing-sector.

11 Cabinet, Government of India, https://www.pib.gov.in/PressReleasePage.aspx?PRID=1781723.

12 Ministry of Electronics and IT, Government of India, https://www.pib.gov.in/PressReleasePage.aspx?PRID=2086605.

13 IndiaAI, "Cabinet Approves India AI Mission at an Outlay of ₹10,372 Crore," March 12, 2024, https://indiaai.gov.in/news/cabinet-approves-india-ai-mission-at-an-outlay-of-rs-10-372-crore

14 Khaitan & Co, *IndiaAI Report 2023*, 2023, https://www.khaitanco.com/thought-leaderships/IndiaAI_Report_2023.

15 "IndiaAI Report 2023."

16 "India May Get Own GPU in 3–5 Years; 18,000 AI Servers to Be Rolled Out Soon: Ashwini Vaishnaw," *Economics Times*, February 4, 2025,

https://economictimes.indiatimes.com/tech/technology/india-may-get-own-gpu-in-3-5-years-18000-ai-servers-to-be-rolled-out-soon-ashwini-vaishnaw/articleshow/117922050.cms?from=mdr.

17 Department of Science & Technology, *National Supercomputing Mission*, https://dst.gov.in/national-super-computing-mission.

18 "New Start of AI Revolution in India: Ashwini Vaishnav Launches IndiaAI Compute Portal and AI Kosh," *Sangri Today*, https://www.sangritoday.com/new-start-of-ai-revolution-in-india-ashwini-vaishnav-launches-indiaai-compute-portal-and-ai-kosh.

19 The White House, *Fact Sheet: The United States and India Committed to Strengthening Strategic Technology Partnership*, January 6, 2025, https://bidenwhitehouse.archives.gov/briefing-room/statements-releases/2025/01/06/fact-sheet-the-united-states-and-india-committed-to-strengthening-strategic-technology-partnership.

20 Micron Technology, *Micron Announces New Semiconductor Assembly and Test Facility in India*, https://investors.micron.com/news-releases/news-release-details/micron-announces-new-semiconductor-assembly-and-test-facility.

21 U.S. Department of State, *New Partnership with India to Explore Semiconductor Supply Chain Opportunities*, https://2021-2025.state.gov/new-partnership-with-india-to-explore-semiconductor-supply-chain-opportunities.

22 Anirudh Suri, "The Missing Pieces in India's AI Puzzle: Talent, Data, and R&D," Carnegie Endowment for International Peace, February 2025, https://carnegieendowment.org/research/2025/02/the-missing-pieces-in-indias-ai-puzzle-talent-data-and-randd?lang=en.

23 Konstantin Pilz and Lennart Heim, *Compute at Scale*, July 2023, https://konstantinpilz.com/data-centers/report

24 Lennart Heim, "This Can't Go On(?) – AI Training Compute Costs," heim.xyz (blog), June 1, 2023, https://blog.heim.xyz/this-cant-go-on-compute-training-costs.

25 Jai Vipra and Sarah M. West, "Compute and AI," AI Now Institute, 2023, https://ainowinstitute.org/publications/compute-and-ai#:~:text=A%20recent%20report%20from%20Andreessen,total%20capital%20on%20compute%20resources.%E2%80%9D.

26 Rohan Anil et al., "PaLM 2 Technical Report," arXiv, May 17, 2023, https://doi.org/10.48550/arXiv.2305.10403.

27 Next Round Capital, *Investing in the AI Infrastructure Boom*, https://nextroundcap.com/investing-in-the-ai-infrastructure-boom.

28 India Brand Equity Foundation (IBEF), *Booming Data Centre Growth in India*, https://www.ibef.org/blogs/booming-data-centre-growth-in-india.

29 India Brand Equity Foundation (IBEF), *Booming Data Centre Growth in India*, https://www.ibef.org/blogs/booming-data-centre-growth-in-india.

30 Aaron Tan, "Indian Public Cloud Market Set to Hit Over $25 bn by 2028," *Computer Weekly*, June 17, 2025, https://www.computerweekly.com/news/366617722/Indian-public-cloud-market-set-to-hit-over-25bn-by-2028.

31 "India to Become AI Use-Case Capital of the World: Nandan Nilekani," *Economic Times*, https://economictimes.indiatimes.com/tech/technology/india-to-become-ai-use-case-capital-of-the-world-nandan-nilekani/articleshow/109926942.cms?from=mdr.

32 Sidecar AI, "Exploring the Growth, Benefits, and Future of Smaller AI Models," https://sidecar.ai/blog/exploring-the-growth-benefits-and-future-of-smaller-ai-models.

33 Inductus GCC, "Global Capability Centres: India's Pivotal Role in Driving Global Transformation," https://inductusgcc.com/global-capability-centres-indias-pivotal-role-in-driving-global-transformation/.

34 Zinnov, "Why the World Should Invest in India's Global Capability Centers (GCCs)," https://zinnov.com/centers-of-excellence/why-the-world-should-invest-in-india-global-capability-centers-gccs-blog/

35 Inductus GCC, "India's Unique Value Proposition: An Ecosystem for Scalable Innovation Through Global Capability Centers (GCCs)," https://inductusgcc.com/indias-unique-value-proposition-an-ecosystem-for-scalable-innovation-through-global-capability-centers-gccs/#:~:text=Engineering%20and%20Research%20&%20Development%20(ER&D,%2C%20scale%2C%20and%20stay%20competitive.

36 NASSCOM, *India's Unique Value Proposition: An Ecosystem for Scalable Innovation*, https://community.nasscom.in/communities/global-capability-centers/indias-unique-value-proposition-ecosystem-scalable-innovation#:~:text=Over%20the%20last%20decade%2C%20India,or%20expanding%20their%20GCC%20footprint.

37 "India's Unique Value Proposition: An Ecosystem for Scalable Innovation"

38 World Economic Forum, "Which Countries' Students Are Getting the Most Involved in STEM?," March 2023, https://www.weforum.org/stories/2023/03/which-countries-students-are-getting-most-involved-in-stem/

39 NASSCOM, *State of Data Science & AI Skills in India*, https://nasscom.in/knowledge-center/publications/state-data-science-ai-skills-india-data-and-art-smart-intelligence.

40 "India's GCC Count Rises to 1,700 in FY24, Revenue Up 40% at $64.6 Billion: Report," *Economic Times*, https://economictimes.indiatimes.com/tech/technology/indias-gcc-count-rises-to-1700-in-fy24-revenue-up-40-at-64-6-billion-report/articleshow/113249180.cms?from=mdr.

41 "GPU-As-A-Service Market Size to Surpass USD 33.91 Billion by 2032 Owing to Growing Demand for AI and High-Performance Computing," *SNS Insider*, April 4, 2025, https://www.globenewswire.com/news-release/2025/04/04/3056012/0/en/GPU-As-A-Service-Market-Size-to-Surpass-USD-33-91-Billion-by-2032-Owing-to-Growing-Demand-for-AI-and-High-Performance-Computing-SNS-Insider.html.

42 CX Quest, *NVIDIA DGX-Ready Certification Boosts Sify's AI Data Centers*, https://cxquest.com/nvidia-dgx-ready-certification-boosts-sifys-ai-data-centers/.

43 Yotta Data Services, *Yotta Collaborates with NVIDIA to Catalyze India's AI Transformation*, https://yotta.com/media/press-release-yotta-data-services-collaborates-with-nvidia-to-catalyze-indias-ai-transformation/.

44 "Unveiling the Future of SaaS: The Impact of Emerging Technologies in 2025," *CEO Today Magazine*, April 2025, https://www.ceotodaymagazine.com/2025/04/unveiling-the-future-of-saas-the-impact-of-emerging-technologies-in-2025/.

45 Amazon Web Services (AWS), *AWS & Accel Launch ML Elevate for Generative AI Startups*, https://www.aboutamazon.in/news/aws/aws-accel-launch-ml-elevate-for-generative-ai-startups.

India's Stakes in Semiconductor Manufacturing and the Future of India-U.S. Bilateral Cooperation in AI

Zeena Nisar

Abstract

In the midst of shifting supply chains and fresh concerns around technology security, India has an emerging stake in the great-power competition between the United States (US) and China. As the US and its allies seek to de-risk from China and build alternative supply chains for critical goods, from semiconductors to vaccines, India is positioning itself as an alternative manufacturing hub. This article underscores the current opportunity for the US and India to deepen bilateral cooperation in domains such as semiconductor manufacturing and AI compute. It outlines the tangible ways in which the US and India

can deepen cooperation in AI through the scaling of legacy semiconductor manufacturing in India and increasing access to the high-performance compute capacity abundant in the US. By targeting hardware and compute capabilities necessary for AI innovation, policymakers in both the US and India can find synergistic opportunities to address their respective infrastructure gaps.

Legacy Semiconductor Manufacturing in India

India's rise as a semiconductor manufacturing hub has been a priority for Prime Minister Narendra Modi's government, aiming to place the country among the top five global semiconductor producers.[1] This ambition is supported by strategic policies, large-scale investments, and growing recognition from industry leaders who see India as a potential replacement for China's manufacturing dominance.[2] As geopolitical tensions and export restrictions challenge China's leadership as the world's leading legacy chip manufacturer, India is positioning itself as an emerging alternative.

Current State of Play

The global semiconductor industry is dominated by legacy chips, especially for everyday electronics, automotive systems, and industrial machinery. According to the Rhodium Group, US fabless chip designers depend heavily on foreign foundries for these chips, with 80 percent of foundry capacity for 20-45nm technology nodes concentrated in China and Taiwan. Similarly, for older 50-180nm nodes, China and Taiwan hold 70 percent of the market.[3] Global reliance on China for legacy chip production has led to extremely vulnerable supply chains, which are prone to geopolitical disruptions and economic coercion.

In 2020, the COVID-19 pandemic caused massive disruptions in the production of semiconductors. Global shortages reverberated across the automotive, industrial, and communications industries, causing widespread supply chain disruptions.[4] It became clear to policymakers around the world that an overreliance on a single source for semiconductors could become a massive liability in the future. Moreover, as the US imposes stricter export controls on advanced chips (below 14nm) aimed at curbing China's technological capabilities, the significance of legacy chips has only grown.[5] With its burgeoning semiconductor manufacturing ecosystem, India has the potential to capture a significant share of this legacy chip market from China.

The US government has already signalled an impending shift in its reliance on legacy semiconductors from China. In 2024, the US Department of Commerce's Bureau of Industry and Security released a report outlining the use of legacy semiconductors in critical supply chains.[6] In December 2024, the Biden Administration's Office of the US Trade Representative (USTR) launched a Section 301 investigation (a statutory authority designed to address unfair foreign practices affecting US commerce) into China's pursuit of market dominance in the legacy semiconductor industry.[7] In April 2025, the Trump Administration initiated a Section 232 investigation (a statutory authority providing the president with the ability to restrict imports of products that can threaten national security) on semiconductors, including legacy chips.[8] Global tensions, supply chain de-risking, and new export control regulations in the US are actively creating opportunities for India to capture legacy chip manufacturing.

India's Strategy to Capture Legacy Chip Manufacturing

India's approach to semiconductor manufacturing has evolved rapidly over the years. The creation of the India Semiconductor Mission (ISM) underscores the Indian government's strategic intent to attract semiconductor-sector investment. Offering a 50-percent project cost subsidy, with state governments contributing an additional 20-25 percent, India's fiscal incentives are among the most generous globally, albeit constrained by the limited total funding of the ISM.[9,10] These incentives are designed to mitigate the high capital costs associated with semiconductor manufacturing, thus reducing entry barriers for domestic and foreign investors.

Recognising the critical role of legacy chips in the global economy, the Modi government has approved various investments, through the ISM, in semiconductor production. In March 2024, the programme approved a substantial US$15.2-billion semiconductor development package, including a US$11-billion joint venture between Taiwan's PSMC and Tata Electronics, focused on producing chips at 28-, 40-, and 55-nm nodes and intended to target the global demand for legacy semiconductors.[11,12] In May 2025, the ISM approved the establishment of an additional semiconductor production facility in Uttar Pradesh, costing US$434.72 million, through a joint venture between India's HCL Technologies and Taiwan's Foxconn.[13,14]

In addition to direct investments in fabrication, the Indian government has made strides in supporting the growth of relevant semiconductor assembly, testing, and packaging (ATP) infrastructure, including the establishment of two ATP facilities and the confirmation of Micron's memory assembly and testing plant in Gujarat—an investment worth US$2.75 billion.[15] By holistically scaling the country's semiconductor manufacturing capabilities, the Modi government is committed to scaling semiconductor manufacturing to compete with existing incumbents, such as China, in the future.

India's Role in Supply Chain De-risking and Opportunities for Bilateral Cooperation

Rising tensions between the US and China have prompted a global trend towards supply chain diversification to reduce dependencies on a single country and mitigate against future disruptions. India has already benefited from this trend in other manufacturing sectors, capturing over-reliant production lines from China in areas such as electronics and pharmaceuticals.[16,17] The same potential exists for legacy chip manufacturing, where India's growing infrastructure, policy support, and large talent pool can attract companies seeking to diversify their supply chains away from China.

The feasibility of India capturing legacy chip manufacturing capacity from China will depend on the country's domestic policies to protect market demand, ensure competitive costs, and continue to build an ecosystem that supports long-term growth in the semiconductor industry. The biggest obstacle to scaling the legacy semiconductor industry in India will be competing against China's industrial policies. Without market pull mechanisms, the industry will fail to scale and maintain production capacity when faced with impossible cost competition from China. Here, the US government is well-positioned to support the scaling of the Indian semiconductor industry, given the country's robust demand for semiconductors. As the US seeks to diversify semiconductor supply chains for national and economic security interests, there are opportunities to direct American buying power for legacy chips in consumer electronics towards India and provide the necessary market demand for the industry to compete against China.

High-Performance Compute Infrastructure and Access in the United States

The US has historically led in Artificial Intelligence (AI) research and development, with strong advantages in cutting-edge innovation, world-class universities, and leading technology companies like Google, Microsoft, and OpenAI.[18] Access to the US's high-performance computing capacity is of strategic interest to India, given its shared interest in pursuing AI innovation.

Current State of Play

The US's investment in high-performance computing infrastructure underscores its commitment to maintaining technological superiority in AI for scientific research, national defence, and economic growth. As of November 2024, the US leads the TOP500 list with 173 supercomputers, reflecting its dominant position in global high-performance computing.[19]

High-performance computing in the country can be found in both the private and public sectors. US government and research labs, such as the Department of Energy's Oak Ridge National Laboratory and Lawrence Livermore National Laboratory, possess some of the most powerful supercomputers in the world. The El Capitan system, currently the fastest supercomputer in the world, is located at the Lawrence Livermore National Laboratory.[20] In the private sector, Graphics Processing Units (GPUs) are integral to high-performance computing for AI innovation. Running AI/ML (machine learning) model training requires parallel computations, a feature of GPUs.[21] Leading providers of high-performance computing processors include Nvidia and AMD.[22] For commercial access to high-performance computing infrastructure, cloud providers like Amazon Web Services (AWS), Google Cloud, and Microsoft Azure integrate HPC infrastructure into cloud-based AI services. Indeed, the US possesses a robust ecosystem of high-performance computing capacity and services to drive AI innovation.

Opportunities for Bilateral Cooperation

For India, access to US cloud-based AI services could provide the computing power necessary to drive the nation's interests in AI innovation without the steep infrastructure costs of high-performance computing. Moreover, as the second-most populous country with a rapidly growing technology sector, India provides a strategic market for US AI cloud providers. Although the US is home to some of the leading firms in this space, Chinese companies, such as Alibaba and Tencent, are building their competition.[23]

Previous and ongoing bilateral agreements between the two countries may provide the institutional pathways for increased bilateral cooperation in this space. Under the Biden Administration, the US-India initiative on Critical and Emerging Technology (iCET) was announced. Launched in January 2023, iCET kickstarted efforts between the US and India in deepening and expanding cooperation in critical technology sectors, including AI.

Under the Trump Administration, cooperation in strategic technologies will ensue under the US-India TRUST (Transforming the Relationship Utilizing Strategic Technology) initiative—a project that seeks to deepen government-to-government, academia, and private sector collaborations. Most importantly, the TRUST initiative includes efforts for a US-India Roadmap on Accelerating AI Infrastructure, whereby the two nations will identify constraints to scaling US-origin AI infrastructure in India, outline industry partnerships and investments for data centre development, and cooperate to generate access to computing power for AI. In addition to scaling AI infrastructure, the two countries have committed to building supply chain resilience in semiconductors and encouraging public and private investments to expand Indian manufacturing capacity.[24]

The TRUST initiative offers optimal pathways for the two countries to pursue mutual aims in AI infrastructure and innovation. For India, the bilateral initiative offers opportunities to scale domestic semiconductor manufacturing and opportunities to expand access to cloud computing power for AI with US-origin infrastructure. At a time when Chinese firms are vying for a share of the Indian cloud market, these demand signals can have a profound market-shaping impact for the integration of US cloud services in Indian AI innovation. For the US, this bilateral initiative can support efforts to de-risk legacy semiconductor supply chains away from China and deepen ties with a like-minded nation in AI. Policymakers of both nations stand to gain from deepening collaborations and cooperation through the TRUST initiative.

Challenges to Trade, Investment, and Scaling in AI

Market Barriers to India's Scaling of Legacy Chip Manufacturing

While India's policy framework and investments in legacy chip manufacturing are promising, a key question remains: Can India compete with the incumbent China's position? India possesses a vast pool of English-speaking technical talent conducive to the overall scaling of the semiconductor industry.[25] In fact, 20 percent of the world's global semiconductor design talent is from India.[26] However, the country faces hurdles, such as labour costs, infrastructure development, and cost competition vis-à-vis China. Moreover, China's top-down strategies and subsidies are difficult to compete against in normal market conditions, especially with regard to industrial overcapacity. The challenge for India will be to develop a manufacturing ecosystem that rivals China's in both scale and efficiency while maintaining global competitiveness in the production of legacy chips. Ultimately, the future of India's semiconductor industry will depend on the nation's ability to compete with China to secure a robust end-use market for domestically produced chips. In particular, China's proclivity for industrial overcapacity will be the biggest barrier to India's ability to scale this industry.

As seen in other industries such as electric vehicles and solar panels, China's state-driven policies and subsidies can lead to industrial overcapacity, where excess production capacity is disproportionate to demand. Although normal bouts of temporary overcapacity can occur in all markets, economic pressure to operate efficiently often corrects course as firms seek to generate profits. When government investment and support artificially sustain industrial overcapacity, firms flood global markets at below-cost prices and thus cannibalise fair competition.[27]

To protect the Indian market from Chinese industrial overcapacity, Indian decision-makers will have to craft domestic and international policies to aggregate market demand for Indian legacy semiconductors.

The Challenges of Aggregating Demand for 'Made in India' Chips

To solidify its place in the global semiconductor landscape, India must align its semiconductor strategies with broader industrial policies that strengthen consumption. Otherwise, semiconductor manufacturing in India will fail to scale production. The nation is already home to a growing electronics manufacturing sector due, in part, to Production Linked Incentive (PLI) schemes, government-initiated incentives aimed at bolstering manufacturing capacity and reducing imports.[28] Moreover, in 2014, the Indian government launched its 'Make in India' initiative, a programme designed to boost domestic manufacturing and draw in foreign capital.[29]

Although the PLI schemes and 'Make in India' have had varying degrees of success, neither has an explicit focus on integrating semiconductor manufacturing into the Indian technology ecosystem—a step that will be essential for long-term success. Encouraging domestic companies to source chips from local foundries, expanding into industries like automotive and industrial automation, and fostering innovation in chip design are ways in which India can build a robust end-use market for its legacy semiconductors.

The semiconductor industry will require a strong domestic electronics ecosystem to sustain demand for locally made chips. To effectively compete with China, India must foster demand for legacy chips within its own borders and internationally with like-minded partners to reduce reliance on cheaper imports from China, and build a self-sustaining semiconductor market.

Barriers to Accessing AI Compute Power

If India seeks to deepen bilateral cooperation with the US in AI innovation and increase the nation's access to high-performance computing, then Indian policymakers must carefully consider the recent trend of US technology security measures. In October 2022, October 2023, and December 2024, the United States made considerable steps to tighten its export control policies on advanced semiconductors.[30,31,32] These export controls protect advanced semiconductors from military end-uses, especially regarding Chinese military modernisation, and were considered a part of the Biden Administration's approach to protecting foundational technologies with a "small yard and high fence."[33]

In January 2025, the US Department of Commerce's Bureau of Industry and Security (BIS) released the AI Diffusion Rule, which establishes a regulatory framework to manage the global distribution of advanced AI technologies, balancing national security concerns with technological innovation. Interestingly, the rule incorporated a trusted end-user programme and country-specific assessments to ensure the diffusion of AI capabilities aligns with US national security interests.[34] In the rule, a "Universal Validated End User (UVEU)" cannot ship more than 7 percent of their total AI computing power to any one middle-tier country.[35] Thus, as a middle-tier country, India would face sales caps from trusted end-users and may face shortages in computing. As of May 2025, the Trump Administration has rescinded the AI Diffusion Rule, removing this sales cap on India's pursuit of computing power.[36] Whether the Trump Administration reintroduces a similar and/or revised diffusional rule remains to be seen. Nevertheless, given the overall patterns of US technology security policies across both the Biden and Trump Administrations, Indian policymakers should carefully consider an alignment in technology security policies in order to maintain bilateral cooperation with the US in AI.

Policy Recommendations

There are synergistic opportunities to deepen AI cooperation between the United States and India. India's growing semiconductor manufacturing capacity could propel the country as a feasible alternative supplier for US companies urgently seeking to de-risk supply chains away from China. For India, US-origin high-performance computing power and cloud services could provide India with access to the technological capabilities necessary to drive AI innovation.

To advance shared interests in AI innovation and infrastructure and proactively mitigate the challenges outlined in this article, the following actions are recommended:

For US Policymakers

- **Formalise a US-India Semiconductor Procurement Compact** to direct American consumer electronics and automotive firms to source a defined percentage of legacy chips from India. Creating stable demand signals to support the scaling of India's semiconductor sector.
- **Expand the TRUST Initiative** to include a dedicated AI Cloud Computing Working Group tasked with expanding US cloud services access in India.
- **Facilitate US private sector investments in India's semiconductor manufacturing** by offering targeted financial incentives or credit support for American firms partnering with Indian foundries.

For Indian Policymakers

- **Integrate Semiconductor Manufacturing into the 'Make in India' Programme** with explicit incentives for domestic companies to prioritise locally-produced chips and embed semiconductors into existing industrial and automotive PLI schemes.
- **Adopt a Market Aggregation Strategy** by mandating or incentivising key sectors (electronics, automotive, industrial automation) to source a portion of their semiconductor needs from Indian fabs.

For Joint US-India Cooperation

- **Redirect US demand for legacy semiconductors** within ongoing bilateral tariff negotiations by placing strategically lower tariffs on Indian legacy semiconductors.
- **Convene an Annual US-India Technology Supply Chain Security Dialogue** to coordinate export control policies, technology security measures, supply chain risk assessments, and responses to Chinese industrial overcapacity strategies.

Through these coordinated actions, policymakers in both countries can make tangible inroads to a resilient, mutually beneficial technology partnership.

Conclusion

As geopolitical tensions reshape global technology supply chains and strategic partnerships, India is emerging as a pivotal player within the US-China technology competition. India, whose expanding legacy semiconductor industry and growing appetite for AI capabilities align with US strategic and economic interests, could become an alternative manufacturer for the US as it seeks to de-risk from China.

However, there are considerable challenges to the future of US-India cooperation. If India seeks to manufacture legacy semiconductors at scale to meet US demand, Indian policymakers will have to counter the market distortions created by China's industrial overcapacity by fostering domestic demand for 'Made in India' chips. Moreover, if India seeks access to US compute power for AI innovation, policymakers will have to consider aligning India's technology security measures with US national security imperatives. Nevertheless, this article has outlined opportunities for policymakers of both nations to proactively address these challenges if they seek a mutually beneficial technology partnership.

Endnotes

1 Charmaine Jacob, "India Wants to Be a Global Chip Powerhouse in 5 Years," *CNBC*, March 18, 2024, https://www.cnbc.com/2024/03/18/india-wants-to-be-a-global-chip-powerhouse-in-5-years-says-it-minister.html.

2 Shrishti Sisodia, "Taiwan FM Joseph Wu Speaks to Wion on India-Taiwan Ties, Semiconductor, Indo-Pacific, and More," *Wion*, April 13, 2024, https://www.wionews.com/india-news/taiwan-fm-joseph-wu-speaks-to-wion-on-india-taiwan-ties-semiconductor-indo-pacific-and-more-710541.

3 Jan-Peter Kleinhans, Reva Goujon, Julia Hess, and Lauren Dudley, "Running on Ice: China's Chipmakers in a Post-October 7 World," Rhodium Group, April 4, 2023, https://rhg.com/research/running-on-ice/.

4 The White House, *Building Resilient Supply Chains, Revitalizing American Manufacturing, and Fostering Broad-Based Growth,* June 2021, https://www.bis.doc.gov/index.php/documents/technology-evaluation/2958-100-day-supply-chain-review-report.

5 Federal Register, "Export Controls on Semiconductor Manufacturing Items," October 25, 2023, https://www.federalregister.gov/documents/2023/10/25/2023-23049/export-controls-on-semiconductor-manufacturing-items.

6 Bureau of Industry and Security, "BIS Publishes Assessment on the Use of Mature-Node Chips," December 6, 2024, https://www.bis.gov/press-release/bis-publishes-assessment-use-mature-node-chips.

7 United States Trade Representative, "USTR Initiates Section 301 Investigation on China's Acts, Policies, and Practices Related to Targeting of the Semiconductor Industry for Dominance," December 23, 2024, https://ustr.gov/about-us/policy-offices/press-office/press-releases/2024/december/ustr-initiates-section-301-investigation-chinas-acts-policies-and-practices-related-targeting.

8 Federal Register, "Notice of Request for Public Comments on Section 232 National Security Investigation of Imports of Semiconductors and Semiconductor Manufacturing Equipment," April 16, 2025, https://www.federalregister.gov/documents/2025/04/16/2025-06591/notice-of-request-for-public-comments-on-section-232-national-security-investigation-of-imports-of.

9 Melissa Cyrill and Yashoda Kapur, "India's Semiconductor Sector: Tracking Government Support and Investment Trends," *India Briefing News*, May 15, 2025, https://www.india-briefing.com/news/setting-up-a-semiconductor-fabrication-plant-in-india-what-foreign-investors-should-know-22009.html/.

10 Ministry of Electronics and Information Technology, Government of India, "India Semiconductor Mission," https://www.ism.gov.in/#:~:text=Schemes%20%40ISM&text=The%20Scheme%20for%20setting%20up,by%20Secretary%2C%20Department%20of%20Expenditure.

11 Samuel K. Moore, "India Injects $15 Billion into Semiconductors," *Semiconductor News*, April 25, 2024, https://spectrum.ieee.org/indian-semiconductor-manufacturing.

12 Cabinet, Government of India, https://www.pib.gov.in/PressReleseDetailm.aspx?PRID=2010132.

13 Ministry of Electronics and Information Technology, *India Semiconductor Mission*.

14 CK Nayak and Surbhi Misra, "India Approves HCl-Foxconn Joint Venture Semiconductor Unit," *Reuters*, May 14, 2025, https://www.reuters.com/world/india/india-approves-hcl-foxconn-joint-venture-semiconductor-unit-2025-05-14/.

15 Dashveenjit Kaur, "The Biden-Modi Meeting Might Mean a New Era of US-India Relations," *TechWire Asia*, June 23, 2023, https://techwireasia.com/2023/06/us-india-relationsleveled-up/.

16 Agatha Kratz, Lauren Piper, and Juliana Bouchard, *China and the Future of Global Supply Chains,* Rhodium Group, February 4, 2025, https://rhg.com/research/china-and-the-future-of-global-supply-chains/.

17 Vikash Agarwalla et al., "Unleashing the Tiger: Indian CRDMO Sector," BCG Global, February 25, 2025, https://www.bcg.com/publications/2025/india-unleashing-the-tiger-indian-crdmo-sector.

18 National Security Commission on Artificial Intelligence, *NSCAI Final Report,* https://reports.nscai.gov/final-report/.

19 "TOP500," https://top500.org/.

20 "TOP500"

21 Nvidia, "Glossary: High-Performance Computing," https://www.nvidia.com/en-us/glossary/high-performance-computing/.

22 David Chernicoff, "How Intel, AMD and Nvidia Are Approaching the AI Arms Race," *Data Center Frontier*, April 6, 2023, https://www.datacenterfrontier.com/machine-learning/article/33002883/how-intel-amd-and-nvidia-are-approaching-the-ai-arms-race.

23 Justin Sherman, "US and Chinese Cloud Firms Battle for Indian Market Share," January 17, 2023, https://globalcyberstrategies.substack.com/p/us-and-chinese-cloud-firms-battle.

24 U.S. Embassy in India, "United States – India Joint Leaders Statement," February 13, 2025, https://in.usembassy.gov/united-states-india-joint-leaders-statement/.

25 "Will India Be the Next Semiconductor Superpower?," *Wired*, https://www.wired.com/sponsored/story/will-india-be-the-next-semiconductor-superpower-hsbc-global-private-banking/.

26 Svara Mehta, "The Future Is Now: India's Journey to Becoming a Global Chip Powerhouse," Cornell SC Johnson School of Business, https://business.cornell.edu/article/2025/04/the-future-is-now/.

27 Camille Boullenois, Agatha Kratz, and Daniel H. Rosen, *Overcapacity at the Gate,* Rhodium Group, March 26, 2024, https://rhg.com/research/overcapacity-at-the-gate/.

28 Aashish Aryan and Prabha Raghavan, "Explained: What Is PLI Scheme, and Which Sectors Will Be Under It?," *The Indian Express*, November 8, 2020, https://indianexpress.com/article/explained/what-is-pli-scheme-which-sectors-will-be-under-it-7001985/.

29 Gaurav Choudhury, "Live Coverage: Launch of Modi's Make in India Campaign - Hindustan Times," *Hindustan Times*, September 25, 2014, https://web.archive.org/web/20140925055526/http://www.hindustantimes.com/business-news/live-coverage-launch-of-modi-s-make-in-india-campaign/article1-1268119.aspx.

30 Bureau of Industry and Security, "Commerce Implements New Export Controls on Advanced Computing and Semiconductor Manufacturing Items to the People's Republic of China (PRC)," October 7, 2022, https://www.bis.doc.gov/index.php/documents/about-bis/newsroom/press-releases/3158-2022-10-07-bis-press-release-advanced-computing-and-semiconductor-manufacturing-controls-final/file.

31 Bureau of Industry and Security, “Commerce Strengthens Restrictions on Advanced Computing Semiconductors, Semiconductor Manufacturing Equipment, and Supercomputing Items to Countries of Concern,” October 17, 2023, https://www.bis.doc.gov/index.php/documents/about-bis/newsroom/press-releases/3355-2023-10-17-bis-press-release-acs-and-sme-rules-final-js/file.

32 Federal Register, “Foreign-Produced Direct Product Rule Additions, and Refinements to Controls for Advanced Computing and Semiconductor Manufacturing Items,” December 2, 2024, https://public-inspection.federalregister.gov/2024-28270.pdf.

33 The White House, “Remarks by National Security Advisor Jake Sullivan on Renewing American Economic Leadership at the Brookings Institution,” April 27, 2023, https://bidenwhitehouse.archives.gov/briefing-room/speeches-remarks/2023/04/27/remarks-by-national-security-advisor-jake-sullivan-on-renewing-american-economic-leadership-at-the-brookings-institution/.

34 Bureau of Industry and Security, “Biden-Harris Administration Announces Regulatory Framework for the Responsible Diffusion of Advanced Artificial Intelligence Technology,” January 13, 2025, https://web.archive.org/web/20250113161122/https://www.bis.gov/press-release/biden-harris-administration-announces-regulatory-framework-responsible-diffusion.

35 John Villasenor, “The New AI Diffusion Export Control Rule Will Undermine US AI Leadership,” Brookings Institution, January 23, 2025, https://www.brookings.edu/articles/the-new-ai-diffusion-export-control-rule-will-undermine-us-ai-leadership/.

36 Bureau of Industry and Security, “Department of Commerce Rescinds Biden-Era Artificial Intelligence Diffusion Rule, Strengthens Chip-Related Export Controls,” May 13, 2025, https://www.bis.gov/press-release/department-commerce-rescinds-biden-era-artificial-intelligence-diffusion-rule-strengthens-chip-related.

Bridging Innovation: U.S.-India Collaboration to Address the Future of Work

Ingrid Erickson

Abstract

This article proposes a framework for United States (US)-India collaboration to address workforce disruptions caused by the deployment of Artificial Intelligence (AI). The framework articulates a plan for joint research through an AI Workforce Research Consortium, workforce development via a bilateral AI Skills Initiative, innovative social protection mechanisms, entrepreneurship promotion through regional innovation partnerships, and shared governance frameworks. The aim for the two sides should be to manage the impacts of AI adoption while maintaining economic competitiveness and social stability. Their partnership

would be uniquely positioned to address the challenge: the US's advanced AI capabilities and ageing workforce complement India's demographic dividend and experience in managing large-scale informal employment. The two countries' shared commitment to democratic values and decades of bilateral cooperation in technology and education provide the foundation for developing scalable solutions that can serve as blueprints for other nations navigating AI-driven workforce transitions while preserving social cohesion and economic opportunity.

Introduction

Labour markets have long been prone to interruptions—from changing national policies and shifts in international relations to natural disruptions such as the COVID-19 pandemic.[a] The growing development and adoption of Artificial Intelligence (AI), particularly generative AI (GenAI), is the latest force reshaping industries, workflows, and labour market structures. AI's disruptive potential lies largely in the expectation that digitised tasks will be automated[b] wherever possible. Using AI instead of human labour is pegged to the near-universal valorisation of efficiency, productivity, and scalability for enterprises—an outcome that AI provides with growing effectiveness and affordability. Yet, delegating tasks once performed by humans risks sidelining workers, at best, and replacing them, at worst.[1]

The hype surrounding AI's impact on the future of work is arguably amplified, yet credible actors such as the World Economic Forum (WEF) agree that its effects—combined with demographic, environmental, and geopolitical shifts—will be substantial: "On current trends over the 2025 to 2030 period job creation and destruction due to structural labor-market transformation will amount to 22 percent of today's total jobs. This is expected to entail

---

a The author's use of the words 'interruption' or 'disruption' in this article are used to denote a moment of upheaval or change where normal practices or ways of doing things are questioned or forced to change.

b Automation has been around since the industrial revolution and refers to utilising machines (e.g., an industrial loom) in place of human labour. In recent decades, automation has tended to refer to robotisation, where one or more parts of a larger set of tasks is completed by robotic automation (i.e., robots in place of human labour). Robots can be programmed to follow simple "if this, then that" instructions. Intelligent automation combines AI with traditional automation to handle tasks that typically require human thinking and decision-making. Unlike basic automation, intelligent automation can adapt, learn from patterns, and make judgment calls. For further discussion of these differences, see: https://www.brookings.edu/articles/automation-and-artificial-intelligence-sound-similar-but-may-have-vastly-different-impacts-on-the-future-of-work/?utm_.

the creation of new jobs equivalent to 14 percent of today's total employment, amounting to 170 million jobs. However, this growth is expected to be offset by the displacement of the equivalent of 8 percent (or 92 million) of current jobs, resulting in net growth of 7 percent of total employment, or 78 million jobs."[2] WEF posits that these labour market evolutions will occur unevenly, impacting different sectors, worker skill levels, and geographic regions discordantly.

This article outlines how the United States (US) and India could strategically collaborate to prepare for a future in which AI disrupts labour markets and reshapes work. Their differences, alongside decades of bilateral engagement in science, technology, education, and economic development, position the partnership to incubate new models of workforce development, social protection, technology governance, and entrepreneurial ecosystems with global relevance. The discussion begins by positioning each of the two countries' labour markets in relation to recent and expected technological changes and then explores potential collaboration pathways to maximise the scope and efficacy of US-India collaboration on the future of work.

The US and Indian Economies from a Labour Perspective

The labour market impacts of AI in the US and India will vary, shaped by their distinct economic structures, demographic profiles, and development trajectories.

The US is an advanced economy and leader in AI research, development, and commercialisation,[3] home to technology firms such as Google, Microsoft, Apple, and Amazon. It also produces some of the world's most highly impactful AI research.[4,5] At the same time, its labour market is shaped by high labour costs and an ageing population.[6,7] In recent decades, offshoring has eroded manufacturing jobs, fuelling discontent among low-skilled and blue-collar workers.[c] The decline of manufacturing, alongside the rise of knowledge-based services, has fostered perceptions of deindustrialisation[8]—a politically potent theme in the 2024 presidential election, which featured promises of onshoring and new trade tariffs.[9] Yet, efforts to expand domestic manufacturing may prove double-edged, as so-called "smart factories" driven by intelligent automation are likely to generate more high-skilled than low-skilled jobs.[10]

---

c Here, 'skills' refer to the knowledge and expertise required to accomplish them. While all occupations encompass some form of skill, employment parlance tends to refer to 'skill' relative to the requisition- acquisition of specialised knowledge. Therefore, a tradesperson would be considered low-skill, a surgeon would be considered high-skill, and an average office worker would be considered middle-skill.

Beyond manufacturing, AI adoption in the US is reshaping highly routinised occupations such as customer service (e.g., chatbots vs. human call-centre operators), transportation (e.g., automated vs. human drivers), retail (e.g., self-checkout, kiosks vs. human salespeople), and administrative support (e.g., virtual assistants, AI agents vs. human assistants).[11] MIT's Task Force on the Work of the Future refers to this trend as the "hollowing out" of mid-level jobs, noting that generative AI is displacing non-expert knowledge workers (e.g., software developers) most rapidly. Specialised knowledge workers and blue-collar occupations, for their part, have been less affected so far.[12] This churn is fuelling rising income inequality and declining economic mobility.[13]

In contrast, India is a developing economy with a far younger demographic profile than the US; over 40 percent of its population are under 25.[14] This presents growth potential, provided education and skill development align with emerging economic opportunities. NITI Aayog's National Strategy for Artificial Intelligence identifies this potential convergence of demographics and economic opportunity as India's greatest advantage as well as a substantial challenge in the future, suggesting that much of India's continuing development is dependent on its ability to upskill its large population of young workers into the formal workforce.[15]

In 2025, over 40 percent of India's workforce remain employed in agriculture, a sector McKinsey identifies as highly prone to AI disruption. Globally, AI applications in agriculture are expected to raise yields by 20-25 percent while reducing labour demand by similar margins.[16] India's information technology and enabled services (ITeS) sector faces similar situations. The National Association of Software and Service Companies (NASSCOM) projects that while up to 30 percent of current IT service jobs may be automated by AI by 2030, embracing AI could create 1.5-2 million new technology jobs during the same period.[17] That the ITeS sector is growing puts more pressure on companies to find (or train) skilled workers in the future in order to maintain this momentum.[18]

A large proportion of India's workforce remains in the informal sector, posing challenges for future growth as AI adoption will occur primarily via formal employment.[19] Social divides—such as the divide between Tier 1 cities and other regions—further shape access to digital infrastructure and education. According to the International Telecommunication Union, urban internet penetration in India exceeds 70 percent, while rural connectivity remains below 35 percent—a disparity that could limit the benefits of widespread AI adoption and deepen existing inequalities.[20]

In sum, the US and India present different strengths in managing the impact of intelligent automation on their respective workforces. The US's ageing population contrasts with India's demographic advantage, yet America's legacy of AI innovation positions it to guide

India in fostering entrepreneurship and designing skill-development opportunities for its youth. Meanwhile, India's insights in dealing with a large informal workforce could benefit the US as it strives to support a growing population of alternate and informal workers and provide an example to spur American regional economic development.

Both nations must confront AI's impact on their workforces, albeit in different cultural, political, and economic contexts. The US faces middle-skill job displacement and wage polarisation, while India must guard against AI deepening its digital divide and formal-informal sector gaps. These distinct yet connected concerns, combined with established bilateral cooperation frameworks in technology and education, position both countries to potentially be advantageous to one another. Recognising this mutuality could help both countries to develop joint solutions for workforce retraining, social protection, and technology governance that not only improve their individual situations but also create models for other countries to follow as well. Building on India and the US's complementary demographics, technological capabilities, and shared inclusion imperatives, promises to create a comprehensive strategic foundation for addressing AI-related labour market disruptions and preparing for a future of work that ensures worker well-being and economic growth.

Recommendations for Future Bilateral Cooperation on AI and the Future of Work

The following sections outline recommendations for a comprehensive framework for US-India collaboration on AI-related workforce adjustments, organised around five pillars: (1) joint research and knowledge exchange through an AI Workforce Research Consortium and shared data infrastructure; (2) workforce development and skill transformation via a bilateral AI Skills Initiative to expand educational exchanges; (3) social protection and support mechanisms, including innovative safety nets; (4) entrepreneurship and job creation through regional innovation partnerships and alternative ownership models; and (5) governance and ethical frameworks to ensure appropriate regulation and worker participation.

1. Joint Research and Knowledge Exchange

An AI Workforce Research Consortium—a dedicated bilateral research initiative[21]—could be created to connect researchers from the two countries. The US National Science Foundation and India's Department of Science and Technology could jointly lead the consortium, alongside other prominent research institutions. Its purpose would be to monitor emerging AI developments in both contexts, identify generalisable trends, and assess social effects such as new AI use cases, shifting skill requirements, and sectoral dynamics. Potential activities could include conducting comparative analyses of automation impacts across sectors and regions, predictive modelling of skill evolution and job transformation, evaluation of intervention strategies, and the exchange of methodologies and findings to inform policy in both nations.

In parallel, the consortium could develop a joint data infrastructure, including privacy protocols for sharing research insights between associated individuals and organisations in both countries. Initial implementation of such an infrastructure could take the form of a cooperative data platform allowing researchers to track AI adoption across sectors and monitor both short- and long-term workforce impacts. Over time, this infrastructure could support the creation of standardised occupational classifications and skill taxonomies, enabling cross-country comparisons at a global level. Although complex and aspirational, such a system would underscore how collaboration between US and Indian researchers can generate valuable insights into AI's impact on work.

2. Workforce Development and Skills Transformation

At present, India and the US work together via the India-US Working Group on Education and Skill Development, launched in 2023 by India's Ministry of Education and the US Department of State.[22] This platform could now be expanded into a full-fledged bilateral AI Skills Initiative to accelerate workforce development and skills transformation in both countries. Initially, the initiative could focus on designing and piloting a comprehensive programme to address immediate reskilling needs while building long-term capabilities. Drawing on each country's labour market differences would help identify critical skills and educational pathways to support worker well-being globally. As AI advances, the initiative could further aim to institutionalise modular, stackable credentials recognised across international labour markets.

The AI Skills Initiative could also oversee industry-based training consortiums across various key sectors such as healthcare, finance, and transportation, working with professional associations in both countries to create shared training resources and platforms aligned with industry skills standards. It could aggregate information on career progression frameworks, implement apprenticeship and work-based learning models, and prioritise small and medium enterprise capability development. To date, industry-led consortiums do exist (e.g., the NASSCOM Sector Skills Councils in India[23] and US industry apprenticeship partnerships), but the proposed AI Skills Initiative would be the first to manage bilateral consortiums across borders.

Relatedly, India could expand its education and exchange programmes with the US, working through organisations such as the US Department of State's Fulbright programme.

Building on existing educational partnerships, these efforts could focus specifically on AI workforce preparation. Examples include specialised Fulbright fellowships for AI ethics, policy, and education research, exchange programmes for vocational instructors and workforce development professionals, supporting community college and polytechnic partnerships for mid-skill technical training, and dual-degree or joint certificate programmes between US and Indian institutions.

3. Social Protections and Supports

To address both individual (e.g., job obsolescence) and societal (e.g., increased unemployment, income inequality) impacts of intelligent automation, India and the US should work together to envision an array of social protections and support (e.g., universal basic income)[24] for workers. One mechanism for achieving this goal would be to develop a channel for interested organisations in both countries to share local approaches and models, potentially overseen by the AI Skills Initiative. This channel could serve as a testbed for innovative support systems like wage insurance, portable benefits, and temporary subsidies, which could be ideated, critiqued, and developed. It could also provide a shared platform for assessing and comparing the effectiveness of these potential solutions relative to local criteria once implemented.

Additionally, the channel could provide a forum for sharing insights about supporting informal, gig, and platform workers—for example, often overlooked in conversations about the future of work—such as the viability of portable/stackable credential[25] and benefit[26] systems. Finally, the channel could address best practices for streamlining the delivery of support services, such as digital public infrastructure advancements in India.[27] Finally, as part of its commitment to worker support, the AI Skills Initiative could act as an expert advisor to regional and international philanthropic organisations interested in creating services or funding programmes to support displaced workers.

4. Entrepreneurship and Job Creation

Entrepreneurship should be nurtured as a driver of AI-related business growth in both countries. Building on India's successful Startup programme,[28] the two governments could launch a joint AI Entrepreneurship Initiative. Its goals would be threefold: lowering financial and governmental barriers for businesses established in both countries, strengthening ties between US and Indian tech talent, and promoting knowledge sharing among entrepreneurs themselves. Under this initiative, each government could work together to establish specialised incubators and accelerators in both countries, a seed fund for startups developing AI applications for underserved markets, support for ventures focused on human-AI collaboration tools and platforms, and the development of mentorship networks connecting entrepreneurs across both ecosystems.

A second recommendation under this pillar, managed by the AI Entrepreneurship Initiative, is to launch a regional innovation pilot programme pairing cities and regions in both countries facing similar transition challenges. Cities could apply or be nominated by their respective states. For example, Pittsburgh or Detroit in the US could be paired with emerging Indian tech hubs like Pune or Indore. These partnerships could promote knowledge exchange among local economic development organisations, foster investment and market access, and support inclusive entrepreneurship models adaptable to diverse contexts.

Finally, the initiative could facilitate discussion on policies that support platform cooperatives and alternative ownership models. These discussions could be aimed at jointly promoting innovative organisational approaches to AI-enabled work, such as funding research and pilot projects that test worker-owned platforms, developing legal and regulatory frameworks to support distributed ownership, creating knowledge exchange mechanisms to share insights on cooperative business models, and implementing training programmes on cooperative governance and management.

5. Governance and Ethical Frameworks

India and the US should create shared governance and ethical frameworks, beginning with the AI Workforce Research Consortium developing, validating, and disseminating shared principles for the ethical and humane application of AI in workplaces. These principles could include a focus on transparency, accountability, and human-centred design, the development of specific guidelines for worker notification, consultation, and participation, the creation of standards for algorithmic management and supervision, and the establishment of frameworks for fair distribution of productivity gains.

Ultimately, it may be necessary to form a new body, say, a US-India AI Workforce Commission, to create a formal structure for aligning regulatory approaches across the two countries. Beginning with the members of the AI Skills Initiative, the body could expand as needed to include salient government, industry, labour, and civil society representation. This body could coordinate international AI governance initiatives at forums like the Group of 20 (G20), the International Labour Organization (ILO), and the Organisation for Economic Co-operation and Development (OECD). It could also oversee the development of shared approaches to platform regulation and worker protection. Finally, such a commission could create specialised working groups on sector-specific challenges.

Finally, a US-India collaboration plan on AI-related job disruption should include an initiative to support workers' voices in both countries. This forum, created under the auspices of the commission outlined above, would ensure that affected workers can participate directly in transition planning related to their personal experiences. In line with this, the commission could support worker councils and representation mechanisms in AI implementation processes, create joint union-management technology committees in key industries, develop digital platforms for worker feedback and participation, and implement training programmes on technology assessment and implementation planning.

Conclusion: A Shared Path Forward

The workforce challenges posed by AI in the US and India are distinct, but their differences create opportunities for mutual learning. While all nations face disruptions from AI's rapid advancement, India and the United States share a commitment to democracy and enterprise that makes them well aligned to create a working coalition that benefits them both—should they choose to. Collectively, the distinct economic profiles, demographic patterns, and technological capabilities of the two countries create the conditions for a comprehensive testbed that could yield a salient set of frameworks to guide organisations and institutions worldwide toward a more stable future in the face of increasing intelligent automation.

By moving quickly on to address the five propositions briefly outlined in this article, both India and the United States can demonstrate their commitment to proactive management of technological change rather than reactive crisis response. Such a partnership would offer a powerful platform for showing the world that technological advancement and inclusive growth can be complementary rather than competing aims. Through decisive action now, these two democracies can establish a blueprint for managing the global challenge of AI workforce transitions while upholding their shared values of human dignity and economic opportunity.

Endnotes

1 Anirban Sarma and Basu Chandola, *A.I., the World, and India: Present Trends and Future Directions*, New Delhi, Observer Research Foundation, 2025, https://www.orfonline.org/research/a-i-the-world-and-india-present-trends-and-future-directions.

2 World Economic Forum, *The Future of Jobs Report 2025,* Geneva CH, World Economic Forum, 2025, https://www.weforum.org/publications/the-future-of-jobs-report-2025/.

3 Stanford HAI Staff, *Global AI Power Rankings: Stanford HAI Tool Ranks 36 Countries in AI*, Palo Alto CA, Stanford University Human-Centered Artificial Intelligence, 2024, https://hai.stanford.edu/news/global-ai-power-rankings-stanford-hai-tool-ranks-36-countries-in-ai.

4 National Science Board*, Invention, Knowledge Transfer, and Innovation,* Washington DC, National Science Foundation, 2024, https://ncses.nsf.gov/pubs/nsb20241/.

5 Brian Buntz, *Quality vs. Quantity: US and China Chart Different Paths in Global AI Patent Race in 2024,* Cleveland OH, R&D World, 2024, https://www.rdworldonline.com/quality-vs-quantity-us-and-china-chart-different-paths-in-global-ai-patent-race-in-2024/.

6 U.S. Bureau of Labor Statistics, *Employment Cost Index*, Washington DC, United States Department of Labor, 2025, https://www.bls.gov/eci/.

7 Mark Mather and Paola Scommegna, *Fact Sheet: Aging in the United States*, Washington DC, Population Reference Bureau, 2024, https://www.prb.org/resources/fact-sheet-aging-in-the-united-states/#:~:text=Focus%20Area,a%20diversity%20gap%20between%20generations.

8 Colin Grabow, *The Reality of American "Deindustrialization*," Washington DC, Cato Institute, 2024, https://www.cato.org/publications/reality-american-deindustrialization.

9 The White House, *Made In The USA: President Trump's Vision is Revitalizing American Industry,* Washington DC, The White House, 2025, https://www.whitehouse.gov/articles/2025/05/made-in-the-usa-president-trumps-vision-is-revitalizing-american-industry/.

10 Tim Gaus and Michael Schlotterbeck, *2025 Smart Manufacturing and Operations Survey: Navigating Challenges to Implementation,* United States, Deloitte, 2025, https://www.deloitte.com/us/en/insights/industry/manufacturing-industrial-products/2025-smart-manufacturing-survey.html.

11 SHRM, *Jobs at Risk: U.S. Employment in the New Age of Automation (Part 1), Alexandria VA, Society for Human Resource Management*, https://www.shrm.org/content/dam/en/shrm/topics-tools/research/jobs-at-risk-brief.pdf.

12 David Autor, David A. Mindell, and Elisabeth B. Reynolds, *The Work of the Future: Building Better Jobs in an Age of Intelligent Machines* (Cambridge MA: MIT Press, 2022).

13 Shira Markoff, *Melissa Grober-Morrow, Factsheet: U.S. Economic Mobility and Policies to Increase Upward Mobility*, Washington DC, Washington Center for Equitable Growth, 2025, https://equitablegrowth.org/factsheet-u-s-economic-mobility-and-policies-to-increase-upward-mobility/.

14 Laura Silver, *Christine Huang, Laura Clancy, Key Facts as India Surpasses China as the World's Most Populous Country*, Washington DC, Pew Research Center, 2023,

https://www.pewresearch.org/short-reads/2023/02/09/key-facts-as-india-surpasses-china-as-the-worlds-most-populous-country/.

15 NITI Aayog, *National Strategy for Artificial Intelligence #AIFORALL*, New Delhi, NITI Aayog, 2018, https://www.niti.gov.in/sites/default/files/2023-03/National-Strategy-for-Artificial-Intelligence.pdf.

16 Daniela Nuscheler et al., *From Bytes to Bushels: How Gen AI Can Shape the Future of Agriculture,* Berlin, McKinsey & Company, 2024, https://www.mckinsey.com/industries/agriculture/our-insights/from-bytes-to-bushels-how-gen-ai-can-shape-the-future-of-agriculture.

17 NASSCOM, *Future of Work 2024: Balancing Priorities in an AI-driven World, Bengaluru*, NASSCOM, 2024, https://nasscom.in/knowledge-center/publications/future-work-2024-balancing-priorities-ai-driven-world.

18 Ricky Li, Ian Shine, *The Future of Jobs in India: Employers Seek to Boost Tech Talent to Drive AI and Digital Growth*, Geneva, World Economic Forum, 2025, https://www.weforum.org/stories/2025/04/the-future-of-jobs-in-india-employers-seek-to-boost-tech-talent-to-drive-ai-and-digital-technology-growth/.

19 G. K. Arora and Prof P. B. Sharma, *India's Informal Economy and the Changing World of Work: Time for Policy Restructuring*, New Delhi, Indian Century Media Group, 2025, https://www.indiancentury.in/2025/06/05/indias-informal-economy-and-the-changing-world-of-work-time-for-policy-restructuring/.

20 ITU, *Facts and Figures 2024,* Geneva, International Telecommunications Union, 2024, https://www.itu.int/itu-d/reports/statistics/facts-figures-2024.

21 Ministry of Education, Government of India, 2023, https://www.pib.gov.in/PressReleaseIframePage.aspx?PRID=1926472.

22 Ministry of Education, Government of India, 2023, https://www.pib.gov.in/PressReleaseIframePage.aspx?PRID=1926472.

23 NASSCOM, *NASSCOM IT-ITeS SSC*, https://www.sscnasscom.com/.

24 Hugh Cameron, *Countries Testing a Universal Basic Income in 2025*, New York, Newsweek, 2025, https://www.newsweek.com/countries-testing-universal-basic-income-2025-2103428#:~:text=As%20global%20wealth%20inequality%20deepens,alternatives%20to%20traditional%20welfare%20models.

25 India Employer Forum, *Stackable Credentials and the Modern Vocational Education in India*, https://indiaemployerforum.org/skill-development/stackable-credentials-in-india/.

26 Laura Padin, *Why Workers Need Real Portable Benefits,* New York, National Employment Law Project, 2025, https://www.nelp.org/insights-research/why-workers-need-real-portable-benefits/.

27 Protean, *Digital Public Infrastructure: Empowering India's Skilling and Employment System,* https://proteantech.in/articles/digital-public-infrastructure-india-skills-employment/.

28 Ministry of Commerce and Industry, Government of India, DPIIT #startupindia, https://www.startupindia.gov.in/.

Balancing Sustainability and Innovation in AI: The U.S.–India Opportunity

Urmi Tat

Abstract

Artificial Intelligence (AI) is rapidly becoming a cornerstone of innovation, economic competitiveness, and public service delivery in both the United States (US) and India. The growth of AI infrastructure, however, poses serious environmental risks. From soaring energy consumption by data centres to the carbon-intensive lifecycle of AI hardware, the AI revolution threatens to undercut global climate commitments unless explicitly aligned with sustainability goals. This article highlights how environmental considerations must be embedded across the AI value chain—from energy sourcing and hardware design to software optimisation and model

deployment. It outlines a pathway for US–India collaboration on 'green AI', recommending six areas for cooperation: setting energy and emissions benchmarks; fostering bilateral task forces and training programmes; incentivising renewable-powered AI infrastructure; funding green hardware research and development; applying AI for climate resilience; and aligning efforts with global governance forums. By tailoring a sustainability strategy to their unique strengths and development priorities, the US and India can lay the groundwork for balancing sustainability and innovation in AI in a manner that is both globally impactful and locally relevant.

Introduction

Artificial Intelligence (AI) systems—from large language models (LLMs) to data-driven analytics—are playing increasingly important roles in advancing innovation and service delivery in both the United States (US) and India. This is evident in the political posturing and policy outlook in both countries: the US is keen on solidifying its position as a global leader in AI to improve its economic competitiveness and national security goals,[1] while India seeks to become an AI powerhouse with an ecosystem that promotes innovation while democratising computing access.[2]

To be sure, the US and India differ in scale and capacity to achieve their AI goals. For FY 2025, the US federal AI R&D funding request is about US$3.3 billion,[3] while India's budget is smaller though growing rapidly. The 2025 Union Budget for India earmarked ₹500 crore (US$60–70 million) for an AI Centre of Excellence in education, ₹2,000 crore (US$250 million) for broader AI missions, and a US$1.25-billion, five-year plan to expand AI infrastructure and data ecosystems.[4] These investments aim to build foundational capabilities and talent. The US leads in model development, private investment (over US$100 billion in 2024), and foundational AI research.[5] India is developing homegrown models aligned with national needs through the India AI Mission, supported by compute infrastructure and datasets like AIKosh. While India trails the US in scale, its AI market is growing by 25–35 percent annually and is projected to reach US$17 billion by 2027.[6]

The rapid growth of AI, however, comes with significant environmental costs. Training and running AI models can be a highly energy-intensive and environmentally detrimental effort. Recent analyses highlight that global data centres consumed about 300 TWh of electricity in 2022, amounting to roughly 1–1.5 percent of the electricity generated worldwide that year.[7] This share is set to grow to 3 percent by 2030.[8] Further, large AI models, depending on the source of energy, efficiency of hardware, and complexity of algorithms, can have enormous carbon footprints: OpenAI's GPT-3, for example, is estimated to emit over 500 tons of CO_2 during training[9]—equivalent to the emissions from electricity usage by more than 100 homes in the US.[10]

To mitigate these concerning trends while allowing for the continued growth and advancement of AI, it is essential to integrate environmental considerations into the design and development of AI models, systems, applications, and governance—and not add them in as an afterthought. Government policies and frameworks should not just incentivise and support industry initiatives to accelerate development and drive innovation, but also reduce the increasing emissions associated with AI. As two allied technology superpowers aiming to achieve AI supremacy, it is apt that the US and India work together to create a framework and benchmarks for the rest of the world on how to achieve this outcome. This article explores the impact that AI has had on the environment and the risks of its unchecked growth on the planet, and how the US and India can collaborate to build sustainable AI infrastructure, use AI to advance climate goals, identify joint platforms for engagement, and prioritise sustainability as a shared strategic objective.

The Environmental Footprint of AI Infrastructure

Modern AI models often require vast computational resources, with both the training and inference stages of LLMs involving thousands of GPU hours. AI model training[11] is the process of creating a custom, intelligent tool that analyses and interprets vast amounts of data to perform certain tasks, like generating new content, making predictions, or classifying information. This is an energy-intensive undertaking. Models, moreover, require periodic retraining to stay accurate,[12] which adds to ongoing energy demands comparable to that of the initial training. The other key stage of an AI model is inference—the process of using the trained model to generate responses. Though this process uses much less energy per query than training, the total energy consumed for inference can surpass that for training,[13] especially at large scales, as inference happens repeatedly over the model's lifetime. Inference generates recurring costs that grow with user numbers and usage frequency. Thus, cumulative costs can be significant over time, particularly for widely used models and services such as ChatGPT.

Researchers also find that model complexity drives energy use: GPT-3 (175 billion parameters)[14] required much more compute (and, therefore, emitted much more CO_2) than earlier models like GPT-1 or GPT-2. By contrast, smaller models, which have lesser parameters and focus on specific tasks or domains, have far smaller footprints.

The demand for AI is also fuelling a construction boom in data centres. In the US, for instance, annual investment in data centre construction has doubled over 2022-24 and data centre capital expenditures of three companies which are leaders in AI adoption now exceed 0.5 percent of the US's GDP (a scale that is comparable to the entire oil and gas industry).[15] A typical hyperscale data centre can draw over 100 megawatts of electricity,[16] equivalent to 350–400,000 electric cars. The International Energy Agency has projected a sharp rise in data centre electricity demand by 2030,[17] driven in part by AI.

Further, the concentration of AI workloads in large facilities means localised impacts can be high. In the US, data centres consumed about 4.4 percent of total electricity in 2023 and are expected to consume approximately 6.7 to 12 percent of total US electricity by 2028,[18] straining grids and requiring upgrades. In India, according to estimates by Nomura, data centres currently account for 0.5 percent of the country's total electricity consumption[19]—a figure projected to rise to 3 percent by 2030. Global demand for data centre capacity is projected to grow by 19–22 percent annually between 2023 and 2030, reaching 171–219 gigawatts, up from 60 GW in 2025. Meeting this surge would require building more than double the capacity added since 2000, but in under one-fourth of the time.[20]

Beyond accelerated electricity consumption, the nature of the energy mix incorporated in AI infrastructure can have other environmental impacts. Data centres in regions powered by coal-heavy grids produce far more CO_2 per kWh than those on clean grids. For example, Hugging Face trained its LLM BLOOM on a French supercomputer that largely used nuclear energy, thus reducing emissions,[21] whereas models trained in coal-dependent locations can emit many times more carbon. India's grid is still largely coal-based,[22] so the AI workloads tend to have a higher carbon footprint per unit of work than in the US, which has more natural gas, nuclear energy, and renewables infrastructure. Though India is rapidly expanding its renewables capacity—targeting 500 GW by 2030[23]—coal remains its largest energy generation source.

Along with their energy demands, data centres also require substantial volumes of water for cooling purposes, with high-performance AI clusters typically needing more intensive cooling to manage heat. In 2022, a single mid-sized US data centre could use 300,000 gallons of water per day[24]—the amount consumed by roughly 100,000 homes in the US. The considerable burden this places on local water resources has resulted in tech firms beginning to evaluate local water risks: Google, for instance, developed a framework to assess watershed health before building a new campus,[25] and opted for air-cooling (which uses more electricity but no water) where local water was scarce. In India, where water is often more constrained in fast-growing cities, its rise as a global data centre hub will increase its demand for energy and water, placing additional pressure on an already strained supply system. This growing energy requirement—largely met through fossil fuels[26]—will also pose challenges to the country's broader decarbonisation goals.

Indeed, it is the entire lifecycle of an AI model that adds to AI's carbon footprint.[27] Building AI infrastructure consumes minerals (silicon, rare-earths, metals) and chemicals.[28]

Once hardware reaches end-of-life, it contributes to e-waste. Current estimates find that AI's share of the internet and communication technology sector's emissions is at a few percent of global greenhouse gases (GHGs), but individual models' footprints hinge on hardware lifespans. Efficient use, reuse, and recycling of chips and servers are, therefore, critical but often overlooked aspects of sustainable AI.

Today, as technology is evolving, rapid hardware and software efficiency gains are being made. State-of-the-art AI chips have roughly doubled in energy efficiency every 2.5–3 years, so that a modern chip can perform the same operations using 99 percent less power than a 2008-era chip.[29] New cooling and server designs also reduce energy use. For example, as far back as 2016, Google's DeepMind AI reduced one data centre's cooling energy use by up to 40 percent, resulting in a 15-percent reduction in power usage overall.[30] Even so, in the absence of intentional design and policy interventions, performance and cost considerations often outweigh sustainability—highlighting the need to embed energy efficiency as a core design principle.

US–India Cooperation: Tackling the AI Value Chain

A comprehensive, ecosystem-wide approach is essential for the US and India to effectively address carbon emissions across the AI value chain. This requires building understanding of and improving efficiency across every stage of the chain's interconnected components, starting with the energy sources that power grid infrastructure and drive electricity generation. Prioritising renewable energy integration and improving grid efficiency—specifically for AI workloads—can reduce emissions at this foundational stage. This can be done through certain ways, such as: intelligent workload scheduling, where non-critical training jobs can be scheduled during off-peak hours when electricity is cheaper and more abundant, or intense computations can be coordinated with periods of high renewable energy generation (for instance, in the middle of a sunny day); geographic load balancing, where an AI company can dynamically shift non-latency-sensitive workloads between data centres in different geographic regions or through grid modernisation; upgrading to a smart grid with advanced sensors, automation, and real-time analytics, as a smarter grid can more effectively manage power flow, reroute electricity around congested areas, and seamlessly integrate the variable output from renewable sources. Moreover, both countries must recognise the value of green data centre design—for example, locating centres near renewable energy sources and adopting advanced cooling solutions could help reduce environmental impact.

The next layer involves hardware that are essential to AI operations—data centres, processors, storage devices, network infrastructure, and cooling systems. Implementing lifecycle management practices and investing in low-power hardware can help minimise the environmental impact of AI. On the software side, optimising algorithms and source codes for energy efficiency is critical. Finally, for operational processes such as model training and deployment, techniques like batch processing and edge computing can further reduce AI's carbon footprint. It is of course important to recognise that regulating the AI lifecycle is not a uniform process, and some parts are much easier to govern than others.

Physical infrastructure like data centres, the power grid, and semiconductor fabrication plants (FABS) are relatively straightforward to regulate in terms of their power consumption. This is because they are centralised, highly visible, and often fall under existing oversight, making it possible to apply specific rules for energy efficiency or location. Conversely, more decentralised components like edge devices, cloud-based workloads, and abstract software layers present a greater challenge. Their distributed, global nature, and lack of transparency make effective regulation much more difficult to implement.

Building on this shared understanding of the AI value chain, the US and India are well-positioned to translate insights into actionable policy and collaborative frameworks. Addressing each layer—from energy sourcing to deployment—requires coordinated efforts that not only leverage technological capabilities but also align with regulatory and economic priorities in both countries. With a clear roadmap for intervention, the next step is to formulate targeted recommendations that can guide bilateral cooperation towards building industry-relevant standards and governance mechanisms while ensuring the innovation engine continues to run.

Recommendations: Towards a Sustainable US-India AI Partnership

For AI to support rather than hinder climate action, a joint US-India governance strategy or framework is essential. The most effective approach is for both governments to create a policy environment where sustainability is rewarded. By designing powerful incentives and clear standards, this partnership can drive an industry-wide shift, turning environmental responsibility into a competitive advantage. The following governance recommendations outline how to achieve this aim:

1. Setting Joint Standards and Promoting Transparency

- **Bilateral energy efficiency and emission metrics:** The two countries must establish shared benchmarks for AI energy efficiency and carbon emissions, similar to Article 40 of the EU AI Act,[31] which mandates harmonised standards on AI systems' performance and energy consumption. The benchmarks could be composed of parameters like software carbon intensity (SCI), data centre power usage effectiveness (PUE), and lifecycle emissions metrics. This transparency will allow regulators and firms to benchmark and improve AI efficiency.

- **Disclosure mandates:** Data centres and AI providers must be required to report AI-related energy usage and GHG emissions. Enhanced transparency will help firms improve performance and allow regulators to assess and guide the sector effectively. Governments could offer grants, tax benefits, and performance-based incentives for firms embracing transparent practices.
- **Subsidies:** Governments can help subsidise the adoption of greener cooling technologies in data centres or the purchase of more efficient servers for compliant companies.
- **Preferential government contracts:** The government, as a major purchaser of technology, can make transparent energy and emissions reporting a key criterion—or even a prerequisite—for winning public sector AI projects. This creates a direct and lucrative market reason for companies to comply.
- **Green certification and audits:** Certification programmes for sustainable AI services should be introduced. Certifications can be tied to energy performance and emissions thresholds, encouraging best practices and consumer trust.
- **International standards:** Both countries should actively shape global norms for 'sustainable AI'. This can be achieved by participating in efforts like the International Telecommunication Union's AI ethics/standards working groups or UN's climate–technology forums to integrate energy and environmental criteria into AI governance. The US and India could jointly propose new standards for AI eco-design or emissions accounting. This will ensure a level playing field and that global AI development decouples from excessive energy and resource use.

Global efforts towards standardisation frameworks can offer a model for such efforts:

- Singapore's National AI Strategy 2.0 outlines the imperative of pairing AI goals with sustainability commitments.[32] In addition, the country has launched a US$30-million fund towards research efforts that optimise software design and function for energy efficiency.[33] The fund will also be used to create green-software trials to let key industry players test the impact of carbon-reduction techniques.
- The EU has invested in the reduction of the energy consumption of powerful AI systems through the Horizon Europe programme that fosters the development of cutting-edge technology.[34] In addition, the EU has launched a digital partnership with Singapore, a component of which is focused on fostering investment in resilient and sustainable digital infrastructure.[35]
- France's national standardisation body has put forward a proposal to begin developing guidelines and metrics that will anticipate technical standards for assessing the environmental impact of AI, in alignment with the EU AI Act.[36]

- **Leveraging TRUST:** This is the premier platform between the US and India for high-tech collaboration, and the green agenda can be incorporated by:
  - **Establishing a "Sustainable AI & Green Computing" Workstream:** Create a dedicated track under the iCET focused on joint R&D for energy-efficient AI hardware and lightweight software models.
  - **Harmonising Standards:** Task this workstream with developing joint methodologies for measuring the energy consumption and carbon footprint of AI models. This creates a common language for transparency.

2. Building Capacity and Knowledge Sharing

- **A bilateral AI Sustainability Taskforce:** The UK has set up an AI Energy Council with the Secretary of State for Science, Innovation, and Technology and the Secretary of State for Energy Security and Net Zero as the conveners, along with representatives from industry.[37] A similar bilateral mechanism between the US and India could help consolidate efforts to keep sustainability at the heart of AI-related progress. This group can track AI's environmental impact, share best practices, and coordinate standards development between the two governments.
- **Training and Consortia:** The US and India must fund programmes to train regulators, developers, and operators in sustainable AI. They must support academic–industry partnerships to research trends, test tools, and inform policy.
- **Pilot Programmes:** The joint deployment of green data centres or sustainable AI models in both countries will help test innovations in real-world settings.
- **US-India SME Alliance for Sustainable AI:** To ensure that small and medium enterprises (SMEs) are not left behind, the US and India should establish a partnership focused on them. This alliance would provide SMEs in both countries with financial incentives, such as joint grants, to adopt energy-efficient AI technologies. It would also create a formal knowledge-sharing platform to exchange best practices in developing lightweight models and green computing, turning the high cost of sustainability into an opportunity for shared innovation.
- **Leveraging GPAI for Thought Leadership:** The US and India can jointly propose and co-chair a new GPAI working group focused exclusively on developing internationally recognised frameworks for AI energy measurement, disclosure mandates, and frameworks for capacity-building programmes, which can then be adopted by member nations.

3. Developing Green Infrastructure and Renewable-Powered AI

- **Renewable energy for AI:** India and the US must incorporate policies to co-locate new data centres near renewable energy sources—India's coastal regions (with abundant wind/solar access), for instance, are ideal for new AI campuses—and should provide joint incentives for centres using solar, wind, or hydro power. Both governments should also support the advancement of geothermal and nuclear energy to provide a stable, low-carbon complement to intermittent renewable sources like solar and wind.
- **Energy storage and smart scheduling:** R&D in energy-aware scheduling, grid optimisation, and on-site solar energy generation with storage to reduce AI workloads' carbon intensity must be encouraged.
- **Open-source tools:** The two countries should promote the reuse of pre-trained models and efficient, open-source codebases to avoid redundant training and reduce software-level emissions. Open collaboration enables broader access to optimised tools and accelerates the adoption of energy-efficient AI practices.
- **Leverage the QUAD network:** The Quad's focus on technology and resilient supply chains makes it an ideal platform to position Green AI as a strategic imperative:
    - **A Quad "Green AI Standard":** Propose the development of a shared standard for sustainable AI hardware and software. This would create a trusted, high-quality benchmark for the Indo-Pacific and beyond, promoting a market for environmentally responsible AI.
    - **Secure & Sustainable Semiconductor Supply Chains:** Within the Quad's work on semiconductors, introduce sustainability and energy efficiency as key performance criteria for the chips that power AI.
    - **Quad AI for Climate Resilience Challenge:** Launch a prize or challenge to encourage innovators from all four countries to develop AI applications that address shared climate challenges, such as early warnings for cyclones or optimising water usage.

4. Hardware Innovation and Circularity

- **Joint R&D for Green AI Hardware:** Bilateral projects to develop low-power chips, advanced cooling systems, and waste heat recycling are crucial. The US semiconductor industry could collaborate with India's emerging chip ecosystem, including initiatives under the India Semiconductor Mission and domestic fab investments, to co-develop energy-efficient AI hardware. Academic initiatives (such as the US-India Science and Technology Endowment Fund grants) could support prototypes of servers that recycle waste heat or use novel materials to reduce power draw.

- **Eco-design and e-waste Policies:** The two governments should share circular economy practices, set reuse targets, and phase out high-energy hardware.
- **Global Best Practices:** The EU's eco-design regulations and Singapore's green data standards can serve as models for the US and India to adopt stricter hardware eco-design rules to phase out the more power-hungry components of AI over time.
- **Leveraging the G20 platform:** With the US set to host the G20 in 2026, there is an opportunity to leverage the platform for conversations on sustainability. This could be the platform for securing high-level political and economic commitment.
    - **Embedding Sustainable AI in Declarations:** Work to include language on the importance of sustainable and climate-conscious AI in G20 Digital Economy Ministerial and Leaders' Declarations.
    - **Promoting Green AI Incentives:** Use the G20's economic focus to share best practices on government incentives (e.g., tax credits and subsidies) that encourage industries to adopt Green AI, framing it as a driver of future economic competitiveness.

5. Leveraging AI for Climate Mitigation and Adaptation: The US and India share a strategic interest in harnessing AI to drive innovation, and climate action offers a high-impact, mutually beneficial use case. AI can accelerate both mitigation—reducing emissions—and adaptation—building resilience to climate impacts—by enabling better prediction, planning, and resource optimisation.

- **Energy systems:** Apply AI to improve renewable energy forecasting, balance grid supply and demand in real time, and optimise battery storage and dispatch to reduce reliance on fossil fuels.
- **Agriculture and water:** AI can be used for precision farming, irrigation planning, and drought forecasting, to reduce emissions and conserve water.
- **Disaster-risk management:** US–India collaboration should be extended to expanding AI-based early warning systems for floods, cyclones, and heatwaves.
- **Joint R&D for climate applications:** Bilateral grants (via the US's National Science Foundation/Department of Energy and India's Department of Science and Technology/ Ministry of Earth Sciences) for AI climate solutions—such as sustainable farming, grid resilience, and disaster preparedness—should be incorporated.

Conclusion

The US and India have a unique opportunity to lead the world in shaping a sustainable and inclusive AI future. As AI becomes increasingly central to economic development and governance, its environmental costs must be addressed head-on. The two countries have complementary strengths: the US offers deep expertise in regulating emerging technologies—through sector-specific standards, environmental safeguards, and voluntary frameworks like the National Institute of Standards and Technology AI Risk Management Framework—alongside its leadership in AI innovation and research. India brings scale, data diversity, frugal innovation capabilities, and a critical Global South perspective. Together, they can co-develop infrastructure, standards, and governance models that reflect ambition, equity, and accountability. Simply borrowing from the EU's regulatory approach would not be conducive to their distinct needs; instead, the US and India must develop a framework tailored to their contexts, priorities, and capacities.

A bilateral memorandum of understanding on green AI would mark a decisive step, aligning digital expansion with climate goals through joint targets, transparency mechanisms, and shared frameworks for environmental assessment. In a world racing to harness AI, a US–India partnership rooted in sustainability could serve not only as a model for others, but also as a foundation for enduring technological leadership.

Endnotes

1 The White House, *Removing Barriers to American Leadership in Artificial Intelligence*, January 2025, https://www.whitehouse.gov/presidential-actions/2025/01/removing-barriers-to-american-leadership-in-artificial-intelligence/.

2 Ministry of Electronics and IT, Government of India, https://www.pib.gov.in/PressReleasePage.aspx?PRID=2108810.

3 NITRD, "AI R&D Investments FY 2019- FY 2025," https://www.nitrd.gov/ai-rd-investments/#:~:text=The%20NITRD%20agencies'%20requested%20investment,FY%202025%20is%20$3316.1%20million.

4 The India AI Mission, *Union Budget 2025-26: Centre allocates ₹500 Crore for AI Centre of Excellence in Education*, https://indiaai.gov.in/news/union-budget-2025-26-centre-allocates-500-crore-for-ai-centre-of-excellence-in-education.

5 Stanford HAI, "*2025 AI Index Report: Key Findings*," *https://hai.stanford.edu/ai-index/2025-ai-index-report.*

6 IndiaAI, *Nasscom-BCG Report Says India's AI Market is Expected to Touch 17 Billion USD by 2027*, February 2024, https://indiaai.gov.in/news/nasscom-bcg-report-says-india-s-ai-market-is-expected-to-touch-17-billion-usd-by-2027.

7 International Energy Agency, *What the Data Centre and AI Boom Could Mean for the Energy Sector*, January 11, 2024, https://www.iea.org/commentaries/what-the-data-centre-and-ai-boom-could-mean-for-the-energy-sector.

8 Institute for Energy Economics and Financial Analysis, "Blue Seas and Green Electrons: Powering India's AI Data Centres," May 13, 2024, https://ieefa.org/resources/blue-seas-and-green-electrons-powering-indias-ai-data-centres.

9 Communications of the ACM, *The Carbon Footprint of Artificial Intelligence*, https://cacm.acm.org/news/the-carbon-footprint-of-artificial-intelligence/#:~:text=rely%20on%20fossil%20fuels%20are,efficient%20hardware.

10 U.S. Environmental Protection Agency, *Greenhouse Gas Equivalencies Calculator*, https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator#results.

11 David Brault, "AI Model Training: What it is and How it Works," Mendix, March 18, 2025.

12 "AI Energy Consumption: How Much Power AI Models Like GPT-4 Are Using – New Stats," PatentPC, https://patentpc.com/blog/ai-energy-consumption-how-much-power-ai-models-like-gpt-4-are-using-new-stats.

13 "The Hidden Cost of AI: Unpacking Its Energy and Water Footprint," IEEE ITCC, https://itcc.ieee.org/blog/the-hidden-cost-of-ai-unpacking-its-energy-and-water-footprint/.

14 "The Carbon Footprint of Artificial Intelligence," Communications of the ACM, https://cacm.acm.org/news/the-carbon-footprint-of-artificial-intelligence/.

15 "What the Data Centre and AI Boom Could Mean for the Energy Sector."

16 "What the Data Centre and AI Boom Could Mean for the Energy Sector."

17 "What the Data Centre and AI Boom Could Mean for the Energy Sector."

18 Department of Energy, "DOE Releases New Report Evaluating Increase in Electricity Demand from Data Centers," December 2024, https://www.energy.gov/articles/doe-releases-new-report-evaluating-increase-electricity-demand-data-centers.

19 EY, *India Energy Sector at Crossroads,* 2024, https://www.ey.com/content/dam/ey-unified-site/ey-com/en-in/insights/energy-resources/documents/2024/ey-india-energy-sector-at-cross-roads.pdf.

20 McKinsey & Company, AI power: Expanding Data Center Capacity to Meet Growing Demand, 2025, https://www.mckinsey.com/industries/technology-media-and-telecommunications/our-insights/ai-power-expanding-data-center-capacity-to-meet-growing-demand.

21 *"India,"* International Energy Agency, https://www.iea.org/countries/india.

22 "Powering India's Data Center Boom," Entrepreneur India, https://www.entrepreneur.com/en-in/news-and-trends/powering-indias-data-center-boom/488459.

23 Down To Earth, "*The 500 GW Switchover*," January 2025, https://www.downtoearth.org.in/energy/the-500-gw-switch-over.

24 J. Roux, "*AI Data Centers Are Draining Our Planet Dry — And No One Is Talking About It*," The Medium, https://medium.com/swlh/ai-data-centers-are-draining-our-planet-dry-and-no-one-is-talking-about-it-cc56d8e503b0.

25 "Assessing Watershed Health in Data Center Host Communities," Google Cloud Blog, https://cloud.google.com/blog/topics/sustainability/assessing-watershed-health-in-data-center-host-communities.

26 "The Carbon Footprint of Artificial Intelligence," Communications of the ACM, https://cacm.acm.org/news/the-carbon-footprint-of-artificial-intelligence/.

27 "What the Data Centre and AI Boom Could Mean for the Energy Sector."

28 "The Carbon Footprint of Artificial Intelligence."

29 David Kiron and Elizabeth J. Altman, "Will AI Help or Hurt Sustainability? Yes," MIT Sloan Management Review, https://sloanreview.mit.edu/article/will-ai-help-or-hurt-sustainability-yes/.

30 Kiron and Altman, "Will AI Help or Hurt Sustainability? Yes."

31 "Article 40: Harmonised Standards and Standardisation Deliverables | EU Artificial Intelligence Act," https://artificialintelligenceact.eu/article/40/.

32 PeiChin Tay et al., "From Strategy to Synergy: What Can We Learn from Singapore's AI Journey?," December 20, 2023, https://institute.global/insights/tech-and-digitalisation/from-strategy-to-synergy-what-can-we-learn-from-singapores-ai-journey.

33 Infocomm Media Development Authority, "New Initiatives to Drive Digital Sustainability," January 24, 2024, https://www.imda.gov.sg/resources/press-releases-factsheets-and-speeches/press-releases/2024/new-initiatives-to-drive-digital-sustainability.

34 European Union, "EU To Invest Close to Half a Billion Euro in Cutting-edge Technologies and Research - Projects Part One," https://digital-strategy.ec.europa.eu/en/activities/invest-close-half-billion-euro-part-one.

35 European Commission, "Antitrust: Commission Sends Statement of Objections to Google over Abusive Practices in Online Advertising Technology," July 14, 2023, https://ec.europa.eu/commission/presscorner/detail/en/ip_23_467.

36 "France Moves to Shape EU's AI Sustainability Standards | MLex | Specialist News and Analysis on Legal Risk and Regulation," https://www.mlex.com/mlex/artificial-intelligence/articles/2329716/france-moves-to-shape-eu-s-ai-sustainability-standards.

37 Department for Science, Innovation and Technology, "Technology and Energy Secretaries Chair First Meeting of AI Energy Council," GOV.UK, April 8, 2025, https://www.gov.uk/government/news/technology-and-energy-secretaries-chair-first-meeting-of-ai-energy-council.

III

PARTNERSHIP FRAMEWORKS and SECTORAL COLLABORATIONS

Bilateral by Design—BRIDGE: A U.S.-India Framework for AI and Global Health Equity

Resham Sethi

Abstract

Artificial Intelligence (AI) is reshaping how societies organise knowledge, deliver essential services, and collaborate across borders. For health systems, the stakes are high: AI can accelerate diagnoses, strengthen surveillance, optimise supply chains, and expand access to care in low-resource settings. India and the United States (US), two large democracies with complementary strengths in biomedical research, digital infrastructure, and global health leadership, are well positioned to lead this transformation. Yet, while bilateral platforms have emphasised semiconductors, defence, space, and telecommunications, health has

not been consistently prioritised—despite its growing importance as both a security concern and a driver of equity. To address this gap, this article proposes BRIDGE: A Bilateral Roadmap for Integrating Diplomacy and Global Equity. BRIDGE organises cooperation across six pillars: institutional anchoring, research and innovation hubs, interoperable regulation and ethics, South–South deployment, global leadership through talent exchange, and equity as a cross-cutting principle.

Introduction: From Parallel Strengths to Shared Outcomes

Over the last decade, both India and the United States (US) have developed a formidable body of assets in Artificial Intelligence (AI) and digital health. However, these trajectories have largely evolved on separate tracks. The US has adopted an innovation-forward stance on AI, with federal agencies developing enterprise strategies, accountability frameworks, and documentation practices that encourage safe adoption in high-stakes domains, such as healthcare. Agencies like the Department of Health and Human Services (HHS), the National Institutes of Health (NIH), and the Centers for Disease Control and Prevention (CDC) have invested in building risk-based governance, research funding mechanisms, and technical capacity to ensure that AI deployment aligns with public trust and ethical use. This represents a mature ecosystem where biomedical research excellence is combined with a growing apparatus for responsible technology integration.

India, in parallel, has operationalised digital public infrastructure for health through the Ayushman Bharat Digital Mission (ABDM). This mission provides consent-based data exchange, national health registries, digital health IDs, and sandbox environments for testing new technologies. By embedding interoperability and equity into the core architecture, ABDM creates the rails on which AI solutions can be evaluated and deployed at scale.[1,2] The country's broader IndiaAI Mission, launched in 2024 under the Ministry of Electronics and Information Technology (MeitY), extends this vision across compute infrastructure, datasets, public–private partnerships (PPP), skills development, and ethical oversight, consolidating a national strategy that blends digital sovereignty with innovation. These frameworks have transformed India into a global hub for digital public goods and scalable technology adoption.[3,4,5]

Despite these parallel strengths, bilateral cooperation between the US and India has not systematically translated them into shared outcomes in health. Existing AI mechanisms have accelerated collaboration in domains such as semiconductors, defence innovation, telecommunications, and space exploration. The US–India AI (USIAI) Initiative, established in 2021 under the Indo–US Science and Technology Forum, has facilitated joint research, workforce development, and policy dialogue.[6] Yet healthcare, though acknowledged as a thematic area, has remained peripheral, with activities largely academic in nature and disconnected from broader foreign policy or health diplomacy agendas. The Initiative on Critical and Emerging Technologies (iCET), launched in 2022, elevated six strategic areas, including AI and quantum, defence innovation, space, telecommunications, and semiconductors. Healthcare was yet to be prioritised.[7,8] By 2025, the Catalysing Opportunities for Military Partnership, Accelerated Commerce & Technology (COMPACT) and the TRUST framework (Transforming the Relationship Utilising Strategic Technology) further entrenched AI collaboration in sectors such as energy, commerce, and biotechnology. However, healthcare was once more sidelined, despite explicit commitments to societal applications of AI.[9]

At the same time, the health relationship between the two countries is deep and proven. The Fifth US–India Health Dialogue in 2023 reaffirmed joint priorities, such as pandemic preparedness, universal health coverage, and non-communicable diseases.[10] Longstanding CDC and United States Agency for International Development (USAID) programmes in India, covering surveillance, epidemiology, HIV, TB, maternal and child health, and polio eradication, have demonstrated operational delivery capacity and trust built over the decades.[11,12,13,14] These health collaborations provide strong platforms that can support an AI-enabled bilateral health agenda; however, they have not been fully leveraged in strategic AI diplomacy to date.

BRIDGE: A Bilateral Roadmap for Integrating Diplomacy and Global Equity, the framework advanced in this article, seeks to translate these parallel strengths into shared outcomes by placing health at the centre of bilateral AI cooperation. It provides a structured implementation path that aligns US biomedical leadership with India's digital infrastructure and deployment capacity. In doing so, it recognises healthcare not as a peripheral adjunct but as a core domain of US–India AI diplomacy, with implications for both domestic resilience and global equity.

The Case for a Health-AI Lane Now

The rationale for a dedicated US–India health-AI lane rests on three interlocking arguments: the potential for immediate public value; the geopolitical dividends of coordinated governance; and the availability of existing institutional rails that can carry this agenda forward.

First, health is a domain where AI can deliver visible and immediate benefits. From earlier outbreak detection to faster diagnosis, smarter supply chain management to workforce optimisation, AI has demonstrated practical applications that align with urgent health system needs.[15,16,17,18,19] In low-connectivity settings, AI-enabled triage and decision support tools are already showing how scarce resources can be used more efficiently.[20,21,22] A bilateral mechanism like BRIDGE translates these case studies into testable, scalable projects, supported by research hubs and pilot deployments that are deliberately designed for use in India, the US, and the broader Global South.

Second, health cooperation yields strategic dividends that extend beyond the sector itself. When nations coordinate on health data governance, safety standards, and model validation, they are also building trust and stabilising regions.[23,24,25] These norms often travel to multilateral forums, shaping the global agenda. By embedding health into bilateral AI cooperation, the US and India would strengthen their credibility as stewards of safe and equitable technology, sending a powerful signal to allies and competitors alike. BRIDGE institutionalises this through bilateral anchoring and interoperable regulatory frameworks that tie together ethical principles and practical tools.

Third, the guardrails for such an agenda already exist. The ministerial-level US–India Health Dialogue provides political cover and an established forum for negotiation.[26] India's ABDM supplies a consent-based, auditable digital backbone, while US agencies bring mature risk frameworks, regulatory experience, and deep research funding streams. What is missing is a permanent lane that consolidates governance, resources, and accountability. BRIDGE provides this structure, while its global leadership and talent exchange pillar ensures that a skilled cadre is sustained to carry the agenda forward. The COVID-19 pandemic underscored that health crises are not only social challenges but also global security threats.[27,28,29,30] They can disrupt economies, expose infrastructure vulnerabilities, and strain political systems in ways that have far-reaching impact across borders. By creating a structured US–India lane for AI in health, both countries would be signalling that they recognise health as a strategic domain central to national resilience, economic stability, and international diplomacy.

Policy Foundations for BRIDGE

The BRIDGE framework does not emerge in a vacuum. It builds upon complementary US and Indian policy trajectories that have, in their own ways, laid the groundwork for the responsible development and application of AI in health.

In the US, AI policy has evolved through three phases: foundational safeguards, expanded multi-sector coordination, and innovation-driven governance. The National AI Research & Development Strategic Plan (2016, updated 2019 and 2023) established federal leadership in AI with priorities centred on long-term investments, ethical alignment, safety standards, and workforce development.[31]

Subsequent executive orders (EO), including EO 13859 (2019), declaring AI a national priority, and EO 14110 (2023), which emphasised safety, trust, and cross-agency alignment, deepened this trajectory.[32,33] By 2025, EO 14179 shifted focus toward innovation, competitiveness, and measurable public benefit, consolidating overlapping guidance and positioning AI as a driver of international competitiveness.[34] For health, the Department of Health and Human Services' (HHS) AI Strategy and the US Government Accountability Office's (U.S. GAO) AI Accountability Framework created specific governance, data, and monitoring tools to ensure that adoption is safe, accountable, and transparent.[35,36]

India's trajectory has been equally ambitious, though anchored in digital public goods. The National Digital Health Blueprint (NDHB) and ABDM established the interoperable infrastructure for consent-based data exchange, national registries, and federated digital identity.[37,38] The IndiaAI Mission (2024) consolidated compute, datasets, skills, ethics, and startup financing into a coherent national strategy.[39,40,41] Regulatory oversight has kept pace: AI/ML-enabled medical devices are classified and licensed under the Central Drugs Standard Control Organisation (CDSCO), Government of India, aligned with the definitions prescribed by the International Medical Device Regulators Forum (IMDRF), and supported by Bureau of Indian Standards (BIS)-adopted international standards such as International Organization for Standardization (ISO) 13485 and International Electrotechnical Commission (IEC) 62304.[42,43,44] Ethical guardrails are provided by the Indian Council of Medical Research's (ICMR) guidelines on AI in biomedical research, while the Digital Personal Data Protection Act (DPDP) (2023) establishes a privacy baseline across all health data flows.[45,46] Together, these instruments provide a coherent ecosystem for the safe development and deployment of AI in health.

Taken together, the US model emphasises multi-agency coordination and international standard-setting, while the Indian model foregrounds digital public infrastructure, scalable adoption, and equity by design. These complementary approaches are ripe for integration under a bilateral framework such as BRIDGE.

Gaps in Current Bilateral AI Platforms

Despite notable policy development on both sides, bilateral frameworks have consistently sidelined healthcare. The USIAI, launched in 2021 under the Indo–US Science and Technology Forum, focused on joint research, workforce development, and policy dialogue.[47] Health was acknowledged but treated peripherally, with most outputs remaining academic. The iCET, launched in 2022, situated AI within a broader economic and security agenda, prioritising domains such as quantum computing, defence innovation, space, advanced telecommunications, and semiconductors.[48] Health was absent yet again.

By 2025, the COMPACT framework and its technology arm, the TRUST initiative (formerly iCET), expanded cooperation to include semiconductors, biotechnology, energy, and national security technologies.[49] While these frameworks included commitments to societal applications of AI, health was again excluded as a named strategic sector. This persistent exclusion represents a strategic oversight. The US and India, as leading democracies with shared values of ethical responsibility and innovation, bring complementary strengths: American biomedical research and R&D (Research & Development) pipelines, and India's digital health infrastructure and real-world deployment capacity. Yet these synergies remain underleveraged.

The absence of healthcare from bilateral AI agendas undermines both nations' capacity to lead on global health equity and governance. The pandemic revealed the potential of AI to be indispensable to public health, from forecasting outbreaks to accelerating vaccine research. Despite this, no structured mechanism exists to translate domestic strategies like ABDM or HHS's AI roadmap into bilateral cooperation. As infectious diseases, non-communicable conditions, and health system shocks increasingly transcend borders, the need for health cooperation through AI becomes more urgent.

The US's and India's Track Records in Global Health

The case for a bilateral AI lane in health is strengthened by both countries' histories as global health leaders. The US has long been the world's largest contributor to global health, with agencies such as the USAID, NIH, CDC, and Department of Defense (DOD) driving landmark initiatives including the President's Emergency Plan for AIDS Relief (PEPFAR) and the President's Malaria Initiative. These programmes dramatically reduced disease burdens, expanded treatment access, and strengthened public health systems worldwide. The US has also been a critical supporter of multilateral institutions, contributing over US$1.2 billion to the World Health Organization (WHO) in the 2022–2023 biennium. In recent years, however, shifts in funding and priorities have scaled back some of these efforts, raising concerns about sustainability.[50,51,52,53]

India, meanwhile, has steadily positioned itself as a trusted humanitarian actor and health responder.[54] Guided by the ethos of *Vasudhaiva Kutumbakam* ("the world is one family"), India has deployed timely disaster and health assistance across regions. Operations such as Maitri (Nepal, 2015), Dost (Türkiye and Syria, 2023), and Brahma (Myanmar, 2025) have demonstrated logistical agility and medical capacity.[55,56,57,58,59,60] During the COVID-19 pandemic, India's Vaccine Maitri initiative delivered over 300 million doses to nearly 100 countries and two UN agencies, underscoring its role as a reliable partner in global health security.[61] India has also provided medical aid in conflict zones, from Afghanistan to Ukraine, reinforcing its reputation as a health first-responder for the Global South.[62,63]

These records reveal that both countries not only have the technical and logistical capacity for global health support but also the political will to act. The next step is to channel these capacities into AI-enabled health diplomacy, ensuring that future collaborations reflect the centrality of data, algorithms, and digital infrastructure in 21st-century health systems.

Building BRIDGE: A Roadmap for US–India AI Cooperation on Health Diplomacy

The BRIDGE framework provides a structured pathway for embedding health into US–India AI cooperation. It organises action across six pillars, each addressing a critical dimension of governance, innovation, deployment, sustainability, and equity.

B – Bilateral Institutional Anchoring. The first pillar recognises that political commitment and governance structures are essential. Health must be elevated as a priority in existing AI frameworks such as USIAI, TRUST, and COMPACT. A Joint Task Force on AI and Global Health, co-chaired by the US Department of Health and Human Services and India's Ministry of Health and Family Welfare, should be established with technical support from the US Office of Science and Technology Policy (OSTP) and MeitY. Embedding a dedicated health track within annual US–India technology dialogues and Quad meetings would ensure that the sector remains central to broader strategic cooperation. Institutional anchoring provides durability, preventing healthcare from being treated as a transient theme.

R – Research and Innovation Hubs. The second pillar emphasises joint knowledge creation and evidence generation. Establishing bi-national Centers of Excellence for AI in health, epidemiology, and biomedical innovation would allow researchers to co-develop context-specific solutions. Collaborative grants could target maternal health, antimicrobial resistance, non-communicable diseases, and disease surveillance. Most importantly, these hubs would operate within secure and ethical data collaboratives, enabling shared access to de-identified datasets for training and validation. By leveraging India's scale and the US's research capacity, these hubs would generate innovations deployable across diverse health system contexts, including LMICs.

I – Interoperable Regulation and Ethical Standards. The third pillar addresses the governance architecture required for safe and trustworthy AI deployment. Harmonising validation, approval, and safety standards using India's ICMR guidelines and the US GAO framework would create a common language for regulation. Bilateral regulatory sandboxes could allow cross-border trials of AI tools in real-world settings, with ethics approvals and algorithmic audits streamlined across jurisdictions. Such interoperability would reduce duplication, accelerate adoption, and build trust in AI products co-developed or validated under the partnership.

D – Deployment and South–South Scaling. The fourth pillar ensures that innovations do not remain confined to labs but reach populations that need them most. A US–India AI Grand Challenge for Global Health could identify high-impact use cases and fast-track them for deployment. Tested solutions could then be co-deployed in third countries through technical assistance programmes, in partnership with WHO, international non-profits, implementation partners, and multilateral development banks. This approach positions the US and India not only as bilateral collaborators but also as joint leaders in scaling ethical AI for health across the Global South.

G – Global Health Leadership and Talent Exchange. The fifth pillar invests in the human infrastructure required for sustainability. Institutionalising fellowships, short-term placements, and exchange programmes for AI-health professionals would create a cadre of experts fluent in both diplomacy and technology. Curricula for diplomats, regulators, and health leaders could build capacity for AI-enabled health diplomacy. By embedding talent exchange into bilateral cooperation, the US and India would strengthen their soft power ecosystems while ensuring that health AI governance is future-ready.

E – Equity as a Cross-Cutting Principle. The final pillar ensures that AI in health remains anchored in accessibility and inclusivity. Equity requires prioritising use cases that address the needs of underserved populations, embedding safeguards against bias in algorithms, and ensuring affordability and accessibility of validated solutions. Equity also demands gender-sensitive design, representation of LMIC contexts in data, and financing models that prevent widening the digital divide. By putting equity at the centre, the US–India partnership can ensure that health AI not only advances innovation but also drives global health justice.

Taken together, the BRIDGE framework creates a comprehensive pathway from political will to operational delivery. It aligns national strategies with bilateral mechanisms and global ambitions, ensuring that AI for health is institutionalised, resourced, and scaled.

Conclusion: The Opportunity That Can No Longer Be Missed

While US–India cooperation on AI has expanded across strategic domains, healthcare has yet to be fully recognised as a central pillar. This exclusion is less an oversight than an area of untapped potential, one where collaboration could yield profound benefits for both nations and the world. Health is the arena where AI diplomacy can demonstrate its greatest value: advancing equity, strengthening resilience, and building trust through innovation.

A dedicated bilateral framework for AI in health would allow the US and India to set global norms, scale tested innovations across the Global South, and showcase how strategic partnerships can deliver shared public good. The BRIDGE framework provides a clear and actionable pathway, but its success depends on political commitment and joint resolve.

As cooperation deepens under initiatives such as TRUST, embedding health into these agendas offers an opportunity to co-develop adaptable AI tools, enhance preparedness for future health threats, and strengthen systems resilience. Elevating health within US–India AI diplomacy is not only feasible but mutually advantageous, positioning both countries to lead in shaping a more equitable, secure, and inclusive digital health future.

Endnotes

1 Ministry of Health and Family Welfare, Government of India, *National Digital Health Blueprint: Report comments invited* (New Delhi: Ministry of Health and Family Welfare), https://mohfw.gov.in/sites/default/files/National_Digital_Health_Blueprint_Report_comments_invited.pdf.

2 National Health Authority, Government of India, *Update on Ayushman Bharat Digital Mission* (New Delhi: Ministry of Health and Family Welfare), https://www.mohfw.gov.in/?q=pressrelease-166.

3 Ministry of Electronics and Information Technology, Government of India, *IndiaAI Mission* (New Delhi: Digital India Corporation), https://indiaai.gov.in/.

4 Ministry of Electronics and Information Technology, Government of India, https://www.pib.gov.in/PressReleasePage.aspx?PRID=2148394.

5 S. Pratap, "IndiaAI Mission: A Major Leap in India's AI Ecosystem," Dr. Syama Prasad Mookerjee Research Foundation, March 26, 2025, https://spmrf.org/indiaai-mission-a-major-leap-in-indias-ai-ecosystem/.

6 Department of Science and Technology, Government of India, "US India Artificial Intelligence (USIAI) Initiative Launched" Government of India, https://dst.gov.in/us-india-artificial-intelligence-usiai-initiative-launched.

7 White House, *Fact sheet: United States and India Elevate Strategic Partnership with the Initiative on Critical and Emerging Technology (iCET)*, https://in.usembassy.gov/fact-sheet-united-states-and-india-elevate-strategic-partnership-with-the-initiative-on-critical-and-emerging-technology-icet/.

8 Ministry of External Affairs, Government of India, *Review Meeting of the India-U.S. Initiative on Critical and Emerging Technology (iCET)* (New Delhi: Ministry of External Affairs), https://www.mea.gov.in/press-releases.htm?dtl/37881/Review_Meeting_of_the_IndiaUS_initiative_on_Critical_and_Emerging_Technology_iCET.

9 Prime Minister's Office, Government of India, https://www.pib.gov.in/PressReleasePage.aspx?PRID=2103037.

10 U.S. Department of Defense, https://www.defense.gov/News/Releases/Release/Article/3586228/joint-statement-on-the-fifth-annual-india-us-22-ministerial-dialogue/.

11 Centers for Disease Control and Prevention, *CDC in India*, 2024, https://www.cdc.gov/global-health/countries/india.html.

12 Centers for Disease Control and Prevention, *India 2024 Fact Sheet*, 2025, https://www.cdc.gov/global-health/media/pdfs/2024/12/India-2024-Fact-Sheet.pdf.

13 Embassy of India, *U.S.–India Cooperation to Protect the Health of their People*, Embassy of India, USA, https://www.indianembassyusa.gov.in/ArchivesDetails?id=1202.

14 IntraHealth International, *The Vistaar Project*, 2025, https://www.intrahealth.org/projects/vistaar-project.

15 P.A. Giri and M.K. Gupta, "Transforming Disease Surveillance through Artificial Intelligence," *Indian Journal of Community Medicine* 49, no. 5: 663–664, https://doi.org/10.4103/ijcm.ijcm_459_24.

16 C.R. MacIntyre et al., "Artificial Intelligence in Public Health: The Potential of Epidemic Early Warning Systems," *Journal of International Medical Research* 51, no. 3 (2023), https://doi.org/10.1177/03000605231159335.

17 M.M. Alwakeel, “AI-Assisted Real-Time Monitoring of Infectious Diseases in Urban Areas,” *Mathematics* 13, no. 12 (2025): 1911, https://doi.org/10.3390/math13121911.

18 V.R. Umapathy et al., “Perspective of Artificial Intelligence in Disease Diagnosis: A Review of Current and Future Endeavours in the Medical Field,” *Cureus* 15, no. 9 (2023): e45684, https://doi.org/10.7759/cureus.45684.

19 Spectral AI, *Artificial Intelligence in Medical Diagnosis: How Medical Diagnostics are Improving Through AI*, 2024, https://www.spectral-ai.com/blog/artificial-intelligence-in-medical-diagnosis-how-medical-diagnostics-are-improving-through-ai/.

20 T. Ciecierski-Holmes et al., “Artificial Intelligence for Strengthening Healthcare Systems in Low- and Middle-Income Countries: A Systematic Scoping Review,” *NPJ Digital Medicine 5*, 162, https://doi.org/10.1038/s41746-022-00700-y.

21 DiMe Society, “Applicability of Artificial Intelligence in Healthcare in Resource-Poor Settings,” DiMe Society Journal Club, February 9, 2023, https://dimesociety.org/journal/applicability-of-artificial-intelligence-in-healthcare-in-resource-poor-settings/.

22 M.S. Khan et al., “Artificial Intelligence for Low Income Countries,” *Humanities and Social Sciences Communications* 11, no. 1422, October 25, 2024, https://doi.org/10.1057/s41599-024-03947-w.

23 O. Spillner, “Rebuilding Trust in Global Health Governance: An Opportunity for Germany,” German Council on Foreign Relations, September 7, 2024, https://doi.org/10.60823/DGAP-24-41192-en.

24 Lakshmy Ramakrishnan et al., “Global Health Diplomacy: Navigating Politics and Security,” Observer Research Foundation, June 6, 2025, https://www.orfonline.org/research/global-health-diplomacy-navigating-politics-and-security.

25 B. AlKnawy et al., “Digital Public Health Leadership in the Global Fight for Health Security,” *BMJ Global Health 8*, no. 2 (2023): e011454, https://doi.org/10.1136/bmjgh-2022-011454.

26 U.S. Department of Defense, https://www.defense.gov/News/Releases/Release/Article/3586228/joint-statement-on-the-fifth-annual-india-us-22-ministerial-dialogue/.

27 B. Mellado B et al., “Leveraging Artificial Intelligence and Big Data to Optimize COVID-19 Clinical Public Health and Vaccination Roll-out Strategies in Africa,” *Int J Environ Res Public Health* 2021 18, 7890.

28 WHO, *Chatbots Against COVID-19: Using Chatbots to Answer Questions on COVID-19 in the User’s Language,* Geneva, World Health Organization, 2022, https://www.who.int/news-room/featurestories/detail/scicom-compilation-chatbot.

29 S Wang et al., “Social Media Insights into Spatiotemporal Emotional Responses to COVID-19 Crisis,” *Health Place* 85, 2024, 103174.

30 J. Lu et al., "An Environmental Uncertainty Perception Framework for Misinformation Detection and Spread Prediction in the COVID-19 Pandemic: Artificial Intelligence Approach," *JMIR AI* 3 (2024): e47240.

31 National Science and Technology Council, Networking and Information Technology Research and Development (NITRD) Program Office, *National Artificial Intelligence Research and Development Strategic Plan: 2023 Update*, U.S. Government, 2023, https://www.nitrd.gov/pubs/National-Artificial-Intelligence-Research-and-Development-Strategic-Plan-2023-Update.pdf.

32 Executive Office of the President, “Executive Order No. 13859: Maintaining American Leadership in Artificial Intelligence,” Federal Register 84, no. 31 (2019): 3967–3972, https://www.federalregister.gov/documents/2019/02/14/2019-02544/maintaining-american-leadership-in-artificial-intelligence.

33 Executive Office of the President, "Executive Order No. 14110: Safe, Secure, and Trustworthy Development and Use of Artificial Intelligence," Federal Register 88, no. 210 (2023): 75191–75224, https://www.federalregister.gov/documents/2023/11/01/2023-24283/safe-secure-and-trustworthy-development-and-use-of-artificial-intelligence.

34 Executive Office of the President, "Executive Order No. 14179: Removing Barriers to American Leadership in Artificial Intelligence," *Federal Register* 90, no. 21 (2025), 8741–8742, https://www.federalregister.gov/documents/2025/01/31/2025-02172/removing-barriers-to-american-leadership-in-artificial-intelligence.

35 U.S. Department of Health and Human Services, *Artificial Intelligence (AI) Strategy*, 2021, https://www.hhs.gov/sites/default/files/final-hhs-ai-strategy.pdf.

36 U.S. Government Accountability Office, *Artificial Intelligence: An Accountability Framework for Federal Agencies and Other Entities* (GAO Publication No. GAO-21-519SP), https://www.gao.gov/products/gao-21-519sp.

37 Ministry of Health and Family Welfare, Government of India, *National Digital Health Blueprint: Report Comments Invited* (New Delhi: Ministry of Health and Family Welfare, 2019), https://mohfw.gov.in/sites/default/files/National_Digital_Health_Blueprint_Report_comments_invited.pdf.

38 Ministry of Health and Family Welfare, Government of India, https://www.mohfw.gov.in/?q=pressrelease-166.

39 Ministry of Electronics and Information Technology, Government of India, *IndiaAI Mission* (New Delhi: Digital India Corporation, 2024), https://indiaai.gov.in/.

40 Ministry of Electronics & Information Technology, Government of India, https://www.pib.gov.in/PressReleasePage.aspx?PRID=2148394.

41 Pratap, "IndiaAI Mission: A Major Leap in India's AI Ecosystem."

42 Central Drugs Standard Control Organization, *Medical Device & Diagnostics*, 2025, https://cdsco.gov.in/opencms/opencms/en/Medical-Device-Diagnostics/Medical-Device-Diagnostics/.

43 Asia Pacific Medical Technology Association, *Guidance on SaMD Regulations: Lifecycle Approach*, https://apacmed.org/wp-content/uploads/2022/01/SaMD-Guidance-Document.pdf.

44 Department of Pharmaceuticals, and Ministry of Chemicals & Fertilizers, Government of India, *Public Notice: List of Available BIS Standards for Medical Devices*, 2022, https://pharma-dept.gov.in/sites/default/files/Public%20Notice_BIS%20Standards.pdf.

45 Indian Council of Medical Research, *Draft Ethical Guidelines for Application of Artificial Intelligence in Biomedical Research and Healthcare*, 2022, https://ourgovdotin.wordpress.com/wp-content/uploads/2022/09/ai_ethical_guidlines.pdf.

46 Government of India, *The Digital Personal Data Protection Act, 2023 (No. 22 of 2023)*, Gazette of India, https://egazette.gov.in/WriteReadData/2023/247847.pdf.

47 Department of Science and Technology, *US India Artificial Intelligence (USIAI) Initiative Launched*, 2021, https://dst.gov.in/us-india-artificial-intelligence-usiai-initiative-launched

48 White House, *Fact Sheet: United States and India Elevate Strategic Partnership with the Initiative on Critical and Emerging Technology (iCET)*, 2022, https://in.usembassy.gov/fact-sheet-united-states-and-india-elevate-strategic-partnership-with-the-initiative-on-critical-and-emerging-technology-icet/.

49 Prime Minister's office, Government of India, https://www.pib.gov.in/PressReleasePage.aspx?PRID=2103037.

50 S. Oum et al., "10 Things to Know About U.S. Funding for Global Health," KFF, https://www.kff.org/global-health-policy/issue-brief/10-things-to-know-about-u-s-funding-for-global-health/.

51 HIV.gov, *PEPFAR: U.S. President's Emergency Plan for AIDS Relief*, U.S. Department of Health and Human Services, https://www.hiv.gov/federal-response/pepfar-global-aids/pepfar.

52 U.S. President's Malaria Initiative, *End Malaria Faster: U.S. President's Malaria Initiative Strategy 2021–2026*, U.S. Agency for International Development, https://measuremalaria.cpc.unc.edu/publications/end-malaria-faster-u-s-presidents-malaria-initiative-2021-2026-strategy/.

53 World Health Organization, *United States of America – Funding*, https://www.who.int/about/funding/contributors/usa.

54 Defence Street, *India Has Emerged as First Responder in Humanitarian Assistance and Disaster Relief (HADR) at Global Level: CDS Gen. Anil Chauhan*, https://www.defencestreet.com/india-has-emerged-as-first-responder-in-humanitarian-assistance-and-disaster-relief-hadr-at-global-level-cds-gen-anil-chauhan/.

55 NatStrat, *Indian Humanitarian Assistance and Disaster Relief in Nepal: Swift, Sure and Selfless*, 2023, https://www.natstrat.org/articledetail/publications/indian-humanitarian-assistance-and-disaster-relief-in-nepal-swift-sure-and-selfless-108.html.

56 Ministry of External Affairs, *Relief and Medical Assistance to Other Nations* (Unstarred Question No. 2324), Rajya Sabha, 2025, https://sansad.in/getFile/annex/267/AU2324_YjqdzN.pdf?source=pqars.

57 Ministry of External Affairs, Government of India, https://www.mea.gov.in/press-releases.htm?dtl/36209/Operation_Dost.

58 Ministry of Defence, Government of India, https://www.pib.gov.in/PressReleaseIframePage.aspx?PRID=2116635.

59 Ministry of External Affairs, Government of India*Operation Insaniyat – Humanitarian Assistance to Bangladesh on Account of Influx of Refugees*, 2017, https://www.mea.gov.in/press-releases.htm?dtl/28944/Operation_Insaniyat__Humanitarian_assistance_to_Bangladesh_on_account_of_influx_of_refugees.

60 Embassy of India, *India Provides Humanitarian Assistance to Nepal Following Jajarkot Earthquake*, Embassy of India, Kathmandu, 2023, https://www.indembkathmandu.gov.in/media-detail/33.

61 Piyush Goyal, "India Shared 300 Million Vaccines Globally During COVID-19," *DD News*, April 28, 2025, https://ddnews.gov.in/en/india-shared-300-million-vaccines-globally-during-covid-19-piyush-goyal.

62 Ministry of External Affairs, Government of India, https://www.mea.gov.in/press-releases.htm?dtl/35463/India_delivers_6_tons_of_medical_assistance_to_Afghanistan.

63 A. Kumar, "Here's All You Need to Know About BHISHM Cubes, PM Modi's Gift to Ukraine," *Business Standard*, August 24, 2024, https://www.business-standard.com/india-news/here-s-all-you-need-to-know-about-bhishm-cubes-pm-modi-s-gift-to-ukraine-124082400490_1.html.

AI-Driven Extreme Weather Forecasting: An Avenue for India-U.S. Collaboration

Priyanshu Gupta

Abstract

As climate change intensifies, the risk of extreme weather events is also heightening. Artificial Intelligence (AI) can revolutionise weather forecasting and risk assessment by integrating machine learning, deep learning, and satellite data into prediction models. This article explores efforts in India and the United States (US) to use AI to strengthen climate resilience. It also outlines a vision for joint research labs, interoperable data platforms, and AI-driven early warning systems for local communities, recommends ways to address challenges (such as data bias and infrastructural disparities) that can hinder data generation, and

proposes strategies for the responsible and inclusive deployment of AI. This proposed India-US partnership can move both countries to a position where they can lead global climate strategies.

Introduction

Global temperatures increased by ~1.2°C above pre-industrial levels (1850-1900) from 2014 and 2023; in 2024, scientists recorded the warmest global temperatures, 1.55 °C above pre-industrial levels.[1] Climate disasters have increased fivefold over the past five decades, resulting in over two million deaths and trillions of dollars in economic losses.[2] Indeed, climate change has led to an era of increasingly extreme weather events worldwide. For instance, in 2023, several areas in northern India experienced catastrophic floods, southern regions faced severe droughts, and many other areas experienced heatwaves.[3] Similarly, the United States (US) has experienced numerous climate-related disasters in recent years, such as hurricanes, floods, and wildfires.[4] Such extreme weather events disrupt agricultural production, strain infrastructure, and disproportionately harm vulnerable communities, such as rural farmers and urban low-income residents.

The rapidly increasing frequency and severity of extreme weather events highlight the need for advanced forecasting systems. Conventional numerical weather prediction models, reliant on complex physical equations and supercomputing, excel in long-term projections but struggle with the speed and granularity required for short-term, localised forecasts of extreme events. Artificial Intelligence (AI) offers adaptive learning and rapid processing of multisource data, making it a powerful complement to conventional forecasting approaches. AI-driven nowcasting processes real-time data from satellites, radar, ground stations, and ocean buoys to deliver high-resolution predictions within minutes. This capability enables early warning, optimises evacuation plans, and informs adaptive strategies, such as protecting crops or managing urban floods.

For both India, where monsoon rains can turn into a deluge, and the US, where hurricanes require swift action, AI offers an opportunity for proactive governance, aligning with both countries' commitment to climate action. Given their expertise in AI, the US and India are well-positioned to drive a transformative shift in forecasting. Through the US-India TRUST (Transforming the Relationship Utilising Strategic Technologies) Initiative,[a] the two countries can advance forecasting, foster policy innovation, and empower communities.

---

[a] US-India TRUST (Transforming the Relationship Utilising Strategic Technologies) Initiative was launched on 13 February 2025. It aims to promote critical and emerging technology applications in areas like AI, defence, semiconductors, energy, and space.

AI's Role in Extreme Weather Forecasting

AI, particularly machine learning and deep learning, can reshape extreme weather forecasting by extracting insights from complex, multidimensional data. Convolutional neural networks (CNNs) is an AI model widely used for pattern detection and image recognition. It analyses satellite imagery from geostationary satellites, such as the Indian National Satellite (INSAT) or the US's Geostationary Operational Environmental Satellite (GOES), by identifying features like shapes, patterns, and textures in the images to detect storm clouds, heat signatures, or cyclone formations with high precision.[5,6,7] For instance, a CNN with multiple convolutional layers can identify convective cloud patterns that indicate flash floods, a critical capability for nowcasting. Recurrent neural networks (RNNs),[b] particularly long short-term memory (LSTM)[c] variants, effectively predict temporal trends, such as rainfall intensity and storm progression, by addressing training limitations for accurate forecasts.[8]

For their part, ensemble learning techniques, such as random forests (combining multiple decision trees independently), and gradient boosting machines (building decision trees sequentially with each new tree correcting the error of previous ensembles to minimise bias)—combine multiple models to enhance reliability and reduce errors in scenarios such as predicting hurricane trajectories. Emerging transformer-based models, inspired by natural language processing, use an attention mechanism to prioritise critical data points, such as atmospheric pressure anomalies, to offer high-resolution nowcasts.

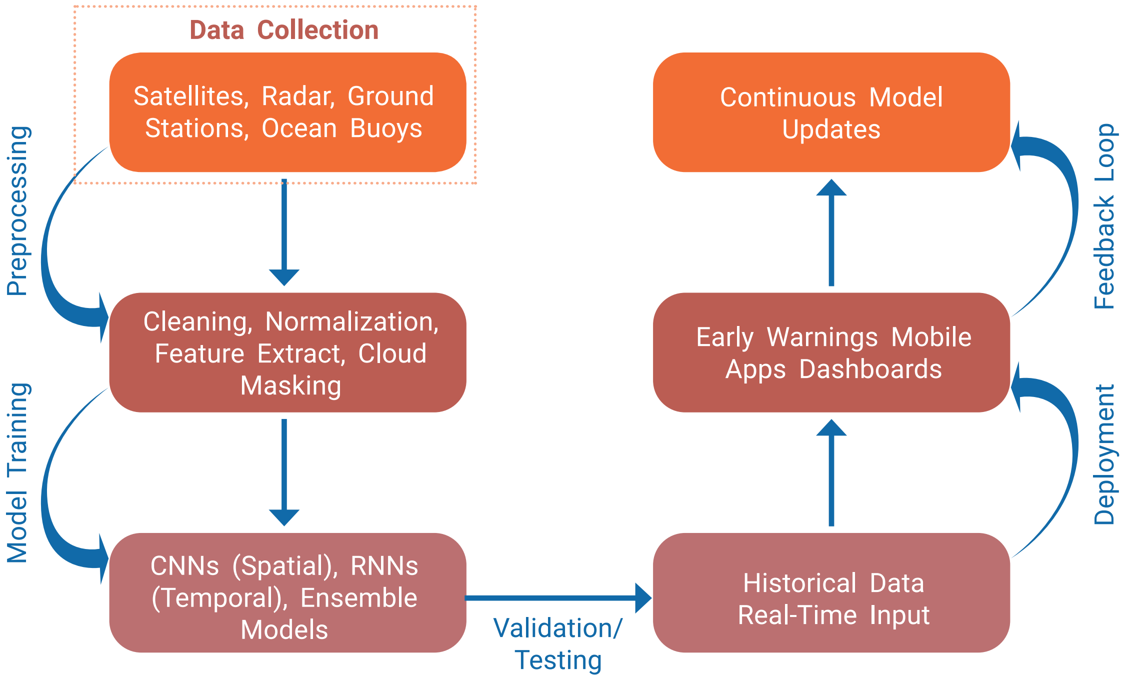
Currently, the AI workflow for weather forecasts or nowcasts begins with data collection from satellites (such as INSAT and GOES), Doppler radars, ground stations, and ocean buoys, capturing variables such as sea surface temperature and humidity (see Figure 1). This is followed by preprocessing, which involves cleaning noise, normalising scales, extracting features such as convective potential, and cloud masking for accurate imagery analysis. CNNs and RNNs analyse spatial and temporal patterns, which are then validated against historical and real-time data, and deployed in user-facing systems. A feedback loop ensures continuous improvement.

---

b Artificial neural network design to process sequential data like time series or text by maintaining previous input memory through looped connections.

c Uses memory cell and gates to preserve long-term dependencies in sequential data unlike standard RNNs, that struggle with long dependencies.

Figure 1: AI Workflow for Extreme Weather Forecasting



Source: Author's own

AI-based weather prediction models are trained using past weather records, such as ERA5 developed by the European Centre for Medium-Range Weather Forecasts (ECMWF),[d] and current weather data.[9] These models are then validated against past extreme events and applied in warning systems to predict future storms.

Such applications have been shown to enhance modelling and the mitigation of extreme weather events through improved nowcasts and risk assessment (based on socioeconomic and environmental data).[10,11] For instance, DeepMind's GenCast model, a transformer-based approach, has outperformed traditional models to achieve sub-kilometre resolution for urban flood and heatwave prediction. GenCast is a machine learning-based forecast approach trained on decades of reanalysis data, which is a consistent set of climate or weather data generated by combining historical weather observations with numerical weather prediction models. It generates 15-day global weather forecasts in just eight

[d] Provides hourly estimates of a large number of atmospheric, land, and oceanic climate variables.

minutes using an ensemble approach, which provides probability-based predictions every 12 hours at a spatial resolution of 25 km, and includes more than 80 different surface and atmospheric variables. Notably, GenCast outperforms ECMWF's ensemble prediction system (numerical weather prediction system runs varied and multiple weather simulations to quantify forecast uncertainty) in terms of skill and speed, delivering more accurate and faster medium-range weather forecasts.[12] By enhancing forecast granularity and accelerating decision-making, AI empowers communities and policymakers to adapt to extreme weather effectively.

AI-Driven Forecasting in Action

India and the US already utilise AI-based forecasting for extreme weather, with India focusing on monsoon and dust storms and the US on wildfires and hurricanes. Bilateral collaboration through shared datasets, co-developed AI algorithms, and technology transfer can enhance predictive accuracy and mitigate the impacts of disasters.

In India, the Indian Meteorological Department (IMD) and the Indian Institute of Tropical Meteorology (IITM) use machine learning to improve monsoon storm forecasting.[13] They integrate satellite imagery from INSAT-3DR/3DS, oceanic indices such as the El Niño-Southern Oscillation (ENSO)[e] and the Indian Ocean Dipole (IOD),[f] and ERA5 data to enhance the accuracy of their predictions. ENSO and IOD are crucial in predicting monsoon variability and extreme weather events such as heavy rainfall or droughts. CNNs are suitable for spatial data, such as cloud patterns from satellite imagery, while LSTMs are effective for time-series rainfall forecasts. A 2023 study used LSTMs to predict all Indian summer monsoon rainfall by incorporating ENSO and IOD data. IITM high-resolution models have enhanced seasonal prediction skills that improve monsoon forecasts.[14] Doppler radars enable short-term (one to two hours) nowcasting, with machine learning models being shown to achieve ~83 percent accuracy for precipitation in North Indian states.[15] Machine Learning techniques, such as neural networks, random forests, and deep learning, are also helpful in detecting and predicting dust storms by analysing satellite and ground data.[16] It addresses challenges such as data quality and computational demands by utilising hybrid models and real-time data assimilation.

---

[e] A climate pattern emerging from sea surface temperature fluctuations in the Pacific Ocean.

[f] Temperature differences in the Indian Ocean.

In the US, AI is used to improve wildfire management and hurricane forecasting. For instance, the National Oceanic and Atmospheric Administration (NOAA) utilises AI models to improve hurricane tracking and intensity predictions by combining satellite data, ocean heat content, and atmospheric variables. A 2024 study demonstrated that deep learning models improved hurricane intensity forecasts by 15 percent compared to traditional methods.[17] To combat wildfires, AI-driven proactive prevention combined CNNs for fire and smoke detection (utilising satellite and drone imagery) with 5G-enabled remote sensing for real-time monitoring.[18] These systems, deployed in states like California, achieve detection accuracies of 90 percent, enabling faster response times.[19] The US Forest Service also uses random forest models to predict wildfire risk and analyse variables such as vegetation dryness and wind patterns, with a reported accuracy of 85 percent for high-risk zones.[20] These advancements reduce economic losses and save lives by enabling evacuations and resource allocation.

Enhancing India-US Collaboration

India and the US are forging a strong partnership on climate through initiatives such as TRUST, the US-India Artificial Intelligence Initiative (USIAI),[g] and the Quad Climate Working Group.

Joint Innovation Infrastructure

Such collaborations can drive innovation by encouraging the establishment of joint AI climate labs, hosted by institutions such as the NOAA and National Aeronautics and Space Administration (NASA) and IMD and the Indian Space Research Organisation (ISRO), to develop AI models for monsoon and hurricane nowcasting, governed by bilateral steering committees to balance resources and intellectual property.

Data Integration and Interoperability

A cloud-based, interoperable data platform could integrate datasets such as INSAT, GOES, and ERA5, as well as ground-based observations, using standardised protocols like NetCDF (network common data form)[h] and APIs (application programming interfaces)[i] to enable real-time access for researchers and policymakers.

---

[g] Its goal is to discuss and identify new R&D areas and emerging AI landscape and address the challenges of developing an AI workforce.

[h] An interface to a library of data access functions for storing and retrieving data in array form.

[i] Set of protocols or rules enables software applications to communicate with each other.

Funding and Private Sector Collaboration

Grants from the US National Science Foundation and the India Department of Science and Technology, and contributions from private firms that have shown interest in AI-driven climate solutions (such as IBM through its Prithvi-weather-climate and Global Raster Attribute Field models) and those with existing forecasting models, such as Google (with the flood forecast model) and NVIDIA (with its FourCastNet model), can be used to fund US-India AI climate initiatives.

The US and India can strengthen AI-driven climate resilience by establishing joint research hubs, combining US computational expertise with Indian meteorological and agricultural insights to develop scalable solutions. Collaborative workshops can upskill professionals in AI and climate science, fostering cross-cultural innovation and driving advancements in these fields. An open-source AI model ecosystem, supported by both nations, will democratise access to climate tools, while aligned ethical AI policies ensure equitable deployment, empowering communities and informing global standards.

Challenges and Opportunities

AI-driven forecasting faces various challenges that require innovative solutions. Inconsistent data quality, particularly in India's rural regions which have sparse ground station coverage and fewer monitoring stations, leads to biased models that underpredict risks for underserved communities.[21] Similarly, rural regions in Midwest US have limited weather stations, which makes it more challenging for weather models to accurately predict extreme weather events.[22]

Training complex AI models requires costly, energy-intensive high-performance computing, often inaccessible to smaller Indian research institutions and American state agencies with limited budgets. Additionally, in some US and Indian communities, a distrust of technology creates resistance among local governments and disaster management agencies to adopt these tools.[23,24]

Despite these challenges, US-India collaboration on AI-based forecasting presents opportunities to develop open-source, explainable AI models using techniques such as SHAP (Shapley Additive exPlanations)[j] for interpretability, which can build trust and foster bilateral innovation.[25] Crowdsourced data collected through citizen science apps can

---

[j] It explains the output of any machine learning model.

enhance model accuracy in data-sparse regions. Lightweight AI models, optimised for edge devices, can reduce computational costs and enable deployment in low-resource settings in both nations. Collaborative research can build on the US's expertise in advanced technology and India's strengths in frugal innovation, enabling both countries to lead the way in developing ethical, inclusive AI for climate resilience.[26]

Importantly, AI-based forecasts can help communities better prepare for extreme weather. The IMD has developed mobile apps, such as Mausam and Meghdoot, that provide real-time weather updates, forecasts, and warnings to support farmers and the wider public. Such apps use AI and machine learning to enhance forecast accuracy and offer crop advisories and alerts for extreme weather events such as storms, heatwaves, and heavy rainfall.

Machine learning-driven flood alerts, integrated with Doppler radar, can deliver flood warnings in vulnerable cities, such as Mumbai and Miami, and guide urban planners in deploying barriers to evacuate at-risk areas, minimising the loss of life. AI heat mapping informs green infrastructure planning in cities like Chennai and Houston, reducing urban heat island effects and enhancing liveability for millions.

Conclusion

As the number of extreme weather events increases due to climate change, AI-powered forecasting and adaptation provide a lifeline for communities worldwide, and the US-India partnership in AI can lead this transformation. By utilising CNNs, RNNs, and transformer-based models, and combining datasets from NOAA, IMD, NASA, and ISRO, this collaboration can deliver rapid and precise predictions on storms, heatwaves, and floods, thereby limiting damage to life, infrastructure, and the economy.

Joint AI climate labs, interoperable data platforms, ethical AI guidelines, and capacity-building initiatives will ensure scalable, inclusive solutions. Notably, forecasting models emerging from this partnership can be scaled globally, particularly in the Global South, to shape ethical AI governance. Challenges such as data biases, model transparency, computational costs, and societal trust require an open-source platform, crowdsourced data, efficient algorithms, and robust ethics to ensure both equity and effectiveness.

India and the United States can lead in developing global climate resilience by using TRUST, USIAI, and the India AI Mission to co-develop AI-driven solutions. Further, joint innovation hubs and public-private partnerships under TRUST will accelerate the development of impactful technologies, setting a global benchmark.

Endnotes

1 World Meteorological Organization, *Warmest Year on Record at About 1.55°C Above Pre-industrial Level*, Geneva, World Meteorological Organization, 2025, https://wmo.int/news/media-centre/wmo-confirms-2024-warmest-year-record-about-155degc-above-pre-industrial-level.

2 James Douris and Geunhye Kim, *Atlas of Mortality and Economic Losses from Weather, Climate and Water Extremes (1970–2019)*, Geneva, World Meteorological Organization, 2021, https://library.wmo.int/viewer/57564/download?file=1267_Atlas_of_Mortality_en.pdf&type=pdf&navigator=1.

3 Anuj Prakash Kushwaha et al., "Land and Atmospheric Drivers of the 2023 Flood in India," *Earth and Space Science* 11, no. 10 (2024): e2024EA003750, https://doi.org/10.1029/2024EA003750.

4 Adam B. Smith, *U.S. Billion-dollar Weather and Climate Disasters, 1980–Present* (NCEI Accession 0209268), Asheville, NC: NOAA National Centers for Environmental Information, 2022, https://doi.org/10.25921/stkw-7w73.

5 Snehlata Shakya, Sanjeev Kumar, and Mayank Goswami, "Deep Learning Algorithm for Satellite Imaging Based Cyclone Detection," *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing* 13 (2020): 827–839, https://doi.org/10.1109/JSTARS.2020.2970253.

6 Soumyajit Pal, Uma Das, and Oishila Bandyopadhyay, "Detecting Tropical Cyclones in INSAT-3D Satellite Images Using CNN-Based Model," in *Computer Vision and Image Processing. CVIP 2022*, Communications in Computer and Information Science, ed. Dinesh Gupta et al. (Cham: Springer, 2023), 351–363, https://doi.org/10.1007/978-3-031-31407-0_27.

7 Ritesh Pradhan et al., "Tropical Cyclone Intensity Estimation Using a Deep Convolutional Neural Network," *IEEE Transactions on Image Processing* 27, no. 2 (2018): 692–702, https://doi.org/10.1109/TIP.2017.2766358.

8 Xingjian Shi et al., "Convolutional LSTM Network: A Machine Learning Approach for Precipitation Nowcasting," in *Advances in Neural Information Processing Systems* 28 (2015), https://proceedings.neurips.cc/paper/2015/hash/07563a3fe3bbe7e3ba84431ad9d055af-Abstract.html.

9 Hans Hersbach et al., "The ERA5 Global Reanalysis," *Quarterly Journal of the Royal Meteorological Society* 146, no. 730 (2020): 1999–2049, https://doi.org/10.1002/qj.3803.

10 Gustau Camps-Valls et al., "Artificial Intelligence for Modeling and Understanding Extreme Weather and Climate Events," *Nature Communications* 16, no. 1 (2025): 1919, https://doi.org/10.1038/s41467-025-56573-8.

11 Thomas Vandal et al., "DeepSD: Generating High Resolution Climate Change Projections through Single Image Super-Resolution," in *Proceedings of the 23rd ACM SIGKDD International Conference on Knowledge Discovery and Data Mining*, 1663–1672 (2017), https://doi.org/10.1145/3097983.3098004.

12 Alix Soliman, "DeepMind AI Weather Forecaster Beats World-Class System," *Nature* 636, no. 8042 (2024): 282–283, https://alixsoliman.com/wp-content/uploads/2025/01/nature_deepmind-weather-ai_in-print_alix-soliman.pdf.

13 Udit Narang et al., "Artificial Intelligence Predicts Normal Summer Monsoon Rainfall for India in 2023," *Scientific Reports* 14, no. 1 (2024): 1495, https://doi.org/10.1038/s41598-023-44284-3.

14 Bipin Kumar et al., "Deep Learning Based Short-Range Forecasting of Indian Summer Monsoon Rainfall Using Earth Observation and Ground Station Datasets," *Geocarto International* 37, no. 27 (2022): 17994–18021, https://doi.org/10.1080/10106049.2022.2136262.

15 Aayushi Tandon et al., "Efficacy of Machine Learning in Simulating Precipitation and Its Extremes over the Capital Cities in North Indian States," *Scientific Reports* 15, no. 1 (2025): 10345, https://doi.org/10.1038/s41598-024-84360-w.

16 A. M. Mutawa, Abdullah Alshaibani, and Laalea A. Almatar, "A Comprehensive Review of Dust Storm Detection and Prediction Techniques: Leveraging Satellite Data, Ground Observations, and Machine Learning," *IEEE Access* (2025), https://doi.org/10.1109/ACCESS.2025.3541075.

17 Buo-Fu Chen et al., "Climate Trends of Tropical Cyclone Intensity and Energy Extremes Revealed by Deep Learning," arXiv (2024), https://doi.org/10.48550/arXiv.2402.00362.

18 Stanley Chinedu Okoro et al., "A Synergistic Approach to Wildfire Prevention and Management Using AI, ML, and 5G Technology in the United States," arXiv, 2024, https://doi.org/10.48550/arXiv.2403.14657.

19 Azlan Saleh et al., "Forest Fire Surveillance Systems: A Review of Deep Learning Methods," *Heliyon* 10, no. 1 (2024), https://www.cell.com/heliyon/fulltext/S2405-8440(23)10335-5.

20 Jinping Lu et al., "A Study on Forest Fire Risk Assessment in Jiangxi Province Based on Machine Learning and Geostatistics," *Environmental Research Communications* 6, no. 12 (2024): 125020, https://doi.org/10.1088/2515-7620/ad9cf2.

21 Nidhi Jamwal, "Data Drought: The Challenge of AI Weather Forecasting in India," *Dialogue Earth*, April 26, 2024, https://dialogue.earth/en/climate/data-drought-the-challenge-of-ai-weather-forecasting-in-india/.

22 Adam B. Smith, *US Billion-Dollar Weather and Climate Disasters, 1980–Present*, Asheville, NC, National Centers for Environmental Information (NOAA), 2022, https://doi.org/10.25921/stkw-7w73.

23 Stavros Sindakis and Gazal Showkat, "The Digital Revolution in India: Bridging the Gap in Rural Technology Adoption," *Journal of Innovation and Entrepreneurship* 13, no. 1 (2024): 29, https://doi.org/10.1186/s13731-024-00380-w.

24 Alec Tyson and Brian Kennedy, *Public Trust in Scientists and Views on Their Role in Policymaking*, Pew Research Center, 2024, https://coilink.org/20.500.12592/5aibltw.

25 Scott M. Lundberg and Su-In Lee, "A Unified Approach to Interpreting Model Predictions," in *Advances in Neural Information Processing Systems* 30 (2017), https://proceedings.neurips.cc/paper/2017/hash/8a20a8621978632d76c43dfd28b67767-Abstract.html.

26 Rudra Chaudhuri and Konark Bhandari, "The US–India Initiative on Critical and Emerging Technology (iCET) from 2022 to 2025: Assessment, Learnings, and the Way Forward," Observer Research Foundation, 2024, https://coilink.org/20.500.12592/1taadh7.

Artificial Intelligence in Defence Partnership and Policy

Katelyn Radack

Abstract

Artificial Intelligence (AI) is poised to reshape defence partnerships by enhancing interoperability even as it raises new ethical and strategic challenges. This article examines the evolving security relationship between the United States (US) and India, using it as a test case for exploring the potential of integrating AI into defence cooperation. The analysis situates interoperability within three dimensions—technological, human, and procedural—arguing that AI's learning capacity amplifies both the benefits and vulnerabilities of combined operations. It highlights how shared democratic values and converging strategic interests position Washington

and New Delhi to deepen collaboration. It also underscores persistent hurdles, including protectionism, supply-chain risks, and ethical divergences in the development and fielding of AI-enabled systems. By aligning on principles of transparency, accountability, and lawful conduct, the US and India can not only maximise operational compatibility but also shape global norms governing AI in security and defence.

Introduction

Interoperable technology and complementary ethical frameworks are critical as Artificial Intelligence (AI) enters the security and defence sector. The learning character of the technology may reinforce existing security partnerships by increasing the accruing benefits of status quo relationships while raising barrier costs to new ones. The growing United States (US)-India partnership could serve as a test case for how technology, ethics, and geopolitics converge in defence. Both countries are placed to overcome hurdles and maximise the mutual benefits of AI-enabled defence based on shared values and interests and increased cooperative planning and training.

Interoperability

US Army Regulation 34–1, *Interoperability*, defines it as "the ability to act together coherently, effectively, and efficiently to achieve tactical, operational, and strategic objectives."[1] It is based on cyclically reinforcing technological (materiel), human (shared knowledge and trust), and procedural (congruent ethical use model) compatibility between organisations. Interoperability offers greater capability, deterrence against adversaries, and reduced operational costs. However, it also demands substantial investment in technology, doctrine, and personnel at the tactical and operational levels, while posing risks at the strategic level.

Technology

Machine autonomy is related to but distinct from AI, and each serves as a powerful combat multiplier on its own. Their combination promises not just evolutionary but revolutionary change in the security environment, adding complexity to interoperability between partners, especially in human and procedural compatibility.

According to the United Nations Office of Disarmament Affairs, autonomous systems—capable of executing tasks independently once activated—have existed since the 1980s, primarily in defence and surveillance (e.g., missile detection and interception).[2] Technological complexity now extends some systems' capabilities to the autonomous use of offensive lethal force.

Manned-unmanned teaming (MUM-T) refers to the evolving role-sharing between humans and autonomous systems in security functions such as target identification, engagement, and response. Autonomous systems facilitate command and control to shift from direct to remote, and engagements from manned to unmanned systems. Drawing on the OODA Loop (observe, orient, decide, act), levels of autonomy are described as “man in the loop”, “man on the loop”, and “man out of the loop.” Each stage offers faster response but reduces opportunities for human input.

AI, which adds a learning component to the pattern recognition and rote execution of autonomous systems, further shifts human inputs from machine-augmented to machine-autonomous functions. Its incorporation has the potential to reshape the conception and execution of defence, security, and conflict. While greater autonomy enables speed and accuracy beyond human capacity, it also reduces transparency and creates an ethical grey zone regarding accountability, especially in offensive employment. Given the data needed to train such systems, the record of human operators and the cultural context of moral and ethical codes become paramount and a potential point of friction between partnered nations with divergent priorities and standards.

Today’s technology already enables some systems to apply offensive lethal force autonomously—a concern first noted in UN debates on lethal autonomous weapons systems (LAWS) in 2013. In 2018, UN Secretary-General António Guterres described such weapons—lacking an agreed legal definition but guided by use-based rather than capability-based criteria—as “politically unacceptable and morally repugnant.” Citing humanitarian, legal, security, and ethical concerns, the UN advocates the creation of legal instruments to regulate, and in some cases prohibit, their development and use. Yet these capability-based criteria clash with national defence research, production, and procurement incentives, given the speed and cost advantages that “man out of the loop” systems could provide.

Without dismissing the technological hurdles to equipping militaries with AI-enabled systems and platforms, this article focuses on the ethical challenges of their development, and particularly, their synchronised use in combined environments.

The Geopolitical Context

The 2018 renaming of the US Pacific Command (PACOM) to the Indo-Pacific Command (INDO-PACOM) reflects the central role envisioned for India in Washington’s strategic pivot to Asia. Shared democratic political culture, complementary economic interests, and mutual suspicion of China underpin the US-India relationship. Alongside Japan and Australia, the two countries helped launch the Quadrilateral Security Dialogue (Quad) in

2004, and since 2016 have recognised each other as Major Defence Partners. This status opens new doors for bi- and multi-lateral exchange. As examples, India is upgrading its military with US and US-ally technology, and the two countries now participate in dozens of bi- and multi-lateral, joint and joint-combined exercises ranging from the platoon to theatre level, emphasising maritime security and interoperability, and humanitarian and counter-terrorism missions.[3]

The technology revolution is a primary battleground in the great-power competition between the US and China and in regional dynamics between India and China, making it a key arena for US-India cooperation. A 2024 Center for Strategic and International Studies report identifies AI as one of the five technology fields—along with quantum computing, semiconductors, climate technologies, and biotechnologies—undergoing a "Sputnik moment".[4] The same report also identifies the US-India partnership as essential for both states to resist China, and subject to the "economic emerging security trilemma of promote, protect, and partner policies," that shadow all technology and security sharing. The Joint Leaders' Statement following the Modi-Trump meeting on 13 February 2025, emphasises and expands cooperation in defence and these key fields through new initiatives and the removal of existing barriers.[5]

India, a leader of the Non-Aligned Movement during the Cold War, has maintained strong political independence and advocacy for multipolarity. Its defence, political, and economic ties reflect this stance. India preserves close relations with Russia, a legacy of its USSR ties for both necessity and expediency, and is a founding member and leading voice of BRICS—an organisation of the Global South and developing countries that favour a rebalancing of the global order away from US-led Western dominance. At the same time, as India's relationship with China has become more competitive, it has pivoted towards Western bloc suppliers for defence technology and leaned into more US-favourable rhetoric, at least in the security domain.

According to the Stockholm International Peace Research Institute (SIPRI), India has been the world's largest arms importer by value since 1950, accounting for 9.5 percent of all military imports between 2018 and 2023.[6] Owing to maintenance and armament needs for its legacy systems, Russia remains India's largest supplier, accounting for 39 percent of its arms imports in this period.[7] India is also a substantial importer of Russian oil and natural gas, particularly since the 2022 invasion of Ukraine and despite US sanctions—an issue of growing concern in Washington. At the same time, India has expanded purchases from other US/-allied/-partnered suppliers (France at 29 percent, Israel at 12 percent, and the US at 11 percent), while also incentivising domestic innovation and production.[8] This pattern suggests a cautious shift meant to maintain geopolitical independence, while tilting towards the traditional US-led "western alliance".

In January 2023, the Biden and Modi administrations launched the Initiative on Critical and Emerging Technology (iCET) and the India-US Defense Acceleration Ecosystem (INDUS-X) to further US-India technology and defence cooperation.[9] These frameworks link government, academia, and business interests to maximise research and manufacturing capability, emphasising co-production and adoption to (re)vitalise both countries' defence industrial bases. Priority areas include intelligence, surveillance, and reconnaissance (ISR); undersea domain awareness; air combat and support; munitions systems; and mobility.[10] Under the more general desire to "accelerate the joint adoption of cutting-edge commercial technologies for military solutions and capability enhancement of both countries' defence," the framework specifically notes Indian acquisition of the MQ9B (Reaper) remote/autonomous ISR platform, and the "launch of an AI Multi-Domain Situational Awareness product jointly developed by General Atomics and 114ai to support joint all-domain command and control."[11]

In February 2025, Trump and Modi reaffirmed their countries' partnership with a renewed focus on technology. Their statement builds on iCET by establishing the US-India TRUST ("Transforming the Relationship Utilising Strategic Technology") initiative, reaffirming INDUS-X, and launching a parallel non-defence framework called INDUS-Innovation. It also promises a US-India Roadmap on Accelerating AI Infrastructure by year's end, including plans to expand research, development, and deployment through the Autonomous Systems Industry Alliance (ASIA).

These frameworks and the rhetoric surrounding them signal the baseline and aspirations for interoperable capability between the US and India. By sharing and especially by co-developing and producing defence systems, the US and India build in an increased level of tactical and operational technological compatibility. At the strategic level, such cooperation is effective only when accompanied by human (trust) and procedural (ethical) alignment. Through these statements, US and Indian political leaders are promoting the push to grow together in technology and defence towards an interoperable future in which each benefits and learns. However, particularly given the depth of revelation and potential vulnerabilities that will be involved in AI-enabled interoperability, the US's and India's solutions to the promote-protect-partner trilemma have a wide spectrum of outcomes.

Overcoming Hurdles and Maximising Opportunities

Promote-Protect-Partner

The potential multiplier effects of synchronised and networked AI weapons systems built on shared data models create strong incentives for equipment and technology compatibility and sharing. These gains represent solutions to the "promote" and "partner" corners of the trilemma and would build on (especially) the technology aspect of interoperability.

In promoting AI, both the US and India have much to gain from investing in their domestic strengths. Supporting national sectors and firms is essential to build domestic resilience and power. India's high-tech sector excels in developer talent and has a robust industrial manufacturing base. The US is a leader in AI and other emerging technologies, with deep integration into the defence sector and a robust data infrastructure. Both states pursue policies that combine–protect (e.g., the US CHIPS Act, India's data protection laws) and promote–partner approaches (e.g., the expanding ecosystem under the TRUST umbrella). National security is often used as the justification for protectionism, especially in emerging and essential technology and manufacturing fields. Every technology leader has an incentive to protect their innovation since diffusion erodes the developer's relative advantage compared to recipient co-users. For goods, foreign dependence creates potential supply-chain choke points; in networked systems, each platform (and user) is a potential point of security vulnerability that could allow adversary access.

For AI systems, the choice between partnership and protectionism involves supply chain risks for physical components as well as data, along with greater vulnerability from expanded access points. This risk is exacerbated by the possibility that (co-)developers and users could introduce unwanted examples into training data, leading to misapplied use. Applying the technology-human-procedural interoperability framework to overlap the promote-protect-partner emerging tech trilemma, any attempt at cooperative AI development must rest on a deeper level of trust and ethical alignment than in other sectors, given AI's learning function.

In the defence sector, incorporating AI into security platforms amplifies the risks already present in technology co-production or sale. As systems grow more complex and their numbers increase, buyer-seller relationships will become "stickier", driven by the benefits of large-scale compatibility and the rising defensive and economic costs of defection.

Arms sellers typically erect barriers to prevent buyers from mixing and matching across competitors. Developers/sellers fear that proliferation will erode the effectiveness gained by unique capabilities, and in networked systems, that links between their platforms and an adversary's could reveal vulnerabilities. Protectionists also raise the opportunity cost of buyer defection. In the US, unilateral restrictions span a wide range of technologies: both end items (e.g., night-vision devices) and dual-use components (e.g., AI chips) are blocked from export—or even personal transport abroad—to keep them from potential adversaries. Looking at the fears of networking, the US blocked the F-16 upgrade programme for India and Turkey following those countries' purchases of the Russian S-400 surface-to-air missile system.

The US's emerging TRUST ecosystem, which includes iCET and INDUS-X, demonstrates instead a plurilateral solution and a partnering approach to solving the technology advantage problem. TRUST's framework—which specifically names AI as a targeted field of integration—weds the US and India in co-production of dual-use and defence-focused technology and thus blurs the buyer-seller relationship. The stickiness of the relationship, however, not only exists but may even be deepened, as each state is intrinsically subject to the benefits of technological advantage and the risks of technological diffusion.

Implications for US-India Interoperability: Technology, Human, Procedure

Regarding the technological compatibility component of US-Indian interoperability, materiel alignment is underway. Unilateral protectionist initiatives have been either rolled back or eliminated in favour of partnering plurilateral approaches. US and US-allies' arms transfers to India are rising as Russia's taper; political leaders have endorsed joint research initiatives to expand co-capabilities; and the US has approved the sale and co-development of systems with key strategic technology.

By partnering in defence research, development, and production, and focusing on AI as a combat enabler, the US and India are directly addressing an interoperability gap and strengthening the ties between India and its fellow Quad members. For Australia and Japan, respectively the seventh- and eighth-largest arms importers in the world, the US is already the primary seller and defence partner; providing 75 percent of Australia's and 80 percent of Japan's materiel.[12] The upshot benefit of tightening the armament supply ecosystem in the Quad is a reduction in time- and resources-sapping friction in joint operations. In addition to addressing the technological component of commanders' ability to bring systems seamlessly into battle, shared development and procurement also enhance the human component of interoperability by streamlining combined operational execution.

Human interoperability is built on shared knowledge and trust—commanders' willingness as well as their ability to exercise combined power. Operating on the same systems can enhance this, but it is not a necessity. Observation, co-use, and repeated joint employment can build familiarity with equipment and confidence in operators. For US-India and Quad relations, the strongest indicators here are the expansion in number and scope of the joint and combined exercises in which the states take part.

Procedural congruity—the ethical and doctrinal approach militaries take in combat—is the final element needed to achieve the highest level of interoperability. On an AI-enabled battlefield, it underpins and reinforces the technological and human dimensions, making it both the starting and ending points of co-employment. A shared ethical foundation concerning when and how to use combat equipment becomes essential in systems that share data and learn from their operators and engagements. For India and the US, respect for the law of armed conflict and broader societal values on human rights form the ethical grounds of their military doctrines.

India

India's pivot towards the US and its allies for arms procurement seems a rational defence, economic, and political choice. The country gains access to systems with proven performance while hardening the US tilt towards India in the India-Pakistan balance. Although India's pivot away from Russian arms predates the invasion of Ukraine, it has been reinforced by Ukraine's success (using US- and NATO-supplied arms) against a larger, initially perceived technologically superior Russian force. China—a primary security concern for both India and the US—is building its own defence sector but still receives 78 percent of its imported arms from Russia. China, in turn, is the primary exporter of arms (80 percent) to Pakistan, reinforcing India's historic rival.[13] By increasing its share of US armaments that have proven successful in other conflicts and increasing its role in the research, development, and production of defence systems through INDUS-X and iCET, India gains increased access to and input in shaping systems to confront these neighbours.

Concerns also exist. India values geopolitical autonomy, and the deep technology sharing that AI may demand (especially with the US) could erode both the perception and practice of independence. Currently, India balances participation in US-led institutions such as the Quad and G7 with support for initiatives that challenge that order, including BRICS; it also joins calls for UN Security Council reform and expansion. In a multipolar world, closer partnership with the US and pursuit of broad, multisector technology integration might be seen as choosing sides, thereby reducing India's flexibility and market access to alternative courses of action.

The United States

For the US, partnership with India promises strategic, political, and economic benefits. India's demographic and geographic size and location, and its professionalised military (ranked fourth globally behind the US, Russia, and China are valuable assets against expanding Chinese influence.[14] The US-India roadmap targets naval cooperation, expanding port access and maintenance capacity in INDO-PACOM, and securing an interoperable partner to uphold freedom of navigation and maritime territorial rights against Chinese encroachment. Over two-thirds of their joint exercises are maritime-focused. India's active Chinese and Pakistani land borders, along with counterinsurgency missions, provide opportunities to collect, test, and train autonomous and AI systems. Additionally, economic complementarities between the US's advanced and India's developing economies also creates a dynamic, scalable base for industrial research and production.

For the US, risks reflect realpolitik concerns. Alliances build collective power but tend to erode individual advantage. The US's closest alliances (NATO, the US-Japan Alliance, and the US-Korea Alliance) were formed in the post-Second World War and early Cold War period. These were not equal partnerships but frameworks for US dominance: allies were disarmed (Japan) or encouraged to limit military investment (NATO, especially France and Germany) in exchange for US security guarantees. This historical model is now unpopular in the US and sets unrealistic expectations for senior-junior partnerships in security agreements. India, in contrast, has long pursued a flexible, independent foreign policy and is vocal about its ambition for increased regional and global influence. It stands to gain not only vis-à-vis China but also at Washington's expense. Neither country will accept an unequal partnership, and any perception of outsized influence could strain the trust and respect underpinning human interoperability.

Global Frameworks

Beyond technical and human expediency, US-India cooperation in AI will shape the normative frameworks governing this dual-use technology's security applications, both international and domestic. In addition to concerns about the blurring line between defence and offence, AI as a domestic tool risks eroding civil and human rights through overt or subtle means. Competitors are already setting precedents: Russia is advancing AI-enabled drone warfare in Ukraine, while China leverages technological gains to monitor advancements to track and control its population, consolidating Communist Party rule.

The Law of Armed Conflict and the Geneva Conventions establish rules for conflict regarding acceptable use of force, treatment, conduct of combatants, and protection of non-combatants. Yet applying these rules in practice is often contentious, and perceptions of compliance can complicate data-sharing and undermine interoperability. Accusations of violations have shadowed most participants, including the US in Iraq and Afghanistan, and India in border disputes with Pakistan and in counterinsurgency operations. The shift from conventional state conflict to insurgencies, non-state actors, and terrorist attacks has already blurred distinctions on acceptable targeting of personnel and infrastructure. Training AI for such conflicts—especially if authorised to conduct offensive actions autonomously—raises profound ethical challenges.

These ethical questions concerning the use of AI-enabled weapons must also consider the counterpoint of non-use in the face of an adversary equipped with a peer system. Automating target identification and engagement may appear morally dubious, yet so too, might withholding such capability when facing enemy AI-enabled firepower. If machine decision speed far exceeds human capacity, do commanders have an obligation to automate not only defence—generally considered acceptable use for automated systems—but to “defend forward” (a term often used to ameliorate offensive action) to help preserve lives within their own ranks? Disagreement in command opinion on this question could be another troubling ethical line for interoperable forces.

Domestically, democratic norms, respect for individual freedoms, and human rights are shared ethical pillars. Yet Freedom House identifies both the US and India as part of a global trend of democratic backsliding.[15] Despite falling scores, both still rank well above strategic competitors and fellow AI developers, Russia and China.[16] Research shows that AI replicates the racial and ethnic biases of the societies in which it operates, raising concerns about its role in sustaining societies committed to freedom and equality.[17] Failure of social structures and values at home could, in turn, undermine the human-trust and procedural-ethical foundations of US-India interoperability.

Echoing concerns raised at the United Nations, both American and Indian citizens support government and international regulation of AI to prevent misuse. This shared concern can be an important bulwark against the normative spread of autocratic states’ repressive strategies. In co-developing AI systems, the US and India should bear these competitors in mind while upholding their own ethical standards at home and abroad, or risk undermining interoperability and influence at operational and strategic levels.

Conclusion

The AI revolution will transform the security and defence sector, reshaping the cost-benefit landscape of interoperability, partnership, and alliance. For the US and India, an expanding partnership that includes targeted investment in AI and other emerging technologies alongside increased security cooperation is not only beneficial but may be essential to strategic goals such as countering Chinese expansion and reinforcing a rules-based system that values human and civil rights.

Although networking and AI integration amplify the risks and vulnerabilities of interoperability, they also magnify the benefits. Through arms sales, technology transfer and co-development, and joint exercises, the two states can strengthen technological, human, and procedural congruity—reducing costs, enhancing deterrence, boosting operational capacity, and shaping the norms that will govern the next technological era.

Endnotes

1 Headquarters, Department of the Army, *Army Regulation 34-1*, *Interoperability* (Washington, DC, Department of the Army, April 2020), https://armypubs.army.mil/epubs/dr_pubs/dr_a/pdf/web/arn19606_ar34-1_final.pdf.

2 United Nations Office of Disarmament, "Lethal Autonomous Weapons Systems," United Nations Office of Disarmament, https://disarmament.unoda.org/the-convention-on-certain-conventional-weapons/background-on-laws-in-the-ccw/.

3 "India-U.S.: Major Arms Transfers and Military Exercises," Congress Research Service, July 9, 2025, https://www.congress.gov/crs-product/IF12438.

4 Center for Strategic International Studies, *Staying Ahead in the Global Technology Race*, October 2024, Center for Strategic International Studies, 2024, https://features.csis.org/global-tech-race/.

5 The White House, "United States-India Joint Leader's Statement," February 13, 2025, https://www.whitehouse.gov/briefings-statements/2025/02/united-states-india-joint-leaders-statement/.

6 Stockholm International Peace Research Institute, "Arms Transfer Database," https://armstransfers.sipri.org/armstransfer/.

7 SIPRI, "Arms Transfer Database."

8 SIPRI, "Arms Transfer Database."

9 The White House, "Fact Sheet: The United States and India Committed to Strengthening Strategic Technology Partnership," January 6, 2025, https://bidenwhitehouse.archives.gov/briefing-room/statements-releases/2025/01/06/fact-sheet-the-united-states-and-india-committed-to-strengthening-strategic-technology-partnership/.

10 US Dept of Defense, "Roadmap for US-India Defense Industrial Cooperation," June 5, 2023, https://media.defense.gov/2023/jun/21/2003244834/-1/-1/0/roadmap-for-us-india-defense-industrial-cooperation-final.pdf.

11 The White House, "Fact Sheet."

12 SIPRI, "Arms Transfer Database."

13 SIPRI, "Arms Transfer Database."

14 Global Fire Power, "2025 Military Strength Ratings," https://www.globalfirepower.com/countries-listing.php.

15 Freedom House, "Freedom House 2025 Country Reports: USA, India," Freedom House, https://freedomhouse.org/explore-the-map?type=all&year=2025.

16 Freedom House, "Freedom House 2025 Country Reports: Russia and China."

17 "Racism and AI: Bias from the Past Leads to Bias in the Future," Office of the High Commissioner on Human Rights, July 30, 2024, https://www.ohchr.org/en/stories/2024/07/racism-and-ai-bias-past-leads-bias-future.

AI and Advanced Space Technologies: A Perspective on India-U.S. Collaboration

Mandeep Rai

Abstract

As the new space age, characterised by increased private involvement in space technologies, marks a decade of successes, India-United States (US) space collaboration stands at a prime position. Having demonstrated their excellence in space technology with Artificial Intelligence (AI) at the forefront, the two countries are forging symbiotic ties that could be a blueprint for other space-faring nations to follow. Recognising the importance of space in achieving economic, security and scientific objectives, India and the US are leveraging each other's strengths to build world-class AI research laboratories focused on space,

powered by dedicated AI infrastructure and talent, to become leading AI producers and not mere AI consumers. This article examines the prospective areas of collaboration in the space sector between the US and India, leveraging AI, based on their mutual strengths.

Introduction

Space is no longer a distant frontier restricted to scientific research; it has evolved into a leading sector shaping global security, economic progress, and technological innovation. The first objects to cross the Karman line—the imaginary line 100 km above sea level that separates the Earth's atmosphere from outer space—were the German-manufactured V2 rockets in 1934. However, what would be called the 'space age' would dawn some two decades later, in 1957, when the erstwhile Union of Soviet Socialist Republics (USSR) launched its first satellite (Sputnik 1), sparking off a space race between the US and the USSR which culminated with the US's Apollo moon landings, starting 1969.[1] Since then, space exploration has seen unprecedented growth and development, ushering in a new era of satellites and deep-space probes.

Both the US and India have developed mature space programmes and stand at the forefront of space usage, embracing Artificial Intelligence (AI) with shared interests and ambitions. For example, the US National Aeronautics and Space Administration (NASA) is applying AI across civil space missions, enhancing capacities in mission planning, autonomous navigation, and data analysis. Simultaneously, leading private players like SpaceX are deploying AI for next-generation launch and recovery missions like precision landing, in-orbit refuelling, and autonomous flight control. Meanwhile, downstream application companies like Maxar and Planet Labs are leveraging AI for applications for climate monitoring, disaster response, and geospatial intelligence. The AI adoption is also expanding in the fields of material science, pharmaceuticals, orbital assembly, and space tourism, reflecting a systemic evolution in the commercial space sector.[2]

In India, meanwhile, the Indian Space Research Organisation (ISRO) has integrated AI in deep-space missions, such as the widely lauded Chandrayaan-3 mission.[3] It is also harnessing AI for developing launch vehicles, spacecraft operations, Big Data analytics, and space robotics. The Indian private sector is increasingly adopting AI, with Dhruva Space integrating it into onboard systems,[4] TM2 Space launching the country's first AI space laboratory,[5] and AlphaMERS Ltd collaborating with ISRO to develop AI models for detecting marine pollution.[6]

In the coming years, their collaboration is bound to lead to further advancements in satellite technology and commercial space ventures. Advances in areas such as human spaceflight cooperation, Earth observation, lunar exploration, joint technological and expert exchanges in space situational awareness, and deepening space industrial ties are poised to reach new levels. AI-driven disruptions in the space domain are no longer a prospect but a certainty.

India's AI and Space Confluence

India has one of the fastest-growing space developer communities globally, accounting for 16 percent of the world's AI talent.[7] It has demonstrated momentum in the AI sector, with government-backed infrastructure under the INDIA-AI mission[8] delivering homegrown AI applications such as Hanooman[a,9] and Sarvam-1.[10] The Indian Space Policy 2023 stresses the need for international collaborations, both to build indigenous capability and to promote private sector participation in space.[11] These complementary trends in the space and AI sectors position India as an important player in steering the future of AI-driven space innovation.

The role of AI in India's space ecosystem is already tangible, having been effectively deployed for the 2023 Chandrayaan moon mission.[12] Partnerships were entered into with a number of private entities, especially academia and startups, to support the use of AI in launch vehicle optimisation, spacecraft autonomy, Big Data analytics, space robotics, earth observation, and space traffic management.[13] This was in keeping with the broader Indian agenda of enabling joint research and knowledge exchange between the private and government sectors, promoting technology transfer, and scaling the domestic space industry to new heights.

US Policy Directives Driving AI and Space Exploration

The US continues to lead in private sector investment in AI globally, accounting for 70 percent (around US$67 billion) of total global AI investment.[14] Its approach is underpinned by strategic policy frameworks that aim to deepen international cooperation in the space sector. Its 'Strategic Framework for Space Diplomacy',[15] released in May 2023, which builds upon its National Space Policy of 2020,[16] signals its commitment to forging space alliances with like-minded nations. In December 2023,[17] it issued further guidelines aimed at strengthening international space partnerships, with special directives to the US Space Force to broaden its global engagement. The US Space Force's 'Data and AI Strategic Action Plan 2024-25,[18] which sets out its international space strategy, has prioritised collaborative

---

[a] Hanooman and Sarvam are indigenously developed Large Language Models (LLMs) proficient in Indian languages with multimodal AI capability to generate text, speech, and videos. These are aimed at making AI affordable and accessible to both businesses and common people.

innovation with industry partners and international allies.[19] In line with this vision, US President Donald Trump's executive order of 23 January 2025[20] stressed ensuring ethical AI innovation, removing ideological bias in AI systems, advancing workforce development, and leveraging AI to enhance economic competitiveness and national security. In February 2025, during the official working visit of Indian Prime Minister Narendra Modi the US reaffirmed its commitment to space diplomacy by enhancing civil collaboration in space exploration, promoting the application of critical and emerging technologies, commercial space collaboration, sharing of expertise, and professional exchanges.[21]

Thus, mutual interests and cooperative mindsets align India and the US. Collaboration in space technology is also essential to their broader strategic alignment to counter China, especially in the Indo-Pacific region.

Current Trajectory of Bilateral Collaboration

Space cooperation between the US and India strengthened around 2005, when the two countries established their Civil Space Joint Working Group (CSJWG).[22] This cooperation has since matured under five strategic pillars: (a) the Artemis Accords,[23] (b) the India-US Defence Acceleration Ecosystem (Indus-X),[24] (c) the Transforming Relations Utilising Strategic Technologies (TRUST) initiative, (earlier known as the Initiative on Critical and Emerging Technologies (iCET)),[b] (d) enhanced defence cooperation, and (e) a strengthened relationship between NASA and ISRO.[25]

India signed the Artemis Accords to advance its lunar goals and future missions in space exploration. In May 2022, the US and India announced their iCET framework,[26] strengthening collaboration across civil, security, and commercial sectors; during PM Modi's US visit in February 2025,[27] iCET was rebranded as TRUST to advance cooperation in space as well.

---

[b] The Artemis Accords, formulated in 2020, set forth a set of principles to govern the civil exploration and use of space. So far, 55 countries, including India, have signed the Artemis Accords.
Indus-X seeks to advance defence and technological collaboration between India and the US.
The TRUST initiative (earlier called iCET) seeks to strengthen US-India civil space cooperation, as well as cooperation in other areas such as critical minerals, pharmaceuticals, semiconductors, and advanced materials.

An ISRO astronaut was part of the 14-day US-India mission to the International Space Station (ISS) aboard the Axiom-4 mission launched in June 2025.[28] A NASA-ISRO Synthetic Aperture Radar (NISAR) satellite is also scheduled for launch this year,[29] which will advance capacities in disaster management, climate change monitoring, and infrastructure assessment across the globe. A 'Space Innovation Bridge' has also been proposed under Indus-X to foster US-India startup partnerships in satellite technology and space situational awareness.[30] The growing US-India space cooperation in defence has deepened with India's participation in the US Space Command's Global Sentinel exercise,[31] and with the ongoing missile technology export reviews to support commercial satellite launches.[32]

Recommendations

Challenge Traditional Space Systems with Disruptive Innovation

Disruptive innovation in satellite imagery intelligence is reshaping the way nations observe and understand the Earth, and this transformation could be a key area for deeper US-India collaboration. As legacy monolithic satellite systems give way to agile constellations and AI-enhanced platforms, both countries are aptly positioned to co-develop next-generation earth observation (EO) technologies. The US strength in EO lies in advanced imaging payloads and analytics platforms. India brings in cost-effective satellite manufacturing and launch capabilities, demonstrated by the growing private space sector and ISRO's proven record in EO missions.

While it is understood that both nations are pushing for indigenisation through Atmanirbharta and MAGA, the critical aspect of IP (Intellectual Property) remains essential for effective cooperation. A selective IP sharing alliance can open avenues for co-development under trusted frameworks requiring IP localisation and co-ownership. Together, they can advance capabilities in hyper-spectral imaging and AI-driven geospatial intelligence for numerous uses including disaster monitoring, climate monitoring, urban planning, and regional security. Under the TRUST initiative, in the US, NASA, along with the Office of Space Commerce (OSC)[c] and the Department of State, can lead this partnership; in India, ISRO can be the principal actor, while the Indian National Space Promotion

---

c OSC (Office of Space Commerce) is responsible for fostering conditions for economic growth and technological advancements in the US commercial space industry.

and Authorisation Centre (IN-SPACe)[d] and Indian Space Association[e] (ISpA) serve as enablers for driving innovation through private entities. Such a partnership would promote technological synergy at its core while simultaneously advancing geopolitical alignment.

Collaborate Further on Innovation, Regulation and Research

The US and India should further leverage their combined strengths in AI, space exploration, and cutting-edge research. Fragmented AI research hinders progress; both nations should promote joint research initiatives, provide open data platforms, and develop shared solutions powered by AI. By creating collaborative international regulatory frameworks and advancing sustainable space operations, the US and India can lead responsible space exploration. A two-way alignment seems advantageous with academia, industry, and government accelerating AI together, while space diplomacy can address key challenges like space debris, cyber-security, and equal access to space resources. Through joint research, co-investment in AI-driven technologies, and the establishment of cross-national education programmes, both nations can integrate advanced AI into space missions, from autonomous satellite operations to real-time data analysis.

In India, the Indian Institute for Space Science and Technology (IIST) plays an important role in nurturing young space talent while premier institutions like the different Indian Institute of Technology (IITs) actively contribute to research activities. The US, for its part, advances its space research through the Jet Propulsion Laboratory at NASA, supported by space labs in leading universities like MIT, Caltech, and Stanford University to undertake cutting-edge R&D activities.

A collaborative programme under NASA and ISRO focusing on fusion of AI in space applications, commercial space innovation, and space diplomacy can serve as a foundation for the establishment of a Joint Space Innovation and Governance Institution that would nurture intellectual collaboration between faculty and students from both countries. It should be dedicated to advancing shared research goals in AI for the entire spectrum of space activities, breaking down traditional silos.

---

[d] IN-SPACe (Indian National Space Promotion and Authorisation Centre) is a single-window, autonomous agency in India under the DoS (Department of Space) for all space sector activities of private entities.

[e] ISpA (Indian Space Association) is an apex non-profit industry body for collaborative development of the private space industry, with the objective of enhancing international collaboration in space.

Regulate for Innovation, Craft Policies for Investment

The world is struggling to find the right balance between regulation and innovation of new technologies—this is also the case with the space sector. Although regulatory frameworks ensure safety and security of space activities, excessive restrictions can hinder innovation and stifle technological progress. The challenge lies in evolving adaptive regulations that promote continuous innovation, stimulate public and private sector investment, and ensure long-term sustainability. To drive AI adoption in space, the US and India could establish a Joint Strategy Board for specialised investment in IN-SPACe under the Department of Space (DoS), which could serve as a legal representative body for joint ventures and simplify space-related trade. The board could also work as a collaborative governance platform for the integration of AI in space, align "AI in space" policies, ensure their compliance, share best practices, and promote breakthrough innovation.

Build Partnerships for Resilient AI Hardware

The challenges posed to spacecraft semiconductors by the harsh space environment are significant. They include vibration, radiation and pyroshock, out-gassing of adhesives, plasma and photoelectric effects, resulting in malfunctions or even catastrophic failures.[33] While space-ready, radiation-hardened semiconductors have been developed which offer adequate resilience against space affects, their performance remains low compared to the semiconductors in regular commercial use, thus restricting the deployment of cutting-edge AI frameworks. In India, ISRO and the Semi-Conductor Laboratory (SCL)[f] have unveiled the VIKRAM3201 and KALPANA3201[34] microprocessors for space applications which, though seemingly outdated for commercial computing, are said to be highly reliable for space missions. A critical design trade-off remains between high transistor density for commercial computing and ensuring radiation resilience; space semiconductors need to be larger than commercial ones.

In the US, NASA's Planetary Decadal Study has outlined a roadmap for space exploration, emphasising the need for more computational and autonomous power for future missions.[35] To address this, NASA's High Performance Spaceflight Computing (HPCS) project has developed a radiation-hardened 64-bit system on chip[g] for enabling AI at the

---

[f] An autonomous body under the Ministry of Electronics and Information Technology.

[g] A system on chip is a complete electronic system fused on a single integrated circuit. These are prevalent in modern electronic devices including smartphones, laptops, and IoT devices due to reduced size, and low cost and power consumption.

edge in human exploration missions.[36] Meta and Booz Allen have partnered with Nvidia and HPE on the Space Llama AI programme,[h] to deploy open-source AI model Llama in space.[37]

The 'new space' community is increasingly open to deploying low-cost commercial off-the-shelf (COTS) space equipment that leverages cutting-edge technologies. This presents an opportunity for US-India collaboration in component manufacturing for commercial space launchers with a balanced risk-to-cost ratio, with IP considerations addressed jointly by both countries in a mutually beneficial manner. Combining radiation-hardened functional bases with the latest COTS technologies could enable a hybrid implementation, integrating a COTS GPU in small satellites for high-speed processing. While the COTS GPU alone cannot mitigate radiation effects, it can be safeguarded by a radiation-hardened device, ensuring functionality even in the face of radiation-induced disturbances.[38,39]

Develop AI-enabled VLEO Satellites

Satellites operating in the Very Low Earth Orbit (VLEO), below the 200-km range, have transformative potential to enhance sensing and communication capabilities in reducing the cost of modelling, agriculture, mapping, Internet of Things (IoT) integration, hyper-spectral imagery analysis, and 6G communications.[40] VLEO satellites have inherent advantages of reduced radiation effects and space debris risks, making them a safer and cost-effective alternative to higher orbits, with launch costs reduced by 10-50 percent and observation/communication capabilities increased by 2-4 percent.[41] Companies like Redwire Space and Skeyeon in the US,[42] alongside ISRO in India, are making strides in air-breathing electric propulsion systems, which utilise rarefied atmospheric air instead of propellant to stabilise satellites against atmospheric drag. Indian start-up Bellatrix is also working in this emerging sector.[43] India and the US could thus collaborate on using AI for modelling complex fluid dynamics and molecular interactions that were computationally challenging with traditional methods; they could together work on applying Machine Learning (ML) to design intake geometries, thereby optimising fuel usage, and predicting wear and tear from exposure to atomic oxygen.

---

[h] Space Llama is a custom-tailored AI language model that works without internet access on ISS. It enables astronauts to solve mission-critical problems faster with the help of advanced AI in austere and disconnected environments.

Harness Future Technologies

The space sector is set to be revolutionised with the use of advanced technologies such as Quantum Computing, Edge AI, and AI-driven autonomous systems. The following are some of the upcoming technologies that present opportunities for India-US collaboration:

(i) Agentic AI

Agentic AI,[i] churning out large volumes of data in real time, can enable spacecraft to make intelligent decisions. Deep-space research can benefit from very Large Language Models (LLMs) deployed onboard, interpreting complex astronomical data. Similarly, very Small Models can be used to introduce sophisticated AI capabilities on platforms such as CubeSat[j] and VLEO satellites. Advances in near infinite memory would enable retention of operational history and adaptive learning during long-distance missions.[44] Moreover, human-in-the-loop augmentation[k] will remain an essential component for mission control payload analysis, thereby ensuring transparency and trust.

(ii) Quantum Computing, Edge AI and AI-powered Cyber Frameworks.

Big leaps in quantum computing will unlock unprecedented processing capabilities, which will help in threat detection, predictive analytics, and secure communications. Simultaneously, deploying Edge AI can ensure decentralised decision-making aboard satellites and space stations. Autonomous AI systems are set to expand possibilities in enabling maintenance, debris removal, and protection of space assets with minimal human intervention. To ensure space systems' safety and protection against cyber threats, AI-powered cyber security frameworks can serve as the first line of defence, ensuring the integrity and resilience of critical space infrastructure.

---

i Agentic AI, as distinct from the simpler generative AI, uses sophisticated reasoning and planning to solve complex, multi-dimensional problems.

j CubeSat is a class of satellite with a small form factor of 10 cm cubes with mass between 1-12 Kgs. These are launched alongside larger space craft for education, technical and scientific purposes.

k 'Human in the Loop' is a collaborative approach integrating human expertise into the lifecycle of AI/ML systems. It aims at enhancing the accuracy, reliability and adaptability of systems harnessing unique capabilities of both.

(iii) Digital Twins, Blockchain and Neuromorphic Computing[i]

AI-powered digital twins offer sophisticated simulation environments for predictive analytics, enabling identification of vulnerabilities, context-based mission training, and proactive risk mitigation. The confluence of AI and blockchain technologies can bolster more secure satellite communications through decentralised, tamper-proof data exchanges, offering robust protection for military and governmental assets against cyber threats. Lastly, the advent of neuromorphic computing that emulates the neural architecture of the human brain,[45] promises to enhance the energy efficiency and real-time processing capabilities of AI systems in space, transforming autonomous space functions and ensuring adaptive space operations in the years ahead.

Conclusion

India and the US must leverage each other's strengths to build world-class AI research labs focused on space data, powered by compute infrastructure and talent. Owing to its advanced space programme, its thriving digital economy, its large workforce, and rich data resources, India is uniquely positioned to take forward the scaling of AI in space. The US too, has private sector innovation, research apparatus, and state-of-the-art infrastructure for cutting-edge AI development.

A dedicated AI-first roadmap aligned with economic growth, envisioning AI as a national asset rather than a standalone industry, is needed for both countries. From India's perspective, the current focus of collaboration through the avenues of TRUST, INDUS-X, and open FDI, along with government support for the commercial sector will contribute to fulfilling its aim of *Viskit Bharat* by 2040. For the US, partnering with India offers a strategic avenue to keep China's regional hegemony in check, and to diversify its critical technology supply chain in line with its space and geopolitical ambitions.

---

i 'Digital twins' refers to a virtual/digital representation of a real-world system designed to represent a physical object accurately. It covers the entire lifecycle of a system, from real-time data inputs, simulation, and machine learning, to reasoning for decision-making.

Endnotes

1 Mikko Punnala Arto Ojala, Santeri Punnala and Heidi Kuusniemi, "The Space Economy: Review of the Current Status and Future Prospects," in *Space Economy*, ed. A. Ojala and W.W. Baber, (Singapore: Palgrave Macmillan, 2024), 10.1007/978-981-97-3430-6_2.

2 Timothy Papandreou, "AI Is Unlocking the Multi-Trillion Dollar Space Economy," *Forbes*, August 1, 2024.

3 "Over the Last Three Years, ISRO Has Been Steadily Leveraging AI in Its Key Programmatic Areas," PIB Delhi, August 3, 2023.

4 Amoha Basrur, "AI in Space Operations: Opportunities and Challenges," *Hindustan Times*, June 6, 2025.

5 "Hyd's TakeMe2Space Secures Rs 5.5 Crore in Pre-Seed Funding to Launch India's First AI Laboratory in Space," *The Times of India*, July 4, 2024.

6 "Bengaluru Firm Ties Up with ISRO to Develop AI Model to Identify and Profile Marine Pollution," *The Hindu*, August 28, 2024.

7 Bain & Company, "From Buzz to Reality: The Accelerating Pace of AI in India," June 20, 2023.

8 Digital India Corporation, *IndiaAI: The National AI* Portal of India, https://indiaai.gov.in.

9 Hanooman AI, *Hanooman: India's Multilingual GenAI Platform*, https://hanooman.ai.

10 Sarvam AI, "Introducing Sarvam-1: India's First Open Source Indic Language Model," *Sarvam AI Blog*, December 14, 2023, https://www.sarvam.ai/blogs/sarvam-1.

11 Department of Space, Government of India, *Indian Space Policy 2023* (Bengaluru: Indian Space Research Organisation, 2023), https://www.isro.gov.in/media_isro/pdf/IndianSpacePolicy2023.pdf.

12 NASSCOM Community, "The Brainpower behind Chandrayaan-3: Data Analytics and AI Take the Lead," NASSCOM Community, https://community.nasscom.in/communities/analytics/brainpower-behind-chandrayaan-3-data-analytics-ai-take-lead.

13 Indian Space Research Organisation, "POEM-4 Payloads," https://www.isro.gov.in/POEM_4_Payloads_spadex.html.

14 All India Radio, "India Ranks 10th with $1.4 Billion Private Investment in AI," *NewsOnAir*, April 3, 2024, https://www.newsonair.gov.in/india-ranks-10th-with-1-4-billion-private-investment-in-ai-un/#:~:text=The%20US%20leads%20the%20world,position%2C%20with%201.4%20billion%20dollars.

15 U.S. Department of State, "U.S.-India Space Framework: A New Era of Cooperation," May 2023, https://www.state.gov/wp-content/uploads/2023/05/Space-Framework-Clean-2-May-2023-Final-Updated-Accessible-5.25.2023.pdf.

16 U.S. Federal Register, "The National Space Policy," December 16, 2020, https://www.federalregister.gov/documents/2020/12/16/2020-27892/the-national-space-policy.

17 The White House, "Fact Sheet: Strengthening U.S. International Space Partnerships," December 20, 2023, https://bidenwhitehouse.archives.gov/briefing-room/statements-releases/2023/12/20/fact-sheet-strengthening-u-s-international-space-partnerships/.

18 United States Space Force, "Data and Artificial Intelligence FY2025 Strategic Action Plan," https://www.spaceforce.mil/Portals/2/Documents/SAF_2025/USSF_Data_and_AI_FY2025_Strategic_Action_Plan.pdf.

19 Sandra Erwin, "Space Force to Roll Out Strategy for International Collaboration," *SpaceNews,* April 9, 2024, https://spacenews.com/space-force-to-roll-out-strategy-for-international-collaboration/#:~:text=The%20Space%20Force's%20effort%20to,critical%20for%20communications%2C%20intelligence%20gathering.

20 The White House, "Removing Barriers to American Leadership in Artificial Intelligence," January 2025, https://www.whitehouse.gov/presidential-actions/2025/01/removing-barriers-to-american-leadership-in-artificial-intelligence/.

21 The White House, "United States–India Joint Leaders' Statement," *Briefings and Statements,* February 13, 2025.

22 Geospatial World., "Indo-US Space Cooperation," *Geospatial World*, 2025, https://geospatialworld.net/prime/special-features/indo-us-space-cooperation/.

23 Mike Wall, "Artemis Accords: What Are They and Who Has Signed On?," *Space.com*, October 13, 2022, https://www.space.com/artemis-accords-explained.

24 Ministry of Defence, Government of India, Innovations for Defence Excellence, "INDUS-X," https://idex.gov.in/indus_x.

25 Ministry of External Affairs, Government of India, *India–USA Bilateral Relations*, https://www.mea.gov.in/Portal/ForeignRelation/US_Bilateral_Brief_0125.pdf.

26 U.S. Embassy & Consulates in India, "Fact Sheet: United States and India Elevate Strategic Partnership with the Initiative on Critical and Emerging Technology (iCET)," U.S. Embassy & Consulates in India, https://in.usembassy.gov/fact-sheet-united-states-and-india-elevate-strategic-partnership-with-the-initiative-on-critical-and-emerging-technology-icet/.

27 Ministry of Information and Broadcasting, Government of India, https://pib.gov.in/PressReleaseIframePage.aspx?PRID=2103037.

28 "Axiom-4: Shubhanshu Shukla Launch Details & Updates, June 25," *The Hindu*, June 25, 2025, https://www.thehindu.com/sci-tech/science/axiom-4-shubanshu-shukla-launch-details-updates-june-25/article69734764.ece.

29 NASA Jet Propulsion Laboratory, "NASA-ISRO Synthetic Aperture Radar (NISAR)," https://nisar.jpl.nasa.gov/.

30 "One Year of the INDUS-X: Defense Innovation Between India and the US," Carnegie Endowment for International Peace, June 2024, https://carnegieendowment.org/research/2024/06/one-year-of-the-indus-x-defense-innovation-between-india-and-the-us?lang=en.

31 U.S. Space Force, "U.S. Space Command Hosts Global Sentinel 2025 Exercise," April 24, 2025, https://www.vandenberg.spaceforce.mil/News/Article-Display/Article/4175650/us-space-command-hosts-global-sentinel-2025-exercise/.

32 The White House, "Fact Sheet: The United States and India Advance Growing Space Partnership," December 18, 2024, https://bidenwhitehouse.archives.gov/briefing-room/statements-releases/2024/12/18/fact-sheet-the-united-states-and-india-advance-growing-space-partnership/.

33 Nigel Charig, "Spacecraft Design: Redefining Quality for the New Frontier," *Power & Beyond*, May 14, 2024, https://www.power-and-beyond.com/spacecraft-design-redefining-quality-for-the-new-frontier-a-e850f8cc81171e16a25d74af789cc887/.

34 Sibu Kumar Tripathi, “Vikram and Kalpana: ISRO Develops High-Speed Microprocessors for Space Missions,” *India Today*, March 18, 2025, https://www.indiatoday.in/science/story/vikram-and-kalpana-isro-develops-high-speed-microprocessors-for-space-missions-2694875-2025-03-18.

35 NASA, “Decadal Survey,” NASA Science: Earth Science, https://science.nasa.gov/earth-science/decadal-surveys/.

36 NASA, “High Performance Spaceflight Computing (HPSC),” https://www.nasa.gov/game-changing-development-projects/high-performance-spaceflight-computing-hpsc/.

37 Catherine Clifford, “AI in Space: Meta’s LLaMA Model Aboard the ISS with Booz Allen,” *CNBC*, April 25, 2025, https://www.cnbc.com/2025/04/25/ai-space-meta-llama-iss-booz-allen.html.

38 John Keller, “Radiation-Hardened Space Electronics Enter the Multi-Core Era,” Military & Aerospace Electronics, June 21, 2017, https://www.militaryaerospace.com/computers/article/16709760/radiation-hardened-space-electronics-enter-the-multi-core-era.

39 Xun Jiang et al., “Long Term Memory: The Foundation of AI Self-Evolution,” arXiv, 2025, https://arxiv.org/abs/2410.15665.

40 Jonathan O’Callaghan, “Sky Skimmers: The Race to Send Satellites into Very Low Earth Orbits,” *BBC Future*, February 9, 2025, https://www.bbc.com/future/article/20250207-sky-skimmers-the-race-to-send-satellites-into-very-low-earth-orbits.

41 Space Ambition, “The New Space Frontier: Why VLEO Is an Emerging Trend,” *Space Ambition*, December 2024, https://spaceambition.substack.com/p/the-new-space-frontier-why-vleo-is.

42 Adithya Kothandhapani, “VLEO: The Not-so-Virgin Orbital Regime,” *Adithya Pani*, https://adithyapani.substack.com/p/vleo-the-not-so-virgin-orbital-regime.

43 Edd Gent, “Indian Startup Plans to Build Ultra-Low Orbit Satellite,” IEEE Spectrum, October 3, 2024, https://spectrum.ieee.org/low-earth-orbit-satellite-india.

44 Lars Kunze, Nick Hawes, Tom Duckett, Marc Hanheide, and Tomáš Krajník, “Artificial Intelligence for Long-Term Robot Autonomy: A Survey,” arXiv, 2018, https://arxiv.org/abs/1807.05196.

45 Rajesh Malviya, Ramanakar Danda, Kiran Maguluri, Vinod Kumar, “Nanotechnology Perceptions Neuromorphic Computing: Advancing Energy-Efficient AI Systems through Brain-Inspired Architectures,” *Nanotechnology Perceptions* 20, 2024: 1548-1564. 10.62441/nano-ntp.vi.2974.

Exploring the Symbiotic Relationship Between Open Transaction Networks and AI

Neeraj Jain

Abstract

This article examines the symbiotic relationship between Open Transaction Networks (OTNs) and Artificial Intelligence (AI) in transforming digital commerce. Through conceptual analysis, a three-stage evolutionary framework is outlined wherein OTNs evolve from current basic interoperable protocols to AI-embedded, cross-border commerce networks. AI can enhance OTN accessibility through multilingual interfaces and personalisation, while OTNs provide consent-based real-world data that reduces algorithmic bias in AI models. The convergence of Agentic AI with OTNs enables transaction management and self-

managed ecosystems that democratise commerce, particularly benefiting underserved populations and small businesses. This symbiotic relationship requires robust governance frameworks and stakeholder collaboration to ensure inclusive, scalable digital commerce transformation while maintaining accountability in AI-enabled networks. Ultimately, the convergence of OTNs and AI promises to foster innovation, improve operational efficiency, and support scalable, equitable digital ecosystems worldwide.

Introduction

Digital economies around the world are undergoing a paradigm shift, moving away from centralised, monolithic platforms towards decentralised and interoperable networks that prioritise inclusivity, innovation, and scalability. At the forefront of this transformation are open transaction networks (OTNs), a set of open and interoperable frameworks powering transaction networks like India's Open Network for Digital Commerce (ONDC), Digital Energy Grid,[1] Open Agri Net,[2] Pix,[3] and similar initiatives across the globe. Some OTNs are fully operational (e.g., ONDC, Unified Energy Interface), while others are in the conceptual or pilot stages.

The evolution of OTNs can be visualised in three stages:

- **Stage 1 - Early Evolution:** The present stage is one in which early networks are evolving in a manner where established e-commerce transaction modes are interwoven with open protocols for the boundary-less flow of transaction data.
- **Stage 2 - OTNs Embedded with Agentic AI:** Coinciding with the evolution of Stage 1, Agentic AI has emerged as a major proposition for the future of transactions. Stage 2 is one in which OTNs within countries are getting increasingly embedded with Agentic AI and the use of AI to accelerate OTN adoption.
- **Stage 3 - Cross-Border Integration of Agentic AI–Enabled OTNs:** Stage 3 can be visualised as being the evolution of cross-border OTNs with embedded Agentic AI. It is, however, likely that in the case of certain digitally advanced countries (e.g., India and Singapore) or closely integrated trading unions (such as the ASEAN or the EU), Stage 2 and Stage 3 may evolve in an overlapping manner.

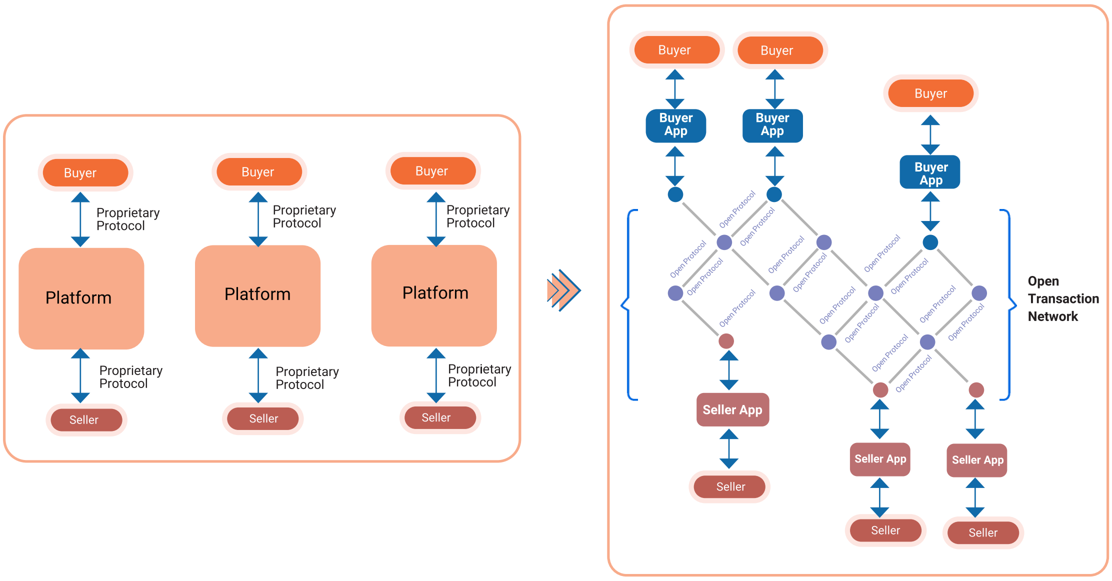
OTNs generate rich and transparent datasets that can be leveraged to refine underlying AI models, helping reduce biases and optimise performance. AI enhances the accessibility and inclusivity of open networks, while OTNs provide real-world data that strengthens AI models. This article examines the mutually reinforcing relationship between AI and OTNs.

When enhanced with AI, OTNs hold tremendous potential to democratise commerce, improve operational efficiencies, and foster innovation across the value chain. Through AI integration, the open network enables self-managed, purpose-centric ecosystems (designed for defined use cases) that distribute costs and risks while fostering rapid scalability. 'Self-managed', in this context, refers to the network's ability to adaptively coordinate actors and resources, balancing autonomy and collective outcomes without requiring top-down management.

Understanding Open Transaction Networks in Digital Commerce

Conceptually, OTNs mirror foundational protocols like SMTP/IMAP for email and HTTP for the web, providing universal standards for value exchange.[4] They represent a fundamental shift from the current platform-centric model, which confines transactions to closed ecosystems. They establish an open, interoperable network that enables buyers and sellers to transact seamlessly regardless of their chosen platform for digital presence and commerce (Figure 1). This architecture is premised on decentralisation and openness.

Figure 1: An Illustrative Decentralised Network



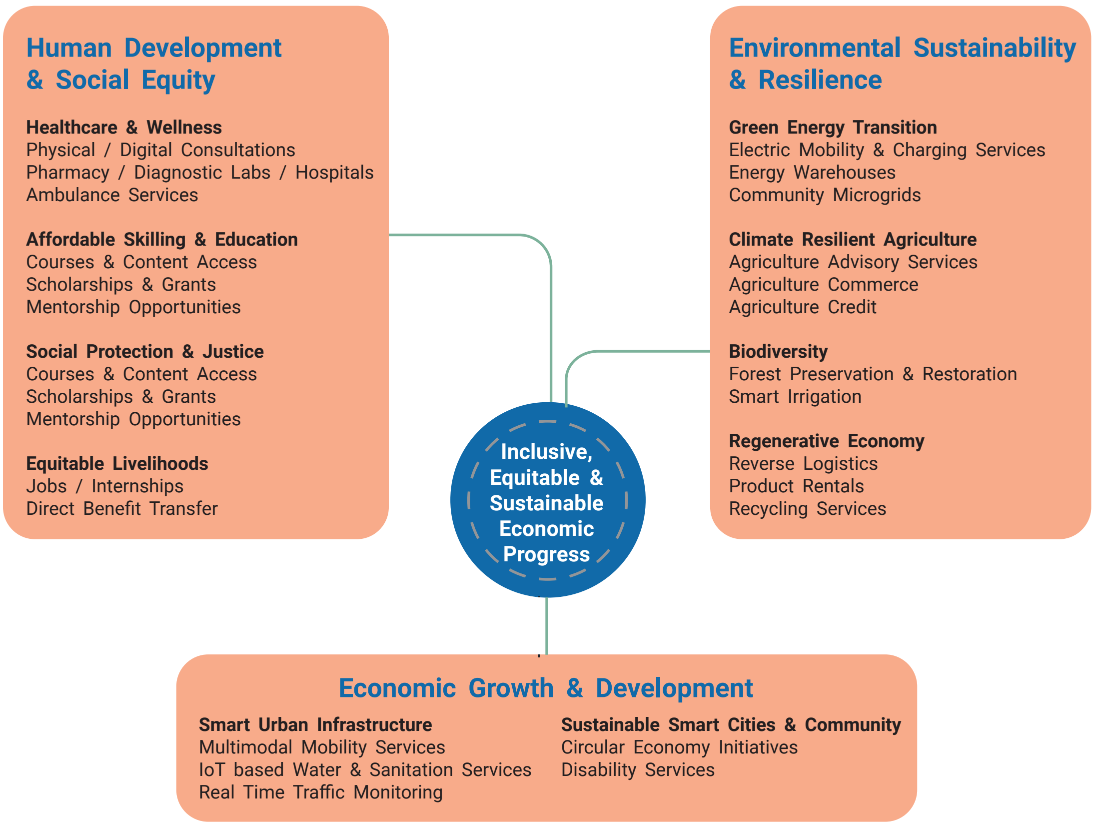
Source: Adapted from Beckn Protocol documentation[5]

OTNs foster innovation and competition by ensuring that no single entity holds disproportionate influence over the market. Any product or service that can be catalogued, or a combination that falls within the purview of digital commerce, can be transacted on an OTN.

In essence, open networks exhibit the following features:

- Interoperability: Standardised protocols enabling diverse systems to communicate seamlessly
- Decentralisation: Reduced reliance on central intermediaries or dominant platforms
- Open Protocols: Publicly available specifications that allow anyone to build compatible solutions
- Network Effects: Its value increases with each new organisation, large or small, joining the ecosystem, amplifying collective benefits.

Figure 2: Use Cases of OTNs



Source: Center for Trustworthy Technology, Augmenting the Global Digital Economy through Open Transaction Networks.

A range of OTNs are emerging; some of which are focused on specific sectors such as agriculture[6] or energy,[7] while others span multiple domains to address unique local challenges and promote inclusive digital participation. While individual OTNs are internally interoperable (i.e., participants within a given OTN can transact seamlessly), cross-domain and cross-border interoperability is a work in progress. As standards mature and OTNs achieve interoperability across national boundaries, they can unlock substantial economic value through seamless, protocol-based trade and collaboration—especially for Medium, Small and Micro Enterprises (MSMEs) that are currently excluded from cross-border markets due to cost, complexity, and a lack of visibility.

OTNs are inherently designed to prioritise universal inclusivity and accessibility, ensuring equitable service delivery to all residents, including those in the most remote and underserved communities. AI serves as a critical enabler in this endeavour by addressing linguistic divides through vernacular language support. Beyond mere translation, AI's advanced reasoning capabilities dynamically generate contextually relevant insights, thereby reducing information asymmetry and empowering users with actionable, localised knowledge. This synergy aligns well with the principles of universal access and social inclusion.

The AI-Driven Acceleration of OTNs' Growth and Efficacy

The penetration of digital commerce in most countries, especially in the Global South,[8] remains in the low single digits despite widespread connectivity, smartphone adoption, and a young, aspirational population. Language is the key barrier in its uptake[9] (e.g., in India, each state has its own language), along with varying levels of digital literacy, the unavailability of digital interfaces in local languages, and information asymmetry.

Digital commerce has a big value chain, and different types of AI provide diverse advantages as AI has evolved from Predictive to Generative, and ultimately Agentic AI. Predictive AI analyses historical data to forecast future outcomes, such as predicting customer purchasing behaviour or demand trends. In digital commerce, this capability leads to improved inventory management and personalised marketing strategies that can increase sales and reduce waste. Generative AI (Gen AI) creates new transformation opportunities like catalogue creation, images, or chat responses based on learnt patterns. It can enhance customer engagement through personalised content, automate content creation, and improve overall user experience. Agentic AI is evolving rapidly through multi-modal capabilities that can autonomously make decisions and execute a wide range of actions, such as searching through various data sources, breaking down complex tasks into multiple workstreams and synthesising their results into conversational responses. These responses can range from providing personalised recommendations to automating end-to-end customer service responses.

AI interventions can improve efficiencies for both buyers and sellers:

- **Buyer's Side - Multi-modal Multi-language Interface:** Voice-enabled buyer apps and chat platforms like WhatsApp, Instant Messenger, or Instagram, powered by technologies such as real-time translation, transliteration, automatic speech recognition, text-to-speech and speech-to-text, can support natural language interactions across various national and international languages. The buyer will be able to complete transactions from search to payment and post-order transactions with a hybrid option of voice, text, visual, and even gestures for specific use-cases. The buyer would have the flexibility to switch among the different inputs seamlessly. Contextualised search will be enabled in regional languages and dialects. In this case, the product and service description will be in a similar dialect, assisting the buyer in making informed choices. The conversation between the buyer and the buyer app would support multi-lingual interaction, e.g., Hindi-to-English and French-to-English, making the interaction more natural and realistic.
- **Buyer's Side - Personalisation and Recommendation Engine:** Agentic AI can facilitate personalisation for buyers and sellers based on the user's interaction history. Better personalisation can help with up-selling and cross-selling of products and services while also adhering to data privacy regulations of the respective country. With Agentic AI, personalised assistance at scale becomes possible, allowing systems to understand each user's tastes, choices, buying patterns, and history, moving beyond generic cohort-based recommendations.
- **Buyer's Side - Ensuring Trust and Authenticity in Ratings and Reviews:** Ascertaining authentic reviews and ratings has been a perennial challenge with digital commerce. AI features can help detect fake reviews by using a combination of techniques, including Natural Language Processing (NLP). AI Agents are now capable of examining reviews for fraudulent patterns, such as extreme sentiments, repetitive phrases, generic language, keyword stuffing, or duplicated content.
- **Seller's Side - Catalogue Creation and Management:** One of the bottlenecks for small businesses, nano entrepreneurs, and artisans has been creating good quality catalogues of their products and services that comply with legal metrology standards while providing a compelling experience for buyers. By leveraging computer vision AI models, small businesses can create professional-grade catalogues with user-friendly tools in a short span of time. AI-driven cataloguing can help standardise

product experience by ensuring compliance, correctness, and completeness of the information, thereby reducing errors and inconsistencies in listings. This can further opportunities to create AI agents that learn from the catalogue data.

- **Seller's Side - Risk Assessment Models:** The rich transaction data could enable better approaches to business risk assessment. Financial institutions could develop better lending models based on actual business performance rather than traditional metrics, or use alternative data to construct underwriting algorithms. This could transform small businesses that lack a verifiable credit history, enabling them to access loans at market rates. By making data-driven decision-making accessible to millions of small businesses, this could help unlock the efficiency and growth potential of the country's vast informal sector.

Agentic AI and OTNs: The Next Big Leap in Digital Commerce

The convergence of decentralised OTNs and agentic AI[10] represents a paradigm shift that can help countries leapfrog to widespread digital commerce inclusion. OTNs provide the open "rails" that allow disparate digital platforms to communicate and transact in a standardised, machine-readable language. Agentic AI acts as the intelligent "engine", creating unprecedented opportunities for scale, innovation, and equity. When Agentic AI operates on open network rails, the result is a self-managed, intelligent ecosystem. AI agents can autonomously discover services, negotiate terms, manage transactions, and orchestrate complex workflows across multiple providers, creating massive value for both consumers and sellers. This combination transcends simple automation, leading to intelligent, goal-oriented orchestration within a truly decentralised framework.

Agentic AI transactions can be broadly classified into two categories based on their impact and risk:

- **Informational Transactions:** These are read-only operations that do not change the system's state and are considered low risk. The retrieval of information is one such task.
- **Actionable Transactions:** These transactions involve changes to the system's state or the transfer of value, carrying a higher risk. Such transactions must undergo a rigorous process involving intent capture, consent validation, and audit logging to ensure transparency and accountability.

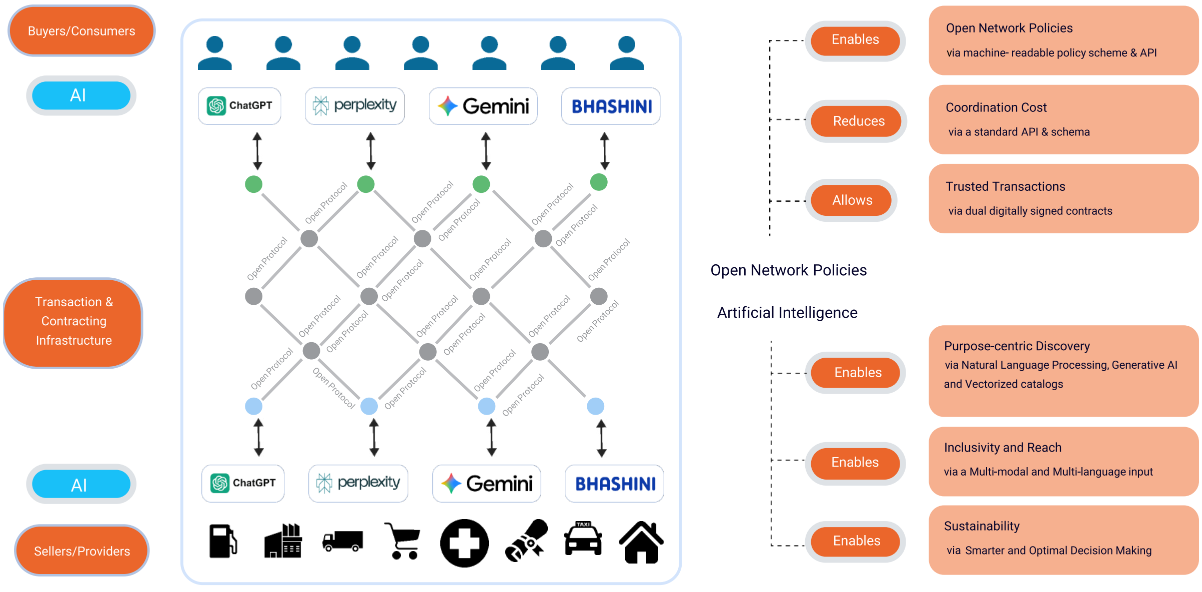
The appropriate classification of the above transactions into various interaction modes between humans, AI agents, and underlying transactional systems is crucial for designing secure and effective AI integrations within OTNs. These interactions can be categorised as follows:

- **Human ⟶ AI Agent (Informational):** In this mode, users query the AI for data, and the AI provides an answer. A typical example is asking, "What's my order status?".
- **Human ⟶ AI Agent (Transactional):** Users instruct the AI agent to perform actions. Example: "Order groceries for this week", where the AI processes the purchase transaction.
- **AI Agent ↔ AI Agent:** Two AI services coordinate to fulfil complex requests. For example, an inventory management AI communicates with a payment processing AI to complete a purchase when stock is confirmed available.
- **AI Agent ⟶ Human:** In this scenario, AI confirms or seeks clarification from the human user. Example: "Price has increased by 5 percent since you started checkout—proceed with purchase?"
- **AI Agent -> Robot:** AI agents coordinate with automated warehouse systems (robots), instructing robotic systems to pick, pack, and ship items based on purchase orders.

Training AI agents on open transaction protocols (such as the Beckn Protocol) equips them with a native, machine-level understanding of commercial concepts. Organisations and developers can achieve this by leveraging standardised protocol documentation, API specifications, and established transaction patterns. Once trained, AI agents move beyond simple recognition to actionable comprehension, developing a shared understanding of key commercial functions such as buying, selling, pricing, and fulfilment. This shared 'transaction language' can then be translated in real-time into concrete, executable, traceable, and trusted micro-contracts—standardised, legally binding digital agreements that define the terms of a transaction. Such contracts can be generated and finalised instantly ("on the fly")[11] between any two AI agents operating across the network.

The following is a pictorial representation of the above concept and the advantages of AI and OTN in the transaction. AI brings in inclusivity and reach, as the buyer can speak in their own native language without having to understand technical protocols.

Figure 3 : Conversational AI Enhancing the OTNs with Accessibility and Inclusivity



*All logos are for illustrative purposes only. Not a representation of actual fact

Source: Adapted from Beckn Protocol documentation[12]

As AI advances, the future interaction layer will be form-factor agnostic, allowing agents to adapt to evolving consumer requirements. Rather than traditional commerce platforms disappearing entirely, they are likely to integrate AI capabilities and interoperate through open protocols. For example, a gamer will be able to place an order on gaming consoles without switching to a food app, or a driver will be able to place orders through voice-based commands to their car's infotainment system.

Countries that invest in "AI-ready" OTNs—meaning OTN infrastructures designed with AI integration capabilities, appropriate APIs, and governance frameworks—can ensure that AI serves the public interest while driving innovation. Examples include India's ONDC, Brazil's Pix, and emerging frameworks in Southeast Asia. However, challenges such as training costs, inference costs, data privacy, governance, transparency, fairness, and the time taken for market maturation must be addressed collaboratively by AI service providers and policymakers to ensure inclusivity and accessibility without compromising consumer rights.

Modern AI systems represent a shift from deterministic, rule-based technologies toward probabilistic, learning-based approaches. This evolution requires robust frameworks for accuracy (models that perform well on intended tasks), reliability (consistent performance across different conditions), fairness (equitable treatment across different population groups), and transparency (explainable decision-making processes). Rather than viewing AI as unpredictable, implementing the appropriate governance structures that account for its probabilistic nature while maintaining trust and accountability is key. These principles are increasingly codified in emerging AI governance frameworks and international standards for responsible AI development.

Symbiotic Relationship Between AI and OTNs

Real-world data is a key input for modern AI systems, and OTNs have the unique potential to enhance its availability. Currently, there are substantial concerns that large language models rely heavily on synthetic data[13] for extensive training, which poses significant risks to model reliability and may lead to performance degradation or collapse. OTNs like digital ID and digital payment collect large amounts of data from buyers and sellers after obtaining informed consent.[a] This ethically sourced, consent-based data can significantly enhance the training and post-training data of frontier AI models by providing diverse, real-world inputs. Unlike synthetic data, which risks compounding inaccuracies or biases, human-generated data from OTNs is grounded in actual behaviour and transactions. As a result, OTNs can help overcome the "data walls"[14] on AI development, enabling the creation of more accurate, robust, and inclusive frontier AI systems.

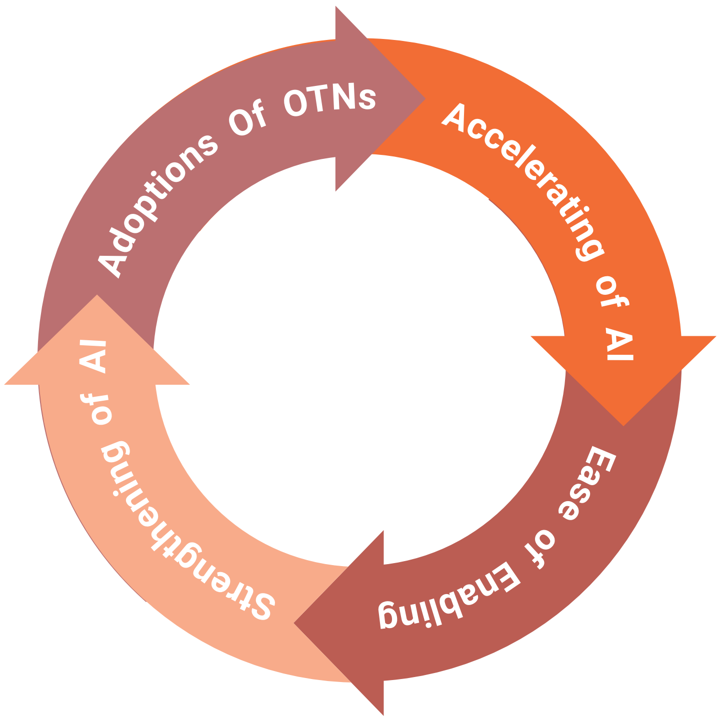
Over a period of time, OTNs can provide structured and standardised data that could potentially lead to significant gains in model performance. However, they address a deeper systemic issue in AI development beyond data standardisation-'algorithmic bias',[15] one of the key impediments to building trust. OTNs can help reduce algorithmic bias through several mechanisms: (1) by including more diverse populations in training datasets through their inclusive design, (2) by providing standardised data collection methods that ensure consistent representation, and (3) by enabling continuous monitoring and feedback loops that identify biased outcomes. However, it is important to acknowledge that while OTN data can help mitigate certain forms of bias, it cannot eliminate all bias—new forms may emerge that require ongoing vigilance and corrective measures. For example, a country's interoperable digital health platform, when integrated with AI, may generate unfair results if the model is trained on a dataset that underrepresents

[a] OTNs follow the laws of the land and informed consent is taken from the buyer/consumer whose data is recorded. Consent is time-bound, for a definite purpose and explicit. For e.g. in Account Aggregator the consent is taken for each loan service provider and time frame is explicitly defined. The consent artefact is designed to be Open, Revocable, Granular, Auditable, provide Notice, and maintain Security by design (ORGANS). (https://sahamati.org.in/faq/)

certain ethnicities. It might misdiagnose diseases common in those populations or fail to recognise symptoms altogether, and further, patients in remote regions might be offered less-effective treatments due to a lack of data representing their specific health conditions.[16] AI translation might perpetuate cultural biases that are especially harmful for multilingual societies.[17]

Historically, marginalised populations are often underrepresented in AI datasets,[18] leading to algorithmic outcomes that are inaccurate or even harmful to these communities. Most importantly, OTNs can formalise an ethical way of collecting data through a consent-driven mechanism,[19] thus diversifying datasets and embedding equity at the foundation of AI systems.

Figure 4: The Virtuous Cycle



Source: Author's own

In a nutshell, the convergence of AI and OTNs indicates a paradigm shift toward accessibility, inclusivity, and economic democratisation. Their mutually reinforcing relationship—AI enhancing OTNs, and OTNs refining AI—promises to reshape global digital ecosystems as depicted in the figure above.

Conclusion

While most industry AI use cases involve integrating AI into existing applications to supplement or replace functions, newer advancements like OTNs mark a remarkable evolution. Here, AI is not just a component; it is the core application or platform. ChatGPT's[20] and Perplexity's[21] shopping features exemplify this paradigm shift. The AI tools are shaping search engine optimisation (SEO) strategies and revolutionising the way websites are optimised for search engines. AI allows search engines to provide more accurate, user-centric results, highlighting the importance of semantic search, where search engines understand the context and intent of a user's search query, ensuring a more personalised and effective search experience.[22]

Several advancements in AI are underway, including multimodal AI, which involves systems that integrate text, image, voice, and other inputs to facilitate more natural interactions, federated learning, which enables privacy-preserving machine learning by keeping sensitive data on users' devices, and hyper-personalisation that allows for increasingly detailed customisation based on subtle behaviour patterns. With Autonomous AI involving systems that make ordering decisions with minimal human oversight, as well as advances in natural language understanding, voice commerce will become mainstream. By strategically implementing AI features in OTNs that prioritise real customer and business value, digital commerce can gain significant competitive advantages while fostering more resilient and efficient operations for the future.

Enabling AI on OTNs requires an approach rooted in responsibility, inclusivity, and contextual awareness. This demands responsible AI practices, compliance with data privacy regulations, robust governance frameworks, and local language contextualisation to align with the digital literacy levels of users and the maturity of a country's digital infrastructure. The cost for AI to operate at population scale is an equally important issue. AI usage in OTNs must be democratised, affordable, and usable across diverse socio-economic segments. To turn this vision into reality, the participation and contributions of the market ecosystem, policy advocates, and the funding ecosystem towards the use of AI in OTNs are crucial for its social alignment and scaled adoption.

Endnotes

1 FIDE and IEA, "The Beckn Protocol for Energy: A Vision Paper for Building a Global Open Network for Energy," Beckn Protocol, https://energy.becknprotocol.io/vision-paper/.

2 OpenAgriNet, "OpenAgriNet," https://openagrinet.global/.

3 Banco Central do Brasil, "Pix," Banco Central do Brasil, https://www.bcb.gov.br/en/financialstability/pix_en.

4 Open Network for Digital Commerce, *Democratizing Digital Commerce in India,* January 2022, Open Network for Digital Commerce, 2022, https://ondc-static-website-media.s3.ap-south-1.amazonaws.com/res/daea2fs3n/image/upload/ondc-website/files/ONDCStrategyPaper_ucvfjm/1659889490.pdf.

5 Beckn Protocol, "Beckn," Beckn Protocol, https://becknprotocol.io/.

6 OpenAgriNet, "OpenAgriNet."

7 "The Beckn Protocol for Energy: A Vision Paper for Building a Global Open Network for Energy."

8 J.P. Morgan, *Global E-Commerce Trends Report*, New York, J.P. Morgan, 2024.

9 Kalaari Capital, "ONDC - Commerce without Boundaries," https://kalaari.com/ondc-commerce-without-boundaries/.

10 Surabhi Agarwal, "ChatGPT Meets Beckn in Fide's AI Agent BecknGPT," *The Economic Times*, May 28, 2024, https://economictimes.indiatimes.com/tech/technology/chatgpt-meets-beckn-in-fides-ai-agent-beckngpt/articleshow/110474506.cms?from=mdr.

11 Performics India, Decoding ONDC.

12 Beckn Protocol, "Beckn."

13 H. Chen, "On the Diversity of Synthetic Data and Its Impact on Training Large Language Models," *arXiv e-prints* 2410.15226 (2024), doi:10.48550/arXiv.2410.15226.

14 Vahan Petrosyan, "The AI Data Wall: What It Is and How to Overcome It," *Superannotate*, October 11, 2023, https://www.superannotate.com/blog/ai-data-wall.

15 S. Nagar and D. Eaves, "Interactions between Artificial Intelligence and Digital Public Infrastructure: Concepts, Benefits, and Challenges," *arXiv e-prints* 2412.05761 (2024), doi:10.48550/arXiv.2412.05761.

16 Marco Iansiti and Karim R. Lakhani, "Managing the Risks of Generative AI," *Harvard Business Review*, June 2023, https://hbr.org/2023/06/managing-the-risks-of-generative-ai.

17 Kushagra Sikka, "Lost in AI Translation: Ethical Analysis of Cultural Bias in Language Models and Digital Assistants" (2024).

18 Judy Wawira Gichoya et al., “AI Pitfalls and What Not to Do: Mitigating Bias in AI,” *British Journal of Radiology* 96, no. 1150 (2023), https://doi.org/10.1259/bjr.20230023.

19 Ministry of Electronics and Information Technology, Government of India, "Consent Technology Framework v1.1," https://dla.gov.in/sites/default/files/pdf/MeitY-Consent-Tech-Framework%20v1.1.pdf.

20 Paresh Dave, "OpenAI Adds Shopping to ChatGPT," *Wired*, October 30, 2024, https://www.wired.com/story/openai-adds-shopping-to-chatgpt/.

21 "Shop Like a Pro with the New Shopping Feature on Perplexity," *Perplexity,* October 30, 2024, https://www.perplexity.ai/hub/blog/shop-like-a-pro.

22 Christos Ziakis and Maro Vlachopoulou, "Artificial Intelligence’s Revolutionary Role in Search Engine Optimization," in *Springer Proceedings in Business and Economics,* eds. Rashed Alghafri et al. (Springer, 2024), https://doi.org/10.1007/978-3-031-51038-0_43.

IV

FORMS and MODES of AI GOVERNANCE

Polycentric AI Governance: Rethinking Vulnerability Databases

Vaibhav Garg

Abstract

This article explores the concept of 'polycentric governance' in the context of Artificial Intelligence (AI) and cybersecurity. It argues that traditional state- and market-based approaches may be insufficient to address the dual-use nature of AI, and the evolving nature of associated risks. A third option is community-based governance, which has been successful in the management of physical resources such as forests and lakes. The analogue for AI would be AI Model Lake Ecosystems (MoLEs), which constitute AI models and associated open-source libraries that are used by developers to build AI solutions. Currently, such MoLEs

communicate the properties of individual models via Model Cards. This article suggests supplementing them with MoLE Vulnerability Databases (MoLE-VDs) to address AI supply chain risks and improve vulnerability management. Such databases may complement conventional approaches, such as the US-led National Vulnerability Database, while addressing their historical limitations. The article closes with a discussion of potential US-India cooperation in developing such AI MoLEs as well as associated MoLE-VDs.

Introduction

To regulate or not to regulate Artificial Intelligence (AI)—this is the question that many nation-states are trying to answer regarding markets. The underlying goal is to promote 'good' innovation, while curtailing 'bad' innovation. Much of AI, like with most technology, is dual-use and thus, ideal policy interventions are not always clear. This is further complicated by many nations equating AI to a literal arms race, which when won, offers an insurmountable advantage in both kinetic and cyber warfare.[1] A similar dynamic is evident in private sector AI organisations, which believe in a first-mover advantage, regardless of the broader market context.[2]

Thus, to root out the problems of bad innovation in AI, it is important to look beyond states and markets. One solution is to explore polycentric models of governance, which have proven to be sustainable and successful in the context of the Internet, such as for Internet Routing.[3,4] These have resulted in solutions such as the Anti-Botnet Code of Conduct for Internet Service Providers (ABCs for ISPs) for sectoral governance,[5] Payment Card Industry Data Security Standard (PCI-DSS) for industry-wide governance,[6] and OpenRAN for international solutions.[7]

Such polycentric governance has sometimes been criticised for sub-optimal outcomes, specifically those that result in the so-called 'Tragedy of the Commons'.[8] Yet, avoiding these failures is possible. Elinor Ostrom's Nobel Prize-winning work highlights specific design criteria that are to be met for optimal polycentric governance of natural resources.[9] In this context, this article focuses on AI, cybersecurity, and managing vulnerabilities. In previous works, this author has argued for the development of AI Model Lake Ecosystems (or MoLEs), which can be managed through polycentric governance by local stakeholders, akin to physical lakes.[a,10] This article builds upon that concept to argue for the creation of MoLE Vulnerability Databases—which may address some of the current concerns

---

[a] A physical lake constitutes tangible resources such as fresh water and fish, and corresponding governance mechanisms may aim to ensure sustainability by mitigating against pollution and overharvesting. A MoLE may similarly constitute digital resources such as AI models, associated libraries and datasets. Corresponding governance may aim to ensure good AI development by mitigating against supply chain attacks and context appropriate use.

around vulnerability disclosure and management—and specifically, the scope for US-India cooperation in this area.

AI's Cybersecurity Problem

One of the innovations that AI may enable is in the domain of cybersecurity and cybercrime. These functions can be divided into three domains:

1. AI may enable additional cybercrime by lowering the barrier to engage in such activity.[11]
2. AI may be used to defend against both conventional and AI-enabled cyberattacks.
3. AI itself, including cyber defence AI, may become the target of cyberattacks.[12]

Much attention has been paid to the first of these issues—the prospect that AI may be used by cybercriminals.[13] To address this, researchers are building frameworks to evaluate the cyberattack capabilities of mainstream AI.[14] At the same time, cybercriminals are building dedicated AI solutions that are specifically fine-tuned for cybercriminal purposes (e.g., WormGPT).[15] It is a conventionally accepted view that these AI capabilities, from both mainstream AI and those designed for cybercriminal activities, may result in lowering the bar for cybercriminal activities. As a result, defenders will need to mitigate a larger volume and variety of cyberattacks.

A frequently proposed solution is for defenders to use AI to scale defences.[16] For example, AI-based solutions can be used to scan public code repositories to detect leaked secrets, such as passwords, keys, and tokens.[17] These tools, by nature, are dual-use technologies. They can be used by legitimate cybersecurity researchers to identify and mitigate gaps in the risk posture of an organisation or digital products. Simultaneously, they can be used by cybercriminals to find and exploit those same gaps. This creates a second policy issue, which is the need to limit the proliferation of dual-use AI-based cybersecurity technologies to good actors.

The final concern is the potential for attacks on AI being used by cyber defenders themselves. As AI capabilities become more advanced, their use within organisations will increase exponentially, especially in the domain of cybersecurity. Conventional AI has been used for decades in malware detection, Data Loss Prevention (DLP), and phishing detection. More advanced AI capabilities promise automation for patch generation and security operations use cases.

Consider the use case of patch generation, a narrower use case for code generation. Software companies claim that they deploy AI to write a large amount of code.[18,19] Yet, studies have shown that AI-generated code may be less secure and harder to debug.[20] Furthermore, AI-generated code may add new vulnerabilities.[21] Thus, the AI used for improving cybersecurity may itself become a cybersecurity problem.

Heads, I Win; Tails, You Lose

The dynamic outlined in the previous section creates a particularly challenging problem for policymakers. Cybercriminals use AI to scale attacks. This then forces defenders to use AI for protecting their assets. Cybercriminals then pivot to attacking the AI itself, which now becomes a central point of failure. Furthermore, many of these attacks are hard to anticipate due to the emergent nature of risk in AI.

Slopsquatting is an example of these hard-to-predict attacks. As developers use LLMs to write code, the underlying AI models hallucinate and generate names of dependencies, such as libraries or packages that do not exist. Attackers leverage this vulnerability by creating malicious packages with the same names. In turn, developers may download these packages and inadvertently create a malicious product. For example, malicious packages on the Python Package Index (PyPi) claiming to be ChatGPT were used to hide malware.[22]

One solution would be for organisations to stop using AI-generated code. However, as AI enables easier and faster discovery of vulnerabilities, industry and society need new ways to scale patching. Research indicates that the average patch time for critical vulnerabilities is often over 60 days, while over half of cybersecurity breaches are due to unpatched systems being exploited.[23] While numerous socio-technical reasons explain delays in patching,[24] one key reason is the absence of the patch itself. AI can be used to scale the generation of patches.[25] Thus, avoiding AI-generated code is not an option. If we expand this to the broader use of AI for cybersecurity risk reduction, policymakers cannot manage the speed at which cybersecurity professionals adopt AI for cyber defence. Policymakers may lack the expertise to create ex-ante interventions, a problem exacerbated by emerging technologies.[26] Ex-post liability may be impacted by whether firms are judgment-proof. As many firms in this space are newer and smaller, this is a significant concern for an effective regulatory regime.[27] Note that larger and more established firms can simply avoid ex-post liability by spinning off their AI cybersecurity business as a separate legal entity.

At the same time, markets alone may not adequately manage the emergent risks from using advanced AI models for cybersecurity. Given the dearth of AI security researchers, many organisations lack the expertise to make a first-party determination of the reliability of AI security solutions. Furthermore, the field of cybersecurity lacks public benchmarks against which AI models can be tested—this would otherwise offer less-resourced organisations an easy indicator of quality. Finally, there are no obvious incentives for individual private sector actors to share the lessons learnt from the failures of using AI to scale cybersecurity in their organisations.

Polycentric Governance and AI Model Lake Ecosystems (MoLEs)

Given that states and markets alone may not adequately address the cybersecurity risks of AI, one must look to identify new policy interventions, as well as associated stakeholders. For instance, physical resources, such as forests, have been managed as a common-pool resource by the establishment and enforcement of community norms. To ensure that such management is both effective and sustainable, economist Elinor Ostrom, examined many such arrangements across multiple countries, cultures, and resource types. She concluded that successful management of common-pool resources requires adhering to specific design principles.[28]

In previous works, this author has noted that AI development is contingent on Model Lakes.[29] Put simply, a Model Lake is a database that hosts a variety of AI models upon which AI developers can build their products. Individual stakeholders can build dedicated model lakes that support their specific sector, industry, or use cases, which can be further combined to offer an overall MoLE.[30] The sustainable governance of these ecosystems can be enabled by mapping governance mechanisms to Ostrom's Institutional Analysis and Development (IAD) Framework, colloquially referred to as the Common Pool Resources (CPR) Framework.[31] Thus, an AI MoLE can be managed just like a physical lake ecosystem through norm-making between stakeholders who are aligned on incentives to sustain a MoLE.

For example, consider the use of Model Cards, which are essentially markdown files that document and communicate a model's intended use and its limitations.[32] Model Cards aim to educate downstream AI developers to select the right model based on their constraints, such as environmental impact. While this transparency-based governance mechanism addresses one dimension of IAD, incorporating other dimensions, such as through bug bounties, may enhance the impact of the primary mechanism.[33]

It is important to note that the design of such polycentric governance mechanisms is made possible due to the alignment of incentives of the Resource User (RU) and the Resource Producer (RP). The former needs to ensure that they are using reliable models that will satisfy the constraints of their use case. The latter wants to convey the quality of their models and drive adoption. Furthermore, designing polycentric governance through the lens of Ostrom's IAD results in solutions that are self-reinforcing and thus, more sustainable. Additionally, since governance mechanisms are co-designed by RUs and RPs to address specific problems, they are less likely to result in cosmetic governance that increases compliance costs without associated risk reduction.

MoLEs Vulnerability Databases (MoLE VDs)

This author has previously described how independent stakeholders with common interests can create MoLEs to address AI supply chain risks. The aforementioned work specifically covered the design of Model Cards and how their impact can be improved through the addition of mechanisms like bug bounties.[34] This section of the article builds upon MoLEs to address how cybersecurity practitioners can manage the risks of using AI for cyber defence, especially when that AI manifests new vulnerabilities that can be exploited by attackers.

As developers determine the criteria for selecting a specific model from a MoLE for their use case, one criterion should be the cybersecurity of that model. Unfortunately, cybersecurity is hard to measure directly; vulnerabilities issued against a specific AI library, as well as the severity of that vulnerability, are commonly employed proxies. The former is usually determined based on Common Vulnerabilities and Exposures (CVEs),[35,36] and the latter based on the Common Vulnerability Scoring System (CVSS) score.[37] Both have been criticised by academics[38] and practitioners.[39,40]

For instance, the process of issuing vulnerabilities is often delayed and is contingent on acceptance from the project maintainer (in the case of open source) or the vendor (in the case of proprietary software). Similarly, CVSS scores have also been found wanting for appropriate context in their calculation. Additionally, there is the governance of the CVE and the corresponding process of communicating vulnerabilities through the National Vulnerability Database (NVD), which is maintained by a single entity, creating a single point of failure. NVD has had historical challenges with funding.[41]

However, MoLEs can create and issue their own vulnerability reporting and management programmes. A MoLE may design locally-appropriate criteria for accepting or issuing CVEs and publish a dedicated database. Maintainers and vendors, i.e., RPs, who disagree with an unreasonably onerous criterion can quit the MoLE, giving them the ability to influence the community's norms. Simultaneously, RUs can exclude RPs that do not adhere to the community's norms. The same can apply to the criteria used by MoLE communities to rate the severity of a vulnerability. As the community members have the best understanding of the community's use cases, they can devise appropriate, context-specific scoring systems to create a risk-based vulnerability scoring that informs the community's remediation process.[42]

Finally, this kind of norms-based and community-oriented governance process for vulnerability management is also helpful for maintainers of open-source technology. If a specific model is of critical importance to the community and a particularly severe vulnerability is issued against that model, the community can crowd-source funding to advance the creation of an associated patch. This can be helpful to support open-source projects, which often struggle with access to resources. Community support can also manifest in the form of RUs offering development time to write the code for the patch, test it, or share the results of deploying the patch in their environment, all of which can speed up patch deployment.

US-India Cooperation on MoLEs

The previous section noted how the creation of MoLE-based vulnerability databases (MoLE-VDs), alongside contextual scoring systems that account for the needs of the local ecosystem stakeholders, can potentially address the current limitations of CVEs, CVSS, and NVD. National governments are key stakeholders in this ecosystem. India and the US—the two largest democracies in the world—aim to drive the adoption of AI that aligns with democratic values. By enabling the design of MoLEs that promote the adoption of democracy-aligned AI models, these countries can address the problem at the source by addressing upstream dependencies.

Furthermore, the enabling of such MoLEs can address supply chain risks, including those related to cybersecurity. These can help mitigate risk for a variety of downstream dependencies, even when the downstream consumers lack the necessary cybersecurity expertise. One example of such co-operation between the US and India is evident in the OpenRAN initiative, which helped address supply chain challenges in the Communications Sector.[43]

Private sector actors in both countries may be incentivised to support such co-operation. First, it may help address concerns about fragmentation, as noted by open-source advocates.[44] Second, addressing the risks at a model level upstream can help AI products being produced by less-resourced teams downstream. Thus, such co-operation may reduce the private actors' third, fourth, or n^{th} party risk. Third, MoLEs may enable private sector actors to find ways to identify, understand, and then mitigate community, sector, or industry-specific 'common weaknesses' in AI models.

Consider Slopsquatting. Researchers note that models often hallucinate the same package names over and over.[45] Stakeholders in MoLEs can coordinate their resources to identify these package names and work with the appropriate repositories, such as NPM, to create benign placeholder packages. Alternatively, they could request the takedown of malicious packages. Finally, when a critical issue is identified—one that can have cascading effects across the community members of a MoLE, such as a whole sector—members can pool resources or request assistance from public entities. Note that developers in India and the US are likely to rely on the same open-source components for similar use cases: JQuery is as popular in the US as it is in India.[46] Thus, the countries can collaborate to address common risks.

The two countries may leverage their unique strengths to advance this collaboration. The US has a legacy of convening multistakeholder processes, such as those for Internet Governance. India, on the other hand, boasts a significant AI workforce that can be deployed to both find and address vulnerabilities in AI models. Together, the two countries can jumpstart the creation of AI MoLEs and associated VDs by prioritising key areas of concern in cybersecurity.

For example, one solution would be to start by creating a MoLE for AI libraries that support email security, i.e., phishing detection and spam detection. Another would be to create a MoLE for software security, i.e., static and dynamic code analysis. Both governments can leverage existing organisations, such as the Open-Source Security Foundation, or create entirely new entities to build these MoLEs.

Conclusion

AI can potentially be a force multiplier for cybercriminals. Cybersecurity professionals must respond with the adoption of AI for defence purposes. This gives cybercriminals a golden target: the AI itself. Model Lakes like HuggingFace have already seen attackers successfully manipulate packages to inject malicious options.[47] Simultaneously, legitimate AI also results in emergent behaviour that can be leveraged by cybercriminals for new kinds of attacks, such as slopsquatting.

It is critical that information about these issues is communicated in a risk-appropriate manner to the impacted communities. However, the current process of issuing CVEs, calculating CVSS, and publishing via NVD has limitations. These may be exacerbated by the current policy landscape.[48] It is important to then consider policy solutions that look beyond markets and states to address the cybersecurity risks posed by an institution's use of AI, including for cybersecurity itself.

Endnotes

1 Sean Oesch et al., "Agentic AI and the Cyber Arms Race," *Computer* 58, no. 5 (2025): 82-85.

2 Fernando Suarez and Gianvito Lanzolla, "The Half-truth of First-mover Advantage," *Harvard Business Review*, April 2005, https://hbr.org/2005/04/the-half-truth-of-first-mover-advantage.

3 Alexander Klimburg, "The Internet's Two Bodies: Understanding the Multistakeholder Reign," *Digital Governance Discussion Group*, November 4, 2024, https://dgdg.blog/the-internets-two-bodies-understanding-the-multistakeholder-reign/.

4 M. Mueller, "Sovereignty and Cyberspace: Institutions and Internet Governance (speech, 5th Annual Vincent and Elinor Ostrom Memorial Lecture, Bloomington, IN, 2018).

5 Messaging Malware Mobile Anti-Abuse Working Group, "Anti-Botnet Code of Conduct for Internet Service Providers," Federal Communications Commission's CSRIC Working Group #7, https://www.m3aawg.org/abcs-for-ISP-code.

6 PCI Security Standards Council, https://www.pcisecuritystandards.org.

7 O-RAN Alliance, https://www.o-ran.org.

8 Garrett Hardin, "The Tragedy of the Commons," in *Classic Papers in Natural Resource Economics Revisited* (Routledge, 2018), pp. 145-156.

9 Elinor Ostrom, *Design Principles and Threats to Sustainable Organizations That Manage Commons,* Center for the Study of Institutions, Population, and Environmental Change Workshop in Political Theory and Policy Analysis, Indiana University, 1999, https://beyondostrom.blog.rosalux.de/files/2013/05/Design-Principles-and-Threats-to-Sustainable-Organizations-That-Manage-Commons.pdf.

10 Vaibhav Garg, "All the AI Risks We Cannot See," Observer Research Foundation America, January 21, 2025, https://www.orfonline.org/expert-speak/all-the-ai-risks-we-cannot-see.

11 Vaibhav Garg and Jayati Dev, "Artificial Intelligence and the New Economics of Cyberattacks," *Usenix*, August 29, 2024, https://www.usenix.org/publications/loginonline/artificial-intelligence-and-new-economics-cyberattacks.

12 Garg and Dev, "Artificial Intelligence and the New Economics of Cyberattacks."

13 Wenbo Guo et al., "SoK: Frontier AI's Impact on the Cybersecurity Landscape," *arXiv preprint,* arXiv:2504.05408(2025).

14 Mikel Rodriguez et al., "A Framework for Evaluating Emerging Cyberattack Capabilities of AI," *arXiv preprint,* arXiv:2503.11917 (2025).

15 Mohamed Firdhous et al., "WormGPT: A Large Language Model Chatbot for Criminals," in *2023 24th International Arab Conference on Information Technology*, IEEE, 2023, pp. 1-6.

16 Pranoy Jainendran, "The Necessity of State-led Initiatives for Large Language Models in Cybersecurity," Observer Research Foundation, July 4, 2024, https://www.orfonline.org/expert-speak/the-necessity-of-state-led-initiatives-for-large-language-models-in-cybersecurity.

17 Comcast Cable, "xGitGuard: AI Based Secrets Detection," https://github.com/Comcast/xGitGuard.

18 Jack Kelly, "AI Writes Over 25% Of Code At Google," *Forbes,* November 1, 2024, https://www.forbes.com/sites/jackkelly/2024/11/01/ai-code-and-the-future-of-software-engineers/.

19 Simon Sharwood, "30 Percent of Some Microsoft Code Now Written by AI," *The Register,* April 20, 2025, https://www.theregister.com/2025/04/30/microsoft_meta_autocoding/.

20 Jessica Ji et al., "Cybersecurity Risks of AI-Generated Code," Center for Security and Emerging Technology, November 2024, https://cset.georgetown.edu/publication/cybersecurity-risks-of-ai-generated-code/.

21 Thomas Claburn, "LLMs Can't Stop Making Up Software Dependencies and Sabotaging Everything," *The Register,* April 12, 2025, https://www.theregister.com/2025/04/12/ai_code_suggestions_sabotage_supply_chain/.

22 Laura French, "Fake ChatGPT, Claude PyPI Packages Spread JarkaStealer Malware," *SCWorld,* November 22, 2024, https://www.scworld.com/news/fake-chatgpt-claude-pypi-packages-spread-jarkastealer-malware.

23 Jannik Linder, "Patch Management Statistics," *Gitnux,* https://gitnux.org/patch-management-statistics/.

24 Nesara Dissanayake et al., "Software Security Patch Management-A Systematic Literature Review of Challenges, Approaches, Tools and Practices," *Information and Software Technology* 144 (2022): 106771.

25 Greg Otto, "DARPA Believes AI Cyber Challenge Could Upend Patching as the Industry Knows It," *CyberScoop,* April 30, 2025, https://cyberscoop.com/darpa-ai-grand-challenge-rsac-2025-patching/.

26 Tyler Moore, "The Economics of Cybersecurity: Principles and Policy Options," *International Journal of Critical Infrastructure Protection*, 3 (2010): 103-117.

27 United Kingdom Department for Science, Innovation, and Technology, *AI and Software Cyber Security Market Analysis,* https://www.gov.uk/government/publications/ai-and-software-cyber-security-market-analysis/ai-and-software-cyber-security-market-analysis.

28 Ostrom, "Design Principles and Threats to Sustainable Organizations that Manage Commons.

29 Koyena Pal, David Bau, and Renée J. Miller, "Model Lakes," *arXiv preprint,* arXiv:2403.02327.

30 Garg, "All the AI Risks We Cannot See."

31 Thomas Dietz, Elinor Ostrom, and Paul C. Stern, "The Struggle to Govern the Commons," *Science* 302 (2003), no. 5652: 1907-1912.

32 Margaret Mitchell et al., "Model Cards for Model Reporting," in *Proceedings of the Conference on Fairness, Accountability, and Transparency*, 2019, pp. 220-229.

33 Garg, "All the AI Risks We Cannot See."

34 Garg, "All the AI Risks We Cannot See."

35 CVE, "CVE™ Program Mission," https://www.cve.org.

36 David W. Baker et al., "The Development of a Common Enumeration of Vulnerabilities and Exposures," in *Recent Advances in Intrusion Detection*, 7(1999).

37 Dale Dugal and Dale Rich, "Announcing CVSS v4. 0," in *35th Annual FIRST Conference*, 2023.

38 Julia Wunder et al., "Shedding Light on CVSS Scoring Inconsistencies: A User-centric Study on Evaluating Widespread Security Vulnerabilities," in *2024 IEEE Symposium on Security and Privacy* (2024).

39 Connor Jones, "Ivanti and Juniper Networks Accused of Bending the Rules with CVE Assignments," *The Register,* January 22, 2024, https://www.theregister.com/2024/01/22/ivanti_and_juniper_networks_criics_unhappy/.

40 "A Vulnerability Management Crisis: The Issues with CVEs," Cloud Security Alliance, https://cloudsecurityalliance.org/blog/2024/11/21/a-vulnerability-management-crisis-the-issues-with-cve.

41 Julie Wunder at al., "On NVD Users' Attitudes, Experiences, Hopes, and Hurdles," *Digital Threats: Research and Practice* 5, no. 3 (2024): 1-19.

42 Lucas Senos Coutinho et al., "How Context Impacts Vulnerability Severity: An Analysis of Product-Specific CVSS Scores," in *Proceedings of the 13th Latin-American Symposium on Dependable and Secure Computing*, 2024, pp. 17-27.

43 Mohamad Saalim Wani et al., "Open RAN: A Concise Overview," *IEEE Open Journal of the Communications Society 6* (2024): 13-28.

44 "Vulnerability Enumeration Conundrum – An Open Source Perspective on CVE and CWE," Open Source Security Foundation, April 23, 2025, https://openssf.org/blog/2025/04/23/vulnerability-enumeration-conundrum-an-open-source-perspective-on-cve-and-cwe/.

45 Joseph Spracklen et al., "We Have a Package for You! A Comprehensive Analysis of Package Hallucinations by Code Generating LLMs," *arXiv preprint*, arXiv:2406.10279 (2024).

46 Built With, "jQuery Usage Statistics," Built With, https://trends.builtwith.com/javascript/jQuery.

47 Karlo Zanki, "Malicious ML Models Discovered on Hugging Face Platform," *Reversing Labs Blog*, February 6, 2025, https://www.reversinglabs.com/blog/rl-identifies-malware-ml-model-hosted-on-hugging-face.

48 Cynthia Brumfeild, "CVE Program Averts Swift End after CISA Executes 11-month Contract Extension," *CSO Online,* April 16, 2025, https://www.csoonline.com/article/3963190/cve-program-faces-swift-end-after-dhs-fails-to-renew-contract-leaving-security-flaw-tracking-in-limbo.htm.

Whose Fairness? Challenges in Building a Global Framework for AI Fairness

Jatin Patni

Abstract

Artificial Intelligence (AI) is transforming critical domains like healthcare, finance, education, and public services, but it also raises a new set of ethical, legal, and technical challenges. Among these, resolving the conundrum of "fairness" is perhaps one of the most complex and crucial. Ensuring fairness in AI-driven decisions is a collective responsibility and one of the greatest challenges facing innovators, policymakers, and enforcement authorities. This report examines the concept of 'fairness' in AI through historical, socio-economic, cultural, legal, political, and moral lenses to demonstrate why defining it in the context of AI

remains both difficult and urgent. It explores the technical and contextual challenges in defining and operationalising AI fairness, and lays the foundations for designing a Global AI Fairness Framework.

Introduction: AI as a Double-Edged Sword

"A world of AI haves and have-nots would be a world of perpetual instability. We must never allow AI to stand for "advancing inequality". Only by preventing the emergence of fragmented AI spheres can we build a world where technology serves all humanity."[1]

- António Guterres, Secretary-General of the United Nations, December 2024

Modern AI systems digest huge amounts of data, identify patterns beyond what human ability allows, and act on them at machine speed. The exponential growth in the trifecta of data, compute, and algorithms[2] has pushed AI from laboratory to infrastructure. The broad, irreversible, and transformative impact of AI has been compared to the industrial revolution and the diffusion of electricity.[3]

The payoffs are visible everywhere,[4] with doctors detecting or diagnosing cancer earlier,[5] banks flagging fraud in real-time,[6] and teachers tailoring lessons in overcrowded classrooms.[7] It is penetrating sectors like entertainment,[8] law,[9] transportation,[10] agriculture,[11] e-commerce,[12] and human resources.[13]

However, this same technology comes with a novel set of risks,[14] ones that offer learnings rooted in real-world incidents.[15]

- India's Aadhaar journey demonstrated that the early detection of exclusions (such as those linked to biometric failures in Jharkhand)[16] can be a catalyst for systemic reform. It introduced proactive inclusion initiatives, policy adjustments, and multi-modal biometrics such as AI-powered face authentication, turning a crisis into a case study in how to design for inclusion at scale.[17]

- Amazon's résumé screener penalised female candidates because it was trained on a decade of résumés from a male-dominated workforce.[18]

- COMPAS, a US recidivism tool, assigned higher risk scores to Black defendants, steering judges toward tougher sentences.[19, 20]

The Imperative of Fairness

Regulators are Moving from Guidance to Penalties

The EU AI Act sets fines as high as 15 million euros or 3 percent of annual revenue for failure to meet fairness-related obligations for high-risk AI systems.[21] This makes it one of the few binding regimes with real enforcement power, alongside emerging laws like Canada's AIDA.[22] In short, if innovators are unable to prove that their models are fair, they can expect a hefty compliance bill.

In contrast, most other frameworks such as NIST's AI Risk Management Framework (which treats fairness as a core AI risk category),[23] UNESCO Ethical AI Principles,[24] the Indian Government's NITI Aayog Principles,[25] Japan's METI Guidelines,[26] and the OECD AI recommendations[27] (which flag fairness, inclusivity, and non-discrimination as first-order design principles) are currently non-binding. Such 'guideline' frameworks cannot levy fines, but they still influence industry behaviour and often serve as precursors to enforceable regulation.

Yet there is no single rulebook that identifies which fairness test to run or what "good enough" looks like. NIST itself notes that "standards of fairness are complex and difficult to define because perceptions of fairness differ among cultures." [28] There is currently no agreed-upon, universally enforceable standard for deciding whether an algorithm is fair.[29]
No Undo Button: The Stakes of Biased AI

When an AI algorithm takes critical decisions, such as giving life-saving treatment to a dying patient, a much-needed scholarship to an underprivileged student, or an agricultural loan to a struggling farmer, a wrongful denial could push families into distress. In all of these cases, there's no 'undo' button. The following are some real-world examples from critical sectors:

Healthcare: A widely deployed algorithm called Optum allocated extra care using past health spending as a proxy for health need,[30] leading to a systematic bias against millions of Black patients with comparable levels of need. This proxy objective selection created large racial gaps in access to high-risk care programmes.

Everyday Credit: In India, 19 percent of women borrowers, as against 8 percent of men, are rejected for loans.[31] Mary Ellen, CEO of Women's World Banking, blames scoring algorithms that discount applicants with lighter digital footprints and home-based businesses.[32]

Rural and Migrant Finance: Most digital lenders target urban, young, and employed users. Migrant and rural entrepreneurs with patchy phone data are routinely filtered out, even when their cash flows are good.[33]

Education: During the 2020 COVID-19 pandemic lockdown, the United Kingdom (UK) replaced in-person exams with a grading algorithm. Almost 40 percent of A-level results were marked down, costing many state-school pupils their preferred university places, before a public outcry forced the scores to be voided.[34]

Governments, regulators, and firms are catching up, but in a patchy, largely reactive, and often voluntary way. The EU AI Act classifies healthcare, education, and credit scoring as high-risk, requiring bias assessments, human oversight, and transparency; the US FTC has warned that biased AI can cause consumer harm. Tech companies are developing fairness toolkits (Google What-If, Microsoft Fairlearn, IBM AIF360) and piloting fairness impact assessments.

Fairness Falls through Three Cracks: Funding, Definition, and Operationalisation

Money Flows to Capability, not Guardrails

Everyone loves the idea of fair AI, yet almost all the money still flows to raw capability, and not guardrails. A few numbers showcase such gaps:

- Corporate spending on AI hit US$252 billion in 2024—a record that dwarfs public budgets in most countries.[35]
- By contrast, the UK's flagship Frontier AI Taskforce launched with £100 million[36] and the US AI Safety Institute scraped together US$10 million in authorised funds.[37]
- In boardrooms, the imbalance shows up as well: only 11 percent of US executives say their organisations have fully built the basics of responsible AI.[38]

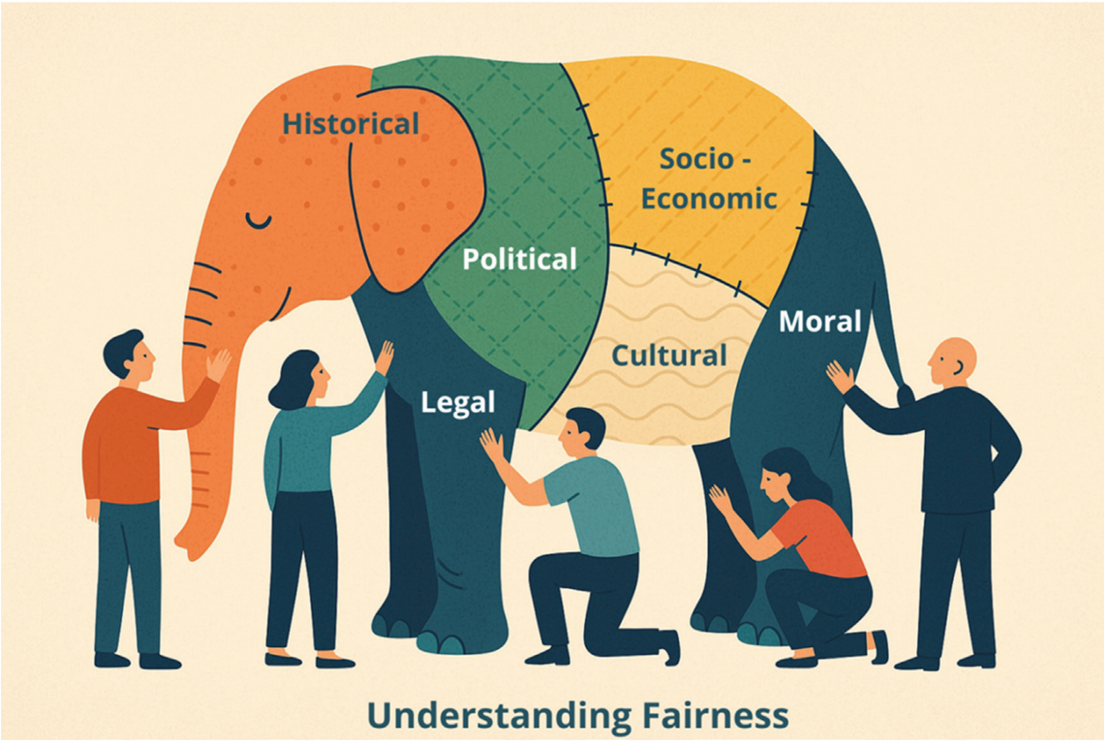
Almost every new dollar is still flowing to "make it smarter," not "make it safer". Unlike critical sectors like nuclear energy, aviation, space, and pharmaceuticals, which are driven by sovereign risk appetites and public sector R&D, AI is dominated by corporations that are driven by the need to deliver profits to their investors and shareholders. This fundamental imbalance between AI performance versus AI safety goals leads to disproportionately low investments in the areas of AI fairness and safety. Although the laws now demand "fair and non-discriminatory" systems, almost none specify how to measure bias; therefore, companies treat fairness as a reputational issue and not an item to be included in the project budget.

Without the three-way push from markets, regulators, and civil society, fairness will remain underfunded while the next billion will be directed towards AI model size.

Fairness as a Patchwork of Ideas

'Fairness' is not a singular concept that can be wrapped in a neat definition. Each society defines fairness differently—it is complex, contextual, and multidimensional,[39] and should be viewed from the historical, socio-economic, cultural, legal, political, and moral-philosophical lenses. These lenses are not mutually exclusive. Culture stems from history, laws echo moral codes, and socio-economic inequities rise from cultural practices. This overlap is not a flaw, but a strength; it allows diverse perspectives to be stitched together. No one lens tells us the complete story; while each provides a glimpse, they form a complete picture when stitched together—a practical vision of fairness that is contextual, pluralistic, and grounded in the real world.

Figure 1: Understanding Fairness through Historical, Political, Legal, Socio-Economical, Cultural, and Moral Lenses



Source: Author's own illustration, created using ChatGPT and Canva.

Fairness Through the Historical Lens

Today's arguments about fairness never start on a level field but rather are shaped by historical events. Centuries of injustice in various forms, such as slavery, colonialism, segregation or caste-based exploitation, can create unfair legacies that persist.

For instance, British colonial rule (1757–1947) enforced extractive land policies and tax regimes that widened extreme poverty and unfair economic structures that favoured the coloniser.[40] The 1947 Partition triggered mass violence and displacement whose aftershocks still shape debates over citizenship and land rights.[41]

Similarly, in the US, where slavery lasted for over 200 years, systemic racial discrimination persisted through segregation laws, denying African Americans basic human rights and freedoms.[42] The wealth gap that opened up during those years still endures; Black families enslaved until the Civil War continue to hold far less education and income than their White peers.

India and the US are hardly exceptions; from Australia's Stolen Generations[43] to South Africa's apartheid[44] and Latin America's colonial land grabs,[45] different territories continue to live with their own unfinished chapters of structural injustice. Because of these histories, countries write reparative measures into law—caste reservations in India and affirmative-action programmes in the US—attempting to balance the scales. The decision to acknowledge and remedy such historical wrongs to repair the social fabric affects the perspective of what constitutes 'fairness'.

When AI decides credit, jobs, or healthcare, ignoring such historical legacies is not neutral. Models must be calibrated by setting historically aware baselines, stress-testing performance on the most disadvantaged groups, documenting any reparative weighting used (where permitted by law), and focusing on subgroup discovery to surface hidden pockets of bias that mirror past exclusions.

Fairness Through the Socio-Economic Lens

Who gets what, and why? That is the fairness test economists use when they track who owns the wealth, who gets good jobs, or who owns the biggest risks. When those numbers drift too far apart, even the IMF argues that in countries "where growth is satisfactory but benefits the poor much less than the non-poor, there is a strong case for shifting resources from those at the top of the income scale to those at the bottom."[46] It urges governments to help redistribute gains to promote social stability and economic justice.

India presents a unique picture of socio-economic gaps due to caste hierarchies, poverty, and the rural-urban divide. A World Inequality Lab study revealed that the top 1 percent now captures 22.6 percent of national income and 40.1 percent of wealth, which is among the steepest skews worldwide.[47] Marginalised communities in rural areas often lack access to quality education, healthcare and technology. Similarly, in the US, which has a large racial and ethnic diversity, there are issues like racial wealth disparity and unequal technological access. A 2022 survey of Consumer Finances data shows the richest 1 percent holding 35 percent of all household wealth.[48]

The COVID-19 pandemic exposed the systemic unfairness, with lower-income and minority communities suffering disproportionately.[49] The inequality story is not confined to India or the United States. Brazil's richest 10 percent now pocket about 60 percent of all national income,[50] while South Africa still tops the World Bank's inequality chart with a Gini coefficient of 0.67.[51] Every region carries its own socio-economic fault lines.

A socio-economic view of fairness pushes us to ask whether this model will widen or narrow the gap. It requires the collective to move in a direction where wealth, technology, and opportunity are not locked into privileged groups. AI systems in critical domains like education, healthcare, and banking must not ignore these background skews. They should have KPIs related to social equity and track outcome gaps over time to prove that the AI can indeed narrow the gap over time.

Fairness Through the Cultural Lens

Norms of loyalty, honour, or hierarchy impact what people see as just or unjust. If this local context is ignored, the same model can land as common sense in one place and a culture shock in another. Recognising cultural context is vital to understanding fairness.

In India and many parts of South Asia, age-old customs around family, caste, and community play a role in defining traditional duties. Conservative household norms across different income groups still disallow many girls from higher study.[52] Giving money or jobs to relatives is viewed as good kinship in some cultures, but comes across as nepotism in others.[53]

In the US, a long tradition of rugged individualism and personal liberty feeds into the idea that success should be personal, often leading to resistance against redistributive policies, even when socio-economic disparities persist.[54]

These values, which are tied to social identity and tradition, shape how people judge an algorithmic decision, demand explanations, or appeal a bad outcome. Designers who ship AI into new markets need to test not just for statistical bias, but also for 'fit' across local cultural norms. They should validate against local dialects, scripts, and conventions; include local community representatives before sign-offs, and ensure cultural acceptance.

Fairness Through the Moral-Philosophical Lens

Every society has its unique answer to the old question: "What is the right thing to do?" That answer rests on the moral traditions it teaches in schools, houses of worship, and courtrooms.

In most Western classrooms, that story starts with Immanuel Kant's demand to treat each person as an end in themselves in his famous "categorical imperative".[55] It moves on to John Rawls's "veil of ignorance",[56] a thought experiment that urges policymakers to design rules for a world where one does not know whether they will be rich or poor, weak or powerful. This emphasises fairness as a political need for a social contract to respect human dignity and fundamental rights, and the need to define the rules of treating people when living collectively as a society.

Other Western schools of thought go in different directions: *utilitarians*[57] weigh outcomes to maximise overall good, even if some individuals lose out, while rights-based *egalitarians* draw a red-line and insist that some rights and freedoms cannot be traded away at any price. For instance, a pure utilitarian might support relocating a few villagers to build a dam if the economic gain is large, whereas rights-based ethicists would emphasise the fairness of respecting those villagers' property and consent.

Other cultural norms, such as the South African ethic of "*ubuntu* (I am because we are)"[58] prioritise community solidarity and collective welfare. The Latin American indigenous ideology of *"Buen Vivir* (good living)"[59] emphasises living in harmony with nature and community, rather than through material accumulation, and encourages a more holistic and sustainable way of life. Across East Asia, Confucian ethics[60] talk about role-based duty and social harmony. Buddhist ethics centres compassion and non-harm; 'do no harm' becomes an ongoing practice of risk monitoring.[61] In many Muslim-majority states, regulators lean on *Sharia*, the duty to safeguard faith, life, intellect, lineage, property, and dignity.

In Indian philosophy, especially the ones rooted in the Bhagavad Gita, the Vedas, and the Upanishads, ideas are neatly mapped into modern ethical governance levers:

- ***Lokasaṅgraha:*** Act for the welfare of the world.[62]
  Relevance for AI: It designates social-welfare KPIs (job creation, grievance redressal time, ecological footprint) as first-order success metrics. Every high-risk model must show a net-positive community impact score before launch.

- ***Niṣkāma Karma:*** Act without attachment to rewards.[63]
  Relevance for AI: Ensure independence between engineers and auditors. When rewards depend on speed to market, fairness becomes an afterthought.

- ***Samatva*:** Keep equanimity in success and failure.[64]
  Relevance for AI: Ensure symmetric error bounds (false approvals and false denials) across gender, caste, disability, and dialects.

- ***Sarva-bhūtastham Ātmanam:*** Radical non-discrimination,[65] see the same self in every being.
  Relevance for AI: Mandatory subgroup discovery on every protected trait, including those not yet named in regulation (transgender status or tribal language). Discrimination tends to hide in such clusters.

- ***Svadharma:*** Perform role-specific duty.[66]
  Relevance for AI: It shifts the question from "what am I allowed to do?" to "what do I owe the world?" Clear, role-specific duties keep accountability from falling in the cracks between teams, a common cause of biased models that sail through launch because "no one owned that part".

- ***Vasudhaiva Kutumbakam:***[67] The world is one family.
  Relevance for AI: It reframes fairness as a duty to safeguard the welfare of every stakeholder the model might touch, not just the rights of its direct users. The workers who label data, neighbours living beside data-centre cooling towers, and even future generations facing e-waste are included under its wing.

Indian morality grounds ethics in duty, obligation, and social welfare. It does not replace Rawls or Kant, but it widens the ethical aperture that can detect harm. Fairness does not merely remain a political or social construct, but becomes the moral obligation of individuals, which sustains the balance of the cosmic order.

From an AI perspective, these moral frameworks directly influence design choices, trade-off thresholds, and governance models. They can affect the extent to which bias mitigation is considered a technical afterthought or as a non-negotiable ethical duty. Integrating moral principles into AI risk controls helps ensure that fairness is not only measurable but also morally defensible across cultures.

The need to balance such competing moral concepts of individualism versus collectivism, and rights versus duties, remains the toughest part of drafting global fairness standards for AI.

Fairness Through the Political Lens

Whoever holds the power, writes the policies, and gets to participate shapes the fairness of an AI system. A country's constitutional design, electoral system, party dynamics, and campaign finance rules influence whose voices are heard.

Electoral design sets the baseline: Countries that elect legislators by proportional representation usually seat more women, minorities, and small-party voices than winner-take-all systems, giving a wider set of constituents leverage when policies are drafted.[68]

Centralised one-party rule: In China, the Cyberspace Administration runs an algorithm registry: every recommender or generative model must be filed, security-assessed, and checked for whether it can "shape public opinion". Only then is it cleared before launch. Citizens have no formal channel to contest bias in those filings.[69]

Centralised democracy: India is noisy and plural, but policy still flows from New Delhi. The centre writes nationwide quotas for Scheduled Castes, tribes, and women (Constitution Article 15) and has published "Responsible AI for All" guidelines that explicitly call for non-discrimination audits in public projects.[70]

Federal patchwork: The US lets each state steer its own course. In the 2025 session, all 50 states put AI bills on the table, ranging from deep-fake disclaimers to outright moratoriums.[71] This decentralisation enables context-specific solutions but also fosters inconsistencies in fairness protections. The post-*Dobbs v. Jackson* ruling (2022) offers a stark example: abortion rights are now determined at the state level. As of early 2025, 14 states now enforce near-total bans while others keep full protection—a live example of how fundamental rights can hinge on zip code.[72]

These divergences illustrate how political organisation, centralised versus federal, democratic versus authoritarian methods, can influence fairness in AI. For AI systems, political structure dictates how regulations are enforced and challenged. Centralised governments can impose universal standards immediately, but provide no real remedy for those hurt by algorithmic discrimination. Decentralised or federal systems enable context-specific adaptation, but can sometimes lead to compliance fragmentation in competing regulatory frameworks.

Fairness Through the Legal Lens

Fairness requires strong constitutional guarantees (free speech, equality, privacy) and independent judicial institutions that enforce them impartially. Democracies typically encode such rights by granting civil liberties (e.g., freedom of religion, expression, and equal protection), but in authoritarian regimes, the legal frameworks tend to serve political priorities.

In the US, long-standing civil rights statutes ban discrimination in credit, housing, and hiring. The Equal Credit Opportunity Act, for instance, bars lenders from weighing race, sex, age, or reliance on public assistance income when scoring loans.[73] The Equal Employment Opportunity Commission's AI Initiative aims to hold automated hiring to the same anti-bias standard as human recruiters.[74] The US's AI Action Plan[75] aims to strip the NIST AI RMF framework of every reference to Diversity-Equity-Inclusion (DEI), redefining fairness as viewpoint parity instead of demographic equity.

The Indian Constitution guarantees equality (Article 14) and bans discrimination on the grounds of religion, caste, or sex.[76] Yet practice can lag behind promise: Aadhaar fingerprint failures have kept some labourers and elderly citizens from ration rolls, with at least 19 out of 57 starvation-related deaths documented since 2015 across multiple states.[77]

AI systems and supply chains can transcend national borders, so there is a need to comply with local legal requirements, adapt to different standards, and respect the idea of reasonable pluralism[78] to address this cross-border AI risk.

Fairness laws such as affirmative action and civil rights can vary across jurisdictions. The case of affirmative action policies for college admissions is one such example. In India, caste-based reservations are constitutionally upheld to address the historical injustices of marginalised communities. While in the US, a recent Supreme Court decision[79] struck down race-based affirmative action in college admissions.

Even the set of protected attributes, such as sex, race, gender, genetic features, language, faith, disability, sexual orientation, veteran status, gender reassignment, pregnancy, and genetics can vary across countries. AI developers should ensure meeting at least the minimum local legal standards by maintaining a live cross-jurisdiction map of protected traits and disparate-impact rules, blocking features that would be unlawful locally, and requiring independent anti-discrimination testing in regulated domains. Another crucial aspect when understanding the legal perspective is that regulations are generally reactive, and not proactive. They might be biased, outdated, or fail to capture the fast-evolving risks of AI. There have been many such regulations that have failed the test of time. For example, the Civil Rights Act in the US was passed after decades of racial discrimination.

Moreover, the answer to *"What's the ethical thing to do?"* and *"What is legal?"* might be very different.[80] A global AI fairness framework can be a great equaliser, which can adapt to the rapidly evolving nature of AI risks.

Defining 'fairness' *as* "treating individuals and groups with justice, equity, respect and impartiality" is a gross oversimplification. Across the world, the meaning of 'fairness' differs based on the perspectives indicated above. Such complexities prevent a universal singular definition, instead suggesting a pluralistic and contextual approach towards defining fairness. This section of the article will revisit why fairness is poorly understood.

Technical Challenge: How to Choose a Fairness Metric

Ask two data scientists to make the model fair, and they may reach for different metrics.[81] One will aim for equality of opportunity metrics,[82] such as equalised odds, the test that refers to procedural equity, meritocratic setup, having a level playing field, and ensuring everyone has equal access to resources and opportunities in domains like criminal justice and exam grading. Going by this view, qualified individuals must share the same chance of a favourable decision, regardless of their group. This view essentially neglects social realities like historical injustices or the marginalisation of communities based on race or caste.

The second data scientist will chase equality of outcomes metrics, such as demographic parity, which focuses on outcome parity across demographics, and having resource redistributive mechanisms in place, such as positive discrimination, affirmative actions, and taxation. There are examples of quotas or reservations in college admissions for marginalised communities, aimed to improve outcome parity, although they sometimes lead to admission denials for qualified general category students.[83] Both views sound reasonable, yet they pull against each other. Kleinberg, Mullainathan and Raghavan showed that when the system is not perfect (which it rarely is), one cannot satisfy both these views at the same time.[84]

It becomes even more complex when the aspect of individual fairness is added. Would this same applicant get the loan in a world where her race, gender, or caste were different?

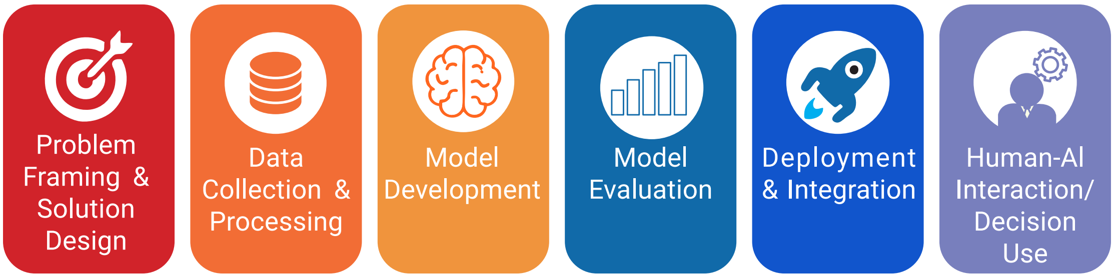
The worldviews related to individual versus group fairness are evidenced to be contradictory and incompatible.[85] Moreover, fairness collides with other ethical principles such as transparency and privacy. Group fairness metrics need the very data that Europe's GDPR labels as "special category"—race, religion, biometrics, sexual orientation—and forbids processing.[86] Firms must therefore collect sensitive traits under a legal exemption, or abandon the metric altogether.

Picking a fairness metric is not just a tweak in the code; operationalising fairness remains a technical challenge with an unresolved moral debate.

Creeping Bias at Different Stages of the AI Lifecycle

Understanding bias at various stages of an AI system lifecycle—right from ideation, data collection, model development, evaluation, deployment, and usage in the real world—is crucial to creating fair AI systems.

Figure 2: Stages of AI System Lifecycle



Source: Author's own, created using ChatGPT and Canva

Table 1: Bias Traps and Real-World Examples Across the AI Lifecycle

Stage	Typical Bias Traps	Real-world Examples
Problem Framing	Framing bias, goal-selection bias and historical blind spots	The Netherlands childcare benefits scandal illustrates how a singular goal of minimising fraud (reducing false positives) can backfire when inclusivity (minimising false negatives) is sidelined. This led to the system falsely accusing thousands of low-income families, many with migrant backgrounds, plunging them into debt and poverty.[87]
Data Collection	Representation bias, Measurement bias, Sampling bias	An MIT audit found that gender classification algorithms performed poorly on darker-skinned women as compared to lighter-skinned men.[88]

Model Training	Label bias, proxy features, aggregation bias	A widely used US hospital tool from Optum predicted future health "need" by looking at past medical spending. Black patients with the same disease burden as White patients had historically incurred lower costs. So, Black patients got less care because their historical bills were lower.[89]
Validation & Testing	Metric choice, threshold tuning	The COMPAS recidivism tool passed overall-accuracy checks yet doubled the false-positive rate for Black defendants (45 percent versus 23 percent for Whites).[90]
Deployment	Context shift, feedback-loop, basis-risk	Amazon's Face Recognition Falsely Matched 28 Members of Congress with Mugshots.[91]
Human Use	Automation bias, confirmation bias, alert fatigue, anchoring	The Epic Sepsis Model sprayed so many false alarms that clinicians tuned it out, missing real cases.[92]

Fairness is not a static check at one point in time. Bias can creep in at every stage of the AI life cycle, and it must be understood, identified, and controlled.

Prospects for a Global Fairness Playbook

A single global rulebook will not work, but a pluralistic framework with universal core principles, grounded with local contextual realities, is workable and already taking shape. Principles inspired by both Indian and Western philosophies can help provide the foundational moral compass for such a framework.

Indian Vedic concepts like *Dharma* (moral duty) and *Vasudhaiva Kutumbakam* (world as one family), which advocate duty and collective welfare, when aligned with Western ideals of individualism, human dignity, and inclusivity, together can form a guiding set of values that are relevant universally. Translating these high-level principles into actionable steps will require identifying local contextual nuances (such as socio-economic, historical, cultural, moral, political, and legal) and tailoring fairness metrics and threshold requirements to them. Caste is not a protected trait in Washington; veteran status is not one in Delhi. A pluralistic framework lets each country focus on its own issues without reinventing the entire playbook.

Such a fairness framework enforces and institutionalises them into binding local laws and regulations that define sector-specific fairness obligations, metrics, and thresholds across the AI lifecycle to avoid blind spots. A standing review board of data engineers, ethicists, and local community representatives inserted at all the different stages costs less than post-deployment litigations.

A Call to Action: From Principles to Practice

Addressing AI Fairness risks proactively requires a multi-pronged approach: a collaboration and alignment between stakeholders. Policymakers, regulators, industry leaders, civil society and researchers must co-create fairness guidelines that are grounded in real-world constraints. While this remains an active area of research, here is an actionable blueprint for stakeholders.

Table 2: An Actionable Blueprint for Stakeholders on AI Fairness

Actor	The Next 18 Months	Three-Year Horizon
Governments & Regulators	- Mandate Fairness Impact Assessments for high-risk deployments - Publish fairness benchmarks and metrics via model cards and data cards for national AI datasets and models - Establish a Bias Bug bounty fund for academics and citizens to find unfairness in AI systems - Setup cross border Fairness Sandbox: a safe harbour for startups.	- Align national policies with global AI governance frameworks (e.g. OECD, UN, NIST). - Build a public incident database and legal safeguards for whistle-blowers. - Fund AI Fairness research fellowships and trainings
Industry & Tech Leaders	- Adopt internal fairness policies & guidelines - Commitments to fairness testing and upskilling - Incentivise fairness KPIs in compensation	- Publish fairness reports publically - Support governments to define sector-specific rules

Academia & Researchers	- Develop context-sensitive fairness metrics. - Build publicly available datasets to enable AI fairness assessments. - Conduct Cross-disciplinary research (such as privacy-fairness tradeoffs).	- Develop tools for fairness testing - Create AI fairness training for developers, policymakers, and regulators. - Collaborate with global AI governance bodies to develop fairness standards and framework.
Civil Society, Multilateral Bodies	- Raise public awareness about AI fairness issues through media, reports, and grassroots initiatives.	- Create global AI fairness funding pools for capacity building in developing nations. - Establish AI Risk Fellowships to upskill Researchers who will bridge the gap between scientific innovation and policy making

Source: Author's analysis, drawing on global AI governance debates

Conclusion: The Road Ahead for AI Fairness

This article sought to illustrate how fairness in AI is inherently a complex, context-driven, and urgent issue. The question is no longer "Should we act?" but "How fast can we move from principle to practice?" As the world stands on the cusp of the AI revolution, it is imperative to either proactively ensure that AI is fair or allow fairness to be an afterthought. Proactively addressing fairness demands actionable global frameworks that are adaptable to local contexts, supported by coherent policies, and cross-border cooperation.

There is an urgent need to build on the foundations set up in this brief to develop a modular toolkit to operationalise AI fairness aimed at bridging high-level principles with real-world implementation needs. The goal is to offer a modular and adaptable framework that policymakers, practitioners, and researchers can apply across diverse socio-technical ecosystems.

Endnotes

1 Meetings Coverage and Press Releases, https://press.un.org/en/2024/sgsm22500.doc.htm.

2 Ben Buchanan, "The AI Triad and What It Means for National Security Strategy," Centre for Security and Emerging Technology, August 2020.

3 Ross Gruetzemacher and Jess Whittlestone, "The Transformative Potential of Artificial Intelligence," *Futures* 135, January 2022.

4 Siddharth Dixit and Indermit S. Gill, "AI, the New Wingman of Development," World Bank, May 2, 2024.

5 Alex Shpachuk, "Top 10 Real-World Artificial Intelligence (AI) Applications in Healthcare," Empeek, September 5, 2023, empeek.com/insights/top-ai-applications-in-healthcare.

6 Akash Takyar, "AI in Banking and Finance," LeewayHertz - AI Development Company, February 14, 2023, www.leewayhertz.com/ai-use-cases-in-banking-and-finance/#AI-impact-on-the-banking-and-finance-industry.

7 "Use Cases - AI-For-Education.org," AI-For-Education.org, November 27, 2023, ai-for-education.org/use-cases/.

8 "The Role of AI in the Entertainment and Media Industry," Appventurez, December 12, 2023, www.appventurez.com/blog/ai-in-entertainment-and-media.

9 Oishika Banerji, "Role of Artificial Intelligence in Law," IPleaders, September 26, 2021, blog.ipleaders.in/role-of-artificial-intelligence-in-law/#Current_state_of_artificial_intelligence_in_law.

10 "Top 15 Real-Life Use Cases for AI in Transportation Industry," Redresscompliance.com, March 7, 2024, redresscompliance.com/top-15-real-life-use-cases-for-ai-in-transportation-industry/.

11 Dmytro Lenniy, "AI in Agriculture," Intellias, February 18, 2021, intellias.com/artificial-intelligence-in-agriculture/.

12 "Top 30 AI ECommerce Applications," AIMultiple, 2024, research.aimultiple.com/ai-e-commerce/.

13 Shaifali, "Top 30 AI Tools for HR," Peoplebox, June 25, 2024, www.peoplebox.ai/blog/ai-tools-hr-teams/.

14 "The AI Risk Repository," Mit.edu, 2024, airisk.mit.edu.

15 "Artificial Intelligence Incident Database," Incidentdatabase.ai, 2024, incidentdatabase.ai/apps/discover/?is_incident_report=true&s=discrimination. Accessed 4 Mar. 2025.

16 A Johari, "Aadhaar Tragedies are on the Rise," *Scroll.in*, January 2019, https://scroll.in/article/895667/a-year-after-jharkhand-girl-died-of-starvation-aadhaar-tragedies-are-on-the-rise.

17 A Verma, "From Fingerprints to Face Auth: Uidai CEO Bhuvnesh Kumar on Securing the Digital Identity of Over Billion Indians," ETGovernment.com., April 2024, 2025, https://government.economictimes.indiatimes.com/news/digital-india/from-fingerprints-to-face-auth-uidai-ceo-bhuvnesh-kumar-on-securing-the-digital-identity-of-over-billion-indians/120558403#:~:text=exceptional%20cases%20with%20care%20and,empathy.

18 "Amazon Scraps "Sexist AI" Recruitment Tool," *The Independent*, October 11, 2018, https://www.independent.co.uk/tech/amazon-ai-sexist-recruitment-tool-algorithm-a8579161.html.

19 "Incident 40: COMPAS Algorithm Performs Poorly in Crime Recidivism Prediction," May 1, 2016, https://incidentdatabase.ai/cite/40/#r707.

20 Jeff Larson et al., "How We Analyzed the COMPAS Recidivism Algorithm," ProPublica, May 23, 2016, www.propublica.org/article/how-we-analyzed-the-compas-recidivism-algorithm.

21 "Article 99: Penalties | EU Artificial Intelligence Act," https://artificialintelligenceact.eu/article/99/.

22 "The Artificial Intelligence and Data Act," January 2025, https://ised-isde.canada.ca/site/innovation-better-canada/en/artificial-intelligence-and-data-act-aida-companion-document.

23 "AI Risk Management Framework | NIST," NIST, May 5, 2025, https://www.nist.gov/itl/ai-risk-management-framework.

24 Recommendation on the ethics of AI, https://www.unesco.org/en/articles/recommendation-ethics-artificial-intelligence.

25 Anna Roy, "Responsible AI for All: Adopting the Framework," NITI Ayog, 2022, https://www.niti.gov.in/sites/default/files/2022-11/Ai_for_All_2022_02112022_0.pdf.

26 Ministry of Internal Affairs and Communications, "AI Guidelines for Business Ver1.0," April 2024, https://www.meti.go.jp/shingikai/mono_info_service/ai_shakai_jisso/pdf/20240419_9.pdf.

27 "OECD AI Policy Observatory Portal," https://oecd.ai/en/ai-principles.

28 Gina M. Raimondo, "Artificial Intelligence Risk Management Framework," National Institute of Standards and Technology, 2023, https://nvlpubs.nist.gov/nistpubs/ai/nist.ai.100-1.pdf.

29 Christos Makridis and Mike H.M., "Fairness in Machine Learning: Regulation or Standards?," Brookings, February 2024, https://www.brookings.edu/articles/fairness-in-machine-learning-regulation-or-standards.

30 Dissecting Racial Bias in an Algorithm Used to Manage the Health of Populations, https://www.science.org/doi/10.1126/science.aax2342.

31 Amol Dethe et al., "Credit Gap: Do Algorithms Deny Loans to Women Borrowers? Explains CEO of Women's World Banking," ETBFSI.Com, March 24, 2025, https://bfsi.economictimes.indiatimes.com/news/banking/credit-gap-do-algorithms-deny-loans-to-women-borrowers-explains-ceo-of-women-world-banking/118517653.

32 Dethe et al., "Credit Gap: Do Algorithms Deny Loans to Women Borrowers? Explains CEO of Women's World Banking."

33 Alex Rizzi and Devina, "Digital Credit Algorithms in India: Expanding Access or Cementing Exclusion?," Center for Financial Inclusion, April 17, 2024, https://www.centerforfinancialinclusion.org/digital-credit-algorithms-in-india-expanding-access-or-cementing-exclusion/.

34 "'F**K the Algorithm'?: What the World Can Learn from the UK's A-level Grading Fiasco," Impact of Social Sciences, November 10, 2022, https://blogs.lse.ac.uk/impactofsocialsciences/2020/08/26/fk-the-algorithm-what-the-world-can-learn-from-the-uks-a-level-grading-fiasco.

35 Anabelle Nicoud, "Key Findings from Stanford's 2025 AI Index Report," IBM, April 25, 2025, https://www.ibm.com/think/news/stanford-hai-2025-ai-index-report.

36 "Britain Invests 100 Million Pounds in AI Research and Regulation," *Reuters*, https://www.reuters.com/technology/britain-invests-100-million-pounds-ai-research-regulation-2024-02-06/.

37 Claudia Wilson, "The US Has Committed to Spend Far Less Than Peers on AI Safety," Center for AI Policy, September 23, 2024, https://www.centeraipolicy.org/work/the-us-has-committed-to-spend-far-less-than-peers-on-ai-safety.

38 PricewaterhouseCoopers, "PwC's 2024 US Responsible AI Survey," PwC, https://www.pwc.com/us/en/tech-effect/ai-analytics/responsible-ai-survey.html.

39 NIST, "Towards a Standard for Identifying and Managing Bias in Artificial Intelligence," March 2022, https://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.1270.pdf.

40 Mirha Butt, "Beyond the Raj: How British Colonialism Continues to Impact Human Rights in India," LSE Human Right, November 29, 2023, https://blogs.lse.ac.uk/humanrights/2023/07/12/beyond-the-raj-how-british-colonialism-continues-to-impact-human-rights-in-india.

41 Rebecca M. Kulik, "Partition of India," Encyclopaedia Britannica, July 9, 2025, https://www.britannica.com/event/Partition-of-India.

42 Lukas Althoff and Hugo Reichardt, "Jim Crow and Black Economic Progress after slavery," The Quarterly Journal of Economics, July 22, 2024, https://academic.oup.com/qje/article/139/4/2279/7718111.

43 "About Bringing Them Home," https://bth.humanrights.gov.au/significance/about-bringing-them-home.

44 World Bank, *Inequality in Southern Africa: An Assessment of the Southern African Customs Union*, Washington DC, World Bank Group, 2022, https://documents1.worldbank.org/curated/en/099125003072240961/pdf/P1649270b73f1f0b5093fb0e644d33bc6f1.pdf.

45 Eduardo Dianderas, "Disrupting the Patrón: Indigenous Land Rights and the Fight for Environmental Justice in Paraguay's Chaco," *Tapuya Latin American Science Technology and Society* 7, no. 1 (2024), https://doi.org/10.1080/25729861.2024.2424101.

46 IMF, *Spreading the Wealth FRANÇOIS BOURGUIGNON*, March 2018, Washington DC, International Monetary Fund, 2018, https://www.imf.org/en/Publications/fandd/issues/2018/03/bourguignon.

47 Nitin Kumar Bharti et al., *Income and Wealth Inequality in India, 1922-2023: The Rise of the Billionaire Raj*, March 2024, World Inequality Database, 2024, https://wid.world/wp-content/uploads/2024/03/WorldInequalityLab_WP2024_09_Income-and-Wealth-Inequality-in-India-1922-2023_Final.pdf.

48 Moritz Kuhn et al., *Income and Wealth Inequality in the United States: An Update Including the 2022 Wave,* National Bureau of Economic Research, May 2025, https://doi.org/10.3386/w33823.

49 Jhon M. Masterson et al., "Disparities in COVID-19 Disease Incidence by Income and Vaccination Coverage September 2021," *Morbidity and Mortality Weekly Report* 72, no. 26: 728–31, https://doi.org/10.15585/mmwr.mm7226a5.

50 "Inequality in 2024: A Closer Look at Six Regions," World Inequality Database, December 6, 2024, https://wid.world/news-article/inequality-in-2024-a-closer-look-at-six-regions.

51 "Overview," World Bank, https://www.worldbank.org/en/country/southafrica/overview.

52 Sanghita Ghosh et al., "Women's Participation in Higher Education in India: An Analysis Across Major States," *Indian Journal of Human Development* 15, no. 2 (2021): 275–94, https://doi.org/10.1177/09737030211030048.

53 "The Nepotism and Favouritism in Politics of South Asia," https://www.paradigmpress.org/SSSH/article/download/810/692.

54 "Individualism and Opposition to Redistribution in the US: The Cultural Legacy of the Frontier," CEPR, December 23, 2017, https://cepr.org/voxeu/columns/individualism-and-opposition-redistribution-us-cultural-legacy-frontier.

55 "Kant's Moral Philosophy (Stanford Encyclopedia of Philosophy)," January 21, 2022, https://plato.stanford.edu/entries/kant-moral.

56 Ethics Unwrapped, "Veil of Ignorance - Ethics Unwrapped," February 17, 2023, https://ethicsunwrapped.utexas.edu/glossary/veil-of-ignorance.

57 Stephen M. Byars et al., "2.6 a Theory of Justice - Business Ethics | OpenStax," September 24, 2018, https://openstax.org/books/business-ethics/pages/2-6-a-theory-of-justice.

58 "The Ethics of Artificial Intelligence Through the Lens of Ubuntu," Montreal AI Ethics Institute, June 2, 2022, https://montrealethics.ai/the-ethics-of-artificial-intelligence-through-the-lens-of-ubuntu.

59 Deborah McGregor et al., "Indigenous Environmental Justice and Sustainability," *Current Opinion in Environmental Sustainability* 43, April 2020, https://www.sciencedirect.com/science/article/pii/S1877343520300075.

60 Pak-Hang Wong, "Confucian 'Trustworthy AI': Diversifying a Keyword in the Ethics of AI and Governance," in *Social and Ethical Considerations of AI in East Asia and Beyond,* February 18, 2025, https://doi.org/10.1007/978-3-031-77857-5_1.

61 Soraj Hongladarom, "How Buddhist Principles Can Help Shape a More Ethical AI," Buddhistdoor Global," July 31, 2024, https://www.buddhistdoor.net/features/how-buddhist-principles-can-help-shape-a-more-ethical-ai/.

62 "BG 3.20-21: Chapter 3, Verse 20-21 https://www.holy-bhagavad-gita.org/chapter/3/verse/20-21.

63 "BG 2.47: Chapter 2, Verse 47 https://www.holy-bhagavad-gita.org/chapter/2/verse/47.

64 "BG 2.48: Chapter 2, Verse 48 https://www.holy-bhagavad-gita.org/chapter/2/verse/48.

65 "BG 6.29: Chapter 6, Verse 2 https://www.holy-bhagavad-gita.org/chapter/6/verse/29.

66 "BG 3.35: Chapter 3, Verse 35 https://www.holy-bhagavad-gita.org/chapter/3/verse/35.

67 "Vasudhaiva Kutumbakam," Wikipedia, May 29, 2025, https://en.wikipedia.org/wiki/Vasudhaiva_Kutumbakam.

68 Joe Allen, "Can Proportional Representation Create Better Governance?," Protect Democracy, May 2, 2024, https://protectdemocracy.org/work/can-proportional-representation-create-better-governance.

69 Matt Sheehan, "What China's Algorithm Registry Reveals About AI Governance," Carnegie Endowment for International Peace, https://carnegieendowment.org/posts/2022/12/what-chinas-algorithm-registry-reveals-about-ai-governance?lang=en.

70 Vidhi Centre for Legal Policy, NITI Aayog, and Government of India, "Adopting the Framework: A Use Case Approach on Facial Recognition Technology," 2023, https://www.niti.gov.in/sites/default/files/2024-06/document.pdf.

71 "Artificial Intelligence 2025 legislation," https://www.ncsl.org/technology-and-communication/artificial-intelligence-2025-legislation.

72 Ivette Gomez, "10 Things to Know About Abortion Access Since the Dobbs Decision," KFF, June 20, 2024, https://www.kff.org/policy-watch/10-things-to-know-about-abortion-access-since-the-dobbs-decision.

73 "CFPB Issues Advisory Opinion on Coverage of Fair Lending Laws," Consumer Financial Protection Bureau, May 9, 2022, https://www.consumerfinance.gov/about-us/newsroom/cfpb-issues-advisory-opinion-on-coverage-of-fair-lending-laws.

74 "EEOC Launches Initiative on Artificial Intelligence and Algorithmic Fairness," US EEOC, https://www.eeoc.gov/newsroom/eeoc-launches-initiative-artificial-intelligence-and-algorithmic-fairness.

75 "America's AI Action Plan," https://whitehouse.gov/wp-content/uploads/2025/07/Americas-AI-Action-Plan.pdf.

76 Government of India, Ministry of Law and Justice, Legislative Department, *The Constitution of India,* https://www.indiacode.nic.in/bitstream/123456789/16124/1/the_constitution_of_india.pdf.

77 A. Johari, "Aadhaar Tragedies are on The Rise," Scroll.in, January 2019, https://scroll.in/article/895667/a-year-after-jharkhand-girl-died-of-starvation-aadhaar-tragedies-are-on-the-rise.

78 Leif Wenar, "John Rawls," Stanford Encyclopedia of Philosophy, Metaphysics Research Lab, Stanford University, 2017, plato.stanford.edu/entries/rawls/#ReaPluPubPolCul.

79 Mark Sherman "Supreme Court Ends Affirmative Action in Higher Education," *AP News*, June 29, 2023, web.archive.org/web/20230629143022/apnews.com/article/supreme-court-affirmative-action-college-race-f83d6318017ec9b9029b12ee2256e744. Accessed 4 Mar. 2025.

80 Manuel Velasquez et al., "A Framework for Thinking Ethically," Markkula Center for Applied Ethics, May 1, 2009.

81 "Common Fairness Metrics — Fairlearn 0.13.0.dev0 Documentation," https://fairlearn.org/main/user_guide/assessment/common_fairness_metrics.html.

82 Moritz Hardt et al., "Equality of Opportunity in Supervised Learning," 30th Conference on Neural Information Processing Systems (NIPS 2016), https://proceedings.neurips.cc/paper/2016/file/9d2682367c3935defcb1f9e247a97c0d-Paper.pdf.

83 "NEET UG 2024 Re-Revised Result: NTA Lowers Cut-off for All Categories, Counselling Date Soon," *The Indian Express*, July 28, 2024, https://indianexpress.com/article/education/neet-ug-2024-re-revised-result-cut-off-for-all-categories-air-rank-holders-percentile-counselling-9478674/.

84 "Inherent Trade-offs in the Fair Determination of Risk Scores," arXiv, https://arxiv.org/pdf/1609.05807.

85 Sorelle A. Friedler et al., "On the (Im)Possibility of Fairness," arXiv, September 23, 2016, arxiv.org/pdf/1609.07236.

86 "Art. 9 GDPR – Processing of Special Categories of Personal Data - General Data Protection Regulation (GDPR)," General Data Protection Regulation (GDPR), August 30, 2016, https://gdpr-info.eu/art-9-gdpr/.

87 M. Heikkilä, "Dutch Scandal Serves as a Warning for Europe Over Risks of Using Algorithms," Politico, April 13, 2022, https://www.politico.eu/article/dutch-scandal-serves-as-a-warning-for-europe-over-risks-of-using-algorithms/#:~:text=Authorities%20penalized%20families%20over%20a,were%20taken%20into%20foster%20care.

88 "Gender Shades: Intersectional Accuracy Disparities in Commercial Gender Classification," Proceedings of Machine Learning Research 81, 2018: 1–15, https://proceedings.mlr.press/v81/buolamwini18a/buolamwini18a.pdf.

89 "Dissecting Racial Bias in an Algorithm Used to Manage the Health of Populations," Science, https://www.science.org/doi/10.1126/science.aax2342.

90 "Incident 40: COMPAS Algorithm Performs Poorly in Crime Recidivism Prediction," May 1, 2016, https://incidentdatabase.ai/cite/40/#r707.

91 Jacob Snow et al., "Amazon's Face Recognition Falsely Matched 28 Members of Congress with Mugshots," American Civil Liberties Union, February 27, 2023, https://www.aclu.org/news/privacy-technology/amazons-face-recognition-falsely-matched-28.

92 "Widely Used Sepsis Prediction Tool Is Less Effective Than Michigan Doctors Thought | NHLBI, NIH," NHLBI, June 29, 2021, https://www.nhlbi.nih.gov/news/2021/widely-used-sepsis-prediction-tool-less-effective-michigan-doctors-thought.

Towards a Vernacularised Taxonomy of Potential AI Harms for India and the United States

Wm. Matthew Kennedy

Abstract

Public entities and private AI model developers are expected to work together to deliver safe and trustworthy AI. Sociotechnical harms from AI adoption and diffusion, however, can take novel and unanticipated forms because of contextual factors. General classifications of AI risk used to align public and private actors are therefore proving inadequate in structuring global efforts to achieve real-world AI trust and safety. In an effort to help public and private AI actors carry out their responsible AI duties in live deployment contexts and across social and cultural contexts, this article proposes a new method—

vernacularisation—for the construction of AI harms taxonomies. This methodology is inspired by recent anthropological ethics approaches to human rights law to overcome the analogous challenge of aligning disparate value systems while also respecting their pluralities. The discussion positions vernacularisation in contrast to doctrinary approaches to responsible AI, and sketches out a model 'vernacularised' taxonomy of harms that AI may cause to the democratic institutions of India and the United States to indicate how it might be used profitably in joint scientific research on sociotechnical AI harms.

Introduction

The burden of ensuring responsible innovation in Artificial Intelligence (AI) does not fall on AI model developers alone but is distributed across the ecosystem of AI actors. Public entities responsible for ensuring good governance, the rule of law, and the administration of justice are a critical part of delivering responsible AI. These entities, which include government regulators, policy-making bodies, key officials, and also public scientific or technical organisations (for instance, in the US, the Federally Funded Research and Development Centers) are charged with representing communities and are the only actors that have the power to require developers to abide by a community's norms.[1] By extension, they play a role in the development of AI systems, helping ensure that the harms AI may cause are identified, limited, and reversible.

Direct measures at the disposal of public entities include creating statutory regulations, empowering agencies and government officials to execute policy, and arriving at sound interpretations of the law during legal disputes. These entities also influence AI development indirectly: by accelerating research into both technological development and policy innovation, maintaining well-regulated markets, and making wise public investments to draw as many people as possible into communities of innovation, evaluation, and utilisation.

There are many reasons why public entities may not be able to perform these functions well, including technical debt (that is, the compounding effects of a shortcoming of technical knowledge within an organisation), fast-moving AI developments, lack of effective jurisdiction, the absence of important legislation, or the existence of complicated, 'patchwork' regulatory instruments. Prominent AI labs themselves may be utilising uncertainties to influence policymakers to adopt friendlier regulatory postures, only complicating matters. For instance, some argue that the narrative of fast-moving AI development (often referred to as 'hype') has been deliberately crafted to forestall important national or state regulation.[2]

For these reasons, many researchers argue that AI systems may potentially cause great harm to democracy itself.[3] Public entities have responded by implementing national and international frameworks for approaching their new AI responsibilities—these typically taking the form of risk management frameworks, typologies, or taxonomies that include the harms that AI may cause to critical social institutions, such as mis- and disinformation in the context of elections. But one serious problem has prevented public entities from fully carrying out their AI responsibilities: the lack of a method to unify generic global risk categorisations with the unique and context-specific harms that AI systems can produce when deployed to specific spaces. This problem is intensified by the fact that societies across the globe are beginning to adopt AI in several high-risk sectors.

As harms produced by AI systems are 'co-determined' by social context, regulating them properly entails understanding the values, norms, and discourses of specific deployment contexts.[4] This is an exceedingly difficult problem, one made more formidable by the growing consensus that prevailing methods and artefacts available for sociotechnical AI harms research are not suitable for assessing the performance of AI in real-world contexts.[5] As a result, AI developers, deployers, and public entities charged with governing this technology can fail to model the AI risk surface by relying only on overgeneral, anticipatory classifications of harms.

This article aims to propose a new method for producing important analytical categorisations of real-world AI harms: 'vernacularisation'. This method can help resolve the global-local paradox that has hampered many AI governance efforts as AI actors shift their posture from anticipatory to real-world evaluation and governance. The article outlines how vernacularisation might be able to produce more context-specific understandings of sociotechnical AI harms. It takes as an example the utility of vernacularisation in developing a toy taxonomy of harms that AI may cause to the world's largest democracies: India and the United States (US), itself a fruitful avenue of research and policy collaboration that public entities (specifically AI metrology, standards, and evaluation science agencies) in India and the US may be uniquely poised to pursue.

Towards a Better Methodology for Understanding AI's Effects on Democracy

Democracy and the 'Global-Local' Paradox

There are many definitions of democracy available; which should researchers use when investigating the effects of AI on democracy? This article refers to the *practice* of democracy rather than the *political ideal*. Among the most important attributes of democratic practice is adherence to the rule of law; the requirement that law derives legitimacy to the extent that it originates from citizens themselves, and a shared adherence to the principle that nobody—including high officials—is exempt from the obligation to follow its provisions. Habitually adhering to the rule of law produces the (lawful) freedom that democratic societies enjoy.[6] Beyond this, social, cultural, and historical variance in democratic practice defies general categories.

Public entities seeking to carry out their duties governing AI—and specifically to ensure that it does not erode democratic practices—have encountered myriad difficulties in standardising their efforts, in large part because democratic practices can vary greatly across the globe. After all, it is one thing to describe democratic practices in general and another to account for different expressions and practices of varied democratic societies. Although many of the natural law principles that underpin democratic ideals are represented as universals, modern practices of democracy are highly localised. As both the US's and India's Constitutions were the result of revolutionary or anticolonial ideologies, they (and the jurisprudence that has resulted) are fiercely autochthonous. That leads even these democratic states that have been greatly important to the development of human rights doctrines to implement them in rather different ways. It is easy to see why this problem of pluralism—the 'global-local' paradox[7]—constantly frustrates efforts to encourage adherence to global normative frameworks such as human rights principles. Indeed, it is from this field that 'vernacularisation' itself originates.

Among AI development communities, this paradox is often experienced as part of the "alignment problem". Although there are many approaches to AI alignment, the most grounded of which is described as an effort to identify the conditions sufficient for an AI system or model to earn the endorsement of its users after a period of sustained and reflective use.[8] AI developers generally maintain that differences in understanding what AI behaviours or outputs produce these conditions (and which do not) can then be represented taxonomically and computationally implemented afterwards.[9] However, most agree that alignment has proven to be difficult because there is a tremendous amount of noise in the kaleidoscopic landscape of human values.[10] Even empirical AI alignment researchers and AI ethicists admit that there will inevitably be tension between conflicting values,[11] and the best that one can do is to develop novel approaches that cultivate "moral imagination"[12] sufficient to overcome the sensation of paradox.[13] AI governance communities tend to interpret this problem differently—i.e., as the alignment of an AI system's persistent social effects with either primary or secondary norms operating within society.

Understanding AI's effects on democratic practice is therefore both a social and a technical problem.[14] This is why public and private AI actors are searching for new methods to evaluate AI system performance in real-world contexts. At the heart of that problem is the need to meaningfully unite global, prescriptive norms with the unique norms, values, and discourses of specific democratic states in ways that do not diminish those unique properties. One way that public and private AI actors have attempted to overcome this problem is to turn (with varying degrees of rigour) to comparative law methodologies. These tools are used to examine local policy ecosystems for evidence that prevailing pro-democratic AI doctrines have been successfully transferred into those jurisdictions to inform sociotechnical AI safety research. This has been effective in some ways, most notably demonstrated by the AI governance profession's uptake of the Center for AI and Digital Policy AI and Democratic Values Index,[15] which measures different states' implementation of broad responsible AI frameworks, such as the UNESCO Recommendation on the Ethics of AI.[16]

However, comparative law methods do not offer a complete solution. An exclusive focus on the transfer of exogenous doctrines into recipient jurisdictions downplays the legitimacy of local AI risk cultures and institutions. From a scientific point of view, it limits our visibility into the actual implementation of those doctrines—a critical source for understanding local "habits" and discourses of responsible AI.[17] This, in turn, may actually increase the risk that efforts to measure progress towards pro-democratic AI ecosystems will undermine the authority of local public entities to carry out their responsibilities: publics (especially in postcolonial democracies) may be wary of trusting externally produced frameworks that cannot account for local dynamics. Ultimately, doctrinary expressions of such responsibilities may or may not be meaningful to local AI actors or the communities for which they are developing or regulating AI.

As the field searches for new methods, it also is looking for a medium through which information can be shared about concrete classes of AI harms that public entities should seek to monitor and reduce.[18] Although all AI actors utilise framework-style schemas to communicate organisational priorities, they are not readily interoperable across development, governance, or regulatory actors. Public entities are much more likely to create frameworks as a prescriptive measure without necessarily suggesting metrics by which actions can be evaluated or a basis upon which those particular actions are grounded. For instance, the US National Institute of Standards and Technology's (NIST) Generative AI Profile, published as part of its highly influential Risk Management Framework, suggests a typology of Generative AI risks, but leaves it to AI developers to determine suitable metrics for identifying, monitoring, and mitigating those risks when the actually occur.[19]

Conversely, actors involved in the development and deployment of AI employ schematic approaches to better classify and measure the magnitude of harms AI systems can cause, even if they are often oriented towards commercialisation or compliance goals. These measures are both technical and sociotechnical. Each relies on a formally validated classification of harms—a "taxonomy".[20] Importantly, this schematic artefact is both the result of empirical analysis and a medium of communication, for instance the recently developed and constantly maintained MITRE ATLAS taxonomy for AI security. Most AI harms or risk taxonomies in use today fall into the first category: they are anticipatory, rooted in local social and cultural context, and not formally validated in real-world settings.

The Potential of Vernacularisation

AI development and governance actors clearly have an active, if unresolved, interest in developing a shared artefact through which to taxonomise harms AI systems can cause in real-world contexts and across societies. In order to model this kind of harm surface, a new approach may prove beneficial: vernacularisation. The methodology of vernacularisation has proved especially useful in mitigating the global-local paradox without sacrificing context-specificity in other high-stakes fields, such as human rights dissemination.[21] In the words of its earliest proponents, the global-local paradox only exists if one insists on treating global frameworks as doctrine.[22] In contrast to doctrinary approaches, communities—and not elites or specialists—drive vernacularisation.

Communities engage in these practices not as 'recipients' shaping 'transfers',[23] but as 'users'[24] availing themselves of useful principles in the configuration of their norms and values.[25] In this way, the methodology promotes alignment to global norms while allowing plural values and discourses also to find expression; indeed, it views them as essential features and not contradictory elements.[26]

Participatory design methodologies have moved AI ethics and safety, responsible innovation, and governance paradigms towards vernacularisation, but that method, as discussed here, has not yet been taken up in AI systems design. This is, in part, because vernacularisation requires more extensive research efforts—a constraint also faced here. However, to demonstrate the method, the next section of the article presents a toy vernacularised taxonomy of harms that AI may cause to the democracy in India and the US.

The taxonomy is largely grounded in proxy sources—official material, grey papers, journalistic reporting (in English and South Asian languages digitally translated into English), and academic research conducted by specialists in the fields of Indian and American digital cultures, information geography, sociotechnical systems design, and social impacts of AI. Although these sources tell us something about community practices and perceptions of AI harms to the unique values that comprise US and Indian democracies, they are admittedly insufficient for producing a fully vernacularised taxonomy. They may, however, suggest a joint scientific enquiry that US and Indian AI social impacts researchers might profitably pursue using the method of vernacularisation.

A Toy Vernacularised Taxonomy of Potential AI Harms to Democratic Institutions in India and the US

The Taxonomy

1) **Epistemological harms**: There is potential for AI to result in systematic degradation of both democracies' information milieus, which in turn, suffocates the public sphere. Judging by Indian and US discourses, this risk presents itself in three ways. Opinions on both sides about which has the most potential for harm appear to differ in many ways.

   a) *Outputs:* Generative AI can produce false or intentionally misleading or manipulative information in text, image, video, and audio formats. The risk that deepfakes may affect the outcome of elections or citizen behaviour during the period is perceived as high among both populations.

   b) *Grounding:* Another category of epistemological risk present especially in American discourses is the existence of what Sandra Wachter has called "careless speech," wherein an AI model will output false but plausible information regarding "something a human would not normally lie about".[27] Unlike deepfakes, which are intentionally misleading, one-off outputs like careless speech risk undermining trust in the information ecosystem in general and present a serious risk to effective democratic participation over time.

   c) *Dissemination*: A third category of epistemological risk relates to AI participation in the rapid dissemination of false or misleading information content. Concern about this particular risk is present, albeit in different ways across both contexts, and largely reflects differences across Indian and American platform preferences for information sharing. For instance, in 2024, Indian users preferred less mediated communication platforms, such as WhatsApp (80.8 percent) or Meta's Instagram (>80 percent),[28] whereas Americans tended to prefer more media-rich if less direct platforms, such as YouTube (85 percent) or Facebook (70 percent) with only 30 percent of Americans using.[29] Some suggest that the difference is explained in part by device usage. Indian users use social media on mobile devices, while American users tend to favour a mix of larger and handheld devices. Others suggest that linguistic diversity shapes this preference, as more direct platforms support multilingual interactions better. These are remarkable differences, as more direct communication platforms may be highly susceptible to botnet attacks[30] that spread fake news, especially when aligned to personal socio-political identities.[31] Techniques for preventing the dissemination of violative content, such as hash-sharing, are also less effective in more direct platforms.[32]

2) **Technocratic harms:** Government attentiveness to the interests of its citizens may diminish in favour of those of large AI developers. As governments are increasingly persuaded that AI is an important strategic technology, and with many citizens continuing to urge governments to take seriously the opportunities that AI applications may afford, AI labs are likely to increase their market power and political influence. This is especially the case when AI developers make large financial or technical investments in sectors that are typically the government's domain, such as in public research institutions or digital infrastructure (DPI). Finally, government use of public and private AI systems to aid service delivery, expand access to political representation, speed up decision-making, and increase information-gathering each poses risks of mismanagement and abuse of government authority.

   a) *Surveillance*: Among the primary risks identified in Indian and American discourses is the risk of AI-empowered surveillance, specifically in law enforcement contexts including police action and personal mobility (e.g., in customs and immigration or intra-state travel). Indian sources regularly cite the introduction of the Aadhaar biometric information system as evidence that Indian public entities are utilising AI-powered technologies to enhance surveillance capabilities, especially of minority populations, in violation of their right to digital privacy. In American sources, a similar concern about the Department of Homeland Security's facial recognition systems installed at airports features regularly,[33] complemented by recent reports of unauthorised data-sharing between federal agencies under the new Trump administration.[34] Public distrust of the government use of AI appears to undermines the expectation that the rule of law will be upheld. At worst, it directly erodes democracy itself.

   b) *Inexplicability*: Discriminative AI systems (those whose outputs are typically either a score or a classification) replicate the decision-making that bureaucratic networks make.[35] As such, AI systems have already been deployed in a variety of procedural applications, such as benefits distribution,[36] visa application processing,[37] and most notably in criminal sentencing.[38] High-profile controversies in each of these use cases have alarmed both the Indian and US communities. Prominent AI fairness researchers argue that systems that rely on machine learning (ML) algorithms that are not interpretable (e.g., neural networks) should not make such decisions alone.[39] Inexplicable decisions may substantially undermine not only public trust in government services but also the culture of petitioning, which is common in both India and the US.[40] They may also lead to miscarriages of justice, which serve to undermine the legitimacy of courts or magistrates.

c) *Irreversibility:* Factors enabling a drift to technocracy may cause irreversible harm to individuals, vulnerable demographics, and society in general, even when those enabling factors are neutralised. For instance, algorithms that assign likelihoods of education, attainment, or recidivism make predictions about individuals based on group characteristics. The sampling error may be mitigated, but those whose education or civil liberties were affected will not be able to reverse those effects.[41]

3) **Resource Mismanagement Harms:** AI may have large-scale impacts on society's critical resources, their value, and distribution. Both Indian and American societies place great value on the idea of economic or social justice, although they are constructed quite differently. At the same time, both societies are concerned about the risk that, in a race to develop AI, states may follow policies that use their own natural, economic, and labour resources unsustainably, diminishing the capacity of society to maintain democratic practices.

a) *Misallocation of resources*: Among the frequently-cited resource management risks in both Indian and American AI and democracy discourses is the massive infrastructural and environmental resource allocations that large-scale AI systems require. Both India and the US suffer from ageing electrical transmission infrastructure. Both states have sought to direct public funds into new (and resuming old) energy production plants to power large, private data centres, but it is not yet clear whether these investments will simply aid powerful AI actors in expanding their market power. Indian and American discourses diverge slightly on environmental resource management: both have voices that caution about governments potentially choosing to direct valuable water resources to AI infrastructure projects (such as the large data centres in Texas, Arizona, South Dakota, Iowa, and in Telangana) instead of local communities, many of whom are dependent on them. Some observers are concerned that precious public resources will be handed over to private interests without the opportunity for meaningful public participation.

b) *Drain theory*: In addition to concerns about natural resources, the risk of AI causing a brain drain features prominently in Indian and American discourses. Although they differ substantially, American concerns revolve around the share of AI/ML researchers that the industry is capturing—more than 70 percent of

AI/ML researchers took up industry posts in 2023, a figure that has doubled in the past six years.[42] The magnitude of technical debt accruing in academic research and the government has many Americans concerned.[43] Indian attitudes point to the significant share of national talent being recruited by foreign AI developers.[44] Public entities may be increasingly unable to effectively monitor and regulate AI developed in or deployed to other democratic societies if technical talent continues to flow primarily to large AI labs in the minority world.

Better Methods Can Help Chart a Way Forward

Just as the way societies distribute responsibility for AI influences the way it is developed, the manner in which entities choose to design, develop, and deploy AI influences how societies make those choices: Do they do so freely? Are they given meaningful access to decision-making? Are their interests represented in these choices? Public entities that are positioned to contribute to the development and deployment of responsible AI must examine these dynamics further instead of working to generalise categories of harm that may be of limited utility for the assessment of real-world AI harms.

Developing a mature vernacular taxonomy entails doing local value discovery work: it requires researchers to 'discover' context-specific AI risks by engaging with local communities of practice. But even this preliminary discussion shows that the Indian and US vernacular regarding the harms that AI may cause to their democratic societies diverge and converge in meaningful ways. There is reason to suggest that relational dynamics are at work here as well—certain risks perceived in the Indian discourse may be the result of knowledge of harms actually experienced in the US context—for instance, the concern to ensure environmental protection when expending public natural resources to build AI infrastructure. But until private and public AI actors devise new methods for addressing new, real-world, and context-specific problems caused by increasing AI adoption, both will struggle to fulfil their obligations to their citizens to ensure that AI systems are developed, deployed and used safely and in a way that earns public trust. Vernacularisation may be one such method.

Endnotes

1 Renee Shelby et al., “Sociotechnical Harms of Algorithmic Systems: Scoping a Taxonomy for Harm Reduction,” in *Proceedings of the 2023 AAAI/ACM Conference on AI, Ethics, and Society* (New York: Association for Computing Machinery), doi.org/10.1145/3600211.3604673.

2 Arvind Narayanan and Sayash Kapoor, *AI as Normal Technology: An Alternative to the Vision of AI as a Potential Superintelligence*, Knight First Amendment Institute, 2025, https://kfai-documents.s3.amazonaws.com/documents/0ee1da899a/AI-as-Normal-Technology---Narayanan---Kapoor-Final.pdf.

3 C. Y. Cyrus Chu, Juin-Jen Chang, and Chang-Ching Lin, “Why Does AI Hinder Democratization?,” Proceedings of the National Academy of Sciences of the United States of America (2025), https://doi.org/10.1073/pnas.2423266122 (2025).

4 Weidinger et al 2023.

5 Reva Schwartz et al., “Reality Check: A New Evaluation Ecosystem Is Necessary to Understand AI’s Real World Effects,” Cornell University, May 24, 2025, arXiv:2505.18893v4.

6 Scott Veitch, *Obligations: New Trajectories in Law* (London: Routledge, 2021).

7 A fairly ubiquitous concept, the tension between global and local is a prominent theme in IR as well. See, e.g., Arndt Sorge, “The Paradox of Internationalization,” in *The Global and the Local: Understanding the Dialectics of Business Systems* (Oxford, 2005), https://doi.org/10.1093/acprof:oso/9780199278909.003.0001.

8 Iason Gabriel, “Artificial Intelligence, Values, and Alignment,” *Minds and Machines* 30, no. 3 (2020):411-437.

9 See, for example, Anthropic 2023.

10 Taylor Sorensen et al., “Value Kaleidoscope: Engaging AI with Pluralistic Human Values, Rights, and Duties,” in *Proceedings of the AAAI Conference on Artificial Intelligence*, doi.org/10.1609/aaai.v38i18.29970.

11 Sorensen et al., “Value Kaleidoscope: Engaging AI with Pluralistic Human Values, Rights, and Duties.”

12 Benjamin Lange et al., “Engaging Engineering Teams through Moral Imagination: A Bottom-up Approach for Responsible Innovation and Ethical Culture Change in Technology Companies,” *AI Ethics* 5 (2025): 607-616, doi.org/10.1007/s43681-023-00381-7.

13 Margarita Boyarskaya, Alexandra Olteanu, and Kate Crawford, “Overcoming Failures of Imagination in AI Infused System Development and Deployment,” Cornell University, November 26, 2020, https://doi.org/10.48550/arXiv.2011.13416.

14 Schwartz et al, Reality Check, 2025.

15 Center for AI and Digital Policy, “AI and Democratic Values Index,” 2023.

16 UNESCO, “Recommendation on the Ethics of AI,” 2022.

17 Patricia Ewick and Susan S. Silbey, *The Common Place of Law: Stories from Everyday Life* (Chicago: University of Chicago Press, 1998).

18 Susan Leigh Star and James R. Griesemer, “Institutional Ecology, `Translations’ and Boundary Objects: Amateurs and Professionals in Berkeley’s Museum of Vertebrate Zoology, 1907-39,” *Social Studies of Science* 19, no.3 (1989): 387-420. https://doi.org/10.1177/030631289019003001.

19 National Institute of Standards and Technology, *Artificial Intelligence Risk Management Framework 1.0,* January 2023, NIST AI 100-1, 2023, https://nvlpubs.nist.gov/nistpubs/ai/NIST.AI.100-1.pdf; National Institute of Standards and Technology, *Artificial Intelligence Risk Management Framework: Generative Artificial Intelligence Profile*, NIST AI 600-1, 2024, https://nvlpubs.nist.gov/nistpubs/ai/NIST.AI.600-1.pdf.

20 Michele Banko, Brendon MacKeen, and Laurie Ray, "A Unified Taxonomy of Harmful Content," in *Proceedings of the Fourth Workshop on Online Abuse and Harms*, ACL Anthology (2020), doi.org/10.18653/v1/2020.alw-1.16.

21 Sally Engle Merry, "Transnational Human Rights and Local Activism: Mapping the Middle," *American Anthropologist* 108, no.1 (2006): 38–51, https://www.law.berkeley.edu/files/MerryAATransnationalHumanRights2006.pdf; [25]Sally Engle Merry and Peggy Levitt, "The Vernacularization of Women's Human Rights," in *Human Rights Futures*, eds. S. Hopgood, J. Snyder, and L. Vinjamuri (Cambridge: Cambridge University Press), 213–236; Mark Goodale, "Vernacularization as Anthropological Ethics," in *The Complexity of Human Rights: From Vernacularization to Quantification*, ed. P. Alston (London: Bloomsbury), 101–116.

22 Sumi Madhok, *Vernacular Rights Cultures* (Cambridge: Cambridge University Press, 2021).

23 Katia Bianchini, "Legal and Anthropological Approaches to International Refugee Law," in *The Oxford Handbook of Law and Anthropology*, ed. M.C. Foblets; M. Goodale; M. Sampignoli; and O. Zenker (Oxford: Oxford University Press), 792–807.

24 Maja Janmyr, "Ethnographic Approaches and International Refugee Law," *Journal of Refugee Studies* (2022), https://doi.org/10.1093/jrs/feac042.

25 Luis Eslava, *Local Space, Global Life: The Everyday Operation of International Law and Development* (Cambridge: Cambridge University Press, 2015).

26 Wm. Matthew Kennedy and Daniel Vargas Campos, "Vernacularizing Taxonomies of Harm is Essential for Operationalizing Holistic AI Safety," *Proceedings of the AAAI/ACM Conference on AI Ethics and Society* (2024).

27 Marina Adami, "AI-generated Slop Is Quietly Conquering the Internet. Is It a Threat to Journalism or a Problem That Will Fix Itself?," *Reuters Institute*, 2024, https://reutersinstitute.politics.ox.ac.uk/news/ai-generated-slop-quietly-conquering-internet-it-threat-journalism-or-problem-will-fix-itself.

28 Tanushree Basuroy, "Penetration of Leading Social Networks in India in 3rd Quarter of 2024.," *Statista*, 2024, https://www.statista.com/statistics/284436/india-social-media-penetration/.

29 "Social Media Fact Sheet: Tech Adoption Trends," Pew Research Foundation, 2024, https://www.pewresearch.org/internet/fact-sheet/social-media/.

30 Martin R. Albrecht, Benjamin Dowling, and Daniel Jones, "Formal Analysis of Multi-device Group Messaging in WhatsApp," in *Advances in Cryptology – EUROCRYPT 2025. EUROCRYPT 2025. Lecture Notes in Computer Science* 15608, eds. Fehr, S., Fouque, https://doi.org/10.1007/978-3-031-91101-9_9.

31 Santanu Chakrabarti, "Duty, Identity, Credibility: Fake News and the Ordinary Citizen in India," *BBC Research*, 2018, https://downloads.bbc.co.uk/mediacentre/duty-identity-credibility.pdf.

32 GIFCT, *2022 Global Internet Forum to Counter Terrorism Report,* GIFCT, 2022, https://gifct.org/wp-content/uploads/2022/12/GIFCT-Transparency-Report-2022.pdf.

33 "How the U.S. Public and AI Experts View Artificial Intelligence," Pew Research Center, April 2025, https://www.pewresearch.org/wp-content/uploads/sites/20/2025/04/pi_2025.04.03_us-public-and-ai-experts_report.pdf.

34 "How the U.S. Public and AI Experts View Artificial Intelligence."

35 Solon Barocas, Moritz Hardt, and Arvind Narayanan, *Fairness and Machine Learning: Limitations and Opportunities* (Boston: The MIT Press).

36 Agneta Ranerup and Helle Zinner Henriksen, "Digital Discretion: Unpacking Human and Technological Agency in Automated Decision Making in Sweden's Social Services," *Social Science Computer Review* 40, no.2 (2020):445-461, https://doi.org/10.1177/0894439320980434.

37 Homeland Security, "United States Citizenship and Immigration Services – AI Use Cases," Homeland Security, https://www.dhs.gov/ai/use-case-inventory/uscis.

38 Ho, Yi-Jen (Ian) and Jabr, Wael and Zhang, Yifan, "AI Enforcement: Examining the Impact of AI on Judicial Fairness and Public Safety," November 25, 2024, http://dx.doi.org/10.2139/ssrn.4533047
Stuart Russell, *Human-Compatible: Artificial Intelligence and the Problem of Control*, (New York: Viking, 2019).

39 Russell, *Human-Compatible: Artificial Intelligence and the Problem of Control*.

40 Rohit De and R Travers, "Petitioning and Political Cultures in South Asia: Introduction," Modern Asian Studies 53, no. 1 (2019): 1-20. doi:10.1017/S0026749X18000537; [20] Richard Huzzey et al., eds, *Petitions and Petitioning in Europe and North America: From the Late Medieval Period to the Present* (Oxford: Oxford University Press). https://doi.org/10.5871/bacad/9780197267721.001.0001.

41 Sorelle A. Friedler, Carlos Scheidegger, and Suresh Venkatasubramanian, "The (Im)possibility of Fairness: Different Value Systems Require Different Mechanisms for Fair Decision Making," *Commun. ACM* 64, no. 4 (2021): 136–143, https://doi.org/10.1145/3433949.

42 Nur Ahmed et al., "The Growing Influence of Industry in AI Research," Science 379: 884-886, DOI:10.1126/science.ade2420.

43 Pew 2025.

44 Anirudh Suri, "The Missing Pieces in India's AI Puzzle: Talent, Data, and R&D," Carnegie India, 2025, https://carnegieendowment.org/research/2025/02/the-missing-pieces-in-indias-ai-puzzle-talent-data-and-randd.

About the Authors

All contributors were part of the 2024-25 cohort of ORF and ORF America's U.S.-India AI Fellowship Program.

United States

Elie Alhajjar
Senior Scientist, RAND

Dr. Elie Alhajjar is a Senior Scientist at RAND, working at the intersection of AI, cybersecurity, and government. His professional background spans national security, AI/ML, quantum technologies, and climate change, and his career has been dedicated to tackling the challenges in these domains through research, policy development, and strategic implementation.

Ingrid Erickson
Associate Professor, School of Information Studies, Syracuse University

Dr. Ingrid Erickson is an Associate Professor in the School of Information Studies at Syracuse University. An ethnographer and organisational scholar by training, her current research focuses on the human qualities and capacities that may be required, or are being revalued, in an increasingly automated future.

Vaibhav Garg

Executive Director, Cybersecurity & Privacy Engineering Research and Public Policy, Comcast Cable

Dr. Vaibhav Garg is the Executive Director of Cybersecurity & Privacy Engineering Research and Public Policy at Comcast Cable. His research investigates the intersections of emerging tech, public policy, and economics. He is a recipient of the 2025 Wilt J. Hildenbrand Jr. Rising Leader Award and the 2015 ACM SIGCAS Outstanding Service Award. He has co-authored over 30 peer-reviewed publications and received the best paper award at the 2011 eCrime Researcher's Summit for his work on the economics of cybercrime.

Divyansh Kaushik

Vice President, Beacon Global Strategies

Dr. Divyansh Kaushik is Vice President at Beacon Global Strategies, where he advises Fortune 100 companies and startups on national security issues related to AI and emerging technologies. Previously, as Associate Director for Emerging Technologies and National Security at the Federation of American Scientists, he was a key resource for Congress and the administration on AI policy and US-China tech competition, contributing to significant legislative measures.

Wm. Matthew Kennedy

AI Ethics, Safety, and Governance Researcher

Dr. Wm. Matthew Kennedy is an AI ethics, safety, governance, and policy researcher, specialising in evaluation methodologies, red teaming, and risk assessments for AI systems developed for "high risk" contexts. Trained as a Ph.D. historian of "scientific" governance, he has nearly a decade of experience in self-managed, collaborative team science. He is passionate about developing practices that ensure AI systems enhance, and do not degrade, democratic values and human rights.

Zeena Nisar

Policy Advisor, National Security Commission on Emerging Biotechnology, U.S. Senate

Ms. Zeena Nisar is a molecular biologist turned policy researcher working at the intersection of economic competitiveness, national security, and emerging technologies. She is currently a Policy Advisor for the US National Security Commission on Emerging Biotechnology, where she leads policy research on strategic investments, financing, and market demand.

Katelyn Radack

Senior Instructor of International Affairs, Department of Social Sciences, United States Military Academy at West Point

Ms. Katelyn Radack is a Major in the US Army. She currently serves as a senior instructor of International Affairs in the Department of Social Sciences at the United States Military Academy at West Point. She holds degrees from Georgetown University (2022), the University of Duisburg-Essen (2013), and George Washington University (2008). Her research interests include emerging technology, language and media, and human security with a regional focus on these issues in the Asia-Pacific.

Honson Tron

Developer Experience (DevEx) Lead, Latent AI

Mr. Honson Tran is a computer scientist with a passion for contributing to all things technology for the betterment of humanity. Honson is the current Developer Experience lead at Latent AI, a startup hyperfocused on democratising AI tooling to accelerate AI deployment to the edge continuum. In his role, he oversees the customer experience and aids in improving technical and non-technical processes within and outside of Latent AI.

India

Priyanshu Gupta

Project Scientist, India Meteorological Department, Government of India

Dr. Priyanshu Gupta is a Project Scientist at the India Meteorological Department in New Delhi. Her broader interests include climate modeling, extreme weather events, satellite data analysis, AI, and air pollution. In studying the effects of extreme weather events and air pollution, she seeks to inform policy decisions that can mitigate risks to vulnerable populations, enhance climate resilience, and promote sustainable development.

Neeraj Jain

Vice President (Technology), Open Network for Digital Commerce

Mr. Neeraj Jain is Vice President for Technology at the Open Network for Digital Commerce. He is a seasoned product and consulting professional with a career that has spanned an extensive portfolio of delivering technology-driven programmes, as well as designing operational needs in-line with the stated organisational priorities.

Jatin Patni

Director, Ernst & Young India

Mr. Jatin Patni is a Director with Ernst & Young India focused on global AI fairness through a Global South lens. He builds principle-based governance across policy, procedures, and control standards, and turns fairness research into deployable safeguards. He leads bias and risk assessments for high-stakes systems in banking, healthcare, and public services. His work brings Global South realities into global AI rulemaking and practice, from data and model audits to dashboards and fairness passports. Trained as a technologist with advanced AI credentials, he bridges code, policy, and execution.

Mandeep Rai

Director, Space Control Centre, India

Col. Mandeep Rai is a seasoned expert in IT, telecommunications, space technology, and strategic leadership, with a track record across diverse domains. As Director at the Space Control Centre in India, he leads operations that support critical space services through the integration of advanced technologies, strategic foresight, and multi-stakeholder collaboration.

Resham Sethi

Senior Program Officer, Digital Health (India & South Asia Hub), PATH

Ms. Resham Sethi is a purpose-driven public health leader at the intersection of AI, digital technologies, and global health. Currently, she leads the Public Health Impact through Artificial Intelligence initiative at PATH, driving efforts to achieve UHC and health equity across LMICs by building AI for health ecosystems and strengthening South-South collaborations.

Raj Shekhar

AI Regulation Fellow, iSPIRT Foundation

A lawyer and public policy professional by training, Mr. Raj Shekhar is currently an AI Regulation Fellow at iSPIRT Foundation, where he focuses on leveraging India's DPI leadership to advance forward-looking approaches to AI regulation designed to support innovation at scale while prioritising public trust and safety. Previously, he led the Responsible AI Charter at Nasscom, championing initiatives to define a comprehensive roadmap for the ethical and inclusive adoption of AI in India.

Megha Shrivastava
MoFA Taiwan Fellow and a Visiting Scholar at the Institute of National Defense and Security Research, Taipei, Taiwan

Dr. Megha Shrivastava obtained her Ph.D. from the Department of Geopolitics and International Relations, Manipal Institute of Social Sciences Humanities and Arts, Manipal Academy of Higher Education, India. She is also an Affiliate Research Fellow at the International Centre for Cultural Studies, National Yang Ming Chiao Tung University, Hsinchu, Taiwan. Her research focuses on emerging technologies, China's innovation models, and AI governance.

Urmi Tat
Manager, Public Policy and Government Affairs, Salesforce India

As Manager for Public Policy and Government Affairs at Salesforce India, Ms. Urmi Tat leads engagement strategies, and advocates for inclusive AI policies by collaborating with governments, lawmakers, and academia. Previously, as a Senior Trade Policy Advisor for the Department for Business and Trade, United Kingdom (UK), she advised on digital strategy and partnerships in India, including the digital trade and innovation aspects of the UK-India Free Trade Agreement.

About the Editors

Andreas Kuehn

Senior Fellow, Technology Policy, ORF America, Washington, DC

Dr. Andreas Kuehn is a Senior Fellow at ORF America and the principal lead of the U.S.-India AI Fellowship Program. He directs ORF America's research and dialogues on technology policy, with a particular focus on advancing US cooperation with like-minded partners through minilateral frameworks. His work is focused on promoting and protecting critical and emerging technologies—including advanced communications, semiconductors, and artificial intelligence—and on strengthening international cybersecurity cooperation to address shared challenges and enhance resilience in ICT supply chains.

Anulekha Nandi

Fellow, Centre for Security, Strategy and Technology, Observer Research Foundation, New Delhi

Dr. Anulekha Nandi is a Fellow, Centre for Security, Strategy and Technology at ORF. Her areas of research include digital innovation management and governance focusing on artificial intelligence, emerging technologies, and digital infrastructures. Her work explores underlying conditions for policy and regulations, ecosystem management, and building blocks for innovation at scale.

ORF America thanks the following members of their staff:

Jeffrey D. Bean

Program Manager, Technology Policy & Editor, ORF America, Washington, DC

Mr. Jeffrey D. Bean is Program Manager for Technology Policy and Editor at ORF America. He manages research on critical and emerging technologies, particularly semiconductors and AI, implements the activities of the Global Cyber Policy Dialogues, and leads engagement on US-India tech policy issues in Washington. Concurrently, as editor, he reviews all long-form research reports ahead of publication for the organisation.

Natalie Boyse

Senior Program Manager, Global Programs, ORF America, Washington, DC

Ms. Natalie Boyse is Senior Program Manager, Global Programs at ORF America. In her role, she helps establish and manage ORF America's global policy programs.

Ishani Chettri

Communications Assistant, ORF America, Washington, DC

Ms. Ishani Chettri is a Communications Assistant at ORF America. She is responsible for producing and curating digital content for ORF America's social media platforms.

OBSERVER
RESEARCH
FOUNDATION

20 Rouse Avenue
New Delhi-110002
Ph: +91-11-35332000 | Fax: +91-11-35332005
www.orfonline.org | contactus@orfonline.org

AMERICA

1100 17th St. NW, Suite
Washington DC 20036 USA
www.orfamerica.org