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Contents

Introduction.....	5
International Scenario and a National Strategy for AI	10
International Scenario.....	10
AI in India.....	11
Enablers and Focus Areas	13
Strategy for AI.....	14
Creating Enabling Policies	16
Governance Mechanism and Structures.....	18
An Apex National Council.....	18
National Council Secretariat.....	18
Centres of Excellence	19
Education/ Skilling and R&D	22
Strengthen Production of Skilled Manpower: Areas, Building blocks, Skill sets	22
Strengthen Research Capability.....	24
Recommended Action Points.....	25
Concrete Steps for quick starting AI related Retraining/Reskilling/Research	26
Reskilling.....	28
The Re-skilling Agenda.....	28
The Collaboration Imperative.....	30
Motivation.....	30
Industry-Academia collaboration	31
Open Innovation Platforms	32
Centres of Excellence (CoE)	34
Sandbox approach to AI Innovation	34
International Linkages.....	35
Suggested framework and institutional structure for POCs.....	36
Portal to enable collaborative frameworks	37
Interdependencies on recommendations of other committees.....	38
Policy and Regulation: Enabling, Debottlenecking and Supporting Collaboration	39
AI Policy Considerations	39
Fostering Innovation	39
Encouraging Employment and Protecting People’s Welfare	40
Liberating Data Responsibly	41
Protecting Privacy and Security	42
Requiring Accountability and Discouraging Discrimination	43

Model for AI policy.....	46
In Conclusion.....	48
Annexure 1: AI Strategy in other countries.....	49
Annexure 2: National AI strategies of some countries	51
Annexure 3: Establishment of a National AI Portal	55
Annexure 4: Use cases for AI in Public Health and Nutrition	59

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Introduction

AI is making visible and widespread impact globally, even after discounting for the inevitable technology hype. Over the last couple of years, AI has changed from a technology with potential to a capability of national importance across the world. USA, China, Japan, UK, EU, and many countries have recognized the role that AI will play in shaping the future of the world. Evolution and further development of the technology that are currently under way or imminent hold even greater potential to enhance manifold or replace human effort across sectors, raising both aspirations and fears. Well-crafted policies, R&D, skills, suitable global collaborative frameworks, innovative startups and targeted budgetary support will help shape and achieve elevated goals as well as address apprehensions. Bulk of the investments in startups in Silicon Valley and China are in AI. It was estimated that in 2016 technology giants invested between 20 to 30 billion US dollars, while startup investments were in the range of 6 to 9 billion US dollars.

The economic impact of AI, as per an Analysis Group study estimates that reasonable range for the global economic impact associated with the use, development, and adoption of AI from 2016 through 2025 is between \$1.49 trillion and \$2.95 trillion. This estimation is based on a set of benchmarks of recent and significant technologies that share similar characteristics with AI including general IT investment, broadband internet, mobile phones and industrial robotics, which provides a useful framework for estimating AI's potential economic effects.

AI can impact almost every sector of the economy. Be it financial services, healthcare, education or even security and governance, AI can be exploited for the benefit of citizens and the country.

A critical imperative for India is to grow AI capability by building on existing strengths and focus the combined power of AI and other associated technologies to address seemingly intractable social, economic and strategic challenges facing the country. In this context, social sectors like healthcare and education, economic arenas like agriculture and financial inclusion and strategic sectors like security and defense stand out.

The Prime Minister himself has provided the central perspective for the AI fraternity with his statement: "*We need to Make Artificial Intelligence in India and Make Artificial Intelligence work for India*". Consequently, the Committee has adopted the vision for AI for India as: "*Leverage the power of AI for National and Global Challenges and Opportunities*". This will necessarily require building AI research and development capabilities, capacity to apply them in various domains (which itself is still an active area of research, e.g., *Transfer Learning*¹) which can help the country. We must have a massive program to train and re-skill manpower for AI. Our research and development must also be globally competitive.

India has numerous problems of a gigantic scale that need to be addressed which can be viewed as opportunities in the journey towards Digital India. The Digital India initiative has been driving creation of technology infrastructure on a massive scale, including connectivity and adoption of digital practices. Our challenges of digital inclusion, diversity of language and culture, transportation, healthcare, education, agriculture, etc. require transformative, scalable technological innovations. We need technologies that can go beyond lab systems and work in the real world. For example, with over 600 widely used languages in India, efficient cross language communication is a necessity for India. Speech to speech

translation in real time across languages has been a dream for ages; now it is fast becoming a reality. Such solutions are heavily dependent on technologies like AI. We need significant growth in speech recognition, machine translation and speech synthesis in Indian languages. This is also needed for healthcare technologies like telemedicine to be effective and impactful at scale on the ground.

Technology interventions are now pervasive in all spheres of life. Advisory systems for soil planning, disease prevention, weed control, etc. can go beyond simple lookup, offering personalized advice customized for one's own soil conditions, using current weather and soil data using AI. Personalization is a key ingredient for inclusion, in communication, in identifying specific issues and offering advice, and many other areas. Personalized service delivery at scale is an engineering challenge.

The use and importance of Artificial Intelligence (AI) has exploded across the world over the last few years. Topics like autonomous cars and drones, predictive data analytics, health care diagnostics, video data analytics, language processing, robotics, etc. have become commonplace in the community that deals with data analytics and artificial intelligence. AI today, is viewed as the great disrupter bringing with it unprecedented opportunities. The last decade was the decade of cloud computing and communication. The next decade is the decade of AI. Countries and global corporations alike are racing to become leaders in AI. We have a precious and limited window for exploiting opportunities in AI. The time to allocate significant resources and act, is right now.

A few decades ago too AI was positioned as the next big-thing that will make machines think and do all sorts of work – that promise never materialized. This time, however, real possibilities for using AI have emerged. The main differences this time, from before which has given AI tremendous potential are:

- (i) data availability in all spheres has shot through the roof due to huge deployment of smart phones, cameras, imaging, e-payments, online systems for commerce, digital governance, IoT technology, etc. – essentially from being data poor, most domains are now data rich,
- (ii) machine learning and data science algorithms have become more sophisticated over the last decades to make use of this big data to develop more accurate models, and
- (iii) compute power, following Moore's Law, and storage capacity have now increased tremendously, making possible high level complex computations involved in machine learning to build sophisticated and more accurate models.

Any domain in which a large amount of data is available, or can be obtained, is now looking to apply the power of AI to create sophisticated models from the data which can be then used for better decision making and predictions. Moreover, powerful new AI algorithms are emerging which work on **small data**, and this is particularly relevant with computing and intelligence being pushed to the edge or the FOG. This is particularly important for India, where the data growth is not yet adequate for us to harness the power of technologies like deep learning in all domains.

An India centric approach will not only rely on developing AI solutions where we have big data but will also accord equal focus and importance to areas where we do not yet have big data. This is because the scale here enables us to build massive amounts of information

very quickly once digitization happens – and that process is accelerating. All we need to ensure is that the data getting generated is usable and suitably annotated. So we need to have a bottoms-up as well as a top-down approach working simultaneously. Sounds contrarian – but this is exactly what India needs.

Data and talent are critical. The Committee recognizes that India, due to a huge smart phones deployment base, rapid deployment of on-line systems and automation, ubiquity of Aadhaar, CCTVs, etc, is also becoming data-rich in many areas. However, use of this data by applying AI techniques for better decision making is lacking. There is no clear strategy to leverage the power of AI in various domains where it can be beneficial, or to build research capability to develop new solutions, or to develop manpower for helping organizations to apply AI techniques. There has to be a calibrated but liberal policy for the use of data in public sector for AI to deliver.

Coming to the issue of **creating and nurturing talent**, there are a few institutions which have Masters level specialization in AI and Machine Intelligence. Nevertheless, AI is often taught as electives in most BE/BTech/MCA/MTech programs in India. But lack of quality faculty, absence of opportunities and experience in practical applications make this largely ineffective or inadequate. It should also be emphasized that developing AI applications requires a process significantly different from the usual software development process, thanks to its heavy reliance on extensive knowledge bases, inherent uncertainty, and the difficulty in acquiring adequate domain knowledge ahead of implementation. In data driven domains like deep learning and machine learning, there are clear stages of training and testing. All these make the development of quality human resources in this area, a challenge that needs to be addressed for India to successfully use AI in addressing its myriad problems.

Existing Indian IT workforce also needs to be **reskilled** in the changing scenario, as companies are adopting solutions powered by technologies like AI, to address some of their tasks. A significant part of our workforce in IT is engaged in such areas. Given that a lot of the new applications being developed under the AI umbrella are data intensive with aspects like data cleaning, and preprocessing, we need to reskill our workforce for these tasks too.

When looking at skilling, we need to look beyond just building AI applications. AI is still an open and highly competitive area, with fresh developments always around the corner. India cannot afford to be mere adopter of technology, it needs to be active in this space for it to be able to play a key role in the international arena and drive the growth of this field at least in areas that are critical in the Indian context. Deep learning, though offering a lot of exciting possibilities, is facing concerns of lack of transparency, and generalizability into the core AI problems. Questions arise on the desirability of a purely statistical approach adopted in current deep learning solutions. Thus, AI continues to be a **fertile research frontier**, and it is important for India to ensure adequate presence here. As a major player in the IT landscape, and home to a very large, young and talented workforce, we have the potential and opportunity to be the world leader here. Through suitable institutional frameworks and policies, we need to nurture innovations in AI. Involvement of industry and other stake holders is key here to ensure that these efforts are directed at relevant concerns. Collaboration with all such stake holders needs to be nurtured for maximum benefit, for research as well as implementation. Suitable frameworks are needed to encourage effective

collaboration, while protecting and respecting the respective interests, and adhering to relevant laws of privacy and security.

AI is not a standalone discipline. The human brain is only about 5% of the weight of a person. But without that 5%, the remaining 95% of the body has little value, and without the 95% body components, the 5% brain has little value. Most AI applications typically have only about 5% of real AI in them. Much of the system is dealing with general information processing, interfacing and management. This is important while looking at building up an **AI ecosystem** in India. We need to support other areas like IoT, drones, and sensors, which play a key role in collecting useful data, and in realizing the intelligence. On the data side, it should be noted that unlike many Western countries, we do not yet have clean data in the desired quantity for most of the domains. Much of our legacy data is not even in digital format and even where it is, is often not standardized. We need to put in mechanisms to ensure **cleaner data collection** for the future, while working with available data in the interim. This also demands innovating AI solutions to work with partial data, with support for online learning as more data comes in. This is indeed a research frontier too and of particular concern for us.

There are various **policy and legal frameworks** and related aspects that need to be addressed. Most of the AI applications are dependent on a huge amount of quality data. Our challenges with respect to data have already been elaborated. While we need to work with such data to kick start development of systems, we need to ensure that new data coming into the system is clean and usable. Implementing predictive diagnosis to improve healthcare, safe driving mechanisms to improve road safety, etc may also require regulatory interventions by way of regulatory enablers. Creation and use of digital data may require change of traditional processes. Out-dated existing rules and policies coming in the way of such development would need to be reviewed and suitably modified, keeping in mind issues such as privacy and constitutional provisions in this regard. Thirdly, given that we would be dealing extensively with human behavioral data for modelling applications in AI, a suitable policy framework would be required. This perhaps can be taken up as we go along; but the first two aspects require attention early on, to prevent the efforts from hitting roadblocks.

Our focus in adoption of AI needs to be on harvesting clear benefits in important areas of concern to us. Building solutions that work in the real world with all its nuances and uncertainties is a challenge. We need to create a conducive framework for **collaborative POCs** that are scalable in important areas like health, education, e-governance, transportation, agriculture, and digital inclusion. In most of these, technological feasibility has already been demonstrated in a controlled environment. We need to ensure that these solutions can work in the prevailing field environment, with necessary modifications. For example, while speech recognition systems work well in a lab environment, the situation is quite different when numerous dialects and accents are encountered or when a person is calling from a mobile phone, or from a public place. We need to focus on building models with proven technical and economic feasibility of large scale adoption. Collaboration has a key role to play in this space too.

This report looks at each of these aspects in detail and recommends action plans and targets for each major component while advocating a concerted strategy that emphasizes creation of an application mindset focused on deployment at scale, R&D, Skilling and a conducive

policy and regulatory framework. Most importantly, it emphasizes the need to leverage the considerable strengths that we have in the IT sector, in the startups space, in academic and technology institutions and the growing momentum in infrastructure.

The next section looks at the International scenario, contrasting it with the Indian scenario, and reviews models of AI strategy of other countries. It also identifies key enablers for AI development and usage. Based on various discussions and studies, a strategy is proposed for India in this chapter. Next, we focus on an institutional structure to continuously refine the strategy and drive concerted action accordingly. The next Section specifically looks at the skilling and R&D and makes some recommendations. The subsequent section looks at reskilling, followed by collaboration imperatives after that. In the next Section we consider cross linkages with other groups. The last Section covers policy and regulatory issues.

Finally, there is an unprecedented opportunity for the country to attain a global leadership role in AI in some niche areas like healthcare, agriculture, financial inclusion, education and skilling, and some strategic areas too. The Committee strongly believes that India can and must aim for nothing less. This report sets out an agenda to do just that. The window is small, the pace of technology advancement is very high and failure to act quickly would translate into a lost opportunity. The need of the hour is to act expeditiously.

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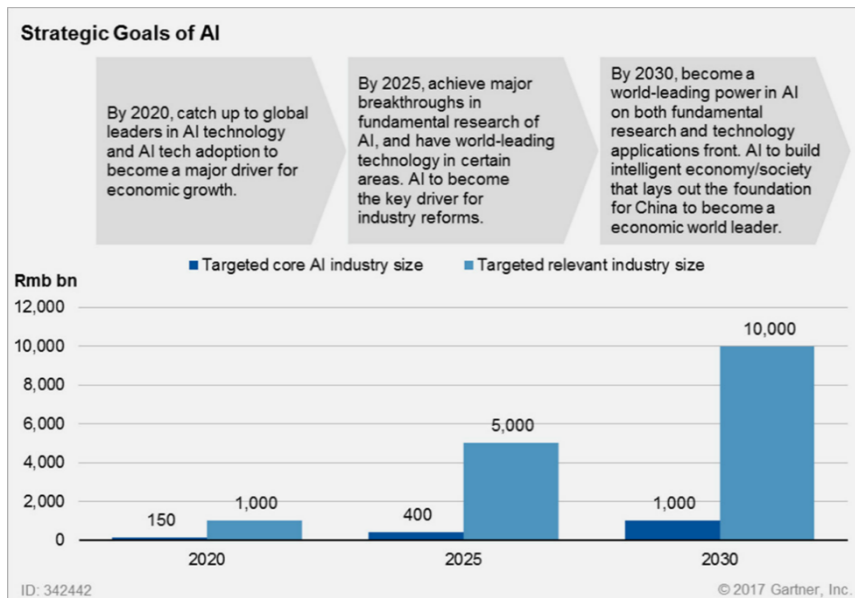
International Scenario and a National Strategy for AI

International Scenario

Due to its enormous potential in transforming business, society and governance, many countries are investing substantially in AI. For example, the State Council of China has unveiled a program in which by 2020 it aims to be at par with the best in the world, by 2025 it plans to have major breakthroughs in AI and for AI to become the primary driver of China's industry, and by 2030 it aims to become the world's premier innovation and research center. The government is planning multibillion dollar investments in enhancing research and innovation in AI. Local governments are also investing in AI use and industry. The Economist reports that the number of papers in AI published by Chinese researchers is now at par with that from US and EU, and the number of patents filed has increased by 200%. Chinese AI companies received \$2.6 Billion in funding. China's BAT (Baidu, Alibaba, Tencent) are investing heavily. Some believe China can indeed surge ahead since it has massive infrastructure, huge investment, widespread deployment of sensors (smart phones, cameras, IoT devices) and of electronic systems for most purposes including payments, etc. Consequently, it has a significant data advantage over the west, an edge enhanced by lower privacy concern and is poised to use it well.

Bulk of the investments in startups in Silicon Valley and China are in AI. It was estimated that in 2016 technology giants invested anywhere between 20 to 30 billion US dollars, while startup investments were in the range of 6 to 9 billion US dollars. National academy of Engineering, US has announced a list of grand challenges for engineering in the 21st century, which includes things like securing cyberspace, advance health informatics, personalized instruction, and so on. These are seen as beyond current technological capabilities, and looking for major technological innovations. AI technologies – available today or on the horizon – will play a key role in meeting these challenges. Not surprisingly, almost every major industry and at a political level, every nation is looking at this field seriously. Annexures 1 & 2 summarize the National AI strategies of some of the key countries in this field. Companies such as Amazon, Nvidia, Microsoft, IBM, etc apart from Google are also investing heavily in AI and related areas.

Countries, notably, China, US, UK have significantly skilled human capital and are leading the world as thought leaders in AI. China, in particular, has made giant strides in last few years and AI is a Mission Mode Project in China with clear targets and PPP partnerships. China's goal is to become the world leader in AI by 2030, with the aim of making the industry worth 1 trillion yuan (\$147.7 billion). The State Council released its three-step roadmap outlining the thinking behind how it expects China to become AI leader of the world. The figure illustrates the three stages and how China Govt is partnering with a variety of private sector companies to advance the state-of-the art in AI.



GOVT + PRIVATE SECTOR

- Baidu – Autonomous Vehicles
- Alibaba – Smart Cities
- Tencent – Medical Imaging
- iFlytek – Voice

Earlier this year, the UK Govt as part of R&D and Industrial Strategy made available a funding of GBP 16 Million through Innovate UK. The funding is for robotics and artificial intelligence technologies in applications such as deep mining, nuclear energy, space and off-shore energy. The gov't is keen to grasp the economic opportunity from developing driverless cars, digital “assistants” like iPhone’s Siri and robots working in hazardous environments such as nuclear facilities.

In Canada, the government announced it will renew and enhance its funding for Canadian Institute For Advanced Research (CIFAR) ¹. The government announced that CIFAR will administer a \$125 million Pan-Canadian Artificial Intelligence Strategy for research and talent, towards cementing Canada’s position as a world leader in AI. The \$125 million strategy aims to:

1. Attract and retain top academic talent in Canada,
2. Increase the number of post-graduate trainees and researchers studying artificial intelligence, and
3. Promote collaboration between Canada’s main centres of expertise in Montreal, Toronto-Waterloo and Edmonton.

As evident from these trends, each country is assessing their national priorities and appropriately crafting a policy framework that can address those national priorities. We are still in the very early stages of AI revolution. By starting now, India has the opportunity to develop a comprehensive National AI Strategy that will be a game changer for solving national scale challenges and deliver massive economic benefits to Indian citizens.

AI in India

As the following instances show, there is significant policy activity that has started in Govt.:

¹<https://www.cifar.ca/assets/government-of-canada-renews-investment-in-cifar-funds-ai-initiative/>

- Niti Aayog and MeITY are actively working to create a National AI Strategy document to define a roadmap for India. DIPP recently released the report of the committee setup to address the use of AI. Ministry of Defence recently setup a committee to look into the use of AI in defence production.
- Karnataka and Telangana Govts. have invested in creating Centres of Excellence in Data Science and Artificial Intelligence in Bengaluru and Hyderabad respectively.
- IT Ministry's National Institute of Electronics and Information Technology (NIELIT) plans to introduce new courses in partnership with industry, to train people in AI.

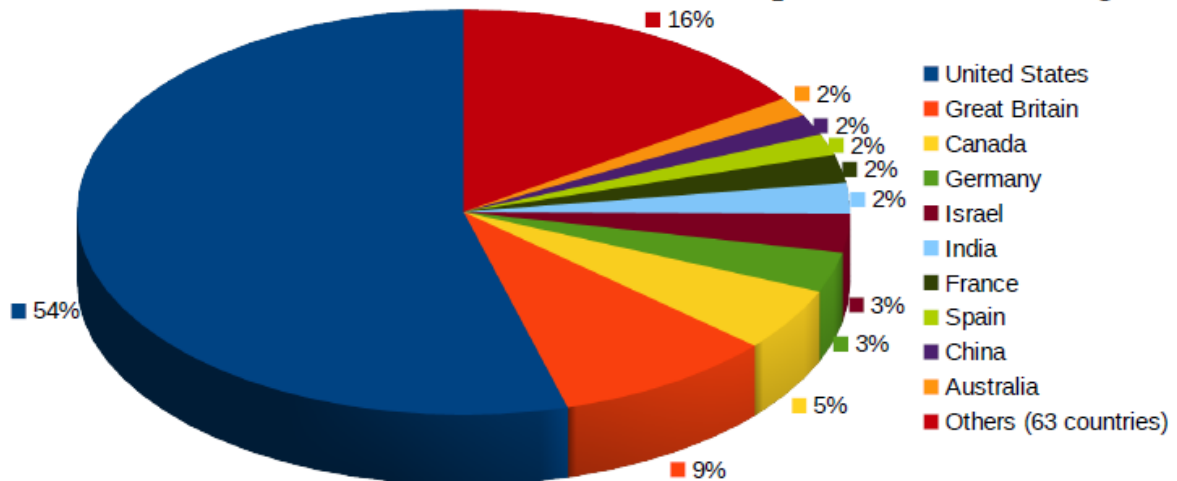
Currently, there are various developments in AI in Indian academia and industry. For example:

- Arvind Eye Hospital, in partnership with Google, is using AI in ophthalmology for diabetic retinopathy.
- Ola is using AI to improve customer experience by understanding driver habits and traffic patterns.
- Govt of Karnataka, in collaboration with Intel, is working towards cutting road mishaps by 30% over the next five years using AI based technology solutions to deal with traffic issues, and prevent road accidents.
- NASSCOM, in partnership with the Governments of Karnataka and Telangana is setting up COEs on AI and Data Sciences in Bangalore and Hyderabad with strong industry collaboration
- There is significant R&D in reputed academic and research institutions in the country – this has been elaborated in Chapter 4.
- With Government support, a number of projects have produced a fair amount of resources in Indian languages for machine translation, speech synthesis and speech recognition.

There are several academic and non-Government institutions that have been active in AI and related areas for long. An illustrative, though not exhaustive list of 10 such institutions is included in the Section on R&D and Skilling.

AI start-ups in India have grown in number. According to a study done by [Excubator](#), that tracks 2300+ companies across the world, 85% of world's AI startups are based in just 10 countries. India is now among the world's top-10 countries in the number of AI Startups.

The AI/ML Landscape: Globally



85% of the world's AI/ML startups are based in just 10 countries.

India features in this top 10 list.

Enablers and Focus Areas

For AI based services and value to take hold in an ecosystem and country, multiple facets need to align and work in concert. The AI strategy should encompass programs that build on the following four focus areas:

- **Create a Strong R&D base:** A good foundation of technologies, Intellectual Property (IP) and algorithms created in the country is key to adopt AI for the opportunities and challenges in the country. This has to be a good mix of basic R&D and more importantly “applied engineering” as the technology needs to be quickly deployed for real-life problem. In AI, we have seen the time gap between new research and the deployment to a data set is very small compared to traditional technologies and hence a mind-set of applied engineering is key.
- **Application Mind set:** From early stage we should look to identify domain areas and specific problems we want to prioritise AI for – as that can help to prioritize and accelerate research, application and data creation for that domain. E.g. Agriculture (e.g. Crop Yield) is a focus area for India, create a National Level mission program that creates the right policies to let a cross functional team of technologists create data sets, algorithms and solutions for desired result. Over a few iterations the data, solutions will get better and deliver higher impact.

- **Leverage the Ecosystem & Start-ups:** National strategy and institutions should create the assets and frameworks to enable entrepreneurs and enterprises to create innovative, financially viable services on top of the assets created. Just as Aadhaar is a national asset on which people can create services, offerings, AI assets (be it Data Sets, Tools/Frameworks or Algorithms) should be available as a foundation on which ecosystem can build the services and offerings needed in the country and also for global scale.
- **Skilling:** Success in AI will need experts to build AI tools and frameworks, to use AI tools. India need to build a strong pool of skills for the short term by skilling/re-skilling the professionals. We should train our bureaucrats to enable them to guide policy making for AI and enable decisions that accelerate building and use of AI. All this will include skills like data set creation, data preparation, data scientists, developers, privacy, public policy etc. Also over longer term our education curricula and pedagogy models need to evolve to align with the needs of a society that relies

AI Leadership for India: Enablers and Focus Areas

Enabling Policies			
<p>Fostering Innovation – Open Technologies; Incentives, Seeding/funding Liberating Data – Responsibly, Strategically Protecting & Promoting Privacy and Security Requiring Accountability and Discouraging Discrimination Encouraging Human Employment and Protecting People’s Welfare – Augment Humanity (Not replace it)</p>			
Targeted Programs & Initiatives			
R&D	Applications of AI	Startups; Ecosystem	Education & Skill Development
<ul style="list-style-type: none"> • Fundamental R&D in AI for solving problems core to India & AI • Define/setup Centres for AI Transformation (R&D and application engineering centers); PPP model; Involve academia + Govt. Agencies • Identify/facilitate nation level research agenda; 	<ul style="list-style-type: none"> • Adoption of AI in various sectors like Health, Transportation, education etc... • Define Grand Challenges and execute with Govt/ecosystem Execute POCs for prioritized options 	<ul style="list-style-type: none"> • Robust bottoms up innovation to leverage AI for India & global opportunities (Startups, Programs in Enterprises and academia) - AI Incubator (Experts, Processes, “Entrepreneurs in Residence”; Infrastructure/tools, etc) • Collaboration Framework (Industry, Academia, Govt, & other stakeholders 	<ul style="list-style-type: none"> • AI awareness/Skills in education Curriculum Development Mentor/Guide MS/PhDs in AI • Build skills required to address upcoming requirements in the Industry.(AI Academy; Courses on Meghraj) • Decision Makers readiness for AI revolution (AI workshops for technocrats/Officials)

more and more on AI and Intelligent systems.

Strategy for AI

Countries across the world have been making rapid progress in AI-based research and application. India would also necessarily need to view AI as a critical element of national policy and strategy. Spurring AI-based innovation and establishing AI-ready infrastructure is critical for preparing India’s jobs and skills markets and to secure its strategic interests.

The core to success in AI Innovation and adoption is the three tenets of ‘Data’, ‘Compute’ and ‘Algorithms’.

- **Data:** AI technology is and will be a service based on data. Given the primacy and ‘Competitive Advantage’ of the Data, the overall strategy will need to ensure focused efforts on digitization of all data. Further, collective efforts from industry, academia, and government will need to be made towards developing an environment where across sectors – specifically medical care, transportation, distribution, and infrastructure etc., IoT enabled information input/output devices such as sensors

are installed, and digitized data collection is mandated. This would need to be done with sufficient considerations towards personal information protection and usage restrictions while also ensuring reliability, security, system flexibility and a balance between data as a competitive advantage for few versus utilization and application of data, and coordination among data lakes.

- **Compute + Communication:** Making available High-Performance compute infrastructure specifically suited for AI applications, such as learning, and inference coupled with communication infrastructure that will enable transmission of information from wide-area sensors and IoT devices securely and with ultralow delay is critical to ensure utilization and application of AI technology in real-time.

The overall strategy will need to factor in and make provisions for enabling High Performance compute infrastructure suited for AI applications available and deployed across key industries, R&D Centers and Educational Institutions, while also enabling the National communication and data backbone to be based on next generation communication infrastructure (5G + etc.)

- **Algorithms:** Understanding AI & deep learning is about understanding the algorithms. It is also critical to understand how deep learning can be used with other AI and analytics components. Using, deploying and development of AI Deep Learning Algorithms will be a part of the focus on Skilling, Reskilling and R&D.

To exploit the transformative powers of AI for national scale human problems, we need the world's best AI researchers, Data Scientists, Applied mathematicians, Computer Scientists and engineers to come together to create national level AI platforms with the following major technology ingredients as elaborated above:

1. Massive amounts of curated, annotated datasets,
2. State-of-the art algorithms that improve and learn using these datasets, and
3. Scalable Compute Infrastructure to run these highly complex algorithms.

Unfortunately, India is lagging in the availability of this highly skilled talent in Academia and Industry. Significant achievements in AI have been fuelled by a strong base of fundamental research.

Clearly, there is much ground that we need to cover before we can even aspire, let alone achieve a leadership role in some niche segments of AI. In the following section, we lay out some of the key elements of the strategy that can get us there. Each of these elements is elaborated in subsequent chapters. AI holds the potential to be a major driver of economic growth and social progress. The need of the hour is for Industry, government, academia and the public to work together to support development of the technology with thoughtful attention to its potential.

At the heart of the strategy is a bias towards implementation – using AI in key sectors that are national priorities to deliver transformative change. This would help build confidence in the substantial difference that AI can make, provided the areas are chosen with adequate care. We discuss the collaborations necessary to achieve this in Chapter 5.

AI is unique among technologies in one respect, apart from its enormous power and even greater future potential. It is a technology which improves with usage – in fact usage would customize and perfect it. Besides, an overwhelming proportion of applied research is being done by corporations that have created enormous wealth through technology platforms – look at US and China for example. It is evident that there is a virtuous cycle of technology adoption leading to wealth creation which fuels further innovation and technology development. Another dimension is that a widespread belief is that the pace of arrival of ever more powerful technologies is outstripping our ability to adopt them, particularly at scale. It is clear that availability of technology is not the biggest constraint today – ability to utilize it and deploy it at scale is. Challenges in applying AI at scale are significant and need as much or more effort and resources as creating these technologies.

Even as we build our own R&D and technology capability, we should adopt and adapt available technologies and build on them, if we aim to take a lead at least in some areas of AI. Finally, as a cynic said, “an ounce of implementation is worth a ton of talk”. We need to keep in mind that for most people, including professionals in other fields, seeing is believing. It is only when real world examples of transformative and beneficial change are created that adoption at scale is enabled. Hence, viewed from any angle, in the overall national strategy, the bias has to be towards implementation with basic research areas being prioritized based on need. Our existing and future wealth of data must be made to work for us. Academia-industry COEs (described in chapter 5) are viewed as key institutional enablers to accomplish this goal. We should also be realistic about what we can hope to accomplish with the quantum of financial resources Government can allocate to R&D and technology development when viewed against the quantum of resources being deployed by other countries and corporations. This sense of proportion and balance between basic research and deployment needs to be kept in mind while allocating scarce resources.

Creating Enabling Policies

India has a unique opportunity and a specific need to lead in ushering an era of human-centric AI. This is a key part of AI strategy for India where the policies and the governance structure will need to be set up in a manner that aids and accelerates AI adoption in a harmonious and sustainable manner.

- Creating a set of guidelines that incentivise and drive innovation in a scalable manner,
- A policy that enables creation of clean data as they are key for generating value from AI. This needs to be done responsibly (to ensure that the stakeholders have confidence in the legitimate and lawful use of data) and strategically to focus on areas of importance for the country (e.g., health and agriculture). The imperative for policy making is to ensure that it creates a national platform for innovators, entrepreneurs and businesses to deliver innovative services in a fair and sustainable manner.
- Policy regime needs to create a robust framework for Data Privacy and Security and ensure that the AI services are deployed accountably. It should discourage any kind of discrimination through technology, data sets or even accessibility. Ensuring this is key to instilling confidence in services and for long term value creation for the country.

- Last but not the least, the policies need to facilitate the usage of technology to augment humans, create livelihoods in new areas as some parts get automated and prepare people for those openings by skilling and re-skilling them. At this stage, the emphasis needs to be on enablement and removal of bottlenecks rather than control (except in respect of data usage).

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Governance Mechanism and Structures

The Committee felt that an appropriate institutional structure is extremely important to drive creation and usage of AI in a manner that addresses the vast range of social and national strategic challenges that the country faces. Each element of the National Strategy highlighted in the previous section would entail various initiatives being undertaken by different arms and ministries of the Government. These are elaborated in the following sections. Collectively, these actions are intended to address challenges relating to R&D, Skilling, Reskilling, establishing Collaborative frameworks for National Missions and creating a conducive regulatory environment for creation and adoption of AI. An overarching Governance structure is imperative to ensure cohesive action and coordination across these diverse streams and multiple National Missions. This structure is equally important to enable and facilitate collaboration between government, industry, academia and non-governmental entities. Such collaboration is considered vital for successful development and deployment of transformative AI-based solutions at scale in the country. Our proposed governance mechanism has three components and these are outlined below.

An Apex National Council

We recommend a National Council on AI at the Apex level with representatives from government, academia and industry as well as a few experts. Representatives from different domains could be co-opted on a need basis, but it is envisaged that there would be similar broad-based Councils for each sector which would steer the National Missions in those sectors based on the frameworks laid down by the Apex Council. Given the cross-cutting nature of the initiative, it may be appropriate for the National Council to be set up by the Niti Aayog and any advice on development and deployment of AI to line ministries be communicated by Niti Aayog.

National Council Secretariat

The National Council would consist of eminent individuals who meet periodically and so would need to be supported by a permanent institutional establishment if it is to make a real impact. This could be an existing institution or a new institution. We will call this the National Council Secretariat, for now. The scope could be narrowly confined to AI or broader covering other technologies associated with AI like Data Analytics and IoT or even wider to encompass opportunities and challenges of the digital economy with one arm dedicated to AI. The need for such an institution has been felt in many contexts. It is important to clarify that the committee strongly feels that a federated structure that confers as much autonomy as possible on the operational institutions like COEs and academic institutions is preferable to centralized control and direction. This is particularly important since AI being a relatively new technology, full freedom to experiment and even fail is critical for overall success. Given the technology-intensity of the agenda, it would be appropriate for this institution to be housed in and tethered to Meity.

At a broad level, there are three kinds of tasks associated with creating and driving the National AI agenda. The first is to draw up and drive the national strategy for AI. This paper provides the starting point for such a strategy. The National Council is the owner and custodian of that strategy and the institution serves as the secretariat to the National Council. Given the rapid evolution of AI and its usage, the strategy needs to be viewed as

continuously evolving rather than static. The central theme of AI for inclusion and human-centric AI would however, remain the guiding principle.

The second task is the function of a Think Tank to consider issues such as the following on a continuing basis:

- How can the country leverage AI optimally for its benefit?
- Which areas (Missions) should the country target for maximal benefit? (Committee B on National Missions provides the initial set)
- In which technology areas and domains should the country aspire for a global leadership role? (We provide initial pointers)
- How can the country abstract the best value by application of AI to the vast amount of data that exists and the enormous and rapidly accelerating amount of data that will be generated in the future?
- Which AI technologies should we focus Government funded research activities on?
- What strategy should we adopt to ensure that AI delivers economic and strategic value and simultaneously adds jobs?
- How do we ensure that regulation brings in controls only where absolutely necessary (like data use and access) but the overall emphasis is on enabling rather than curbing innovative uses of AI?

Of course there are several other such questions that would arise and these are only illustrative.

The third task is to ensure coordination across the multiple initiatives covering R&D, Skilling, Reskilling and collaborative frameworks for adoption and implementation. The imperative of collaboration between Government, industry and academia with the involvement of non-Government institutions would be difficult, if not impossible to deal with in the absence of such an institutional mechanism.

Centres of Excellence

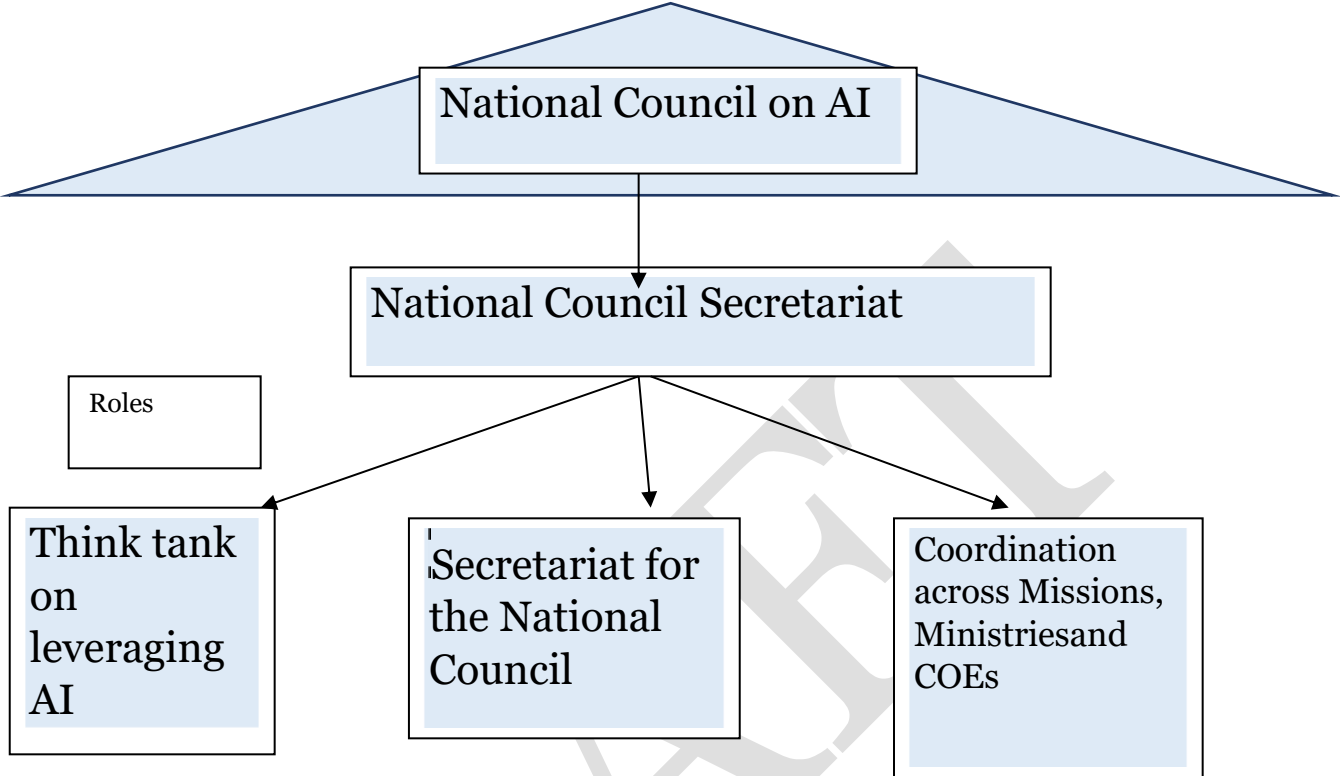
The third component of the recommended institutional mechanism are the Centres of Excellence (COEs). Several COEs need to be established across India, to cater to various priorities and sectors. Loose coordination, rather than tight control, would be needed across multiple Centres of Excellence (COEs). Establishment of COEs is a key element of the strategy to develop and deploy AI and related technologies. These COEs should:

- Be sponsored and funded (at least partly) by the Government (Central and State – the latter to additionally bring in a focus on problem areas pertinent to it)
- Have Industry and academia participation; the former to bring commercialization and deployment expertise and the latter to bring in deeper technology expertise – COEs with deeper technology focus could be academia led with industry participation and COEs with a greater implementation focus could be industry driven with academia support and participation
- Support POCs that would have to be undertaken across sectors (particularly for the identified National Missions) to develop and demonstrate scalable, affordable, transformative solutions using AI.

Some more details on the nature and functions of the different types of COEs will be discussed in subsequent sections of this report.

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The overall structure proposed is schematically depicted as follows:



Education/Skilling and R&D

To achieve the vision of *Leveraging the power of AI for National and Global Challenges and Opportunities*, it is essential to invest in AI research and development and strengthen the education programs in AI to develop needed skilled manpower. The AI ecosystem must consider the following components: Research and development, training, collaboration, data generation and access, computation, dissemination, and IP generation. The IP that is generated from this ecosystem must be protected well and the technology should be transferred to enable quick product development.

The AI ecosystem must encourage a strong collaborative effort between the industry and the academia. The data and computation power that modern day industry possesses cannot be matched in any shape or form by the academia. However, the foundational principles of AI/ML/DL that the academia brings to the table is extremely valuable and cannot be easily found elsewhere. In an ideal ecosystem, these strengths must be recognized and a flourishing environment for interaction must be setup. We discuss this in the section on Collaboration.

Strengthen Production of Skilled Manpower: Areas, Building blocks, Skill sets

Some specific domains and example applications wherein, AI intervention is imminent along with basic building blocks and skill set requirement is given in the following table:

Domains	Example Applications	Basic Building Blocks	Skill Set
Defence and National Cyber Security	Malware Analysis, Predictive Policing, Surveillance for Homeland security, Disaster Management, Intrusion Detection Systems	Speech Technology - Speech recognition, Speech Synthesis, Conversational speech analytics, speech-to-speech conversion; Face recognition; Handwriting recognition; Machine Learning/Deep Learning Libraries; Natural Language Processing/Text analytics, India-Specific Indian Language Databases; Search techniques, Knowledge Representation and Reasoning; AI Chip/Processor Development; Planning; Cognitive Modelling; Robotics;	GPU coding; Programming languages for AI including Python and R; Sensors and Actuators; Basic Communication Standards including ZigBee, Bluetooth, Wireless, wired; Programming embedded systems with peripheral interfaces; Using Basic Data Analytics stack – Data base, AI/ML Interface platform and Visualization interface; Visualization techniques; Cloud computing; Functional testing,
Agri-Tech	Weather forecasting, Agricultural Robotics, Soil and Crop Monitoring		
Health-Tech	Health diagnostics – drug discovery, diagnostic imaging		
Fin-Tech	Financial Fraud in banking sector, data Analytics and predictions in Banking and Insurance sectors		
Intelligent Decision making aided	Manufacturing, E-Governance, Human		

Process Automation	resource process, legal process	Computer Vision; Game Playing; Multi-agent systems;	Performance testing, Penetration testing and Vulnerability Assessment
Education	Assessment of Cognitive ability; Self-assessment based learning; early detection of special children and continuous monitoring of impact of training on them; Artificial speaking robots for counselling	Domain-specific Data Science; Explainable Behaviour of AI systems; Data Sharing and Audit Policies; AI Professional Ethics; Cloud computing; Brain Modelling; Pattern recognition; Convex Optimization; Kernel Methods.	
AI for Edge Devices	Edge devices are going to be all pervasive and will dominate the technological envelope of India. Edge and FOG computing will dominate the future and thus AI for edge devices will be a must.		Knowledge of lower power and mobile computing, AI with small data sets and not big data
AI and Explainability – this will include focusing on reasoning, problem solving and abstract thinking in machines	Explainability is the way AI is going to evolve in future. Our work in AI should also be future ready and future proof.	Research in Explainability in AI will require expertise in all aspects of AI and Machine learning. It will also require expertise and fundamentals of Computer Science and related mathematical areas of Electrical Engineering.	
AI for Cyber Security	Cyber security is important in all walks of life.		

Expertise in all the above exists to a large extent in India. This is evident from the fact that India ranks 6th in terms of research publications in AI over a span of 5 years (2011 to 2015). The countries which are ahead of us are: China, US, Japan, UK, and Germany. The output is limited due to resource constraints.

There is a need to focus on training the current and next generation(s) in both the fundamentals and applied areas of AI. This can be achieved through a systematic approach where this training begins right from the middle school level where students are exposed to real-life examples like weather prediction, score prediction, etc. Since open source ML tools

for achieving AI are great equalizers, students at all levels of education must be encouraged to work with them. These trained students will form a vital part of the AI ecosystem.

Strengthen Research Capability

Creating research and education capability from scratch is hard and a slow process. A better approach is to identify all the academic institutions, which have some research faculty in AI – who have a past record in publishing in AI related conferences and journals, and support these to build some of the Centers of Excellence in AI. An illustrative list of the Institutions, including some not-for-profit and corporate research labs, where good AI research groups exist is given below. This list clearly shows that there is a set of institutions where good nucleus of AI research already exists. This list is illustrative and is not exhaustive, and information is based on what was quickly collected. and includes some R&D groups in companies who engage in public-domain research:

- IISc Bangalore – Has 30 faculty members working on a variety of topics like Deep learning, reinforcement learning, Active learning, Large scale convex optimization, Robust decision making, Explainability in machine learning, NLP, Data Mining, Vision, Clustering, etc.
- IIT Delhi – Has 30 faculty, working in computer vision, NLP, and general AI, data science, etc
- IIT Madras – has 30 faculty, working in reinforcement learning, deep learning, NLP, Speech, Robotics, Cognitive systems, etc.
- IIT Bombay – has 30 faculty members, working in machine learning, data mining, analytics, computer vision, etc.
- IIT Kanpur – has 25 faculty, working in machine learning, analytics, computer vision, etc.
- IIT Kharagpur - has 36 faculty, working in AI algorithms, machine learning, Social network mining, NLP, Statistical inference, etc.
- IIT Hyderabad – have 20 faculty from CSE and EE department working on various aspects of AI, like Deep learning, Convolutional neural networks, Robust data analytics and inference, Bayesian learning, Explainability in machine learning, IoT, computer vision, speech processing, big data. IITH has an explicit M.Tech. specialization in AI and Machine Learning.
- IIIT Hyderabad – Has 27 faculty in Kohli Center for Intelligent Systems, working in Computer Vision, NLP, Robotics, Machine Learning, Cognitive Science, Data Sciences, Speech Processing, Information Retrieval and Extraction and other aspects of AI.
- IIIT Delhi – has 21 faculty and Infosys Center for AI, working in Computer Vision, Pattern Recognition, Deep Learning, Optimization, Medical Data Analytics, Robotics and Autonomous Vehicles, Application of AI for Biology, Graphics (AR/VR), Forensics, Biometrics, Multimedia, Healthcare, Software Decision Process, Wildlife Conservation, Security, and IoT.
- WadhvaniCenter for AI, Mumbai. Center is focused on AI for social good. Plans to have a group of about 20 researchers in a few years.

- Microsoft research, Bangalore. 20 researchers working in topics such as algorithmic foundations of ML, non-convex optimization, NLP, deep learning, applications of ML, AI for systems, and systems for AI, and AI for social good.

Such Institutions can be focal points for establishing some of the **Centers of Excellence (CoE)** in AI focused on academic aspects and may be asked to give a five-year proposal **in AI** in collaboration with one or more industry partners (see chapter on collaborative framework for details). These centers will be required to engage in key aspects of AI to support the national imperatives, development of AI for India, globally competitive AI technology development and AI research. The research funding should be significant so that impacting R and D in AI is achieved, AI technology development is achieved, highly trained manpower in AI is created, and training and reskilling is accomplished. Such institutions could, inter alia, be required to develop well skilled manpower in AI, develop specialized Masters programs focused on AI, and develop course streams (e.g. minor) for Undergraduate programs. These CoEs may be required to:

1. Have some of the goals mentioned above as their R&D goals.
2. Have large number of Ph.D. fellows, M.Tech. and B.Tech. students focusing on R and D in AI and Machine Learning. This will be the AI workforce of tomorrow.
3. Create education materials that can effectively teach and kindle interest in research in the areas listed above.
4. Create material for skilling and reskilling targeting members from all disciplines - legal, commerce, economics, medical, public administration to multiple engineering disciplines;
5. Focus on Architectural design of AI based systems
6. Undertake development, porting, deployment and monitoring of AI based systems
7. Pursue translational and cutting-edge R and D in AI and Machine Learning.

Recommended Action Points

- Identify some AI challenges, which align with some national imperatives. (Committee B on National Missions would be covering this in their report). The imperatives could be those that can be addressed using AI and where either data for applying AI exists or can be obtained or can be quickly scaled up. The CoEs should adopt some of these as their R&D goals.
- Data is the key to applying AI. And for applying Machine Learning approach, a lot of data needs to be properly “labeled”. Without this, AI simply cannot be applied effectively. While each department may create a data cell, an alternative is to create a **Data Institute/Exchange of India**, which is owned by the Government, but is housed in an academic institution (a model like this was followed in US for natural language processing development – it set up an institute in the University of Pennsylvania²). This institute will work with Departments for getting data, cleaning it, labelling it, and making it available, with proper safeguards and privacy protection, to researchers from CoEs and other institutions to develop models and solutions for the grand challenges.
- A high profile yearly conference, which includes brain storming sessions, on AI organized by one of the CoE on a rotating basis. The brainstorming sessions must have a strong global connect global presence.

- A portal along the lines of www.canada.ai should be established, which can provide a platform to consolidate information about all CoEs, AI research groups in India, corporate research in AI, and, government departments who have stated AI related activities.
- Setting up a startup fund that spawn many startups in AI. This is the trend in Silicon Valley and across the globe. For India, this is the only way to leverage and impact the next decade which is the decade of AI.
- Introducing AI component in Bachelors/Masters program across all disciplines. Every engineering student undergoes a course on computer programming irrespective of the discipline. Similarly, every student, not just engineering, but commerce, law etc. must undergo a course on data science and analytics customized to their discipline.
- Hardware for creating and processing data is critical to have the edge in this field. For example, all the big companies who are in AI, have large teams devoted to hardware development. One can argue that AI has come to fore because of this. So, funding programs to develop AI processors, sensing interfaces, robotics hardware is the nucleation step. In fact, this R and D will be a great feeder for startups.

Concrete Steps for quick starting AI related Retraining/Reskilling/Research

1. Support AI research which will address Indian challenges as well as make a global impact.
2. Develop global connect. India cannot work in its own silo.
3. Rethink STEM Education ground-up (schools/universities/workplaces) while we train the baseline developer/CS student base to start experimenting with AI/ML
4. Creation of regulatory sandboxes for researchers to experiment with new use cases
5. Incentives to startups with financial provisions and tax incentives
6. Fix National Data Sharing and Accessibility Policy (NDSAP) and data.gov.in to help provide quality public datasets for academics/startups/developers develop solutions
7. Create multi-disciplinary knowledge network
8. Vitalize AI research and applications by providing sufficient funds.

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We place on record our deep sense of appreciation to the 30 participants who responded to our survey.

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Reskilling

The Re-skilling Agenda

The 4th Industrial Revolution is underway. Almost all industries, including the IT industry are being disrupted by new emerging technologies including Artificial Intelligence. On the one hand, automation is making many traditional jobs less labour oriented (reducing the need for manpower). On the other hand technology is creating vast opportunities for new jobs. It is a vital imperative that the workforce in the Industry is Reskilled to prepare them to move from the older roles to take the new jobs that leverage the new technologies.

Recommendations

We recommend 3 key actions to design/deliver the Reskilling Initiative:

1. Reskilling to be linked to industry needs and build on what is already being done. It is crucial that job roles/skills that people are reskilled in are directly in line with the needs of the IT and other industry in the areas of Artificial Intelligence

The Futureskills Platform is an AI enabled aggregator market-place for learning. It enables individuals to learn about new technologies, job roles and skills needed. It further enables them to get daily feeds on any of these technologies and job roles so they can build their concepts, awareness and mindset on what the technology and role is all about and continuously learn about them. Further it includes a marketplace where individuals can choose courses, get assessed and certified. This platform is being sponsored by the industry as a common utility to get employees started on the journey to get reskilled. Recognition of learning completion and competency will be another significance contribution of the FutureSkills platform that will enable a currency for transnational mobility, with heightened relevance in a global gig economy

12 job roles in AI have already been identified by the industry (including AI Business Analyst, AI Data Architect, AI Data Scientist, AI Dev Ops, AI Hardware Integration Engineer, AI Image Research Scientist, AI Information Security Analyst, AI Language Processing Research Scientist, AI Research Scientist, AI Software Engineer (applications/platform); AI Software Engineer (testing) and AI Solution Architect. For each of these roles, skills are being defined and informal / formal learning paths are being developed. Additionally, model curriculum and assessment norms are also being developed. Once this is done, employees and aspirants will have the ability to understand what these roles are; what skills they require and then enrol in training programs that they can choose from a market-place of training providers and undergo training. Additionally, they will be able to take assessments at the end of the training and earn the relevant credentials/certifications to enable them to get the desired jobs.

2. Formal & Non - Formal Academic Contribution Enabling a Future Workforce – Academia can and must play a critical role. There are at least 3 areas where academic contribution is crucial.
 - (i) In partnering with the industry to define job roles of the future, the skills needed for them and the curriculum/assessment.
 - (ii) In the area of content. There is real need for best in class content from India on AI, including concepts, examples, applications and use cases, localised.

(iii) Formal institutions of learning like Universities and colleges and a growing community of training providers presently struggle to address the training needs of a workforce responding to a dynamically changing industry. The third is in driving train-the-trainer programs and in becoming mentors and guides.

Additionally we should consider the following:

- A blended learning ecosystem combining the present instructional design with the offerings like the FutureSkills platform will act as a panacea to the workforce requirements of this industry.
 - Universities/Colleges, NIELIT, C-DAC, COEs, Resource Centers and Training Provider Centers can operate as training, innovation and entrepreneurial hubs, for both the teacher and the taught.
 - MeitY's investment in infrastructure, bandwidth and devices to enable the future workforce via multiple business models, guided by NASSCOM's thought leadership will be a key enabler.
3. Crucial role of MeitY to catalyze and oversee the program and integrate various actors to deliver the aspiration of this country with respect to AI. We would recommend the setting up of an expert committee jointly by MeitY and NASSCOM that oversees this that oversees this. We would recommend the establishment of a Corpus to fund the different activities. An initial amount of Rs 5,000 crores over 5 years for reskilling in the IT industry and other industries wrt AI is recommended. This would enable the skilling of about 2MM people in AI / AI related job roles (if we assume average Rs 25,000 as training and assessment cost / person). We would recommend the establishment of a dedicated team within MeitY and NASSCOM to project manage this initiative.

The Collaboration Imperative

Motivation

The emergence of AI is driven by the confluence of three significant factors:

1. Growth of data,
2. Breakthrough algorithms and techniques to leverage data, and
3. Availability of powerful and scalable computing infrastructure.

With its significant scale, India is a data rich nation and abundant compute now is affordable. The imperative is to harvest this advantage to create breakthrough techniques that lead to:

- 1) Creating value and social impact by addressing nation's largest needs and problems,
- 2) Delivering solutions at unprecedented speed and investment efficiency
- 3) Achieving global leadership in transformation to AI economy.

This requires outcome-oriented mission mode institutional structures and programs. This chapter aims to provide an implementation framework for an outcome-oriented industry led collaborative framework that will position India as a leader in Human-Centric AI, globally.

The first demonstration of applications of AI have happened in the consumer space, the economic value has been created via targeted advertising by internet giants in USA and China. The real power of AI, though, lies in its **transformative potential to address massive societal challenges** that were traditionally considered to be beyond the purview of computing. Consider following examples of challenges facing India :

1. India stands to lose \$4.58 trillion before 2030 due to Non Communicable Diseases and mental health conditions. Cardiovascular diseases, accounting for \$2.17 trillion, and mental health conditions (\$1.03 trillion), will lead the way in economic loss².
2. ~70 percent of its rural households still depend primarily on agriculture for their livelihood with agriculture having a shrinking share in GDP³.
3. One in six teaching positions in government schools is vacant, a collective shortage of a million teachers according to data tabled in the Lok Sabha⁴.
4. As per the GoI report, road accidents in India, in 2016 led to 17 deaths on roads every hour outlining the need for urgent intervention for smarter transportation infrastructure⁵.

Traditionally such problems required build massive hardware infrastructure requiring significant capital expenditure and yet supply perpetually lags demand and vast inefficiencies stay. Most recent research on AI is shining light towards a path to address

²http://www3.weforum.org/docs/WEF_EconomicNonCommunicableDiseasesIndia_Report_2014.pdf

³<http://www.fao.org/india/fao-in-india/india-at-a-glance/en/>

⁴<http://164.100.47.190/loksabhaquestions/annex/10/AS265.pdf>

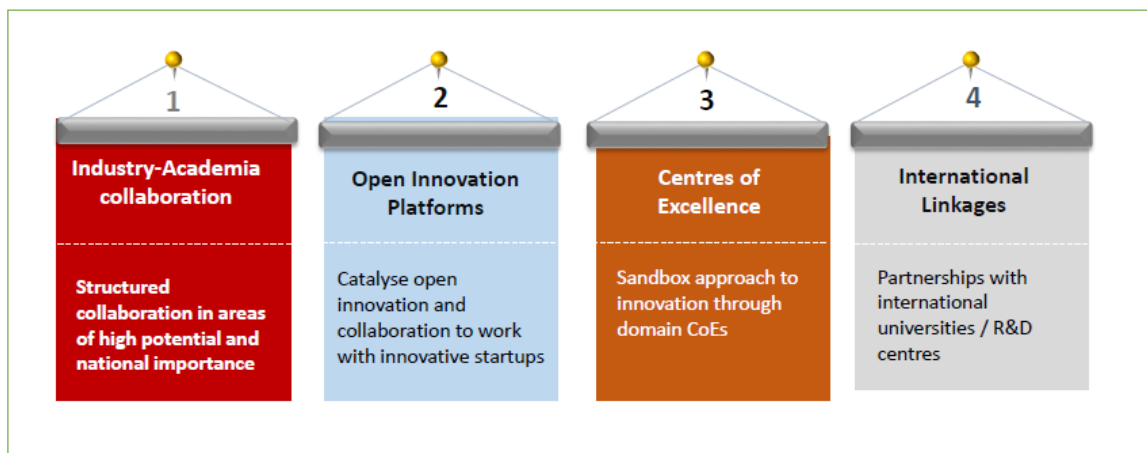
⁵<http://pib.nic.in/newsite/PrintRelease.aspx?relid=170577>

such challenges via AI and computing to enable effective and thereby reduced capital expenditure.

1. Understanding of Non-communicable diseases like depression can be treated via better understanding of brain and mind using AI and computing⁶.
2. Improving agriculture productivity through handling the complexity, uncertainty and fuzziness inherent in this domain and AI is just made to make sense of such problems and enable precise interventions⁷.
3. AI algorithms in collision avoidance systems can give a ~1.5 second advance notice to drivers in a smart city to avoid 93% of road accidents⁸.

AI, therefore, provides a strategic capability to nations and governments that not only address monumental challenges of unprecedented scale but also global leadership opportunity for India in creating human-centric, foundational technologies and digital infrastructure that reimagines implementation and delivery in 21st century.

For an initiative as important and complex as developing and applying Artificial Intelligence to National scale Missions in key social, economic and strategic sectors, it is important that the collective knowledge and power available is tapped. Hence it is critical that we build on the key enablers that would help accelerate innovation in AI and its rapid application on ground to tackle real-world problems. A multi-pronged collaborative framework that includes within its ambit Government, Industry, Academia, Startups and International experts is important to support research in AI technology and AI applications and requisite support to scaling up. We propose a 4-pronged measure, as shown in the figure below, and elaborated subsequently in this regard.



Industry-Academia collaboration

⁶<https://www.nature.com/articles/nn.4499>

⁷<https://link.springer.com/article/10.1007/s13218-013-0275-y>

⁸<https://www.safedrivesystems.com/forward-collision-warning/>

Academia has, and continues to play a fundamental role in artificial intelligence (AI) and machine learning (ML) development. Globally technology companies and academia have built partnerships for innovation in new technology areas. For example, IBM and MIT have created the MIT-IBM Watson AI Lab to carry out fundamental artificial intelligence (AI) research and seek to propel scientific breakthroughs that unlock the potential of AI. In India, there have been partnerships with key institutes in the AI domain. IISc has partnerships with leading companies like Robert Bosch, Faurecia; IIIT Bangalore recently announced partnership with Mphasis to set up centre of Cognitive Computing; IIT Kharagpur has set up AI research center with Capillary Technologies.

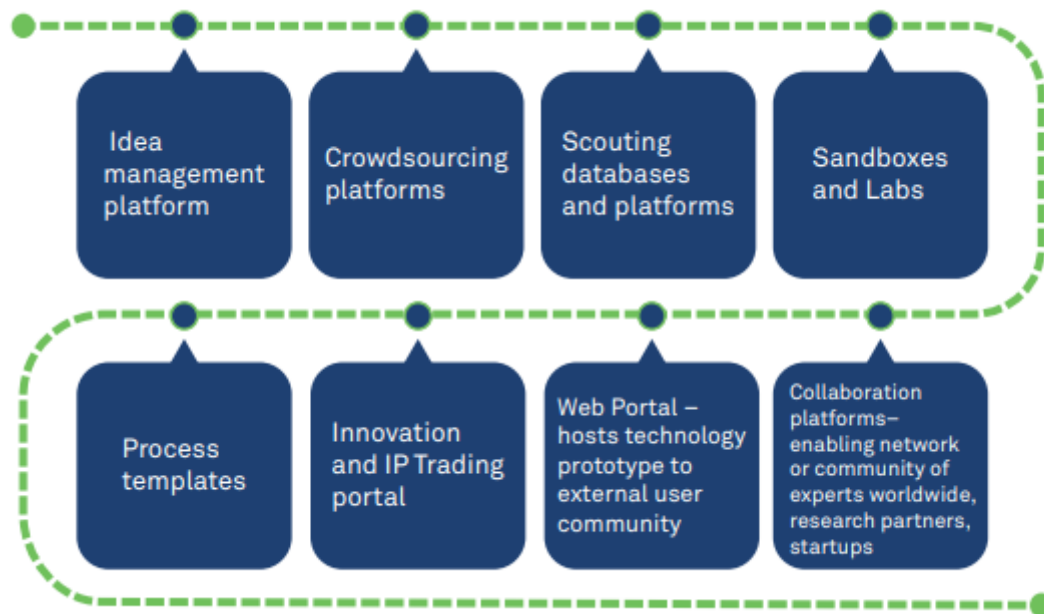
Recommendations for Industry-academic linkages include:

- Technology research centers in universities in partnership with industry to be incentivized through R&D benefits, permit these centers to be set up through CSR grants.
- Creation of industry-academia transfer bureau under Meity, as part of the National Council Secretariat to help in IP creation, patent filing, IP transfer, etc.
- Commercialize research / products build in academia through structured partnerships
- Platform for AI researchers to collaborate, share insights
- Partnerships with best in class global universities

Open Innovation Platforms

Open Innovation can help R&D teams invert innovation processes to speed up R&D cycles in addition to accelerating the pace of innovation. Today, companies are breaking down traditional silos and tapping a much wider ecosystem for new ideas, insights, talent and technology. Open innovation models are finding much broader favor than traditional R&D.

India needs a structured Open Innovation Platform wherein Enterprises, Startups, Accelerators, Government can come together. A structured framework for Open Innovation can include the following components:



Specific recommendations include:

- India.AI Portal to be the one stop platform for discovery of AI startups from India
- AI focused accelerators / incubators through academia and NASSCOM to build enterprise connect
- Identify use cases and joint development programs (POCs) with startups
- Collaboration with international and Indian academia, startups, enterprise to build transformative AI applications.
- Scan international use cases and solutions to see which are applicable to India and its problems, and how those solutions can be brought to India for implementation
- Grand Challenges

They focus on development mobilize governments, companies, startups and NGOs around important issues. They source new solutions, test new ideas, and scale what works.

These challenges to be effective will need a close partnership between the Ministry of Electronics and IT, Domain ministry (eg; Agriculture) and States. As these challenges are rolled out, it is equally important to build frameworks on how these solutions will be deployed as pilots and based on the results adopted at scale. These challenges should be open to global startups, global academia in addition to Indian enterprise, students, academia and startups.

- Fund of funds

It is recommended that MeitY setup a Fund of funds of Rs. 2000 Crore, which will specifically invest in Venture funds/Private Equity funds that have a mandate to further invest in startups pursuing research or applications in AI.

The criteria of investment in the Venture/PE funds will be the following:

- The fund will be managed by experienced professionals with at least 5 years track record of investing in Indian technology startups

The criteria for investment into a startup should be the following:

- It should be developing an innovative product for commercialization,

- More weightage for entrepreneurs working on India specific problems

Centres of Excellence (CoE)

We introduced COE in the Section on International Scenario and National Strategy. For building multi-disciplinary capabilities, Centres of Excellence (CoE) can play a key role as an innovation accelerator to bring together the academia, innovators, industries, government in few chosen areas. The CoEs can be

- Testbed for Democratized Product Development
- Facilitate Datasets
- Facilitate a Lab to market collaborate platform

CoEs are recommended in partnership with academia, R&D organizations, and industry, and can be driven by either of them. These CoE can leverage the sandbox approach (see next section) for innovation, build use cases and enable co-creation and PoCs.

Along with the other directions, building a repository of use cases is an important imperative to demonstrate innovation and the impact it is creating. The CoEs must enable use case creation, wherein a consortium of industry experts and academicians can research the AI innovation, approach adopted, implementation process and impact created. A broad framework for the CoEs can include:

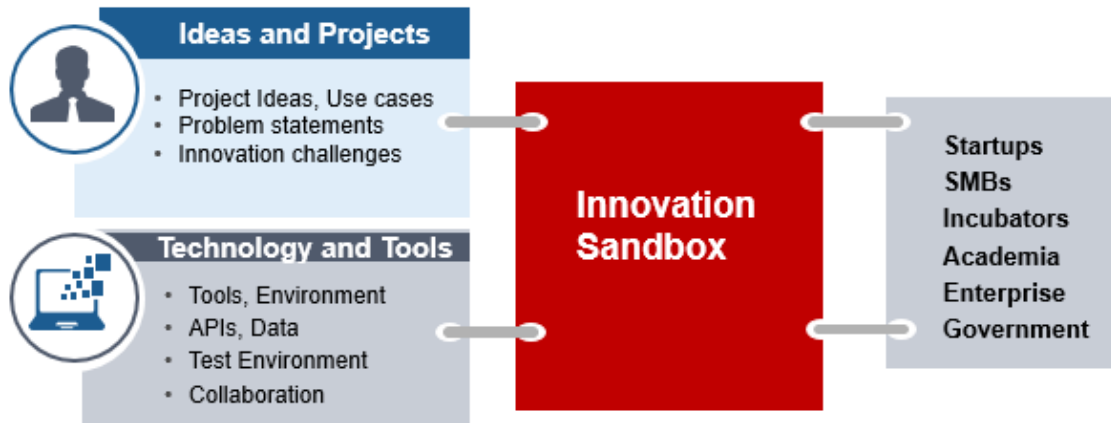


Sandbox approach to AI Innovation

We recommend an Innovation Sandbox approach for solution development wherein startups, enterprise, academia could all collaborate in building new concepts and solutions. Businesses can test innovative products, services, business models and delivery mechanisms without immediately incurring all the normal regulatory and financial consequences of engaging in the activity in question.

One possible Sandbox approach is to setup a secure digital environment, with private logins to Industry and Government participants, and where each participant can load and test their own data. For example, the agriculture department of a state government can load their own data on the sandbox, and hire an agency to run various tests to utilize the unstructured data for various practical applications. Once the sandbox experiment is successful, that agency can take that solution and apply it to real life scenarios in the field.

To catalyze AI innovation at the grassroots, it is recommended that: the government can identify a few key sectors and build innovation sandboxes in partnership with industry and academia.



International Linkages

There are three recommendations for collaborations with the international ecosystems

- Solving problem statements – Invite applications from associations and industry to identify India specific problem statements in sectors such as agriculture, environment, traffic, digital payments, etc. The association then sets up a collaborative team between Indian academia and organizations such as Carnegie Mellon/Stanford/German Research Center/Tel Aviv University. The foreign partner brings their research and development capability, the Indian academia brings their knowledge of the problem statements and the association brings their expertise in managing funding and interfacing with stakeholders. The team then works together to specify what will it take to solve the deep problem, and then move forward towards the solution stage.
- International AI fellow program --- Give incentives for Indian Industry/associations/academia to bring global Indian AI talent to India on 3 year assignments to work on specific problems for India. In the first year 10 fellows could be recruited, and the Central Government could fund the compensation to the tune of 50%, including salary, perks, office, travel, etc. capped at \$100,000 per year. This will amount to \$1 Million for the first year, and if successful, this program could be expanded
- India AI Startup program – Give incentives for Indian incubators to bring global AI startups to India to run PoCs for a period of 1 year. The incentive could be a grant to the tune of \$250,000 payable monthly, with the criteria that the startup has to setup an Indian office, with an International AI fellow on their board for that 1 year. The startups could access data from the Government and work on other collaborative programs proposed by the Government.

Suggested framework and institutional structure for POCs

Given the esoteric nature of the technology and associated skepticism and apprehensions of various domain owners and managers, it is important to demonstrate on ground through POCs the value that AI-based solutions can bring in order to build the requisite level of confidence for scaling up. These POCs should solve carefully identified problems. In most cases, the problem statement as indicated by domain ministries may require considerable elaboration or modification before devising a solution. The solutions so created should pass through several filters including:

- i. be sustainable in existing field conditions of infrastructure, literacy/knowledge of users, working conditions of professionals in the domain
- ii. be transformational for the domain
- iii. be scalable either on a commercial basis or by incorporation into ongoing Government programs to deliver measurable step change in outcomes
- iv. be affordable in Indian context to mass users
- v. be able to deliver tangible outcomes which are indicative of the eventual promise within a time frame of 6-12 months

Creating a POC on the ground would require collaboration between government and solution providers and tested with real-life users. For social and economic sectors like healthcare and agriculture, for example, which are state subjects in the constitution, involvement of state governments is essential. This could be accelerated under a GOI mandated framework that enables a few enterprising states to sponsor and support POCs. The framework should enable rapid deployment of POCs without getting bogged down by the intricacies of a bid process (difficult for an unspecified solution to a problem which itself may undergo changes during the POC) or the burden of regulatory constraints (which cannot be resolved unless it is clear what changes are needed which in turn depend on the success of the POC). Regulatory enablement, discussed in the next chapter, should draw from successful POCs and shape regulation to enable affordable solutions at scale that leverage India's reputation for frugal innovation, but using the latest advances in technology.

Involvement of state and central government is particularly important in social sectors not only because of the overwhelming role that government plays in these sectors, but also because to deliver impact at scale requires thinking and strategy at an eco-system level while most entrepreneurs invent point solutions which may not work in isolation, unless supported by other elements of the eco-system. Hence a supportive, if not participative, approach of government is essential.

Keeping these aspects in mind, it is recommended that in each of the key sectors identified for application of AI, Niti Aayog and Meity should assist the line ministry to identify a few key challenges warranting AI-based solutions and 3-5 states on a competitive basis in consultation with volunteer solution providers and initiate POCs. A high-level committee anchored in Niti Aayog and supported by Meity could drive this process with a mandate to deliver 3-5 POCs in each identified problem within each Mission within the next 12 months.

Funding could be provided for such POCs to cover government institution costs and support to startups selected on a T1 basis (1-2 could be identified for each POC). Large companies,

both service providers and technology providers, could be asked to meet their own costs at the POC stage. This will eliminate the need for a bid process at the POC stage. Scaling up, if funded by the Government, could be through a bid process, based on POC outcomes.

Taking healthcare as an example, an approach to zeroing in on a suitable problem statement for which a solution that meets the criteria indicated above can be evolved in the POC is at Annexure 4. (Contributed by BCG)

Portal to enable collaborative frameworks

Bringing about impact at scale requires collaboration across multiple entities. Once the goal and the key ingredients to accomplish it are known, the first imperative is to know who the potential partners or collaborators can be. Indeed, in many cases, collaboration is needed to identify a precise, ambitious but achievable goal in a defined time -frame. Hence a key enabler for collaboration is a portal that acts as a repository of available competencies in the country and a platform that enables them to come together for a common purpose. Hence a key recommendation is to establish a National Portal on AI as has been done in a few countries. Annexure 3 provides details of a framework and roadmap for such a unified “by India, for India” portal that will be a one stop destination for everything AI in India and a key enabler of collaborations needed for success. Government could own and fund it and industry could establish and maintain it. A suitable budgetary allocation of at least Rs. 10 Cr. may be set aside for this purpose.

Interdependencies on recommendations of other committees

Given the common Terms of Reference for the four committees on AI set up by Meity, obviously, there would be interdependencies between the recommendations of each of the committees with those of the others.

As far as this committee is concerned, we have the following observations. A recurring theme in this report is the importance of data for AI and the need to have suitable regulations that protect privacy but make data available for developing and using AI. While some recommendations have been made in this report, we presume that these aspects both ensuring availability and protecting individual rights, will be fully covered by Committee A. The emphasis in this report has been on adoption of AI and implementation of solutions at scale to deliver transformative impact. This clearly implies carefully selected projects to create that impact. We have not delved too deeply into what those missions should be, or their detailed scoping or the precise problem statement that resonates with both domain owners and solutions providers. This is harder than it might appear at first glance, but we assume that Committee B on National Missions in AI would address the selection and attendant aspects like culling out a few problem statements in each identified field which are amenable to scalable, affordable and transformative solutions using AI.

Lastly, data usage and possible algorithm biases point to the need for ethical norms, adequate care of security and legal issues. We presume that these would be fully covered by the Report of Committee D.

We are confident that an aggregation of these four committee reports would set a meaningful and an ambitious but achievable agenda for the country in development and use of AI. We are sure Meity would take care of overlaps and possible inconsistencies across committees.

Policy and Regulation: Enabling, Debottlenecking and Supporting Collaboration

AI Policy Considerations

The main drivers of public policy towards AI should be solving large societal problems and fostering economic progress. Accordingly, public policy must support industry efforts to bring AI benefits to the economy, to address citizens' concerns and to identify needs for regulatory intervention.

As AI innovation is just beginning, it is crucial now to shape the public policy environment. Oversight by regulators will be essential for society to *trust* AI. Public policy should lower or remove any barriers standing between AI and its enormous potential to benefit our lives, while safeguarding citizen's rights.

Algorithms, hardware, software, and data are integral part of AI and any governance mechanisms for AI and autonomous systems should minimize the risks while harnessing its full potential. Improper and premature regulations can stifle the Industry at its inception. A desirable governance system should be flexible and also capable of accommodating regional priorities and national legal systems.

We suggest the following AI public policy principles, and specific recommendations under each for government consideration:

- Fostering Innovation
- Encouraging Human Employment and Protecting People's Welfare
- Liberating Data Responsibly
- Protecting Privacy and Security
- Requiring Accountability and Discouraging Discrimination

These are discussed below in some detail.

Fostering Innovation

The potential of AI is enormous⁹. AI can enhance human capabilities, automate tedious or dangerous tasks, unleash scientific discovery and alleviate challenging societal problems. Doctors will be able to diagnose conditions earlier and more accurately, leading to quicker treatments and lives saved¹⁰. Automated vehicles will result in safer driving, more efficiency and productivity. Farmers will increase crop yield based on real-time insights from weather and soil data, producing higher yields and more stable food supply even in unpredictable climates.

Realizing the potential of AI requires advances in core AI technologies. Governments must play a significant role promoting those advances. Government investment in AI, public-private collaborations and measures to incentivize adoption by society are public policy

⁹ The global AI and robotics market is estimated to grow to \$153 billion by 2020 (Robot revolution – Global robot and AI primer, Bank of America Merrill Lynch, Dec 2015.)

¹⁰ The market for AI system in healthcare is estimated to grow from \$633 million in 2014 to \$6 billion in 2021 (From \$600 M to \$6 billion, AI systems poised for dramatic market expansion in healthcare, Frost & Sullivan, Jan 2016)

actions that will enable AI to develop and mature.

Equally, governments should gain expertise in AI in order to make effective public policy, to benefit from efficiency gains and to champion AI adoption. Moreover, a new generation of AI specialists and data scientists should be on the radar of schools and universities when preparing new curricula.

Fostering Innovation

Recommendations:

- **Fuel AI innovation:** public policy should promote investment, make available funds for R&D and address barriers to AI development and adoption.
- **Address global societal challenges:** AI-powered flagship initiatives should be funded to find solutions to the world's greatest challenges such as curing cancer, ensuring food security, controlling climate change, and achieving inclusive economic growth.
- **Allow for experimentation:** Governments should create the conditions necessary for the controlled testing and experimentation of AI in the real world, such as designating self-driving test sites in cities.
- **Prepare a workforce for AI:** Governments should create incentives for students to pursue courses of study that will allow them to create the next generation of AI.
- **Lead by example:** governments should lead the way in demonstrating the applications of AI in its interactions with citizens and invest sufficiently in infrastructure to support and deliver AI –based services.

Encouraging Employment and Protecting People's Welfare

Productive work is a fundamental component of individual well-being and high functioning societies. In the same way that AI needs to be designed to function properly, so should society be prepared to leverage AI's benefits while mitigating its impact on the workforce. While AI has the potential to improve many aspects of our lives and to spur economic growth, AI and robotics will bring automation to broad categories of jobs (e.g. fully autonomous vehicles will reduce the need for trucking and taxi drivers). Concurrently, new tasks and jobs will be created requiring entirely different sets of skills. Governments need to understand how AI will impact employment and have a plan to encourage employment in ways that allow technology to assist humans in the pursuit of their work.

From more timely, more accurate medical diagnostics to intelligent, safer transportation, AI will affect all facets of the economy, including the public sector. The economic benefits of AI should be inclusive, accessible and broadly shared by society. Public policies must be

enabled to mitigate inequalities, protect citizens' welfare and help with the transition to a more data-driven economy.

Encouraging Employment and Protecting People's Welfare

Recommendations

- **Retraining:** governments should implement policies that support the up-skilling and the re-skilling of the workforce, particularly in job areas that are less likely to be automated, such as positions focused on person to person interaction.

Liberating Data Responsibly

Most of the AI systems cannot function without data. Machine learning based algorithms are trained with existing data and those data relate to specific usage domains. For instance, if AI is to be used to fight cancer, then data from medical records, genomic information, state of the art treatments and many other domains should be made available. Of particular interest are solutions that allow for the federated access to data from distributed repositories held in different sites, while preserving privacy and security.

Governments are also solicitors, creators and repositories of data. As long as no personal or sensitive information is involved, many of these datasets should be made available for public use. If personal or sensitive information is a requirement to solve critical societal problems (making breakthroughs in personalized medicine), government should partner with the industry and/or Academia, make the required data available to find solutions to using AI with due concern to privacy protections. Anonymization, for example enables sensitive data to be shared without violating privacy. Another example of such protections is the use of AI algorithms that analyze data in several encrypted yet separate datasets, but never require sharing the data outside the encrypted area. As explained before, AI requires data to function and public sector data is a valuable source of information to develop AI solutions to societal challenges.

Liberating Data Responsibly

Recommendations:

- **Keep data moving:** governments should eliminate unwarranted data localization mandates and enable international data transfers through international agreements and legal tools.
- **Open public data:** governments should make useful datasets publicly available when appropriate and provide guidance to startups and small and medium businesses for its reuse.
- **Federate access to data**¹¹: governments should partner with industry to promote AI tools to access protected data for analysis, while not requiring transfer of the data.

Protecting Privacy and Security

Where the data used for AI originates from identifiable individuals, appropriate protections should be implemented to ensure that data is lawfully accessed, processed and kept safe. Robust privacy regulatory frameworks for the protection of personal data and cybersecurity should also apply to AI implementations. Promote technology neutral comprehensive privacy laws based on the Organization for Economic Cooperation and Development's Fair Information Practice Principles (the FIPPs), which are the global common language of privacy.

Promote and support privacy by design¹². FIPPs can be implemented during privacy by design processes to better protect individuals.

Questions may arise regarding the enforceability of privacy protections when a machine uses data autonomously. In these circumstances, accounting for privacy principles when designing technology will help protect individuals.

"Security Safeguards" is one of the FIPPs and it is particularly critical to protect the trustworthiness of AI implementations. AI can be used to foster both privacy and security by predicting the spread of cybersecurity attacks and helping organizations protect their data and AI algorithms/models. A critical component of allowing AI to better protect privacy and security will be the use of cybersecurity data to better predict future attacks. As the compute power of the data center is distributed across the entire network the potential for AI to stop cyber-attacks before they do significant harm will be greatly increased. This is one of many reasons why governments should promote the use and sharing of data for cybersecurity purposes.

¹¹ Instead of centralizing data from several institutions, a federated access to data allows each institution to keep control of their data while enabling joint data analytics across all institutions.

¹² *Privacy by Design* refers to the philosophy and approach of embedding privacy into the design specifications of various technologies.

Promoting Privacy and Security

Recommendations:

- **Adopt/design Robust Privacy Laws:** which should be based on the OECD Fair Information Practice Principles.
- **Implement Privacy by Design:** Implement privacy by design into AI product and project development.
- **Keep data secure:** policies should help enable cutting-edge AI technology with robust cyber and physical security to mitigate risks of attacks and promote trust from society.

Requiring Accountability and Discouraging Discrimination

Trust in AI requires organizations to demonstrate to the public and government regulating bodies that the technology is designed, implemented and operated responsibly.

The Information Accountability Foundation (IAF)¹³ has spent considerable time articulating the essential elements of what is required to demonstrate the responsible handling of information. The IAF's 5 principles are:

1. Organization commitment to accountability and adoption of internal policies consistent with external criteria.
2. Mechanisms to put privacy policies into effect, including tools, training and education.
3. Systems for internal ongoing oversight and assurance reviews and external verification.
4. Transparency and mechanisms for individual participation.
5. Means for remediation and external enforcement.

With only small adjustments (amending the word "privacy" in the second principle to cover broader categories of automated decision making), this work can and should apply more broadly to AI. Organizations which develop and implement AI solutions will benefit from working through the principles as the resulting policies, processes and resources put in place will demonstrate responsible behavior to both regulators and individuals who are impacted by AI solutions.

Applying the principles to AI requires new thinking. As an example, transparency may be more difficult for AI than with traditional data processing. Some algorithms use hundreds of millions of adjustable parameters to function and may be continually updated based upon real-time data. In some cases this makes it impossible to deconstruct how a particular result was produced by the algorithm to accurately trace back a cause. In other words, it may be impossible to understand how a result is achieved, consequently making AI less accountable to the user. However, there is ongoing research to derive rules from deep neural networks, and these algorithms are being used successfully, for example for sensorial

¹³<http://informationaccountability.org/>

recognition (like image recognition and natural language speech interfaces) and fraud detection by financial institutions.

Ensuring fairness of AI results depend on how the algorithms were developed and in the case of AI-based machine learning, also on the data that was utilized for their training. Noting that AI algorithms have the potential to make less biased decisions than people, there is still a risk for unintended bias, and therefore unintended discrimination of individuals. This may happen, for example, when the data used to train the algorithm was not representative of the problem space in question. One example of this situation could be when the training datasets were not free from bias themselves. Means to mitigate bias include using algorithms and data models that account for bias, well-curated training sets, extensive verification and validation of AI systems and being alert to possible ethical or fairness implications from AI based decisions. Government and the private sector should continue to work together to study and develop solutions to regulate discrimination caused by AI implementations.

Requiring Accountability and Discouraging Discrimination

Recommendations:

- **Standing for “Accountable Artificial Intelligence”:** governments, industry and academia should apply the Information Accountability Foundation’s principles to AI. Organizations implementing AI solutions should be able to demonstrate to regulators that they have the right processes, policies and resources in place to meet those principles.
- **Transparent decisions:** governments should determine which AI implementations require algorithm explainability to mitigate discrimination and harm to individuals.

Summary of recommendations

Fostering innovation

- **Fuel AI innovation:** public policy should promote investment, make available funds for R&D and address barriers to AI development and adoption.
- **Address global societal challenges:** AI-powered flagship initiatives should be funded to find solutions to the world’s greatest challenges such as curing cancer, ensuring food security, controlling climate change, and achieving inclusive economic growth.

- **Allow for experimentation:** governments should create the conditions necessary for the controlled testing and experimentation of AI in the real world, such as designating self-driving test sites in cities.
- **Prepare a workforce for AI:** governments should create incentives for students to pursue courses of study that will allow them to create the next generation of AI.
- **Lead by example:** governments should lead the way on demonstrating the applications of AI in its interactions with citizens and invest sufficiently in infrastructure to support and deliver AI –based services.
- **Partnering for AI:** governments should partner with industry, academia and other stakeholders for the promotion of AI and debate ways to maximize its benefits for the economy.

Encouraging Employment and Protecting People’s Welfare

- **Encouraging human employment:** governments should implement programs to mitigate AI’s impact on jobs and devise policies that promote employment. These programs should particularly focus on the effectiveness of incentives in government funded infrastructure projects.
- **Retraining:** governments should implement policies that support the up-skilling and the re-skilling of the workforce, particularly in job areas that are less likely to be automated, such as positions focused on person to person interaction.

Liberating Data Responsibly

- **Keep data moving:** governments should eliminate unwarranted data localization mandates and enable international data transfers through international agreements and legal tools.
- **Open public data:** governments should make useful datasets publicly available when appropriate and provide guidance to startups and small and medium businesses for its reuse.
- **Federate access to data¹⁴:** governments should partner with industry to promote AI tools to access encrypted data for analysis, while not requiring transfer of the data.

Promoting Privacy and Security

- **Adopt robust privacy laws:** which should be based on the OECD Fair Information Practice Principles.
- **Implement privacy by design:** Implement privacy by design into AI product and project development.
- **Keep data secure:** policies should help enable cutting-edge AI technology with robust cyber and physical security to mitigate risks of attacks and promote trust from society.
- **It takes data for AI to protect data:** governments should adopt policies to reduce barriers to the sharing of data for cybersecurity purposes.

Requiring Accountability and Discouraging Discrimination

- **Standing for “Accountable Artificial Intelligence”:** governments, industry and academia should apply the Information Accountability Foundation’s principles to AI. Organizations implementing AI solutions should be able to demonstrate to regulators

that they have the right processes, policies and resources in place to meet those principles.

- **Transparent decisions:** governments should determine which AI implementations require algorithm explainability to mitigate discrimination and harm to individuals.

Model for AI policy

There have been discussions on a layered Model for AI regulations¹⁵. For India, a similar approach could be adopted wherein, Short term, Mid-term and Long term focus for regulations may be identified and worked upon.

- Short term
 - Technology issues – related to credible data availability, data governance, algorithm accountability, transparency and standards as the foundation. (to be in synch with committee 1 on data related issues)
 - Ecosystem issues - enabling policies for development, trials and piloting of AI solutions – new or by removing hindrances and bottle necks.
- Mid-term focus on Ethical issues, which will require deliberations, involvement in global discussions and studying impact– define principles and criteria for ethical outcome. Emergence of AI ethics norms in the IEEE general principles for AI and autonomous systems¹⁶ could be a starting point. Actions driven by algorithms can be assessed according to ethical criteria and principles. Much of the experience in the development and deployment phase maybe leveraged (Committee 4)
- Long term focus on Social and legal issues as an outcome of the above. This will lead to creating institutions with allocated responsibilities for regulating AI and autonomous systems basis norms, regulation and legislations. (handled by committee 4)

Public policy and regulatory framework can be considered in three parts:

- i. Regulations to control use and deployment of AI
- ii. Enabling policies and regulations
- iii. Debottlenecking constraints due to legacy regulations

Usage of AI at scale is in its infancy in the country. Consequently, it is recommended that our initial focus should be on enablement rather than control. It is recommended that we adopt light touch regulation and desist from introducing any regulations designed to control usage and deployment of AI at this stage with the exception of regulatory control of data usage. Regulations governing the storage and use of data are already on the anvil and should encompass usage for developing AI capabilities. It is important that the controls should not be so stringent as to prevent or severely constrain development or deployment of AI, which is heavily dependent on access to properly annotated clean data sets. As recommended in an earlier chapter, a massive effort needs to be mounted to clean and annotate existing data especially that relating to identified Mission projects. In fact, a critical enabling regulation is to ensure that new data getting created should support further development of AI.

Technology issues

¹⁴ Instead of centralizing data from several institutions, a federated access to data allows each institution to keep control of their data while enabling joint data analytics across all institutions.

¹⁵ A Layered Model for AI Governance, Urs Gasser and Virgilio A.F. Almeida, Harvard University, IEEE INTERNET COMPUTING

¹⁶ http://standards.ieee.org/develop/indconn/ec/ead_v1.pdf

Availability of Credible data will depend on data capture and quality management, data discovery and exploration and data security and governance.

- The framework being developed by the data protection committee will be critical, and we recommend that data sharing and data flows should not be restricted as a principle, unless there are National security concerns that cannot be addressed in any other manner
- Standards based approach developed primarily by technologists – e.g. Initiation of IEEE P7003™¹⁷, that defines specific methodologies and processes to help certify the elimination of negative bias in the creation of algorithm will lead to a standards driven approach that may be adopted as development and trials are undertaken. This standard when adopted is expected to allow algorithm creators to communicate to regulatory authorities and users that the most up-to-date best practices are used in the design, testing and evaluation of algorithms in order to avoid unjustified differential impact on users. Similar standards for accuracy, auditability, etc. will have to be developed.

Ecosystem Issues

AI has the potential for cross sectoral impact and sector regulations can have a big impact. The report of the DIPP task force on AI had identified 10 sectors for focus.

Manufacturing	Agriculture	Fintech	Healthcare	Education
Retail	Environment	National Security	Persons with Disabilities	Public Utilities

Committee B is recommending various Missions for AI usage as well.

For adoption

Special framework for trials and piloting of solutions need to be developed. Departments may have special teams focusing on new technologies for trials and adoption. The framework should allow for

- Allocations for trials of multiple solutions
- Acceptance of failure as a possible outcome
- Sandbox wherever required including access to data, with adequate safeguards
- Adequate funding

Regulations

Development and adoption of AI and autonomous systems will require special effort to identify and remove existing hurdles.

- Drones
 - R&D trials of drones being developed also requires full permission and onerous approvals. This can potentially jeopardise R&D efforts in the country
 - Even from a deployment perspective - Drones used in agriculture to monitor crop health and take necessary corrective action needed to be enabled through regulations. Proposed regulations are onerous.
- Healthcare¹⁸

¹⁷ http://standards.ieee.org/news/2017/ieee_p7003.html

¹⁸ https://www.healthcapital.com/hcc/newsletter/05_17/PDF/AI.pdf

- In July 2016, the U.S. FDA issued guidelines meant to encourage entrepreneurs to develop devices that rely on advances in AI and machine learning. India will need similar guidance that pertain to data, applicable approvals required for risk based devices
- Use of evidence derived from aggregation and analysis of real-world data elements
- Liability need to be clarified and safe harbours should be provided for intermediaries. E.g. As Ai participates in the diagnosis / surgical process Future regulations will likely be forced to include language related to liability regarding AI systems
- Regulations for trials of autonomous vehicles maybe clarified
- Digital maps
 - Key to location based Autonomous mobility. The map policy in India has to bring in greater clarity
- Sandbox for fintech solutions ^{19,20}

Many of the Missions and Use Cases of AI would require regulatory support. For example, use of AI-based decision support systems in healthcare would need to be permitted and responsibilities delineated consistent with the principles enshrined in the IT Act, 2008 regarding limitation on liability of intermediaries. Adherence to EHR standards would need to be enforced and rules framed regarding ownership and control of personal medical data. A patient should have the right to demand sharing of data by one healthcare provider with another when needed and default should be punishable. These are mere examples and the report of this committee cannot possibly include recommendations for different sectors/ domains. Instead, what is recommended is that under each of the Missions undertaken (being recommended by Committee B) for AI adoption and implementation, a specific outcome of a successful POC should be regulatory enablement and debottlenecking required.

Similarly, development of security solutions using AI may need to probe existing websites, but this would be illegal even if no harm is intended or caused and even if the owner is party to the development. These examples serve to indicate the kind of regulatory facilitation or uncllogging required.

In Conclusion

The overall approach to Policy, Regulation and collaborative frameworks at this stage should be to

- i. Make public data available for AI with clear and transparent controls
- ii. Enable, rather than constrain, usage through supportive policies and regulations
- iii. Remove bottlenecks arising from legacy regulations that curb adoption of AI. This will need to be systematically examined sector-wise, particularly in the context of the proposed National Missions
- iv. Enable collaboration by encouraging POCs implemented with voluntary contribution by large technology companies and support them with Government counterpart funding especially in social sectors, agriculture, financial inclusion etc. The need is

¹⁹ https://www.jef.or.jp/journal/pdf/214th_Cover_04.pdf

²⁰ <https://gomedici.com/international-fintech-regulatory-sandboxes-launched-by-forward-thinking-financial-authorities/>

to fast track such collaborative experimentation and then enable scaling of successful POCs via market forces or bid process as appropriate.

Annexure 1: AI Strategy in other countries

Global examples of AI Strategy with focus on research and collaboration

Canada	<ul style="list-style-type: none"> • Increase the number of outstanding artificial intelligence researchers and skilled graduates in Canada • Establish interconnected nodes of scientific excellence in Canada's three major centers for artificial intelligence in Edmonton, Montreal, and Toronto • Support a national research community on artificial intelligence
China	Integrated plan that supports promote AI startups, academic research, and moonshot projects. Plan includes incentives for overseas Chinese and global talents to conduct research and found start-up companies in China, promote international exchange and collaboration in research, technology, standards, development, intellectual property rights, and testing certifications; Encourage Chinese companies to expand abroad; Encourage industry associations to set up platforms for international exchange and collaboration
Germany	German Research Center for Artificial Intelligence -Based on application oriented basic research, the center develops product functions, prototypes and patentable solutions. Funding is received from government agencies and industry partners
Japan	Priority areas for R&D that include productivity, mobility, and health, medical care, and mobility. Collaboration between industry, government, and academia to advance AI research
Singapore	AI Singapore brings together all Singapore-based research institutions and the vibrant ecosystem of AI start-ups and companies developing AI products and driven by a government-wide partnership. AI Singapore nurtures a local community of doers and thinkers in AI through a 'makerspace' environment with shared resources and facilities designed to maximise community interaction, collaboration, and encourage adoption of intellectual property generated by AI Singapore.
UK	<u>UK Digital Strategy</u> includes <u>£17.3 million</u> (US \$22.3 million) in funding for UK universities to develop AI technologies
USA	<p><u>National Artificial Intelligence Research and Development Strategic Plan</u> to help guide AI R&D efforts, including</p> <ul style="list-style-type: none"> - develop effective methods for human-AI collaboration, - develop shared public datasets and environments for AI training and testing - Better understand the national AI R&D workforce needs.

DRAFT

Annexure 2: National AI strategies of some countries

The seven most significant national AI strategies from other countries are summarized below:

Country	Key Focus	Strategic Recommendations/Actions
France (Mar 2017)	<ul style="list-style-type: none"> Establish France as a leading technology centre, stimulate its economy, and keep pace with the tech powerhouses of the US and China. Grass-roots stimulation of the French economy. Double the people studying AI in France 	<ol style="list-style-type: none"> Government to invest \$1.85B in AI research in the period through to 2022. The French Institute for Research in Computer Science and Automation (INRIA) to create a national AI research program with five industrial partners. For education, training, research, and the creation of start-ups, streamline things, build adaptable systems, adapted financing & adapted regulations. Build champions and attract existing champions
UK (Oct 2017)	<ul style="list-style-type: none"> Make UK the best place in the world for businesses developing and deploying AI to start, grow and thrive, to realise all the benefits the technology offers. AI Council to manage inter-sector initiatives and training. Public sector systems to be threaded with new AI algorithms. 	<ol style="list-style-type: none"> \$700M funding support package for tech, including for 5G infrastructure and driverless cars in 2017 Budget. Establishment of 'data trusts' to secure and simplify access to public and private agencies. Alan Turing Institute chartered as national institute for data science. Tax breaks and support for inward investment.
UAE (Oct 2017)	<ul style="list-style-type: none"> Usher in a "next generation of government", make the country the "best in the world" by 2071. "invent future opportunities", and compete with global elites 	<ol style="list-style-type: none"> AI Council to run "workshops, programs, initiatives and field visits"; skills and training is a priority. Strategy covers transport, health, space, energy, water, and education.
China	<ul style="list-style-type: none"> Lead the world in AI Application, Research and Innovation. 	<ol style="list-style-type: none"> Execute per schedule for progress with next-generation AI technologies, including big data intelligence, swarm intelligence and autonomous intelligence systems.

<p>(July 2017)</p>	<ul style="list-style-type: none"> • Achieve “iconic advances” in products, software & services by 2020. • Establish AI as the driving force for China’s industrial and economic transformation. • By 2030, make China the default leader for AI theories, technologies, and applications, and the world’s primary AI innovation centre. 	<ol style="list-style-type: none"> I. “vigorously use governmental and social capital” to implement its major AI programmes. II. Ensure multiple-channel financial input by government and markets.
<p>Canada (Mar 2017)</p>	<ul style="list-style-type: none"> • Establish an international profile and ‘thought leadership’ position on the economic, ethical, policy and legal implications of AI. • Drive a conveyor of graduates, excellence in industry and growth in the economy 	<ol style="list-style-type: none"> I. Canadian Institute for Advanced Research (CIFAR) to build and execute National AI Strategy. II. AI Council to manage inter-sector initiatives and training. III. Public sector systems to be threaded with new AI algorithms. IV. With \$125M Funding, 3 Institutes - Amii, the Vector Institute and MILA; chartered to establish leadership in Deep Learning & Reinforcement Learning and to work with researchers, industry and other stakeholders across Canada to spearhead the strategy along with CIFAR.
<p>Japan (Oct 2017)</p>	<ul style="list-style-type: none"> • Execute on roadmap oriented towards industrialization based on Data sciences, AI and robotics. • 3 priority areas - Productivity, Welfare, Mobility and 4th, Information Security as cross over across. 	<ol style="list-style-type: none"> I. Strategic council for AI technology’ as a ‘control tower’ to promote R&D and manage key academic institutions, including NEDO, ICT (NICT) and science and tech (JST) agencies. II. National industrialization roadmap to follow: <ul style="list-style-type: none"> • Phase1 - “utilization & application” of AI. From now to 2020 • Phase 2 - public usage of AI. From 2025-2030. • Phase3; “ecosystem built by connecting multiplying domains” in the period there after.

<p>USA (Oct 2016)</p>	<ul style="list-style-type: none"> • Establish undisputed Leadership in AI & maximize economy benefits. • Prepare for the Future of AI. • AI, Automation and Economy Policy focus to invest in maximizing AI benefits while educating and training workforce for new jobs along with aiding for workers in the transition. • Establish coordinated AI R&D efforts across Federal Government to maximize R&D Impact and capitalize on full potential of AI to strengthen economy and better society. 	<p>I. Big Data innovation ecosystem to enable ability to analyze, extract information from, and make decisions and discoveries based upon large, diverse, and realtime datasets for Federal agencies and the Nation, accelerates scientific discovery and innovation.</p> <p>II. Prepare for the future of AI factoring:</p> <ul style="list-style-type: none"> - AI for Public Good - AI & Regulation - Monitoring AI progress - Development and training of New AI Workforce - Assess AI impact on Jobs - Ensuring Fair, Accountable and Safe AI - Prepare for Global considerations of AI <ul style="list-style-type: none"> - impact across sectors plus special considerations on Cyber Security and National Defense. <p>III. Artificial Intelligence, Automation, and the economy, Policy focus:</p> <ul style="list-style-type: none"> - Invest in and develop AI for its many benefits. - Educate and train Americans for jobs of the future. - Aid workers in the transition and empower workers to ensure broadly shared growth. <p>IV. AI R&D Strategic Plan Focus:</p> <ul style="list-style-type: none"> - Framework to identify S&T needs in AI, track progress and maximize impact of R&D Investments to fill those needs. - Establish priorities for Federally Funded R&D in AI, looking beyond near-term AI capabilities towards establishing long term transformational impacts of AI on society and the world.
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It is evident that National governments across the world and the private sector are making large investments in artificial intelligence (AI) technologies as key drivers of future competitiveness. For countries, the opportunity open is to drive technology-based make

transition to enter “industry 4.0” and from there to “society 5.0”, where all aspects of society are transformed by new information technologies and systems.

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Annexure3: Establishment of a National AI Portal

Importance of the portal

It is recommended that a unified portal for AI be setup for India, in partnership with all stakeholders viz. Government, Industry, Associations, Startups, Entrepreneurs, Academia, and other interested parties. This unified portal will be “by India, for India”, and will be a one stop destination for everything AI in India.

Purpose of the Portal:

- Where all stakeholders & ecosystem can connect, interact and draw value
- All significant work in AI across all stakeholders is showcased
- Create awareness and engagement
- Maintain a presence and build thought leadership through expert content, conversations and more
- Videos/articles/blogs by influencers and others on trends, technology, how tos, etc.

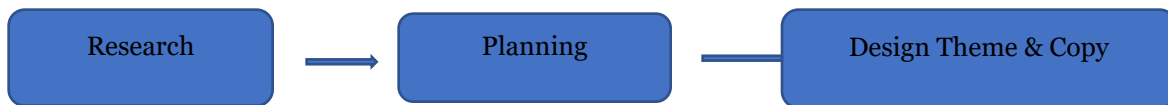
Structure of the portal



Process Plan

Phase 1: Groundwork

This phase will be dedicated to garnering information, research and doing the ground work for the entire scope of work. Leading into building the logic and information architecture, eventually leading to content, design and website creation.



Research

- Industry Research
- Review Key AI Players
- Survey
- Analysis and Learnings

Planning

- Identification & Finalization of Key Content Buckets
- Creation of Sitemap
- Finalization of main and Sub Navigation
- Identification of key design Templates
- Key Templates wire-framing

Design & Copy

- Design Theme (Homepage)
- Setting Copy Tonality
- Design of key templates
- Content Collation, Curation, Rewriting

Phase 2: Development of Portal and Go Live

This phase is all about putting things together – content, technology development, backend, cloud storage, front end UI, user testing and feedback, launch and Go live

Phase 3: PR and Promotions

- Conceptualization and Recommendations for overall marketing plan, media strategy, social media strategy
- Influencer activities online and offline
- Marketing Creatives Designed
- Launch and postings for social media posts
- Partner engagement plan conceptualization- marketing objectives, tracking process etc
- Identify relevant communities for partner engagement

Phase 4: Ongoing content

After the initial launch, content has to be continuously devised, designed and uploaded on the portal

- Crowdsourcing content articles, blogs and essays

- Get a panel of experts from around the world to contribute content

Phase 5: tracking metrics for traffic and engagement

Track metrics of website traffic

Partnership structure for implementation

- MeitY – overall ownership
- NIC – technology
- Industry – Content partner, experts, hosting events
- Academia – research and white papers, access to content
- NASSCOM – Coordinating partner

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Annexure 4: Use cases for AI in Public Health and Nutrition

AI has the potential to bring about paradigm shifts in Indian public health in 5 key areas:

1. Framing of policy/ regulation
2. Patient segmentation and identification of at-risk populations
3. Skilling of front-line workers
4. Clinical decision support systems
5. Demand-side engagement

1. Framing of policy/ regulation

Public Health and Nutrition is complex – where the relationships between inputs and health outcomes is often unclear. For example, Nutrition is a multi-variate topic, with implications on several departments/ sectors – e.g., Public Health, ICDS, PHED, Sanitation, Rural Development, Education, etc – which makes implementation arduous.

However, increasing proliferation of devices and inputs-outcomes data is making it possible to unearth new insights on which inputs/ processes matter most, to help improve outcomes sustainably. For example, World Bank has funded smart phones for 1.4 lakh Anganwadi Workers across the country, who are tracking monthly weight increase of all 0-3 year old children in their catchments.

AI can be applied to these data-sets to continuously “learn” more about the critical causalities – and thus shape policy/ regulation to fund/ promote the resources which are key for improving outcomes.

2. Patient segmentation and identification of at-risk populations

In order to improve outcomes at-scale, a “one-size-fits-all” approach will not work. Instead, a “population health” approach is required, with patient registries/ health records informing how the population is segmented (e.g., healthy, at-risk, simple chronic, chronic co-morbid). Care pathways need to be defined for each of these segments, with pathway-specific operating models (e.g., lighter-touch digital mechanisms to engage the healthy, more intensive mechanisms to prevent disease progression for patients with more acute conditions).

AI will not only help with such risk stratification, but will be invaluable in continuously identifying the different variables (e.g., socio-economic, psychographic) which are insightful predictors of how patient populations should be segmented.

3. Skilling and re-skilling of front-line workers

In the Indian context, three frontline workers are crucial for population-health improvement – Anganwadi Workers, ASHA (Accredited Social Health Activists) and ANMs (Auxiliary Nurse Midwife). However, these cohorts face significant skill deficits, given variable academic qualifications and low-quality training (both in-service and pre-service).

AI has the ability to fundamentally transform how skilling/ re-skilling is approached, moving from a one-size-fits-all push model, to a much more customized model that is pull-based.

For example, several start-ups/ NGOs are experimenting with behavioral economics-based approaches to better engage frontline workers – key for building their capacity. AI can help scale and sustain such efforts by helping to identify frontline worker-specific approaches and platforms that work best to help improve their skills - sustainably.

4. Clinical decision-support systems

India faces a double disease burden: traditional RMNCH-A (Reproductive, maternal, newborn, child, and adolescent health) and communicable diseases (Malaria, Tuberculosis) of the developing world -- and increasing incidence of chronic non-communicable diseases (e.g., Diabetes, Hypertension). However, we continue to face severe shortage of clinicians (both general practitioners and specialists), which will thus require newer models of care delivery and patient triage.

AI can help enable providers deliver sustainably better outcomes, by ensuring that their diagnoses and treatment advice is evidence-based – e.g., ongoing identification of clinical protocols and practices used by their peers which have improved health outcomes.

In addition, AI can help improve patient triage – and identify high-risk patients who require more intensive care. For example, identifying the most critical children in SNCUs (Special Newborn Care Units), who require multiple shifts from Pediatricians. Or predicting an expecting mother's risk of complicated delivery – with patient-specific remedial actions (e.g., delivering at a facility which has the capability for Caesarean section).

5. Demand-side engagement

Patients and care-givers have a critical role to play in ensuring a healthy society, especially given the growing incidence of chronic conditions. Key behaviors include diet-exercise regimen, drug adherence and health seeking patterns.

AI is being increasingly used to power smartphone-based “personal coaches”, which facilitate such behavior change. AI helps these applications develop patient-specific understanding of their barriers-to-change and nudges the patient to improve key health and wellness behaviors.

6. Use of IoT

IoT – maybe in the Clinical Decision Support System (CDSS) or ‘patient segmentation’ category - How the future hospitals will continuously create tons of information about every patient (from every BP reading to every pulse measured at an ICU) and how that information will then be used to develop curated clinical solutions - Maintenance & upkeep of devices / instruments will be auto-triggered – Non-functioning equipment will be a thing of the past

7. Skill Substitution

In addition to re-skilling, **skill-substitution** – Robots performing complex surgeries (already happening in many places) - learning from the experiences of all robot-based surgeries anywhere on the planet

8. AI-based treatment delivery mechanisms

AI-based treatment delivery mechanisms on demand side – e.g., Sugar-level triggered insulin shots

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