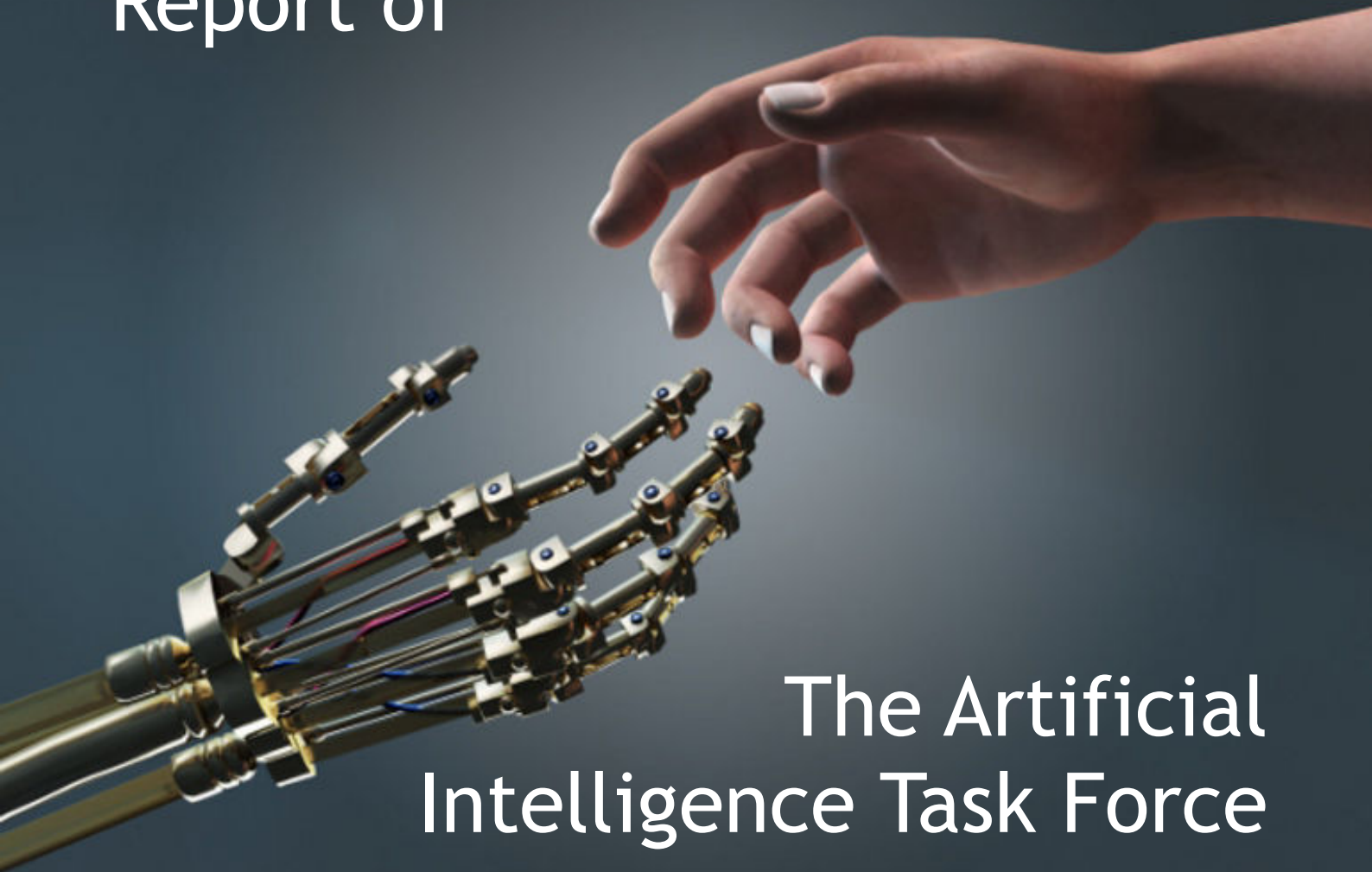


Report of



The Artificial  
Intelligence Task Force



# The Artificial Intelligence Task Force








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## Preface

The members of the Task Force on Artificial Intelligence for India's Economic Transformation constituted by The Ministry of Commerce and Industry, Government of India, consider it a unique privilege to submit this report.

AI being a complex, all-pervasive technology, requires a multi-disciplinary perspective for a better understanding of its adoption and the consequences that would ensue. The Task force comprised members from varied administrative and professional backgrounds that greatly helped in formulating the content of this report taking into account all dimensions including social, legal, ethical, commercial, regulatory, process and technology. In addition, a website (<http://www.aitf.org.in>) was launched to solicit public opinion on various issues related to AI. The Task Force wishes to acknowledge the contributions of numerous individuals and institutions through the website.

We have identified 10 important domains of relevance to India, including Manufacturing, FinTech, Healthcare, Agriculture/Food processing, Education, Retail/Customer Engagement, Aid for Differently Abled/Accessibility Technology, Environment, National Security and Public Utility Services. This report elaborates on specific challenges in the adoption of AI based systems and processes in the identified domains of relevance to India with examples, both national and international, illustrating the benefits of AI to society. Key enablers necessary for development and deployment of AI based technologies as well as ethical and social safety issues to ensure responsible use of AI are discussed. A section is dedicated for AI and its impact on employment in the Global and Indian context. The report concludes with a set of specific recommendations addressed to the Government of India, which we believe are important prerequisites for quick, effective and secure adoption of AI based technologies.

We express our grateful thanks to Hon'ble Srimati Nirmala Sitharaman, then Minister of Commerce and Industry and to Hon'ble Sri Suresh Prabhu, present Minister of Commerce and Industry for their continued support.

**V. Kamakoti**  
Chairman







## EXECUTIVE SUMMARY

The dawn of the 21st century saw electronics becoming pervasive in almost every manufactured object in the world, from toy cars to aeroplanes and from rockets to nuclear reactors. The next transformation is turning electronics hardware and software intelligent, radically changing their relationships with human "wetware". While there is a strong consensus that Artificial Intelligence will be a game-changer and a key factor in economic development, there is a concurrent need to arrive at frameworks that will promote its deployment taking all social factors into account.

The vision guiding this report is AI as a socio-economic problem solver at large scale rather than only a booster of economic growth. The report attempts to answer three policy questions: (1) What are the areas where Government should play a role? (2) How can AI improve quality of life and solve problems at scale for Indian citizens? and (3) What are the sectors that can generate employment and growth by the use of AI technology?

Accordingly, the Task Force has identified ten specific domains of relevance to India, namely, Manufacturing, FinTech, Health, Agriculture, Technology for the Differently-abled, National Security, Environment, Public Utility Services, Retail and Customer Relationships, and Education. Answers to the three policy questions posed in the Report required an analysis of the challenges in each of these domains, the international scene and the gaps at the national level with regard to international peers as well as concrete enablers to accelerate the adoption of AI based technologies in India. Sections 2 and 3 of this report deal with these topics. Real-world case studies, both National and International, are cited to highlight the importance and benefit of AI technologies in the domains. The report also provides a mapping of the 10 domains onto the different Ministries and Departments so that follow-up action can be immediately planned on a whole of government basis.



AI being a highly pervasive and possibly socially-disruptive technology needs to be employed with due caution. Section 4 presents details related to ethical and responsible use of AI technologies, specifically addressing issues related to data ownership, privacy and secure sharing. There has been much discussion and speculation in the popular press as well as at high-profile events such as the World Economic Forum about the impact of AI-driven automation on jobs. This is addressed in Section 5 of this report. While the Task Force is sanguine about the overall impact on employment, there is a need to develop India-specific quantitative models to study the impact of AI-enabled technologies on employment creation, wealth generation and the changing preferences of an AI empowered middle class.

The report concludes with concrete 5-year horizon recommendations to the Government of India. The recommendations are divided into six parts, namely, (1) an Inter-Ministerial National Artificial Intelligence Mission or N-AIM funded under the Union budget to the tune of Rs. 1200 Crores (Rs. 240 crores per year) for 5 years. The main tasks of the Mission shall include establishment and seed funding of six Centers of Excellence, setting up of a generic AI Test bed that could serve as a validation platform for AI based technology developers, creation of an interdisciplinary large data Center for aggregation and interpretation of data generated, coordination with concerned Ministries of Government of India to accelerate development and commercialization of AI based products and technology, increasing awareness of AI through AI-Yatras, interdisciplinary talent conferences, surveys for data collection and challenge funds. Technologies developed as part of the activities coordinated by the Mission would need to be taken-up and scaled up by the concerned Ministries of Government of India; (2) Digital data banks, marketplaces and exchanges to ensure availability of cross-industry data and information for AI-applications, with the requisite sharing related regulations; (3) Standards for the design, development and deployment of AI based systems; (4) Enablers to boost AI based development including data sharing policies and tax and other incentives; (5) AI based curriculums, AI-related education and re-skilling; and, (6) Leveraging key International relationships and participation in AI based international standards setting discussions.





# 1. Introduction

## 1a. What is AI?

Artificial Intelligence “is the science and engineering of making intelligent machines, especially intelligent computer programs”, with ‘intelligence’ being “the computational part of the ability to achieve goals in the world.”<sup>[1]</sup> Varying kinds and degrees of ‘intelligence’ occur in humans, many animals and some machines. AI is related to the similar task of using computers to understand human intelligence but it does not have to confine itself to methods that are biologically observable.<sup>[1]</sup>

AI research has, over the years, diversified into a variety of sub-fields, each attempting to understand and computationally engineer different aspects of what could be construed as ‘intelligent’ behavior. A non-exhaustive list might include computer vision, speech recognition, natural language processing, computational logic, neural networks, machine learning, AI planning and robotics. Ideas and techniques borrowed from areas more commonly found listed under mathematics and computer science, such as statistics, data mining, search, or computational learning theory, also find extensive use in AI systems.

## 1b. Current state of the field - International and National

Over the past two decades the phenomenal “successes in each of the diverse areas of AI has come through the deployment of many known but disparate techniques working together, and most importantly their deployment at scale, on large volumes of ‘big data’; all of which has been made possible, and indeed driven by the internet and the world-wide web”, as “the machines in the web observe and seek to ‘understand’ us better for their own selfish needs, if only to ‘judge’ whether or not we are likely buyers of some of the goods they are paid to advertise ... even these more pedestrian goals required AI techniques that could mimic many of capabilities required for intelligent thought.”<sup>[2]</sup>



More recently, in particular since 2012, techniques using 'deep neural networks' have managed to surpass many domain-specific traditional approaches used for image, speech, and natural language understanding, as well as for planning especially in the arena of robotics. The successes of deep learning are due in no small measure to exponential growth in commodity computational hardware, for example, Graphics Processing Units (GPUs). Further, in many ways deep learning has once again unified the field of AI, with an explosion of new research results that have found their way into diverse applications. <sup>[3]</sup>

As a result, we can now realistically expect AI systems to achieve human-level or better performance in a variety of cognitive tasks: (i) Tasks requiring *Perception* and *Understanding*, for instance, recognizing objects, faces and text from images and video, transcribing voice to text, or summarizing documents and translating one natural language to another. (ii) *Prediction tasks*, for instance, detecting as well as forecasting a machine failing, or a patient having an adverse reaction or hospital re-admission. (iii) *Prescriptive tasks*, for example, making complex decisions, such as which move to make next in a game, or which train to schedule on which track; tasks for which optimal solutions are in principle mathematically computable but in practice computationally intractable and which humans manage quite well using experience and 'gut feel'. Finally, (iv) *Participative tasks*, for example, physical machines (robots) operating autonomously in the real-world, such as self-driving cars, or flexible industrial robots that can be 'taught' new jobs or even learn by watching humans, rather than being programmed.

Most good universities around the world have AI research groups in some measure. Some of the best-known groups are at University of Toronto and University of Montreal in Canada, Massachusetts Institute of Technology and Carnegie Mellon University in the United States of America, and at Oxford and Cambridge Universities in the United Kingdom. Private research organizations such as Google's Deep-mind, Facebook AI Research (FAIR), OpenAI and Meta-mind are also at the cutting edge of AI research,





especially in deep learning. AI research capabilities are spreading globally and there are world-class facilities in Germany, Switzerland, South Korea, China and Japan.

AI research in India is, similarly, present in many of the Indian Institute of Technology(s) (IITs) and Indian Institute of Science (IISc). Young, internationally educated AI faculty members have recently been recruited in all these institutes. Industry research in AI in India is done primarily by some of the Indian Information Technology (IT) companies, and the India-based research labs of multinational companies. New economy companies in India, for example, in e-commerce, on the other hand, have been less visible in the research sphere, though signs of emerging startups conducting joint research with IITs are beginning to be seen. Still, Indian presence at leading AI conferences, while present and growing steadily, is far behind many other nations. At the same time, efforts such as the India-based Conferences on Data Sciences and Management of Data (CODS-COMAD), Computer Vision Graphics and Image Processing (ICVGIP), Pattern Recognition and Machine Intelligence (PReMI) and Advances in Robotics (AIR), are bringing the AI community together and helping drive local research collaborations. It is important to underline that these green shoots are limited, fragile and not yet inter-disciplinary enough to constitute a critical mass. For example, in the health sector Indian biomedical institutions are yet to harness the promise of AI and the interface between clinic and AI is yet to take off despite some efforts in the public health sector and in genomics-focused institutions and growing realization of AI's potential in addressing healthcare shortages.

On the industry applications front, almost every new economy global company, for instance Google, Facebook and Twitter as well as aggregators such as Uber and AirBnb, and e-Commerce companies (mainly Amazon) have deployed significant AI techniques in their business. On the other hand, when we consider traditional enterprises, brick-and-mortar manufacturing, retail or more traditional digital industries including banking, financial services, insurance and even telecom, the situation is not as promising as the new economy companies.



Almost all traditional Fortune 1000 firms are now investing in AI to some extent. According to a recent report based on a survey of 835 executives from 13 global industries,<sup>[4]</sup> while “more than 90% of companies in five industries say they use AI today”, “AI’s greatest impact varies by industry, reflecting the technology’s wide applicability”: “In the auto and CPG industries, the manufacturing function will see the biggest impact, the sales function in retail and utilities, and customerservice in insurance”. Still, “only a few are making bold investments today, which may trigger a competitive imbalance tomorrow.”<sup>[4]</sup>

Interest in AI applications for national defence has also grown in recent years.<sup>[5]</sup> AI can be a force-multiplier for several national security missions. Potential applications include Autonomous Underwater Vehicles (AUVs) and Unmanned Combat Aerial Vehicles (UCAVs) for underwater and aerial defence operations as well as coastal and border surveillance; robot mules for unburdening soldiers; robots for counter-IED and counter-terrorism operations and close-in protection systems against cruise missiles and similar aerial threats. In the Indian context, AI can be particularly relevant in securing public and critical infrastructure, especially urban centers, against terrorism by predicting terror attacks; tracking terror financing and recruitment; and monitoring cross-border infiltration. AI techniques can also contribute to strengthening cyber security. The application of AI to national security missions requires new ways for government and public sector institutions to work with industry and academia as well as new ways to incentivize young researchers to participate in national security projects. The use of AI for national security would also require India’s active participation in shaping international discussions on regulatory aspects, including ensuring respect for applicable international law and the protection of personal data.

To sum up, while large new economy companies in India, in particular e-commerce businesses as well as many startups are beginning to exploit AI techniques, traditional Indian enterprises and governments, on the other hand, do not yet seem to be aware of the potential of AI and have not been investing much in AI applications.



## 1c. Economic Potential and Social Impact

Virtually every industry could be impacted by and simultaneously seek to exploit advances in AI, not only by adopting AI technologies in its current operations but by changing the way it does business. Banks are seeking to go beyond being mere accountants of money and facilitators of payments, for example by exploiting the data they are privy to, i.e., who pays whom for what, they hope to assist merchants in their advertising and pricing strategies. By exploiting AI, insurance can move from provisioning to prevention, for example via mobile apps that track the driving behavior of customers and reward those that drive more safely, and other such tools to encourage fitter and healthier lifestyles. Likewise, apart from the well publicized arena of autonomous vehicles, car manufacturers are also beginning to use data from the hundreds of sensors that populate each modern vehicle to better predict failures and prevent costly recalls. The list goes on, and similar trends are observed for telecom operators, utility companies, retail chains, hospitals and even governments. At the heart of each of these applications lies the intelligent analysis of data.

The retail market in India is expected to hit USD 1.6 trillion at a Compound Annual Growth Rate (CAGR) of 10% by 2026. With the opening of the sector to FDI, there has been a steady centralization and organization of retail by big brands. However, it is still a very small percentage (close to 5%) of the total sales. AI techniques could play a crucial role in this sector. This requires access to real-time consumer data, which in turn mandates the use of sensors as well. This raises concerns related to both consumer privacy and data protection. Regulation and policy creation in such an unorganized, fragmented market is hard and there is an urgent need for enabling solutions that promote business while protecting consumer privacy and data. The Government has fortunately invested in the creation of Unique Identification numbers (UID) called *Aadhaar* Number for all residents of India. The *AADHAR* initiative, the related legal provisions and subsequent developments such as the Hon'ble Supreme Court's judgment on privacy, which declared Right to Privacy as a Fundamental Right, have



created the basis for safe and secure utilisation and sharing of customer data. *Aadhar* data is protected under the *Aadhar* Act and the rules and regulations laid under. The full potential of the Right to Privacy judgment will be realized by data protection laws that govern how private and public companies collect and use data. The Srikrishna Committee chaired by Justice B N Srikrishna, has been constituted to identify key data protection issues in India, to recommend methods to address any potential problems to ensure growth of the digital economy while keeping personal data of people secure and protected, and to suggest a draft data protection bill which would help in streamline the data protection regime in India.

As per Census 2011, in India, out of a population of 121 crores, about 2.68 crore persons in India are 'disabled' which is 2.21% of the total population. Disabled persons (*divyang*) face not only physical barriers but also attitudinal, educational and financial barriers to economic and social growth. Addressing these barriers will unlock the potential of so many people with so much to contribute to the world. Technology, in particular cognitive technology, can play a key role in breaking these barriers. Through advances in machine learning, cognitive systems are rapidly improving their ability to see, to hear, and to interact with humans using natural language and gestures. In the process, they also become more able to support people with disabilities. The same technology can also support an aging population, India having transitioned to an ageing society (percentage of those over 60 years of age more than 7%) by 2011. The fundamental issue in the Indian context is the challenge of developing such technology for intelligent communication in Indian languages. This refers to a set of language technology problems like understanding texts (in digital form or otherwise) written in Indian languages, understanding spoken Indian languages and construction of conversational systems in Indian languages, natural language generation and translation systems for written as well as spoken languages and development of sign language communication system in the Indian context. These technologies are currently in a nascent state but have a huge potential for unlocking employment and skill potential for a large number of youth with





disabilities and deprivations ensuring inclusive growth and empowerment. The more the machines can sense and understand the world around us, the more they can help people with disabilities to overcome barriers, by bridging the gap between a person's abilities and the chaotic, messy, demanding world we live in.

There has been much discussion and speculation in the popular press as well as at high-profile events such as the World Economic Forum about the impact of AI-driven automation on jobs. This will be dealt with in Section 5 of this report.

## **2. AI Grand Challenges relevant to India**

The fundamental challenge in India in any sector is the structural impediment to adoption of technology. In the case of AI, the technology is typically hidden so the impediments may be lesser compared to say, the introduction of Personal Computers. But since the social effects can be significant, there could still be a backlash to perceived effects. Issues can arise due to a variety of reasons including lack of consumer awareness, inability of technology providers to explain benefits to end users and channel impediments in technology delivery like poor Internet access. So impact analysis has to be part of any AI rollout plan.

The most important challenge in India is to collect, validate, standardize, correlate, archive and distribute AI-relevant data and making it accessible to organizations, people and systems without compromising privacy and ethics. Data is the bedrock of AI systems and reliability of AI systems depends primarily on quality and quantity of the data.

The other big challenge in India is absence of widespread expertise in AI technologies. This could lead to policy decisions being taken based on a narrow spectrum of opinions rather than decisions being arrived at on the basis of a broad technical consensus. Consensus-based decisions typically withstand adverse side effects a lot better. This is especially relevant where job loss is a concern.



In summary the major challenges in deploying AI systems in India are:

- Data collection, archiving and encouraging data availability with adequate safeguards, possibly via data marketplaces / exchanges.
- Ensuring data security, protection, privacy, and ethical use via enabling frameworks, both regulatory and technological.
- Digitization of systems and processes with Internet of Things (IoT) systems while ensuring safety from cyber-attacks.
- Deployment of autonomous products (robots, autonomous vehicles) after careful study and mitigation of any impact on employment and safety.

In terms of policy, the questions to ask are:

- I. What are the areas where Government should play a role?
- II. How can AI improve quality of life and solve problems at scale for Indian citizens? and,
- III. What are the sectors that can generate employment and growth by the use of AI technology?

Seen from this perspective, the grand challenges (test cases) for encouraging large scale AI use in India are:

- Improving manufacturing to increase profitability and increase manufacturing jobs, especially in the SME sector;
- Improving healthcare quality, reach and cost;
- Improving agriculture yields and profitability; and,
- Improvement in delivery of public services.

While there are other challenges, the above areas are the ones that might need the most Government intervention. The following subsections deal with specific challenges in enabling AI based systems and processes in the identified domains of relevance, including the above four test cases, to India.



## 2a. Manufacturing

Post-independence, the Indian economy was heavily dependent on the agricultural sector. Over the years India gradually shifted from an agriculture-based economy to a service based economy and skipped creation of a robust manufacturing sector. Many economists believe that skipping the manufacturing sector is the main reason as to why the Indian economy has not developed as fast as other economies of the world.

Some of the major issues in the Indian manufacturing sector are:

- Inability to compete with other Industry heavy nations due to structural factors like legal frameworks and policy initiatives;
- Poor infrastructure including logistics, warehousing, and ports;
- Non-availability of low-cost financing;
- Company and Labour law reforms; and,
- Low levels of automation.

In the last few years the manufacturing sector has been a major focus area for the Government of India. Many initiatives including *Make In India*, are being taken up to foster the growth of this sector. Some of the important steps taken in this direction include:

- Tax reforms
- Upgradation of Road and Rail networks
- Interest rate management

### **Manufacturing: Customizable Handloom Design<sup>[6]</sup>:**

*Ruuh, an AI fueled Chatbox in Social media, generates thousands of designs for handloom weavers to choose from.*





AI can supplement these initiatives in the following ways:

- Digital business transformation leading to process modernization enabling smarter and faster/real-time production decision and planning;
- AI based logistics and supply-chain management;
- Improving quality through AI-based predictive maintenance and reduced rate of rejection through early detection of faults;
- Creating hybrid teams of Human workers and collaborative Robots working together to improve productivity and efficiency (India could in fact be a test-bed for transcending the human versus robot debate); and,
- Judicious introduction of autonomous vehicles, including to decongest inner cities, and driver assistive systems for improving road safety.

### **Manufacturing: Warehouse Management<sup>[7]</sup>:**

*Hitachi, among its other experiments, saw an 8% boost in productivity when it connected a general-purpose AI to its warehouse management system. Each night, the AI system received data from a warehouse management system and developed an automatic scheduling system to prioritize which orders to execute first, and plan worker trajectories through the warehouse to “pick” stock-keeping units (SKUs).*



## 2b. FinTech

The financial services sector in India is facing new challenges. Startups and other attackers are jostling for their place in the market, backed by new technologies. These new Financial Technology companies provide alternative solutions and business models that could render traditional banking processes obsolete in many areas. At the same time, Government's push for financial inclusion through schemes like *Jan Dhan* is creating opportunities for both traditional companies and startups. In this regard, some of the challenges facing FinTech companies are:

- Balancing the scale and innovation
- Anticipation of market demand

Data, confidentiality and access will also pose significant challenges to many AI-powered financial services.

### **FinTech: Financial Monitoring & Risk Management<sup>[8]</sup>:**

Banks are data organizations at heart and consistently work towards deriving insight and value from that data. HSBC is on its way to running data analytics and machine learning in the cloud. Having completed a set of five proof of concepts (PoCs) in partnership with Google, HSBC has revealed pilot projects centering on areas including anti-money laundering and risk simulations. It is helping the bank become a simpler, better and faster organization while improving response time to customer demands.



Broadly, AI will complement Fintech technologies and fuel Fintech growth. Some of the AI based solutions are:

- I. The India stack is creating new opportunities for presence-less, paperless, cashless and consent-based financial transactions. AI could multiply the power of these business opportunities;
- II. Lending is the biggest financial segment and is driven by a key risk metric of a person's ability to payback and willingness to pay back, which is harder to establish. AI could have a significant impact on risk assessment and improve access to capital for Micro, Small and Medium Enterprises; and,
- III. AI is already being used for predicting investment opportunities with the right timing advice. In India, AI could help manage risk related to investment decisions particularly by new participants in the investment sector.

## 2c. Healthcare

In the last twenty-five years there has been a continuing burden of incommunicable diseases and a spurt in non-communicable or "lifestyle" diseases, which accounted for half of all deaths in 2015. Despite its overburdened healthcare services, India is still one of the top three destinations for medical tourism in Asia, according to a 2014 study.<sup>[9]</sup> Unequal access, poor quality and rising costs are three key challenges faced by the Indian healthcare industry.

Realizing the importance of healthcare sector the Government of India has taken steps to tackle some of the basic health issues:

- Open Defecation Elimination Mission
- *Swachh Bharat* Mission
- National Health Policy 2017 (NHP), in particular, increase public health expenditure to 2.5 % from the current 2 % of GDP
- Introduction of Electronic Health Record (EHR).



AI has the potential to transform delivery of health services in rural areas, a challenge India has grappled with since independence. It can help in:

- Creating electronic health data repositories with sufficient high quality annotated health data for machine learning applications;
- Creating nation-scale clinical decision support systems to enable better management of routine clinical problems by less-skilled providers; and,

### **Health: Autodiagnostic Software:**

*An Indian startup, (<https://ChironX.AI>), is working with hospitals and charity foundations such as the Bill & Melinda Gates Foundation to deliver AI-based solutions for early detection of diseases. ChironEye, their flagship software, analyzes retinal fundus images in seconds. It detects diabetic retinopathy, hypertensive retinopathy, age-related macular degeneration, diabetic macular edema and others. It annotates lesions and regions of interest, and assists doctors and even non-specialists to arrive at a diagnosis faster and with much higher accuracy.*

### **Health: Early Detection of Diabetic Retinopathy** <sup>[10, 11]</sup>

*Diabetic retinopathy is a common complication of diabetes and one of the fastest growing causes of blindness globally. It can be prevented if detected early. The problem, especially in the emerging countries in South Asia or Africa, is that there simply aren't enough ophthalmologists to go round: there are 387 million diabetics worldwide who should be screened annually – and only 200,000 ophthalmologists. Machine learning can make the diagnosis of diabetic retinopathy more broadly accessible. A Google developed technology is currently under clinical trials in India and preliminary results look very promising with the algorithm on-par with ophthalmologists. The success of this tool will allow even the GP/primary care doctor to provide an accurate screening service and initiate treatment. This in turn will free up ophthalmologists so they can focus their time on treating the most severe and complex cases.*





- Creating self-learning systems in digital fields like radiology, pathology, and genomics, to augment future healthcare. Genomics across the globe is turning out to be a successful methodology, specifically in the fields of Health and Agriculture. The ability to conduct genome scale sequencing or detection of nucleic acid sequences has opened up the possibility of reading the blueprint of life, and enabled precision medicine with better forecasting of wellness or disease, as well as precision agriculture. However the massive amount of data, typically in terabyte range, generated by sequencing facilities requires automation in processing. AI based interpretation of such data is a necessity for faster turn around times and greater accuracy. In some cancers, AI based systems like IBM Watson, when working in concert with human experts, have reached accuracy beyond human experts alone. The growth of AI in genomics will be under three major categories - predictive, prescriptive, and workflow improvements. Of these, workflow improvements are most mature, with predictive applications being seen mostly in direct to consumer wellness genomics. Prescriptive applications will have the most disruptive potential, especially with the advent of gene editing, and are already reaching acceptance in some cancers and genetic diseases. This is just the beginning worldwide and it is expected that AI enabled precision medicine for Indians will only come from training AI systems with local genomic and clinical data, providing opportunities for the Indian industry. Due to prevalent guidelines, Indian samples cannot be sent outside India for genomic analysis without specific approval, which is a regulatory advantage in this sector.

For effective AI technology aided deployment of the Government of India's initiatives, Indian healthcare sector needs to overcome the following challenges:

- Creation of an Electronic Health Record (EHR) Repository; and,
- Training manpower on the newer technologies.



## 2d. Agriculture/Food Processing

Agriculture and allied sectors like forestry and fisheries accounted for 13.7% of the India GDP in 2013, involving about 50% of India's workforce. The economic contribution of agriculture to India's GDP is steadily declining with the country's broad-based economic growth. Agriculture is becoming an unviable activity in many areas contributing to social problems like farmer's suicides.

Some of the major issues in the Indian agriculture sector are:

- Lack of assured irrigation leading to crop selection based on monsoon rains and poor demand prediction;
- Degraded soils, overuse and misuse of chemical pesticides and fertilizers;
- Non-availability of right seeds, fertilizers and pesticides;
- Capital availability for small and medium farmers;
- Low mechanization and unskilled work force; and,
- Unpredictable demand for agriculture commodities and lack of consumer-farmer connect.

The Government of India is planning to double the income of the Indian farmer by 2022 with a 7-point plan. Some of the important points are:

- Remunerative prices;
- Increasing Productivity; and,
- Increase in Crop Intensity.

### **Agriculture: Predictive analytics based agro-advisory services<sup>[12]</sup>:**

*Tata Consultancy Services' mKRISHI initiative offers personalized predictive analytics based advisory services in local languages to farmers on their mobile phones, which can help in planning and boosting yields.*

### **Agriculture: Smart Farming<sup>[13]</sup>:**

*The irrigation system developed by Avanijal, an Indian startup, monitors and controls irrigation by combining user input and actual on-ground conditions and is helping farmer reap a better yield on their investments.*



AI could add significant value in the following areas:

- Crop Prediction;
- Crop Health (Fertilizer and Pest) management;
- Macro and Micro Irrigation management;
- Intelligent Farm Mechanization;
- Dissemination of Technology know-how;
- Packaging and storage of commodities; and,
- Prediction and reduction of post-harvest losses.

For example, crop selection is very important to Indian farming because 40% of the farmers are dependent upon the Monsoon rains. Crop yields depend- upon the soil type, monsoon dates and rainfall, crop type, seed selection, availability and affordability of fertilizers and pesticides, and others. AI based solutions are ideal for crop selection by taking into account these complex parameters along with the historical data. They can also help dose irrigation depending on soil and weather conditions to minimize water usage and maximize productivity.

### **Agriculture: Precision Farming<sup>[14]</sup>:**

*GRoboMac (Green Robot Machinery Private Limited), an Indian startup, is working to mechanize farm tasks by building smart machinery using 3D vision technology and robotics. The company's first product is a cotton-picking machine that aims at reducing drudgery while maintaining the quality and speed of human picking.*

Another example is crop monitoring, a repetitive and error prone task. By using technologies like IOT, drones, satellite imaging and autonomous robots, data can be collected reliably from the fields, monitored and analyzed by AI based applications to get the right solutions such as applying right amount of fertilizer, and pesticide to spray.





### **Agriculture: Cattle Health <sup>[15]</sup>:**

*A New Zealand Technology Research Firm, Teck Labs has developed an Mobile App named Betty, that uses Artificial Intelligence and Machine Learning to convert the responses to a series of questions on regional farm and weather data by the farmers, to a list of most likely causes of disease in their cattle.*

To achieve the above, the Indian agriculture sector needs to overcome the following challenges:

- Collection, validation, archiving of reliable data and making it available for public consumption;
- Financing building of AI systems for crop prediction, resource management and post-harvest management;
- Manpower training on deployment and usage of AI systems; and,
- Real-time dissemination of information from AI systems.

## **2e. Education**

India has many human resource development challenges, chief among them is education. Some of the major issues in the Indian education system are:

- Lack of teaching resources and individual attention;
- Unequal access to educational opportunities;
- Lack of meaningful vocational training streams in middle and high school unlike countries such as Switzerland and Germany;
- Lack of innovation and creativity; and,
- Outdated pedagogies.



While AI is not the panacea for the above problems, it will probably have the most impact in alleviating resource issues and personalizing education. In fact AI based teaching addresses a lot of issues faced in classrooms like

- Inability of teachers to pay extra attention to students, especially for socially and economically deprived backgrounds who are lagging behind;
- Lack of personalized courses tailored for the individual needs of the students and self-paced learning not involving a judgmental teacher.

The other ways in which AI could help are:

- AI based analytics to accurately measure outcome and thus help the Government direct its resources better;
- Create dynamic courseware, also to enable reskilling in specific sectors.

To deploy AI technologies, Indian education system needs to overcome the following challenges:

- Teacher training in development of tech-enabled solutions; and,
- Making technologies accessible to all schools and deploying them in a collaborative (teacher-student-technology) fashion.

### **Education: K-12 Feedback Driven Teaching-Learning Process<sup>[16]</sup>:**

*Byju's the learning app is using feedback driven learning mechanism powered by machine learning to augment K-12 education. It is now one of the world's fastest growing Ed-Tech companies. ML helps in identifying gaps in conceptual clarity of students and in turn guides the teacher to concentrate and strengthen those very specific gaps. It is powered by deep knowledge graphs of over 50,000 concepts and relationships that have been created to design personal learning journeys. The data generated from variety of student profiles using the app is also helping drive decisions to improve and add to the overall content.*



## 2f. Retail/Customer Engagement

This is an area that requires minimal Government engagement. In terms of policies, the Government should focus on the following:

- Creating a level playing field for small retailers, especially at the policy and taxation level;
- Consumer protection laws especially with respect to data privacy; and,
- Investment in R&D for AI/ Machine Learning (ML) technologies relevant to retail.

Especially with respect to consumer data protection and regulatory policies for its usage, the following needs to be addressed:

- I. **Definitions:** Clear definitions are needed for how the data can and cannot be used.
- II. **Discrimination:** Information on gender, demography and health. should not be used to discriminate against individuals.
- III. **Data Breaches - transparency and accountability:** Establishing transparency guidelines for retailers to publish crimes committed on identity/data theft & fraud.
- IV. **Digital Products Safety Awareness & Reporting:** Establishing guidelines for reporting & creating awareness around product data like Data centralization & real-time information on banned/discontinued products & their safety.
- V. **Standards:** Establishing a framework for basic standards to ensure systems are not breached.



## 2g. Aid for Differently Abled/ Accessibility Technology

As per 2016 statistics India has more than 2.6 crore disabled persons representing 2.2% of the population. Physical and Mental disabilities do not arise only due to congenital defects, illness or accidents; old age is also a significant factor. Old age based disability is not included in the above numbers and probably represents 10% of the population with disabilities not officially recognized by the govt. The attendant societal challenges become apparent especially for the majority of the population that is not able to afford the necessary support. The needs of this segment of the population cannot be seen as a burden to society and creative solutions are the need of the hour. Given the social and fiscal challenges, AI based technologies can go a long way in alleviating the situation. The key issues that need to be addressed are:

- R&D and product development for each major area;
- Technology localization and Technology availability; and,
- Addressing societal issues in adoption, use and maintenance of advanced technologies.

### **Aid for Differently Abled: Lip reading <sup>[17]</sup>:**

*Oxford's AI lab has developed a lip reader software powered by deep learning which would be useful for speech-impaired to communicate.*

Following are some of the important Technology focus areas:

- Visual and Hearing Aids: Visual and hearing loss is a continuum of deficits that affects a significant portion of the “normal” population too - for example short sighted persons. While a whole host of smart glasses, visual and auditory implants are coming to market, AI is crucial to couple their output into the human sensory experience;





- Multi-modal user input devices are the need of the hour to allow the differentially able to seamlessly connect to AI systems. Brain Machine interface is a key modality area for the severely handicapped and offers enormous potential;
- AI-based Mechanical/Mobility Assist Devices - smart walkers, prostheses, wheelchairs, Autonomous vehicles. All these are AI based systems;
- Mental health screening and assistance without stigmatization;
- Robotic helpers who could work together with humans in the health-care industry; and,
- Decision Assist and Cognitive systems


### **Aid for Differently Abled: Sign Language Interpretation <sup>[18]</sup>:**

*Researchers at the International Islamic University Malaysia in collaboration with researchers from New Zealand have developed a system called the Automatic Sign Language Translator (ASLT) that uses machine learning to interpret sign language and convert it into text. The researchers trained ASLT's algorithms on a database of images and videos of native signers, so it could learn to identify distinct signs as well as the facial and upper body movements that often accompany certain signs to improve its accuracy. This helps speech-impaired to communicate.*

## **2h. Environment**

Air pollution, water pollution, garbage disposition, and pollution of the natural environment are all challenges for India. Environmental degradation is one of the primary causes of disease and has long-term livelihood impact. AI can help address most of the current environment issues in India. AI will add immense value in the following areas:

- Intelligent automation to estimate and control at source, the pollution level of smoke, effluents and solid waste being released into air, soil and water;

- 
- Identification of the critical pollutants impacting human health and optimization of remedial efforts and policy;
  - Intelligent automation to estimate and predict depletion of nonrenewable natural resources, green cover, endangered species; and,
  - Prediction of meteorological events such as cyclones, floods and natural disasters due to climatic or other anthropogenic changes.

### **Environment: Sustainable Forestry Initiatives<sup>[19]</sup>:**

*Researchers in Brazil have used neural networks to develop more accurate measures of tree taper—the variation in tree circumference from stump to tip—a critical variable in estimating forest density and health. Rather than using traditional extrapolations of a sample, a neural network is able to better analyze the many variables in tree density found in tropical rainforests. These more accurate measurements can be used to improve sustainable forestry initiatives, such as identifying areas for timber production and preservation.*

The major challenges in implementing AI systems for Environment management are:

- Collection and sharing of environmental data
- Regulatory policies regarding deployment of these systems and continuous monitoring of the proper functioning of these systems.

### **Environment: Predicting Air Pollution<sup>[20]</sup>:**

*IBM researchers have developed a machine learning system that can analyze data about pollution levels in Beijing to forecast changes to air quality up to 72 hours in advance. The system's forecasts are 30 percent more accurate than traditional predictions and have a resolution of one kilometer. The researchers are further developing the system to extend the forecasts up to 10 days in advance.*



## 2i. National Security

National security imperatives require that technology based force multipliers be developed. Some areas where AI based systems could be usefully deployed include:

- Autonomous surveillance and combat systems;
- Adaptive communications systems;
- AI based cyber-attack mitigation and counter-attack systems; and,
- Multi-sensor data fusion based decision-making systems.

### **National Security<sup>[21]</sup>:**

U.S. Department of Defence's Project Maven uses AI to speed up analysis of full-motion video data from tactical aerial drone platforms such as the ScanEagle and medium-altitude platforms such as the MQ-1C Gray Eagle and the MQ-9 Reaper. A single drone with these sensors produces many terabytes of data every day. Before AI was incorporated into analysis of this data, it took a team of analysts working 24 hours a day to exploit only a fraction of one drone's sensor data. Project Maven's transformation of tactical data analysis has proven to be valuable in the fight against ISIS.

The main challenges for deploying systems like these are cost, technology availability and systems management capability deficit.





## 2j. Public Utility Services

Public utility services in India are a long way from delivering on their promise. While AI is not a panacea to all issues bedeviling public services, AI based systems can alleviate these deficits to a significant degree. AI along with *Aadhaar* enabled systems, Data Analytics, and IOT based systems will greatly help in planning and execution of services and monitoring outcome. In particular, root-cause analysis becomes easier when systems fail and planning and monitoring use overall becomes much easier. The challenges to deploying AI based public services are resistance to technology from service providers and data privacy.

### Public Utility Services: Increasing Solar Energy production<sup>[22]</sup>:

*Google launched the sunroof data explorer tool in November 2016 to help communities, cities and municipalities, easily visualize how many rooftops are suitable to install solar, how much power they could collectively generate, as well as how much carbon could be displaced by deploying rooftop solar at scale. This new data layer will show a map of 700,000+ existing solar installations in neighborhoods throughout the United States.*

The following table maps the different Ministries and Departments of The Government of India onto the 10 Domains of Focus discussed in this section. This mapping is important as enablers and socially relevant projects in each domain need to be owned by a single or group of Ministries to ensure correct implementation and adoption.



SL.No.	Domain of Focus	Relevant Ministries of Govt. of India
1	Manufacturing	Coal, Commerce and Industry, Corporate Affairs, Heavy Industries and Public Enterprises, Labour and Employment, Micro, Medium and Small Enterprises, Power, Railways, Road Transport and Highways, Shipping, Steel, Textiles.
2	Fintech	Finance, Commerce and Industry, Corporate Affairs, Micro, Medium and Small Enterprises, Electronics and Information Technology.
3	Health Care	AYUSH, Drinking Water and Sanitation, Health and Family Welfare, Women and Child Development, Youth Affairs and Sports.
4	Agriculture	Agriculture and Farmers Welfare, Chemicals and Fertilizers, Consumer Affairs, Food and Public Distribution, Food Processing Industries, Micro, Medium and Small Enterprises, Water Resources.



SL.No.	Domain of Focus	Relevant Ministries of Govt. of India
5	Education	Culture, Human Resource Development, Information and Broadcasting, Rural Development, Science and Technology, Skill Development and Entrepreneuership, Tourism, Youth Affairs and Sports.
6	Retail / Customer Engagement	Consumer Affairs, Food and Public Distribution, Labour and Employment, Micro, Medium and Small Enterprises.
7	Public Utility Services	Civil Aviation, Drinking Water and Sanitation, Electronics and Information Technology, Information and Broadcasting, Labour and Employment, Law and Justice, Panchayati Raj, Personnel, Public Grievances and Pension, Petroleum and Natural Gas, Power, Railways, Road Transport and Highways, Shipping, Statistics and Programme Implementation, Rural Development, Urban Development.



SL.No.	Domain of Focus	Relevant Ministries of Govt. of India
8	Aid for Differently Abled/ Accessibility Technology	Health and Family Welfare, Human Resource Development, Railways, Road Transport and Highways, Shipping, Urban Development, Women and Child Development, Youth Affairs and Sports.
9	Environment	Chemicals and Fertilizers, Coal, Drinking Water and Sanitation, Earth Sciences, Environment, Forest & Climate Change, Housing and Urban Affairs, Mines, New and Renewable Energy, Petroleum and Natural Gas, Railways, Road Transport and Highways, Rural Development, Shipping, Water Resources, River Development & Ganga Rejuvenation.
10	National Security	Atomic Energy, Defence, Electronics and Information Technology, External Affairs, Home Affairs, Power, Railways, Road Transport and Highways, Shipping, Space, National Security Council Secretariat.





### 3. Enablers for AI Entrepreneurship/ Technology Product Commercialization

India accommodates a middling diaspora of startups (750+) based on Artificial Intelligence, Machine Learning, Big Data and Cloud Analytics.<sup>[23]</sup> A significant number of Start-ups are providing services in Healthcare, FinTech, Customer Service and Education. The most disruptive among these are the ones being funded by big companies/investors who believe in empowering visionary ideas. This is an important clue for policy measures. It seems that big companies collaborating with start-ups is proving to be a successful strategy for universalization in India. Further, IP trends reveal that not many patents have been filed in AI in the past few years as compared to China and US. Therefore there, needs to be strong IP mechanisms to encourage and protect innovations in AI. Government policies need to be framed around corporate stakeholders, educational and legal Institutions, as they seem to be the key enablers for AI technologies and entrepreneurship.

Given India's democratic framework, its diversity and the still widespread existence of social and economic inequities across the nation, it is essential that AI development proceed with the least possible social and economic disruption and with the maximum possible public support. Globally, AI technologies have raised concerns about loss of jobs, safety, privacy and the loss of human control. It is important to examine these concerns carefully in the Indian context, determine the priorities for and the limits of policy interventions and ensure a multi-stakeholder approach to any regulation. Further, India's unique cultural and spiritual heritage, in particular the thousands of years of reflection in India on the nature of consciousness, place the country in a unique position to influence the global debate on the ethics of AI. Thus, domestic regulation discussions should track international discussions and India should actively shape the latter. Specifically, the following points are key to successful adoption of AI based systems:



- Positive social attitudes to machines and trust in autonomous systems would be essential enablers in the Indian context. The success of ongoing initiatives such as QR code based mobile payments would contribute to enhanced trust in AI and human-machine interactions. Success stories of digital and AI applications in India need to be brought up in the national consciousness and taken to all corners of India. Conversely, breaches of information and security that could undermine trust need to be prevented.
- A second important social enabler is data literacy. Most users are unaware of the value of their own data and many collectors of data are not sensitive to quality, comparability and stability issues. This needs to change through a nation-wide campaign and select Government policy interventions if AI entrepreneurs in India are to use Indian data to innovate and create wealth. The sanctity of the data collected needs to be validated by competent economists and statisticians.
- Data is the fuel that powers AI and there is a need for creating ecosystems that can encourage free flow of data and information. Digital data marketplaces and exchanges can serve this purpose but need to be governed properly. It is important to lay down policies that guide businesses in determining rights to their customer data and the form in which such data sets can be traded on data exchanges / marketplaces, provisioning for appropriate penalties and liabilities in case of breaches. Providing information on data lineage and provenance of data sets being traded on such platforms will also help stakeholders in determining rightful ownership through mechanisms such as block-chain and also help trace data / information value chain and during audits, that need to be scheduled periodically on such platforms.
- Policies need to be framed not just for sellers but also for buyers for the legally acceptable uses to which data sets that they procure from data marketplaces can be put to and more importantly what they cannot do with such data sets - identifying individuals / entities by triangulating across different data sets, for example may be prohibited to preserve privacy. A right mix of stakeholder groups should further deliberate on such



policy frameworks as well as the need for regulations and/or a regulatory authority, much as SEBI does for stock exchanges. An example of a Digital data exchange is the Data Republic in Australia, an initiative to create a cross-industry data marketplace.<sup>[24]</sup>

- AI will disrupt jobs in some sectors but at the same time in line with the historical experience with other technologies and as described in Section 5, it will create jobs directly (collection and archiving of data for use in AI-applications, making and servicing all the AI-rich devices and applications) and indirectly (creating new economic opportunities by enhancing efficiency, particularly in the financial and transport sectors, improved user interfaces and lowering negative externalities such as pollution, disability and disease). Above all, AI may in fact be essential to retaining the competitive edge in many areas of manufacturing and services, thus preventing the future loss of jobs. It could also play a useful role in retraining and reskilling to address employment gaps created by technology shifts. The key challenge on job disruption is that unlike previous technological revolutions, time available for retraining and redeployment may be shorter. New opportunities arising from AI would be exploitable in India only if the people with the right skills are available in the country. A nation-wide effort - ranging from primary schools to universities - is needed on education and training. We need to start preparing the workers of tomorrow who will work collaboratively with machines today. This effort would also have a positive effect on social attitudes. The role of State Governments is very important and they must be involved at various stages.
- In the corporate sector, proper adoption of AI Technology requires organizational maturity to formulate, implement, go live and continuously improve use cases based on machine learning. This requires focused development of manpower skills with holistic understanding of the domain.<sup>[25]</sup>

In the following subsections, the key enablers to adoption of AI technologies in each of the domains of relevance to India are listed.



### 3a. Manufacturing

- Common Data Exchange Standard for Machine to Machine communication and the development of other standards to enable AI use; AI could also be employed to monitor and assess application of existing standards in the manufacturing sector so as to improve quality and safety;
- Design and development of advanced cooperative industrial robots that can work with other robots or with humans. The essential safety issues need to be solved;
- Industrial internet consisting of network of machines, robots, products, humans, sensors and actuators, for intelligent automation;
- Shorter production cycle consisting of integration of design/drawing - manufacture - product cycle through intelligence augmentation with humans in the intelligent automation loop. Additive manufacturing like 3D printing to go from initial conceptual design to final products with human input at different stages.
- Provision for sandbox testing of new technologies like autonomous vehicles and collaborative robotics with expedited approvals as is done say in Europe, U.S. and Singapore;
- Upgradation of curriculum both for vocational training, which needs to include newer machine tools with hands on training promoting usage of robotics and smart machines (Industrial IoT);
- Creation of centers of excellence in educational institutions specifically for AI/deep learning and Robotics, preferably in collaboration with industry. A network of centres mandated to work in the design and development of essential building blocks of AI technologies relevant to India could be created on a national level and funded through the Union Budget along the lines of Canada's Pan-Canada AI Strategy, which is administered through one research centre.
- Providing subsidies for both the companies developing AI technologies, through tax breaks; and, the user/customers of these technologies through subsidies and national challenge funds so as to foster innovations.





### 3b. FinTech

- Data availability (even if it is anonymized) of past transactions from as many financial institutions as possible;
- Open Application Programming Interfaces (API) from financial institutions including banks to access their data and services; and,
- Decision making and smart analytics by AI algorithms, driven by data, enabling more efficient work-flows in financial institutions.

### 3c. Healthcare

- Auto-diagnostic tools and new types of Robots for advanced collaborative tasks that fit in-between man and machines in prevention, health care and rehabilitation;
- Data availability ranging from public health data being reported from the primary health system to electronic health records at tertiary centres;
- Training of selected physicians and other healthcare workers in data science, with mandatory introduction to the subject within the health curriculum; and,
- Think tank for formulating frameworks to define ethical use of health data and the usage of health advice from AI systems.

### 3d. Agriculture/Food Processing

- Infrastructure for farmer-consumer connect to decide on quantity, variety and pricing;
- Data analytics related to climate, harvest yield, disease;
- Building a robust crop information system for crop advice and management for each agro-climatic zone;
- Encourage farmers who deploy AI based modern techniques including by subsidizing AI-based modern farming equipment; and,
- Train rural development officers in crop data information use and develop training modules for farmers in emerging techniques.



### 3e. Education

There is a need to employ AI in the teaching process and at the same time teach fundamental courses on AI towards development of manpower with AI-based skills. Potential applications include:

- In higher education augmenting face-to-face teaching with Massively Open Online Courses (MOOCs) in which distribution of material, examinations and certification would be online;
- Making education smart and individualized as per a person's needs and capabilities by adjusting syllabus, course hours, and credit system. Institutions and teachers must be open-minded to these concepts and work to gain the necessary competencies;
- Special emphasis on using AI for courses for skill upgradation and retraining;
- Development of basic and fundamental courses in engineering education at the Under Graduate and Post Graduate levels that cover:
  - Communication technology
  - Embedded system
  - Artificial Intelligence
  - Robotics
  - Big data & learning analytics
  - Innovation & entrepreneurship
  - Cyber Physical Systems
  - Cryptography
  - Multi-disciplinary systems design
  - Concurrent engineering
  - Project Management



- Introducing the systems engineering and integration approach in engineering courses. This should not only cover the theory of developing sub systems like robots and intelligent automation units, but should also cover the final systems integration aspects;
- Introducing in existing engineering and management courses new business thinking that requires not only the classical skills to manage and develop projects but also how to communicate and collaborate in the global village, how to be creative in developing solutions to adapt to change, how to deal with uncertainty and make good predictions in the presence of incomplete, corrupted and noisy data.
- Develop courses that deal with identifying newer applications where robots and intelligent automation can augment human-machine systems, or human-human systems, essentially augmenting the joint intelligence; and,
- Upgrading or reskilling existing industry and shop floor workers with basic knowledge so that they can operate newer man-machine systems that coexist with humans.

### 3f. Retail/Customer Engagement

- Policies and regulations for customer data protection and product safety & standards;
- Human machine interfaces for enhancing productivity and customer engagement through augmented reality, natural language communication and smart logistics. Such AI based applications could also help the elderly and to track their consumption habits;
- Special AI-based applications for India's traditional artisans and crafts people to promote innovation and better connect with Indian urban and global markets; and,
- Intelligent transportation, driverless cars, trucks, mobile robotic transportation systems that engage with the public.



### 3g. Aid for Differently Abled/Accessibility Technology

- I. Supporting R&D for development of multi-modal assistive interfaces involving Vision, Speech and Natural Language Processing (NLP) and other sensory inputs;
- II. Special support for commercialization of AI based assistive technology and devices;
- III. Enabling innovators to work with NGOs to create an eco-system of accessibility product development; and,
- IV. Facilitate Brain Machine Interface (BMI) technology development by establishing collaboration platforms for brain researchers and AI engineers. Such initiatives have happened under EU and U.S. programmes on Brain research leading to innovative product and system design.

### 3h. AADHAR/Big Data

- All-out effort for recording, digitization and collection, validation and archiving of data in all sectors, which as a labour-intensive activity will also create employment just like other infrastructure projects do;
- Provision of incentives for provision of reliable data; and,
- Come up with Indian data formats for all the sectors/sub sectors for AI applications, by drawing upon the available relevant International standards.

### 3i. Environment

- Classification and quantification of pollution levels due to smoke, effluents and solid waste;
- Standards (Hardware and Software) for measuring pollution levels and Regulations for deployment;
- Infrastructure to collect data that includes pollution measuring sensors, communication and processing of sensed data; and,
- Data analytics for nonrenewable natural resources, green cover and endangered species.





### 3j. National Security

- Given the multi disciplinary nature of the task, a consortium of MSME industries to be created for development of autonomous systems such as UAVs and UUVs, including subsystems and components;
- Provision of grants, realistic data and cyber security tools to develop methodologies for protecting digital assets and data from external cyber threats and attacks; and,
- Existing infrastructure including NATGRID, Humanit (Human Intelligence), SIGINT (Signal Intelligence), COMINT (Communication Intelligence), Imagery data and video surveillance from aircrafts, CCTV data from urban areas and critical infrastructure locations, and, Radar data and Satellite Imagery to be integrated on a unified platform. AI based Techniques to be embedded in the backbone of the platform to provide need-based real-time information to various security agencies involved in threat mitigation.

### 3k. Public Utility Services

- Provision for Geo-Tagged sensor based collection of data related to measurement of usage and availability of essential resources.
- Robust communication infrastructure to aggregate data collected from different sources to a common platform. In this regard, existing Indian Geo-Platforms provided by Indian Space Research Organization (ISRO) including Bhuvan<sup>[26]</sup> and Indian Regional Navigation Satellite Systems (IRNSS) can be leveraged.<sup>[27]</sup>
- Predictive maintenance using AI to not only maximize availability of critical infrastructure to the economy but also to increase return on capital investment in public services. There would also be substantial safety benefits in sectors such as railways, nuclear power plants and civil aviation.



## 4. Ensuring Responsible Use of AI – Ethics and Social Safety

This aspect of AI is probably the one that is the most difficult to deal with since many aspects of AI disrupt current social norms and ways of thinking. In general, legal and social constructs need to evolve to deal with autonomous systems. It is especially crucial that AI systems have

- explainable behavior, demonstrable either explicitly or statistically;
- are engineered for safety and security; and,
- are rigorously audited to ensure non-contamination by human biases and prejudices.
- Legal provisions that are applicable to human (individual or body corporate) users of AI systems should continue to apply *mutatis mutandis* to autonomous machines; specific liability provisions may have to be worked out for certain categories of machines. AI developers must ensure that relevant and applicable legal provisions are respected during the development of AI systems;
- While this may still be in the future, rights and responsibilities of autonomous entities is an area that needs to be examined. Our thinking has to evolve in this area and parallels from animal rights evolution can be a useful place to start. The EU has formally started efforts in this area;
- AI systems must be transparent i.e. they must be known to humans as machines and their performance, including their learning, must be verifiable/auditable. All relevant test & evaluation data must be shared with the users. AI researchers should ensure that an independent social ethics panel screens their research proposals;
- Data on which AI systems rely must continue to be protected at least at the same level of assurance as the original database; such data and the data that AI systems generate must not be shared with third parties



unless otherwise approved by the data owners. Pass through or amplification of data/algorithmic biases must be corrected as soon as they become apparent.

- At present there are no industrial standards for robots in India, apart from the norm that humans and robots do not share the same workspace. With new types of safe robots that are being currently developed for working with humans, new standards need to be in place to facilitate their deployment;
- Complete autonomy cannot be given to weaponized platforms due to their potential unpredictability, inability to detect friend or foe perfectly in a chaotic and shifting theatre of war, which may result in fratricide and the challenges such platforms might pose to military command and control. There might also be issues related to the law of armed conflict such as the ability to retract safely during surrender of the enemy and correctly analyzing situations involving civilians or objects protected by IHL using in-built intelligence; and,
- As AIs and robots permeate society, it is imperative that all aspects of human/robot interaction are well thought out. The Government needs to urgently foster inter-disciplinary research on AI/human interaction so that various scenarios can be gamed out and transition plans arrived at to deal with each scenario.



## 5. AI and Employment

Every wave of technological automation has impacted the employment profile of a society, with the significant transformations wrought often being visible only in hindsight. However, in each of these cases increased productivity and demand for new products and services has always generated new avenues for human economic activity. Past trends, wherein new technologies have disrupted existing job market indicate that most jobs that are replaced are mostly tedious, repetitive, labour-intensive and monotonous, while jobs that are less likely to be replaced are those involving human interactions, judgment and ability to take complex decisions. With a high degree of inter-disciplinary nature, AI will certainly not be an exception to this.

In 2015 the information technology research firm Gartner predicted that one-third of existing jobs will be replaced by software, robots, and smart machines by 2025 <sup>[28]</sup>. Interestingly, in the global arena, Gartner has predicted that AI will create 2.3 million new jobs while eliminating only 1.8 million jobs in 2020 suggesting that while some of the jobs that exist today disappear, it is likely that new jobs may appear. A 'Future of Jobs in India' study, commissioned jointly by Federation of Indian Chambers of Commerce and Industry (FICCI) and National Association of Software and Services Companies (NASSCOM) with Ernest & Young (EY) which looks at the impact of advanced technologies has projected that 9% of India's 600 million estimated workforce would be deployed in new jobs that do not exist today, while 37% would be in jobs that have radically changed skill sets <sup>[29]</sup>. On the other hand, research by the World Bank cites more pessimistic figures about automation threatening 69% of the jobs in India and 77% in China <sup>[30]</sup>. Based on estimates cited recently in Indian publications, the following are the key trends for the AI industry in India during the year 2017 <sup>[31]</sup>.

- AI Industry in India is currently estimated to be \$180 Million annually in revenue;
- Almost 38% of AI professionals in India are employed with large sized companies, with a more than 10000 total employee base;



- Startups (less than 200 employee base) employee 33% of AI professionals in India;
- On an average, Indian AI companies have 188 employees on their payroll;
- 27% AI professionals in India earn in the salary bracket of 10-25 lakhs and almost 5% of AI professionals earn more than 50 lakhs per annum;
- 10 leading organizations with the most number of AI openings this year are - Accenture, Wipro, Adobe, JPMorgan, Amazon, SAP, L&T Infotech, Nvidia and Intel;
- In terms of cities, Bengaluru accounts for around 37% of AI jobs in India; and,
- The Banking & Financial sector is the biggest influencer in AI job market with 47% of all jobs posted on AI being from the banking sector.

Figures 1 and 2 illustrate the socio-economic impact of AI in India <sup>[31]</sup>.

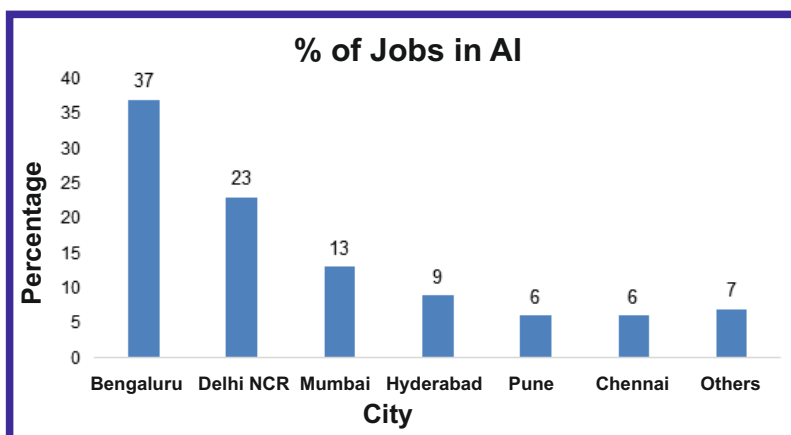
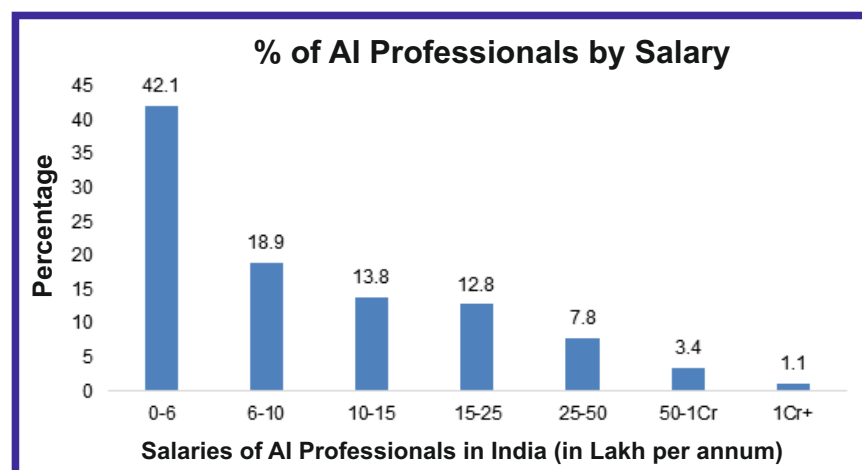


Figure 1

Figure 2





There is currently some evidence to suggest that while AI is automating jobs, it is expected to be creating many new jobs as well. According to survey respondents across global industries “Companies with the biggest revenue and cost improvements from AI last year see the need for at least three times as many new jobs in each function by 2020 than companies with the smallest improvements from AI in 2015.”<sup>[4]</sup> AI will also create new areas of economic opportunity, in some accounts transforming the very nature of wealth generation. At the very least, it would be an important factor in retaining jobs through retention of competitiveness in key sectors as those sectors deploy AI globally for efficiency improvements.

A few examples of new forms of economic activity that could and are already being created, and how Indians at all economic levels could benefit from new jobs spawned by such activity include:

- (I) **School for Machines:** Many artificial intelligence technologies seek to mimic fundamental cognitive abilities innate to human beings that include basic visual abilities such as recognizing faces, places, and levels of damage as well as reading across multiple languages, and understanding speech. For all such cases, AI systems need to be trained using data generated by humans. Crowdsourcing platforms such as Mechanical Turk (<https://www.mturk.com/>) and Crowdfunder (<https://www.crowdfunder.com>) are already providing a marketplace for people to apply their innate cognitive skills, as well as higher-level abilities to generate data that is used to teach AI system. With mere basic computer literacy and access to the Internet a large swathe of the Indian population especially at the lower middle-class as well as in rural India could take up these jobs.



- (ii) **Advisory solutions involving man-machine collaboration:** AI offers the opportunity for expert knowledge and data based experience to be compressed via machine-learning into computer-based advisory solutions. Such advisory solutions are possible, and already being developed/deployed in various areas from agriculture (for example, mKrishi <sup>[12]</sup>), health (rural healthcare), and, financial advice (as recommended by the RBI report on household finance <sup>[32]</sup>). However, given the lack of digital literacy, penetration and awareness especially in rural India, there is a potential opportunity for job creation in bringing these advisory services to the vast majority of Indians; the mKrishi example is already under way. All such initiatives need scaling support so that they can eventually become self-sustaining economic engines for employment that uplift the lives of citizens across both urban and rural India.
- (iii) **Health care:** In the health-care sector, the jobs that require human interaction such as nurses, physicians, and counselors are unlikely to disappear. Further, those jobs that involve decision making with complex inputs, empathy, ethical consideration and judgment are unlikely to be taken over by AI. In fact AI could aid health professionals by relieving them of routine and monotonous administrative jobs and freeing them to be more involved in patient care. The need for bioinformatics experts, counselors, health care analytics will increase. Technicians will be needed to re-skill or up-skill to take advantage of AI assisted diagnostics and robotics. In India where healthcare is woefully understaffed, in the short to medium term, assisted and augmented AI may make remote areas accessible to doctors through cutting-edge technology and free doctors to attend to critical care. However, there is a need for training, re-training, and educational content development to bring people involved in healthcare up to speed. Introduction of AI as a part of curriculum for health care professionals especially technicians and nursing staff will go a long way to speed up the uptake of AI technology and increase employability.



(iv) **IT Services/BPOs:** The AI intervention into any sector has two components, namely, the Information Technology component and the Automation component. On the IT component side, the Business Processing Outsourcing (BPO), Back-offices and Sales & marketing jobs are those that will be affected the maximum by AI based technologies. Specifically the jobs that could be replaced include Market Research Analysts, Data Entry Operators, Software test Engineers, System Engineers, Customer Service Executives, Telemarketers, Bookkeeping clerks, Receptionists, Proofreaders, and, Retail Sales people. As per current projections, jobs of low skilled workers in India's IT/BPO service sectors are set to fall from 2.4 million in 2016 to 1.7 million in 2022 <sup>[29,30,31,33,34,35]</sup>. The new jobs that will be created are Data Scientists, Language Processing Specialists, AI Research Scientists, Data Architects, User experience (UX) designers, Man-Machine Teaming Manager, AI Business Development Manager, Data Detective, RPA Developer, and, Wireless Network Specialist. Thus, there is undoubtedly a need for re-skilling the current workforce to adapt to the changing environment. Specific areas for re-skilling include Natural Language Processing, Neural Networks, Data Analytics, Pattern Recognition, and, Tools like Python, Hadoop, SAS, R and Tableau.

Annexure-2 presents an interesting case study of Indian organizations (TTC + XLPAT Labs) that have benefitted from augmenting AI into their business process by reskilling their current workforce and hiring new skills.

The details and statistics presented above are restricted to the IT component of AI based interventions, while the automation part which is a major component need to be carefully studied. In general, there is a need to develop India-specific models to study the overall impact of AI-enabled technologies on employment creation, wealth generation and the changing preferences of an AI empowered middle class. This will help build consensus on the potential impact of such technologies on jobs. Retraining for new job profiles and technologies could then be organized in specific sectors and the right balance struck in introducing AI technologies.





## 6. Specific Recommendations to Government of India

According to Kentaro Toyama “Technology - no matter how well-designed - is only a magnifier of human intent and capacity. It is not a substitute.”<sup>[36]</sup> Successful adoption of AI will depend on three factors: People, Process and Technology. AI adoption will expand rapidly if the end-users accept its benefits and use it, there are processes that unambiguously define safe and responsible use, and the technology itself is available. Government, civil society, industry, academia and R&D establishments need to work with synergy to make this happen.

This section presents a set of recommendations addressed to the Government of India flowing from the three policy questions raised at the beginning of the report - what are the areas in which Government intervention is required and would have the maximum impact, what are the areas in which AI can help resolve India's problems and what are the areas where it can boost economic growth and employment. It is the Task Force's view that the Government should focus on a set of common and critical enablers that support the use of emerging AI Technologies across all the different domains of focus described in the preceding sections, build the necessary infrastructure and frame policies that level the playing field for development of AI based products and services. The democratization of development and use involves not only equal access to all but also assigning ownership and framing transparent rules for usage of the infrastructure. ***AI should be seen as a scalable problem solver in India rather than only as a booster of economic growth.*** This vision should guide the implementation of the eight key recommendations below:

1. Fund under the Union Budget an Inter-Ministerial National Artificial Intelligence Mission (N-AIM) that will act as a nodal agency for coordinating AI related activities in India. The Mission shall involve



itself in three major activities, namely, core activities (*listed below*), coordination of AI related projects of national importance; and, establishing Centers of Excellence.

- **Core Activities:**

- Fund establishment of a **network of alliances among Academia, Services Industry, Product Industry, Start ups and Government Ministries** including, but not restricted to, Knowledge Clusters in geographies such as NCR, Bengaluru-Hyderabad, Chennai, Kolkatta-Kharagpur-Guwahati, Mumbai-Pune, Trivandrum, Chandigarh-Mohali, and Kanpur-Varanasi to fuel research, development and deployment of AI based products and services in the varied domains of focus. The UK example of the Knowledge Quarter in London is pertinent in this regard;
- Funding National level studies to **identify concrete projects in each domain of focus**, specifically, those that address important social issues such as cataract detection by mass screening aided by an AI-based diagnostic tool, automation of hazardous jobs such as manual scavenging and disaster recovery plans using AI powered robotics;
- Fund a National level survey on identification of clusters of clean annotated data necessary for building effective AI based systems in each domain of focus as well as **methodologies to record** such data.
- Establishing and administering National AI **Challenge funds and Capture The Flag competitions** specifically targeting design, development and prototyping of AI based systems for solving problems of the society at large. This shall also involve defining the problem, provision of real data sets and criteria for measuring efficiency based on domain specific Key Performance Indicators (KPI);
- Fund AI awareness rising at scale, especially in the rural hinterland, through *AI-Yatras* along the lines of the successful Society for the Promotion of Indian Classical Music and Art Culture Among Youth (SPIC MACAY) Lecture-Demonstrations.



- Convene Talent Conferences (*Hack-a-Mela*) where inter-disciplinary insights can be generated for applying AI to problems of Urban Planning, Transportation, Public Health, smart power grid and smart water grid; and for promotion of innovation in AI.
- **Coordination of Projects of National Importance**
  - Coordinate with concerned Ministries of Government of India to accelerate development and commercialization of AI based products and technology through Public Private Partnership models and Startups; Special emphasis to be given to\_(a) high precision manufacturing sectors; (b) Precision Agriculture; (c) Accessibility aids for the physically challenged; (d) Smart cities - effective delivery and improvement of services such as Clean Air monitoring, efficient public transportation, electricity and water supply, and fuel distribution; (e) smart resource usage specifically, environment versus energy tradeoffs - including smart power grid and smart water grid; and, (f) Predictive maintenance of public utility infrastructure including power plants. Technologies developed thus to be preferentially taken-up and scaled up by the concerned Ministries of Government of India;
- **Centers of Excellence**
  - Promoting interdisciplinary research spawning disciplines such as Humanities and Social Sciences, Law, Science, Medicine and Engineering to facilitate deeper understanding of the possibilities and implications of adoption of different AI based technologies and products; arriving at mechanisms for identification and assessment of risks while using AI based systems; and, defining frameworks for design and development of risk mitigation/contingency plans. The RIKEN Centre for Advanced Intelligence Project (AIP), Japan<sup>[37]</sup> is an interesting example in this direction. Six such centers, each concentrating on each one of the six problems of National importance mentioned above need to be established and funded.



The CoEs will generate basic building blocks to be used by the industry. These would include but not be restricted to technologies for autonomous cars/trucks, medical assist devices, health genomics, agri-genomics, health-diagnostics, industrial automation, robotics, cyber-security and FinTech. The locations for these centers need to be chosen based on the presence of entities and expertise related to the respective domains.

- Establishing a **generic AI Test Bed** for verification and validation of Key Performance Indicators of different AI based products and Technologies. This could include regulatory sandboxes for certain technology relevant to India, for instance Health, Manufacturing and Retail, along the lines of Japan's sandbox for self-driving trucks; and,
- Fund an inter-disciplinary and dedicated **large data integration center** in pilot mode to develop an autonomous AI Machine that can work on multiple data streams in real time and provide relevant information and predictions to public across all domains.

The duration of the Mission should be for a period of at least 5 years for it to achieve tangible results; the level and sources of funding can be reviewed after 5 years and can be supplemented at any stage as needed by private companies incorporated in India. The recommended funding for the Mission is a total of Rs. 1200 Crores (Rs. 240 crores per year) for 5 years, in which Rs. 50 crores per annum be allocated for the core activities, Rs. 25 crores per Center of Excellence per annum for each of the six Centers, Rs. 20 crores per annum each for the Generic AI test Bed and large data integration center. The funding for the projects of National importance shall be done separately by the concerned Ministry/group of Ministries.

2. **Data banks, exchanges and ombudsman:** Enabling setting up of **digital data banks, marketplaces and exchanges to ensure availability of cross-industry data and information,** with necessary





sharing related regulations. The Ministry of Information Technology may be the nodal agency for coordinating the setting up of the above mentioned facilities, while the Ministry of Commerce and Industry need to drive the regulations related to data ownership, sharing and privacy issues. The Ministry of Commerce and Industry need to create and functionalize a data-ombudsman, on lines similar to banking and Insurance, to quickly address data-related issues and grievances.

**3. Standard setting:** AI based systems being highly inter-disciplinary require operation standards that involve understanding of multiple domains. Some examples include:

- Data storage and privacy standards;
- Communication standards for Autonomous Systems including Autonomous Cars; and,
- Standards for interoperability between AI based systems.

The role of the Bureau of Indian Standards is crucial. Standards are evolving across the globe for many AI inspired systems and protocols. India should actively participate in these Standards working groups to be in the forefront of international norms on AI based technologies.

**4. Enabling policies:** Policies to encourage and enable development and deployment of AI based products need to be evolved by The Government of India. Two important recommendations include

- Data policy including ownership, sharing rights and usage policies; The Ministry of Information Technology and Ministry of Commerce and Industry may lead this effort as every AI based system is a domain-inspired software-operated one; and,
- Tax incentives for income generated due to adoption of AI technologies and applications, for socially relevant projects. This involves certification of a technology as AI-based and then fixing the incentive. This would involve the concerned Ministry under whose domain the application fits in as well as the Ministry of Information Technology and the Finance Ministry.



5. **Human Resource Development:** Devising an AI Education strategy to develop human resource with necessary skill sets to meet the demand for AI based professionals. This involves arriving at a target number of human resources required on a yearly basis for each skill set across each of the domains of focus and methodologies to train/re-train them. This also includes recommending AI-related curriculums for school, diploma, undergraduate and postgraduate education with a focus on the above identified skill sets needed for AI based technologies. The Ministry of Human Resource Development and the Ministry of Skill Development and Entrepreneurship may lead this effort;
6. **Reskilling: Identification of skill sets required for AI** based technology development and mapping the same across different levels of professional education - diploma, undergraduate, postgraduate and research as well as creating an AI Readiness Index to measure the readiness of different states across India to adopt AI. The National Skill Development Corporation, India may lead this effort;
7. **International rule-making:** Participating actively in shaping international policy discussions on governance of AI related technologies. This would require appropriate inter-ministerial consultative mechanisms that make regular recommendations for Government policy and positioning at relevant international forums. The role of the Ministry of External Affairs is crucial to ensure positioning of India's views in the International forums; and,
8. **Bilateral cooperation:** Leveraging key bilateral partnerships such as with Canada, Germany, Israel, Japan, Russia, Singapore, UK and the U.S. to develop AI solutions for social and economic problems, and for sharing of best practices in regulation. The Ministry of External Affairs and relevant departments such as the Department of Science and Technology may lead this activity.



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\* \* \* \* \*



# Annexure 1





## Terms of Reference

*(for Task Force on Artificial Intelligence (AI) for India's Economic Transformation.)*

Rapid advance in Artificial intelligence (AI), including Machine learning, is an important technological development that can significantly impact all spheres of economic activity. In manufacturing for example, AI can be used to create machines which can learn on the job or work in cooperation with humans and accordingly deliver a much wider range of work than possible today. There is a need to harness the new possibilities thrown open by AI developments while ensuring that possible economic and social concerns arising out of use of this new technology are addressed. India, with its significant ICT base and human resources, needs to be at the forefront of developing this technology and its applications responsibly to maximize the contribution of AI to India's economic transformation.

Accordingly, the Task Force on Artificial Intelligence shall focus on the following aspects:

1. The Task Forces shall identify specific areas of application for AI technologies and make recommendations for the faster adoption of AI in these areas in both private and public sectors. The Task Force may also identify areas of Government functioning where AI can be employed to lower costs and improve efficiency and service. The task force would also take the feedback from both private and public sectors as to their plans, needs and concerns towards the application of AI in their respective industries.
2. The Task Force shall deliberate and suggest ways through which perceived concerns about AI use, including data privacy, employability and algorithm bias, can be addressed and AI applications can be developed with least negative social impact.
3. The Task Force shall recommend elements for policy and for a legal framework to enable the leveraging of AI for economic benefit in the Indian scenario. Measures for financing AI start-ups or enhancing availability of growth capital shall also be made.







4. The Task Force shall deliberate and give its recommendations on need for imposing any regulations in the field, say for public safety, without raising the regulatory burden for industry. Any existing regulations that limit and impede the development of AI technologies or their adoption by private/public sector shall also be examined and recommendations for necessary reforms made.
5. The Task Force shall deliberate on ways of promoting research in the field including possibilities of private and public sector collaboration and setting up of focused centres of excellence. Specific recommendations for skill development shall be made. Ways and means to promote education and training, say through curriculum upgradation, shall also be examined.
6. The overall objective should be to develop sufficient capabilities in the country so that India becomes one of the leaders in an AI-led economy.

The Task Force shall meet as may be necessary and give its initial recommendations for reflection in the Industrial Policy within a period of one month. A fuller report shall be submitted in three months.

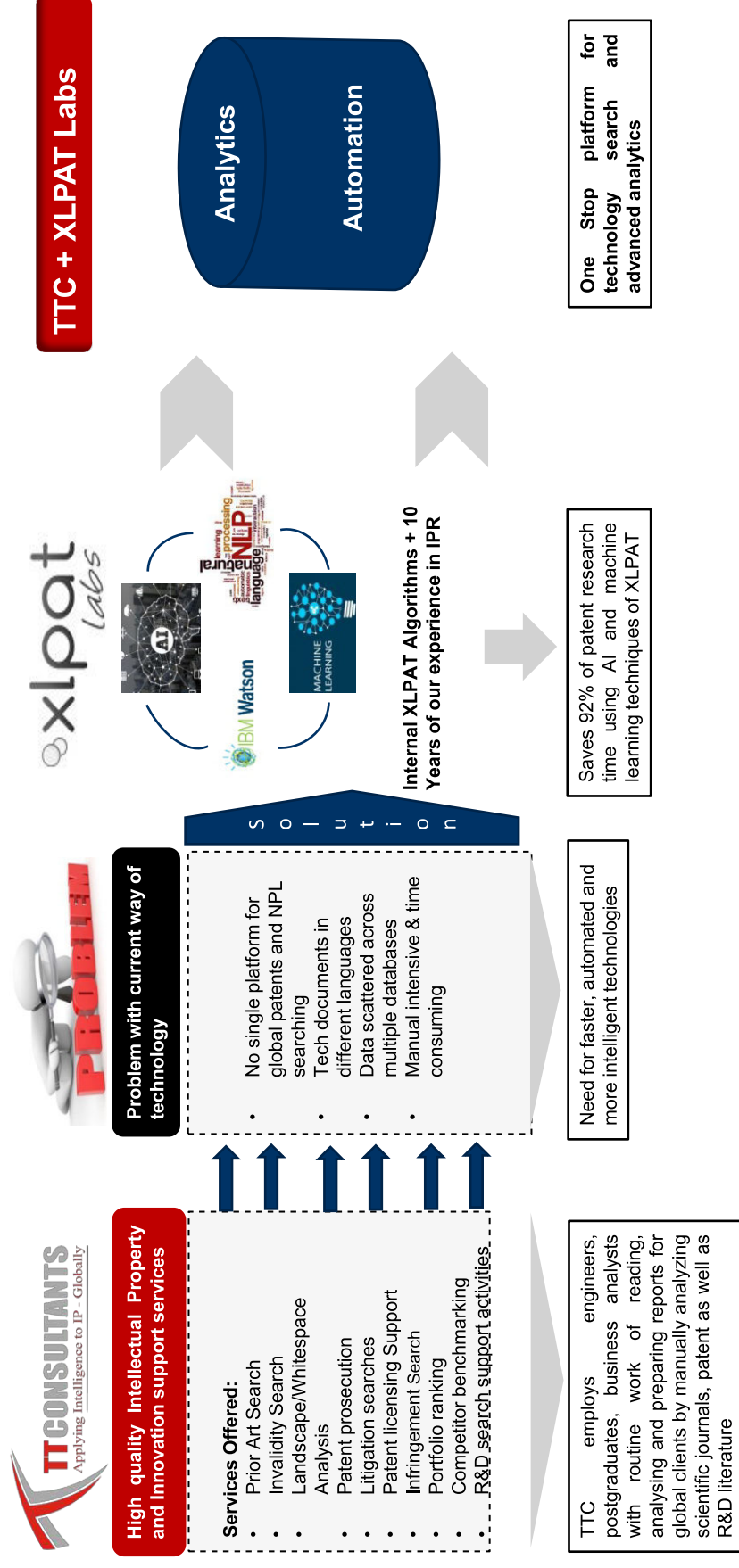




# Annexure 2



## TT Consultants and XLPAT – Case Study of Man-Machine collaboration to achieve efficiency and cost savings for global clients while reskilling current workforce and hiring workers



## XLPAT(IP Software Company) helping TTC(IP services company) to grow

### Need of the hour

#### 1 | Improved Quality & Consistency

- Increase in data every year requires extensive manual screening and analysis
- This might hamper high quality and consistency of product output
- Automation at first level screening and analysis reduces manual workload and thus results in improved quality

#### 1 | Time & Cost Efficiency

- Every business aims to implement cost effective processes and systems
- Automation driven work flow reduces manual burden and therefore results in saving precious time and cost

#### 1 | Scaling up of process

- An extensive data analysis requires screening and analysis of documents approximately more than 2000 in number followed by report making and quality check
- Automation by XLPAT refines these 2000 documents for deep-dive analysis and eases human effort
- The complete process gets scaled up with high efficiency, offering more in less time

#### 1 | Reskilling of current manpower

- Manual tasks of searching and analysis are replaced by machine
- More time can be spent on innovative and high value tasks
- Such work environments require re-skilling of current workforce to focus on creativity and innovation instead of only searching
- Reskilling in the field of data analytics, AI tools, neural networks, UX designing etc.

### XLPAT Workflow

Machine analyzes the data and provides its decisions



Decisions are analyzed by Human and confirmed



Report sent to the client

### Outcome

- Value for money
- Quality output
- Accurate decisions
- High efficiency

New skill sets/reskilling that will be needed for existing engineers

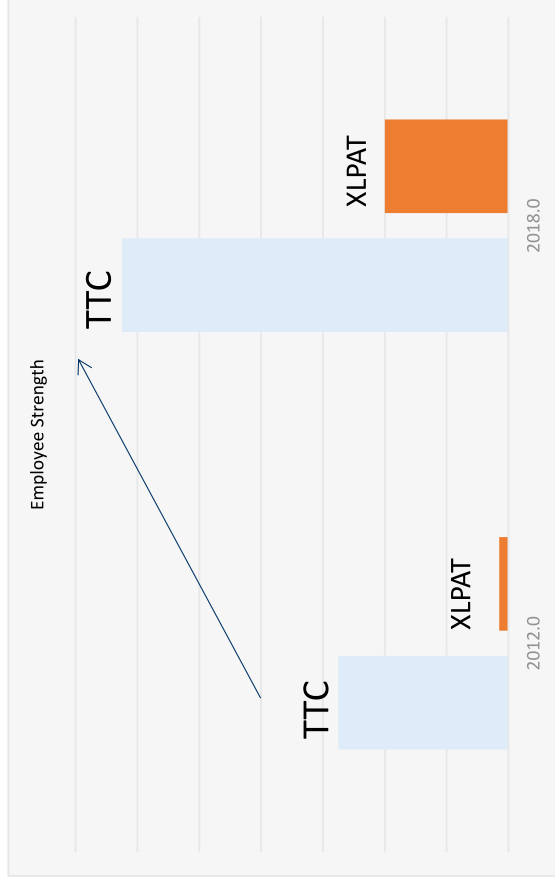
Hiring of people for diverse tasks

- Engineers
- Coders
- Data Analysts
- UI (User interface) Designers
- UX (User experience) Designers
- Automation Testers





## TTC (IP services company) employee strength increased after XLPAT (IP Software Company) introduction in 2012



With the introduction of XLPAT in 2012, employee strengths of both the companies increased due to following reasons:

- With automation output to the client increased as scalability of operations expanded
- More workload carrying ability with automated analysis assisting the manual team leading to more productivity.

- Engineers were retrained on new skills to make them efficiently interact with machines
- With AI doing part of the engineers job, they can spend more time on innovation and research to make new products
- Engineers increased their learning capacity to upscale the client reports
- New skills set were created to fill the gaps for which XLPAT hired fresh resources (UX designers, Testing engineers etc.)
- Automation and Manual inputs resulted in higher growth rate for the organisation



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The Task Force acknowledges the contributions made by the representatives from MeitY, DRDO, UIDAI, DST and NITI Aayog. We thank Shri. Narendra Bhooshan, DDG, UIDAI, MeitY and Shri. Piyush Poddar, Google for their suggestions.

