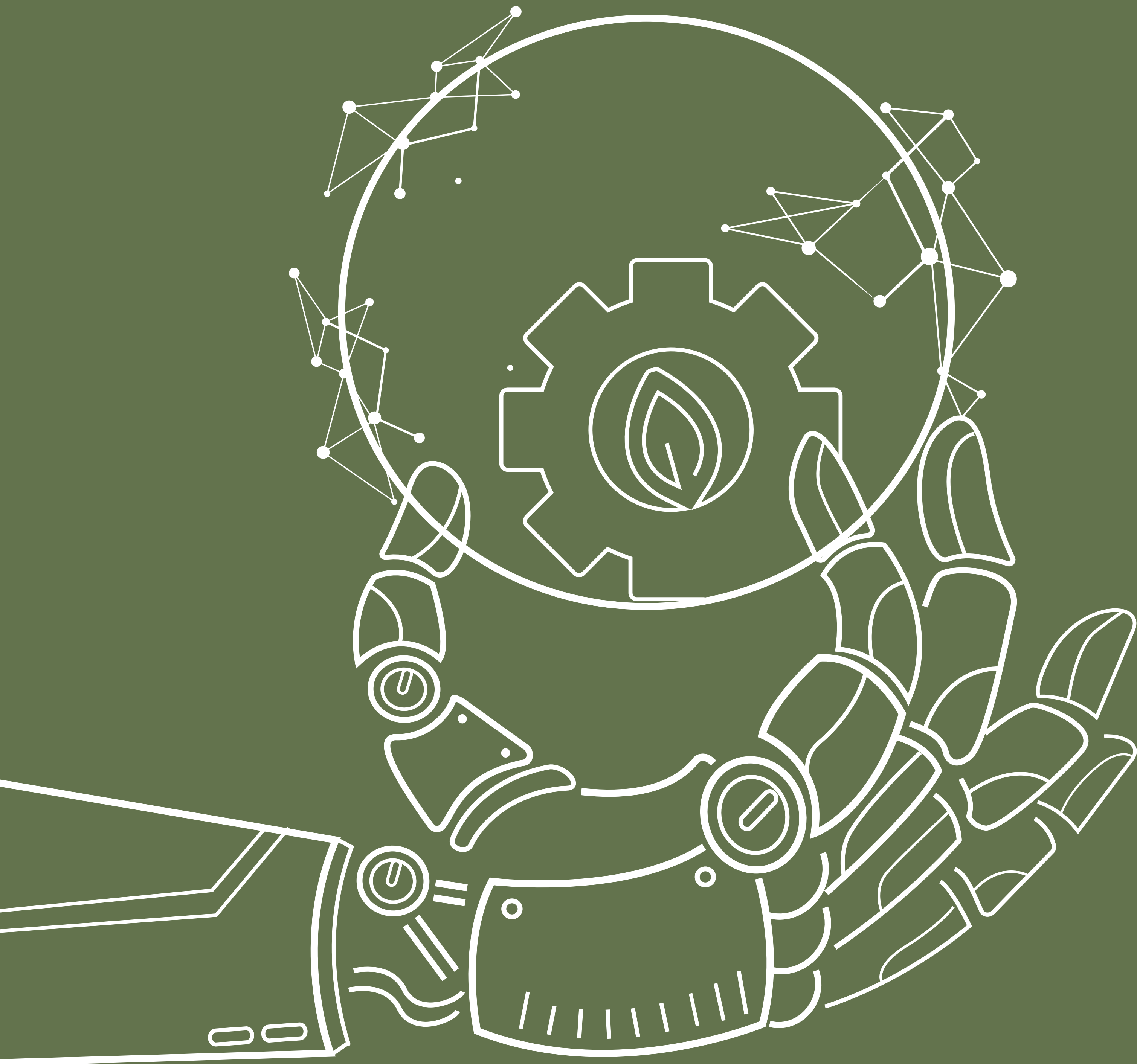
Artificial Intelligence in India - Vol. 8



Artificial Intelligence for Sustainability

Dr. Vikrom Mathur, Zaheb Ahmad, Angelina Chamuah

FRIEDRICH EBERT STIFTUNG

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Preface

"After all, we make ourselves according to the ideas we have of our possibilities."
V.S. Naipaul

There is no doubt that the technological advancement has become the game changer of our times. From the Industry 4.0 discourse launched in Germany in 2011 to the scientific advisory report presented to the former US president Barrack Obama on big data and privacy concerns in 2014, to India's NITI Aayog Artificial Intelligence for All strategy of 2018. A lot of debates have culminated in the questions about the Future of Work in the context of the International Labour Organisation's Centenary in 2019. Triggered by the disruptive forces of technology based start-ups and new business models, a new race for innovations and war for talents has arisen and with it, a new form of global and fierce competition.

Technology has become the holy grail of progress though it did not take long to realise that there is a social dimension attached to it. The platform economy has had severe effects on the bargaining power of suppliers and workers. Data analytics opened a whole array of ethical questions regarding personal tracking and privacy. Further, technological upgrades create productivity gains by efficiency which in turn requires reduced human labour. This poses a particular threat to emerging economies, like India, which need to create new jobs on massive scale for its young and growing population.

The utopia around Artificial Intelligence in the times of jobless growth presents a whole new set of challenges. Is the Indian economy ready to ride the AI wave? Who will benefit from AI: investors, big tech, users, or society as a whole? What is and can be India's role in this global race for innovation? Is tech gender neutral? What about privacy and user protection? How to ensure decent work and social protection in this new age tech revolution? But mostly, how can we turn Artificial Intelligence for All into a reality?

To foster this debate, the FES India Office has teamed up with several experts and organisations across the country to explore ground realities with the objective to understand how technology is already unfolding in selected sectors, draft scenarios of what might happen and to ensure proper safeguards are put in place at the right time.

Artificial Intelligence like any other technology is neither good nor bad. It is what we make out of it - the rules and regulations – which define the outcome of the game. Just like other countries, in India too, a mass scale application of AI is far from being established. It is still in a nascent phase and can be moulded into a success story. A success story in India AND an Indian success story for all.

Patrick Ruether and Mandvi Kulshreshtha
March 2020
Friedrich-Ebert-Stiftung, New Delhi

Note of thanks

Friedrich-Ebert-Stiftung India office is thankful to its partner Tandem Research for preparing this research paper. Tandem Research is an interdisciplinary research collective that generates policy insights at the interface of technology, society, and sustainability. FES India and Tandem Research have co-organised six policy labs to unpack AI applications in key sectors like sustainability, healthcare, education, agriculture and urbanity.

We are grateful to our colleagues at Tandem Research for preparing the research, drafting this paper and refining the manuscript to reflect our joint vision. We have to express our appreciation to all the experts and resources persons who participated in these labs, for their constructive contribution and valuable time during the course of this research.

Tandem Research's Technology Foresight Group (TFG) brings together multiple stakeholders to collectively and iteratively diagnose issues and challenges pertinent to technology and society futures in India. The present paper was developed at the AI Lab held in October 2018. The brief is based on discussions of the TFG but should not be seen as a consensus document — participant views differ and this document need not reflect the views of all participants.

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List of abbreviations

AI	Artificial Intelligence
ATREE	Ashoka Trust for Research in Ecology and the Environment
BNHS	Bombay Natural History Society
CaTRAT	Camera Trap Repository Analysis Tool
CLiMA	Climate Modelling Alliance
CO2	Carbon dioxide
CWC	Central Water Commission
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GM	Genetically-modified
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IoT	Internet of Things
IPCC	Intergovernmental Panel on Climate Change
IRI	International Research Institute for Climate Prediction
MeitY	Ministry of Electronics and Information Technology
MoHUA	Ministry of Housing and Urban Affairs
NASSCOM	National Association of Software and Services Companies
NITI Aayog	National Institution for Transforming India
OECD	The Organisation for Economic Co-operation and Development
PwC	PricewaterhouseCoopers
SDGs	Sustainable Development Goals
T&D	Transmission and distribution
US	United States of America
WHO	World Health Organisation
4IR	Fourth Industrial Revolution

I. AI and the anthropocene

Escalating ecological emergencies as well as the effects of climate change on livelihoods and living conditions across the world have led to urgent calls for policy and public action on sustainability.[1] In 2000, Nobel laureate Paul Crutzen, labelled the current ecological epoch in which we find ourselves as the age of the 'anthropocene'.[2] The term anthropocene signifies the lasting and irreversible impact of human activity on the earth's geological processes. Crutzen writes, "because of the anthropogenic emissions of carbon dioxide, global climate may depart significantly from natural behaviour for many millennia to come. It seems therefore appropriate to assign the term anthropocene to the present in many ways human dominated geological epoch".[3] It has been argued that anthropogenic changes to the global environment have set the planet on the path to a sixth mass extinction.[4] As a powerful metanarrative, the anthropocene marks a shift in how we see ourselves today, and how we plan to view the relationship between humans and the natural world in the future.

It has been argued that anthropogenic changes to the global environment have set the planet on the path to a sixth mass extinction.

In light of the anthropocene, there has been growing justification for the need for more efficient systems, and the decoupling of human well-being from the destruction of 'nature' through recourse to technological means.[5] While the anthropocene calls out the negative impact of anthropogenic activity on a planetary scale, other have pointed out the role that the 'technosphere' plays within this epoch.[6] The technosphere, defined as the 'large scale, unplanned, undesigned and spontaneous crystallisation of diverse and previously disparate elements of technology into the networked, global system', draws attention not only to the human beings at the heart of the anthropocene but also the role of large scale technological systems, in which the former find themselves embedded, and which are largely outside their control.[7] Further, this asymmetry between human agency and technological complexities, seen as a lack of human control over the outcomes of their production, is perhaps where an optimistic imaginary about technological fixes emerges from.[8] The technosphere is somehow both 'natural' and inevitable in this framing, and largely outside human control.

A cluster of digitally driven technologies of the the so-called fourth industrial revolution (4IR)—Artificial Intelligence (see box 1), robotics, the Internet of Things (IoT), cloud computing, 3D printing, nanotechnology, biotechnology, and quantum computing, to name but a few—fuel the imaginaries of the technosphere. In a much-cited paper[9], Cantrell, Martin, and Ellis, explore the idea for a 'wilderness creator'. They write "the wilderness creator is a conceptual design for an autonomous landscape infrastructure system that creates and sustains wildness by enhancing nonhuman influences while countering all forms of human influence".[10] The wilderness creator would devise its own strategies for protecting nature and wildness, for instance; deploying drones to exterminate invasive species, or robots to clean up litter or catch poachers.

Imagining intelligent systems, as the stewards for a livable and sustainable planet, the wilderness creator is emblematic of the desire for feasible technological solutions to the issue of the environmental crisis. While debates around the anthropocene have drawn attention to the complex assemblages of humans, capital, and technology impacting the environment, at the same time, the imagined solutions are also often technologically driven. For example, rapid acceleration in computational power, and advances in the field of Artificial Intelligence (AI), have precipitated a rising confidence in the capabilities of AI interventions and algorithmic authority.[11] A range of AI-based applications are being imagined as critical solutions for pressing and anticipated challenges- from the use of AI in climate and weather forecasts, autonomous farming, widespread decentralised energy grids, fully automated and connected urban transport systems in cities, to real-time digital dashboard for the earth.

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There has been a rise in the number of aspirational and optimistic narratives around emerging technologies, of which 'AI for Good' is one.[12] These narratives of AI solutionism to address pressing socio-economic challenges for the benefit of society is propelling investments and driving research and innovations in health, agriculture, education, and urban management, among others. At the AI for Global Good Summit in 2017, the United Nations emphasised the need to leverage AI technology to achieve the Sustainable Development Goals (SDGs). These include: applications to monitor agriculture through satellite imagery and data analytics for micro-insurance to smallholder farmers (SDG 2: Zero hunger); using satellite imagery to monitor flood events (SDG 11: Sustainable cities and communities); monitoring biodiversity, and predicting and preventing deforestation, tracking livestock (SDG 15: Life on land); and tracking activities of fishing vessels (SDG 14: Life below water).

In light of discussion around AI's role in the global environmental sphere, this paper first presents emerging use cases of AI for sustainability in both the global and Indian context. This paper is based on inputs from the AI for Sustainability lab[13] as well as desk research. The aim of the paper is to identify the likely challenges and risks in use of AI for sustainability in order to initiate policy discourse in India.

The subsequent section discusses the different categories under which AI applications have been developed in relation to environmental sustainability challenges in general. The following section outlines the emerging applications and use cases of AI for sustainability in India specifically, focusing on five areas—agriculture, energy, environmental monitoring, wildlife conservation, and water systems. This is followed by a section on the analysis of challenges and risks posed by the development and deployment of AI-based technologies.

II. Global use cases of AI for sustainability

Artificial intelligence (AI), as a field is difficult to define, as the definitional and conceptual scope of AI is constantly evolving.[14] Some of the field's earliest founders have broadly defined it in terms of human intelligence, arguing that artificial intelligence would refer to machines, that 'could do any work a human can do'.[15] Currently, artificial intelligence encompasses a range of sub-fields and techniques, such as machine learning, deep learning, natural language programming, and computer vision. The vast majority of AI-based applications—such as intelligent recommendations, facial recognition and voice synthesis—are possible due to advancements in machine learning algorithms.

The global push for the use of AI as a tool to achieve sustainability goals is due to its ability to collect and analyse vast amounts of environmental data. Optimistic accounts claim that "using AI for environmental applications has the potential to boost global GDP by 3.1– 4.4 per cent, while also reducing global greenhouse gas emissions by around 1.5 – 4.0 per cent by 2030".[16] However, the rapid pace of technological change, commercialisation, and use, and its net impacts on the earth's resources may be unprecedented and difficult to anticipate.

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Despite concerns around the environmental impact of the AI industry, its ability to perform complex large-scale functions such as process optimisation, predictive analytics, and efficiencies of scale, the application AI to sustainability challenges is gaining some ground. For many use-cases, AI provides an attractive alternative to manually collecting and processing huge volumes of data, such as information from IoT networks and images from drones, camera-traps and satellites. Because of this functional ability, AI applications are now being widely applied to address several environmental problems, some of which are presented below:

- **Climate and risk modelling:** This refers to the use of AI and big data to create models and simulations in order to predict and understand planetary risks and mitigate environmental disasters. Modelling systems also incorporate climate and earth systems modelling inorder to study patterns of changes, accompanying risks and fill gaps in traditional methods of climate modelling.[17] For example, scientists at Caltech's Climate Modeling Alliance (CLiMA) are working on climate models using AI to predict how warm the earth will be in the coming decades.[18]

- **Species tracking, monitoring and management:** AI-based facial recognition systems can be used to track, and monitor animal species. For example, WildTrack and senseFly have developed AI-powered drones and image recognition solutions to collect information about endangered species in a non-invasive way.[19] The tool analyses images of the footprints of cheetahs, rhinos, and other endangered species to identify them, track them, and determine what threatens them. Similar solutions have been developed for monitoring green cover and inventorying forests, recognising their ecological, social, and economic benefits. SilviaTerra uses high-resolution satellite imagery, and US Forest Service inventory and field data to train machine-learning models to measure forests, study the effects of climate change and improve habitats.

Conservation Metrics provide an automated alternative to labor-intensive wildlife survey efforts, combining remote sensing technology, acoustic analyses, statistics, and AI to reduce costs and increase the scale and effectiveness of wildlife metrics.[20] For Cornell University's Elephant Listening Project, Conservation Metrics used algorithms to analyse data collected from acoustic sensors embedded throughout Nouabalé-Ndoki National Park in the Democratic Republic of the Congo.[21] Its system isolates elephant calls—the low-frequency rumbling sounds used for communication—from the recordings, and derives insights such as population size and herd movement.

More direct interventions in terms of species management not only involve tracking and monitoring movements, but also include technological interventions, as seen in the case of COTSBots- which are modular mobile robots- used to cull crown-of-thorns starfish in the Great Barrier Reef and protect corals.[22]

- **Predictive analytics and hyperlocal advisory:** Predictive analytics combines data from sensors, IoT-enabled devices, satellite and drone imagery to provide real time and hyperlocal advisory. For instance, in the context of smart agriculture, the predictive analytics solution from Resson are able to virtually scout an entire field to detect, classify and geo-locate specific anomalies, pests and diseases, in order to provide assistance on how to better manage yields, crop inputs and agronomy decisions.[23]

- **Resource management systems:** AI and IoT technologies are used to monitor and maintain resources such as energy and water, through the use of machine learning algorithms.These technologies are able to identify usage patterns, demand, fault predictions and prediction of external shocks—such as solar flares, hurricanes and earthquakes—allowing for better preparation against energy and water-related disruptions. For example, Fracta uses AI, specifically machine learning, to assess the condition and risk of breakdown of drinking water distribution infrastructure. Fracta analyses data related to the type of soil in which pipes rest, the topography, and weather records, and then applies machine learning to find patterns across an entire city or region, that offer clues as to which pipes are at the greatest risk of leaks or failure.[24]

While these are some of the current applications and trends of AI development in the context of sustainability, the World Economic Forum outlined a vision document which also suggests a number of potential future applications of AI.[25] This includes applications such as the creation of a 'real time digital dashboard of the earth', which would allow 'monitoring, modelling, and management of environmental systems' on a global scale. However, Jennifer Gabrys argues that such technological interventions into earth's systems are not merely recording information about the environment, but generating new environments and environmental relations.[26] Research by Crawford and Joler on the anatomy of the AI system Amazon Alexa, shows that the production of a single unit involves a complex network of global value chains: connecting the lithium reserves of Salar lake in Bolivia to factory workers in the Philippines, international Amazon warehouses and finally consumer living rooms across the world.[27]

Research shows that the production of a single unit of AI involves a complex network of global value chains.

The creation of new environmental relations and changes are also being driven by private players and large tech companies, who are prioritising AI research and development. For instance, under its AI for Earth program, Microsoft has been enabling the development of applications to help address issues of sustainability. Recognising the need to significantly increase the world's food production by 2050, challenged by limited additional arable land and receding water levels, Azure FarmBeats[28] has been pitched as an efficient and low-cost precision farming solution. The project enables data-driven farming in order to increase farm productivity and reduce costs for farmers. Low-cost sensors deployed on farms collect real-time data on factors that may affect the growth of the crops during cultivation processes including; wind speed, wind direction, soil moisture and temperature, CO_2, atmospheric moisture and temperature, and atmospheric pressure, as well as rain and light exposure. The project connects sensor data with additional information from drones, satellites, and weather stations to turn it into actionable intelligence for farmers, using AI and machine learning.

Green Horizon is a 10-year initiative launched by IBM in 2014 which aims to support sustainable urbanisation.[29] Currently being trialled in heavily polluted cities—Beijing and Johannesburg—the initiative uses connected sensors spread across the cities to capture data for numerous factors that contribute to air pollution such as traffic, humidity and weather. The cumulative data is then broken down by AI to pinpoint trends and generate granular, high resolution pollution forecasts.

Another example is Google's AI solution DeepMind which leverages machine learning capabilities to predict the energy output of wind farms, and also to reduce the amount of energy needed to cool its data centers.[30]

While global AI innovations are at advanced stages of deployment, in India, domestic interventions mirroring these advances are still at a nascent stage. Additionally, due to varying social, political and institutional contexts, the usage of AI applications will differ across countries. For instance, assessing the impact, benefits and challenges of water resource management systems will be unique and distinct when applied in India, as opposed to Australia. Even within a single country, the interaction between the different elements and stakeholders in the case of AI use will vary. It is therefore necessary to take stock of the sociological contexts in which real world AI applications are being embedded.

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III. Use cases from India

In the Indian context, the rise of fossil fuels use, increasing consumption as a result of globalisation, the development of industry and rapid urbanisation has precipitated a number of serious environmental concerns related to water, energy, depletion of forest cover and animal species. In the past decade, India has witnessed several severe droughts in states such as Maharashtra, as well as unmitigated flooding in both urban and semi-urban sites. A NITI Aayog report predicts that by 2020, at least 21 cities will completely run out of groundwater resources.[31] With nearly 600 million Indians facing high-to-extreme water stress—and about 200,000 people dying every year due to inadequate access to safe water—the situation is likely to worsen as the demand for water will exceed the supply by 2050.[32]

India is also facing several other environmental problems including greenhouse gas (GHG) emissions. As a nation, it is the third largest emitter of GHGs after China and the United States.[33] Aside from contributing to global climate change, the immediate effects of GHG emissions and air pollutants have become markedly prominent in Indian cities. Several Indian cities—many from the Northern region—already feature on the World Health Organisation's (WHO) list of the most polluted cities.[34] Growing concerns around environmental sustainability in India are further bolstered by the Intergovernmental Panel on Climate Change (IPCC) 1.5 °C report, which presents a compelling reason to act now to limit temperature rises. An increase of 1.5°C in global temperatures is likely to lead to variability in precipitation patterns, rising sea levels, glacial melt, and increased frequency and intensity of extreme weather events such as heatwaves and droughts.[35] Coastal countries and agricultural economies like India could be worst affected.

While out of the five focus areas identified by NITI Aayog in the 'National strategy for AI in India' discussion paper—healthcare, agriculture, education, smart cities and infrastructure, smart mobility and transportation—at least three will have implications for sustainability and the environment. In particular, development of AI-based applications in agriculture, smart cities and infrastructure, smart mobility and transportation are likely to have a direct impact on sustainability and the environment.

Alongside a commitment to the development of AI in India, India has signed the Paris Agreement on Climate Change, and has therefore committed to sourcing at least 40 per cent of its electricity generation from non-fossil sources by 2030. This includes increasing renewable energy capacity to 175 gigawatts by 2022.[36]

Recognising the potential of emerging technologies such as AI in addressing social and ecological challenges, national and state governments and public agencies such as NITI Aayog, have partnered with tech companies to develop AI solutions for sustainability. Startups and smaller private tech companies also dot the AI landscape for sustainability in India.

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Current AI use cases in India can be categorised into five key areas related to sustainability:

i) Agriculture; ii) Energy; iii) Environmental monitoring; iv) Wildlife conservation and v) Water systems. Each of which are discussed below.

Agriculture

Recognising the contribution of agriculture to the Indian economy, as well as its importance to issues of sustainability and food security, an array of AI solutions are being developed for the sector. Precision farming is the most prominent among these. Precision farming uses AI and IoT sensors to ensure that soil and crops receive exact levels of irrigation and nutrients for optimum health and productivity. Fasal, incubated at the National Association of Software and Services Companies' (NASSCOM) Centre of Excellence for AI and IoT, is one such precision farming solution that monitors a variety of critical parameters on farms to assess the health of crops. Fasal then uses AI and data science to make on-farm predictions around; ideal growth conditions, resource requirements including irrigation, sprays, fertilizers, and other preventive measures. Based on these predictions, real-time actionable insights are created for specific day-to-day operations, and are then communicated to farmers. AI solutions for the sector are also being developed through public-private partnerships. NITI Aayog and IBM have partnered to develop a pest and disease prediction model using AI to provide real time advisory to farmers.[37] Pilots of the project are being implemented in the states of Assam, Bihar, Jharkhand, Madhya Pradesh, Maharashtra, Rajasthan and Uttar Pradesh. CropIn, funded by the Bill & Melinda Gates Foundation enables data-driven farming through its 'SmartFarm' platform, which helps derive real-time insights on standing crop projects across geographies based on local wealth information and high-resolution satellite imagery.

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), in collaboration with Microsoft, and the government of Andhra Pradesh, has developed an AI sowing application that sends sowing advisories to participating farmers on the optimal date to sow.[38] Since a large number of farmers in India do not have the financial ability to adopt expensive technologies, this AI solution does not rely on networks of IoT sensors, or other machinery deployed on farms. Instead, the application employs AI to interact with weather forecasting models and extensive rainfall data. Sowing advisories are then sent via text messages to participating farmers.

Energy

AI solutions for the energy sector seek to improve energy efficiency by monitoring distribution networks and providing predictive analytics on energy consumption. India suffers from one of the highest levels of electricity transmission and distribution (T&D) losses globally. India's T&D losses equal nearly 20 per cent of the total amount generated—more than twice the global average.[39] Avrio Energy provides AI solutions for business operations. It uses machine learning to analyse overall energy consumption and provides recommendations to achieve energy savings. SenseHawk has been developing AI solutions specifically for the solar energy sector. Its AI system processes infrared images from drone scans to construct thermal maps of solar sites in order to detect and classify hotspots and curb losses.

Mahindra's WindPulse system provides analytics solutions for wind farms. Specialised machine learning algorithms are used to improve the overall productivity and revenue of wind farms. ThingsCloud offers AI powered solar inverter solutions for residential energy systems. Its inverters allow residential societies to monitor their energy consumption, conserve excess energy, and store backup power for utilisation during grid outages.[40]

Environmental monitoring

Every year, a significant amount of crop residue is burnt to clear agricultural fields in India, resulting in significant greenhouse gas emissions and air pollution.[41] Blue Sky Analytics has developed Zuri,[42] an AI-driven platform that uses satellite data for improved monitoring of farm fires, supply chain and pricing analysis, and alternative allocation of crop waste to other industries. Oizom[43] offers end-to-end environmental monitoring solutions based on AI, including IoT devices which monitor ambient air quality, odour, and dust levels. With in-built IoT compatibility, the devices transmit data to its cloud based server. The data is then analysed by Oizom's AI system to predict the environmental conditions of surrounding areas, using methods like interpolation, extrapolation and environmental modelling.

Wildlife conservation

In collaboration with the Indraprastha Institute of Information Technology, Delhi, the Tiger Cell has developed CaTRAT (Camera Trap Repository Analysis Tool)[44] for studying tigers. The application uses AI and machine learning protocols to identify tigers and assign unique identifiers for each one. In 2018, researchers from the Karnataka Forest Department and the Nature Conservation Foundation studying the distribution and habits of leopards, used AI to examine a collection of more than 1.5 million camera-trap images.[45] The Ashoka Trust for Research in Ecology and the Environment (ATREE) has been using machine learning algorithms to facilitate ecosystem mapping and create a bioresource atlas for Sikkim.[46] The Bombay Natural History Society (BNHS) has partnered with Accenture Labs to develop a citizen science platform to identify birds from the Indian subcontinent.[47] This cloud-based solution uses machine learning and computer vision to recognise species from digital photographs.

Water systems

The Central Water Commission (CWC) has partnered with Google to develop early warning systems for floods in India. Machine learning models analyse real-time river measurements provided by the CWC along with data on topography, and use fluid dynamics to forecast floods.[48] The EqWater project[49] at the Indian Institute of Science, Bengaluru supported by the Ministry of Housing and Urban Affairs (MoHUA), seeks to deploy IoT, machine learning, predictive analytics, and big data to make water distribution fair and efficient in major Indian cities. The project uses data from sensors in the water distribution network to create a geospatial map of water flow, and combines other data points—demographic data, water levels in reservoirs and water bills—to predict peak demands and supply gaps.

IV. Challenges and risks

The AI for Good narrative has propped up AI as a transformative tool that can solve the most complex problems and challenges faced by humanity. Undoubtedly, AI could provide greater data analysis, pattern recognition, automation and augmentation potential to enable more effective and complex sustainability solutions. The use of AI, however, raises complex, ethical concerns around the collection of data, loss of human control, bias in algorithms, data-driven monopolisation, and the resource costs of developing and deploying energy-intensive AI systems.

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Discrepancies in datasets

The ability of AI systems to help predict and provide actionable insights is dependent on datasets used in initial algorithmic training. If AI systems are exposed to other types of data that might not have been represented in training sets, it could have grave implications for the use of AI, especially in applications such as farming support. In India, local datasets for the agricultural sector are either not readily available for most areas, or tend to be inconsistent.[50] Building AI solutions for the agriculture sector without complete and accurate data could be detrimental for Indian farmers. For example, AI-based farming advisories built on faulty or incomplete datasets could ruin an entire year's harvest. In its application for sorting and grading of produce using computer vision, robust AI models trained on diverse datasets would be needed to make AI systems bias-free.

Concentration of knowledge and power

The increasing use of farming advisories may be leveraged by agricultural corporations to suggest the use of proprietary seed varieties and a suite of agricultural chemicals—exacerbating both the financial indebtedness linked to the high-cost of genetically-modified (GM) seeds[51] and health risks associated with the use of chemical fertilisers[52]—all while increasing their stronghold over global farming behaviour. The development and adoption of costly AI systems will not only be easier for large corporations to implement due to access to resources, compute power, data storage and cloud infrastructure, it will further accentuate the concentration of power in the hands of a few powerful actors. Based on privately-held market research data, an OECD report from 2018 notes the dominant position of Monsanto in the global seed market.[53] In 2019, Monsanto merged with Bayer, creating an agro-chemical powerhouse. Monsanto plans to develop AI for its agriculture business by combining AI with its research and development platforms—plant breeding, plant biotechnology, crop protection, agricultural biologicals and digital advisors—and developing solutions by integrating all of these elements.[54] The concentration of power is not just limited to large agricultural corporations but also extends to Big Tech companies such as Google and Microsoft. For example Microsoft, through its collaboration with ICRISAT[55] and government agencies such as the Ministry of Electronics and Information Technology (MeitY), is to offer AI-based farm advice regarding seeds and sow times.[56] These advisories run the risk of a few companies monopolising market intelligence and anti-competitive practices in providing agri-business advisories.

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Contextual relevance and affordability

The problems associated with AI in its application in different contexts is comparable to simulations in Earth Sciences. Not only do simulations and models tend to ignore forms of local knowledge, in some cases they also fail to consider the dynamics of the contexts where they are applied. For instance, the New York-based International Research Institute for Climate Prediction (IRI) monitors the earth's climate system and uses computer

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models to forecast climatic conditions. When predicting the effects of El Niño on the fishing community in Peru, only the commercial fishing operations which could access its data using sophisticated technologies benefited, subsequently creating an uneven playing field for local fishermen who had no financial means or skills to access its climatological data.[57]

In a similar vein, the application of AI in agriculture may lead to the depletion of local knowledge systems that have context-specific nuances that AI models could gloss over. The biological, geophysical, social and political contexts in which knowledge is transplanted are often heterogeneous, and what is a reasonable assumption in one context may be quite inappropriate in another.[58] Further, for many marginal farmers already facing indebtedness, adopting AI-backed agritech might not be financially feasible. In India, indigenous precision farming solutions have been adopted by commercial farms such as Grover Zampa vineyards.[59] The adoption of precision farming solutions by larger, financially able farms is likely to increase competitiveness in the agriculture sector, making it difficult for marginal farmers to continue their operations.

Climate cost of technology

Growing research on the climate cost of AI systems point to the resource intensive processes and high environmental costs associated with the development of AI. Following a study conducted by researchers at the University of Massachusetts, Amherst suggests that training just one AI model produces nearly 300,000 kilograms of CO_2 emissions.[60] This is comparable to the amount of CO_2 emissions that a human would generate over 60 years, with the annual average carbon footprint of a human estimated to be about 5,000 kilograms.[61] The significant material and environmental costs of AI systems is likely to have disparate impact on different geo-political locales. For example, the dependency of AI and its related technologies (such as IoT) on large scale data centres and electronic devices contributes to the mounting problem of e-waste as well as high energy consumption through data centres and server farms, in the case of AI technologies. For India, the consequences could be severe, since it is the fourth largest producer of e-waste after China, the United States of America, and Japan,[62] whilst also importing e-waste from developed countries.[63] Furthermore, energy generation from low carbon sources and renewables is moderately low, currently ranging between 17–19 per cent of the total energy production of the country.[64]

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In the quest to build better systems, AI models increasingly require more computational power. This has led to the tech industry becoming a newly significant contributor of GHG emissions. Estimates suggest that the tech industry generates between 2 – 2.5 per cent of global GHG[65] emissions, on par with that of the aviation industry.[66] Trend analysis of the tech industry's carbon footprint on global emissions suggest a rise upwards of 3 per cent of global emissions by 2020, and as much as 14 per cent by 2040.[67] Increasingly, AI applications are also being used to augment production processes of the oil and gas industry. AI Now Institute's 2019 report notes that large technology companies at the forefront of AI development have been aggressively marketing their AI services to oil and gas companies to help optimise and accelerate oil production and resource extraction.[68] Efforts to use AI to achieve sustainability and climate action could be undermined by the high-energy consumption of AI applications, especially if non carbon-neutral energy sources are used.

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Many changes related to AI applications are still emerging and have not yet fully unfolded, thus the likelihood of unintended consequences and unknown impacts is also significant. With the increasing development and use of AI systems employing drones, satellites, cameras and gathering data related to the environment, tracking activities on land or marine habitats, and monitoring energy consumption patterns raises critical concerns such as the invasion of privacy, and surreptitious surveillance. It is also important to locate the challenges of AI from a non-human, multi-species lens as well. For instance, research on the militarisation of conservation using technologies such as drones to monitor animals and apprehend poachers has raised ethical concerns regarding the impact of such technologies on animal habitats.[69]

V. Sustainable AI?

Global environmental and sustainability challenges are wicked problems. In Clumsy Solutions for a Complex World, Verweij and Thompson argue that simple solutions rarely work for wicked sustainability problems.[70] To position AI as yet another silver bullet to address the complex and intractable challenges of sustainability is problematic. Many deep-rooted problems around socio-economic and political systems, some of which already relate to technologies, will need to be addressed if AI is to be widely used to solve environmental challenges. Within the wider narrative of technological solutionism, it has been argued that 'the replacement of old and inefficient technologies with more efficient ones can often be presented as an apolitical process, leaving wider society untouched'.[71] The development and deployment of technologies are implicated within wider societal complexities and therefore have to be understood as socio-technical systems. Thus, while AI might solve a specific problem, it could also give rise to newer social and environmental challenges as well as amplifying existing ones.

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AI could certainly improve systems for collection and analysis of environmental monitoring data and provide better evidence to inform policy and galvanise public attention. However, decades of inaction around climate change, and other global environmental issues affecting biodiversity and forestry, has shown that more advanced science does not automatically translate to better public and policy action. In fact, calls for more evidence to understand the science of climate change through increasingly complex and data intensive models and simulations has been used by those opposed to climate action to stall action.[72] We know enough to start acting on many of the sustainability challenges and more data will not drive better decisions; social and political will.

The environmental impacts of AI use are also critical to emphasise. As AI systems become more efficient, their usage and deployment will increase, which would require further energy production, creating additional e-waste. Life-cycle assessments of AI's energy use, material use and waste generation will eventually be needed to weigh against its environmental and sustainability outcomes for different areas. Currently, there is a paucity of such research, but it is urgently needed. To add to the complexity, researchers at OpenAI have highlighted that since 2012, the amount of energy used for the largest AI training models has been doubling every 3.4 months[73]—a rate exponentially faster than Moore's Law which suggested that the speed and capability of computers would double every two years. This would mean understanding the effects of technological infrastructures and taking steps to ensure it does not lead to an increase in energy consumption and e-waste generation.

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AI applications which intervene directly in the earth's processes are also being developed, with large scale detrimental effects—for instance, the use of AI in mining. Vancouver-based gold mining company, Goldcorp has collaborated with IBM Watson to help determine specific areas for extraction, calculate geological models with more certainty, and interpret vast amounts of data—from drilling reports to geological survey information.[74] Rio Tinto has been using fleets of autonomous vehicles inside its iron-ore mines.[75]

Within the AI research community, proposals for making AI more sustainable, fair, and inclusive are underway. Dillon Reisman and others at the AI Now Institute suggest the use of Algorithmic Impact Assessments to help companies, governments, and communities assess the social implications of automated decision making, and determine whether the use of AI systems would be appropriate.[76] In India, IT industry bodies such as NASSCOM have highlighted that the AI start-up ecosystem in India needs digital infrastructures and greater access to data, in the form of initiatives such as Agristack, a data repository to support technology startups specifically in the agriculture sector.[77] The initiative to create open access data is also seen as a way to level the playing field for emerging start-ups, especially in the context of global tech companies who dominate the space of AI innovation in India. However, open data can often be a misnomer. Many open data-set repositories are only open to a certain extent, with most of the valuable or in demand data being behind paywalls. In a similar vein, NASSCOM suggests that all the data need not be free—data market models could be explored where people buy and access data. Closing off datasets behind paywalls, much of which are available to big corporations, could stifle public interest innovation by smaller players. While notionally, transparency offered by open-source data sharing can reduce the concentration of power by allowing smaller enterprises and actors to access datasets and mitigate the effects of data monopoly, further consideration and institutional mechanisms need to be put into place. Research also needs to analyse the politics of open data practices within the context of broader institutional frameworks.

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While the development of AI in India to solve developmental and environmental issues is a key aim of the government, it is important that AI development is aligned with human values, rather than just efficiency gains. On one hand, the development of AI systems based on learnings from the Indian context could speak more directly to Indian conditions, on the other the current state of indigenious innovation for the development of AI in agriculture is still at a nascent stage. Building both social and technological capacities would be necessary at all levels of government, academic institutions and industry in order to benefit from indigenous research and development of AI systems. This would not only require funding, but also the creation of knowledge support system incubators, while also building knowledge and regulatory capacity among government agencies and personnel through pilots and experimentation.

The ultimate goal of sustainability should be to reduce consumption and our subsequent ecological footprint. Technological innovation and efficiency may not guide us towards this. More technology does not lead to less consumption. In fact, Jevon's Paradox asserts that it will do just the opposite. Also known as the rebound effect, Jevon's Paradox suggests that improved efficiency leads to increased demand which ultimately escalates consumption and pressure on resources. Therefore, efficient technology is leading to the creation of more technology. This presents a profound paradox that challenges the assumption that technology will help us 'de-couple' our impact on the environment. Using the rationale of efficiency to justify the deployment of AI may not be an adequate approach from the perspective of sustainability.

The ultimate goal of sustainability should be to reduce consumption and our subsequent ecological footprint. Technological innovation and efficiency may not guide us towards this.

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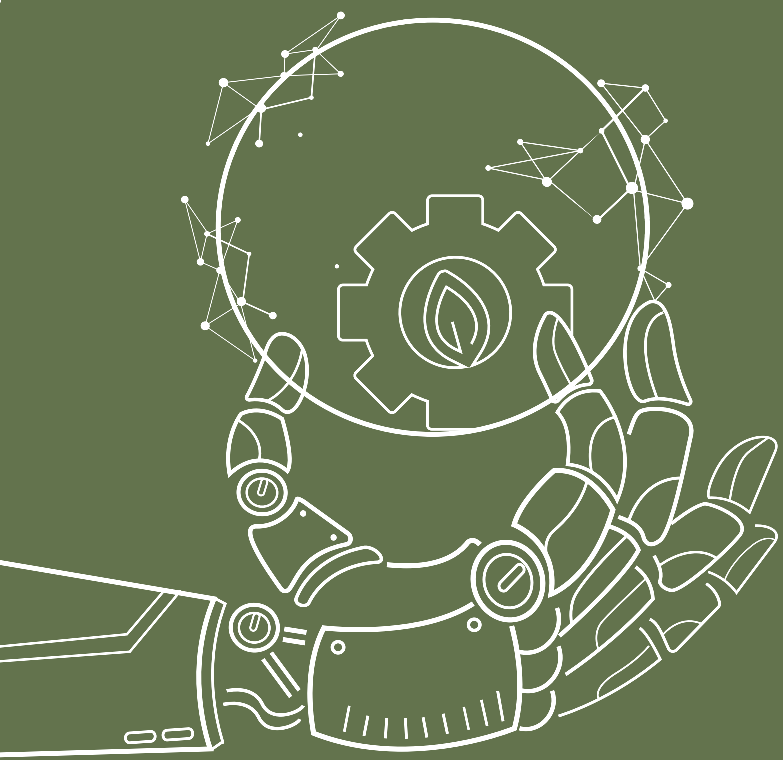

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