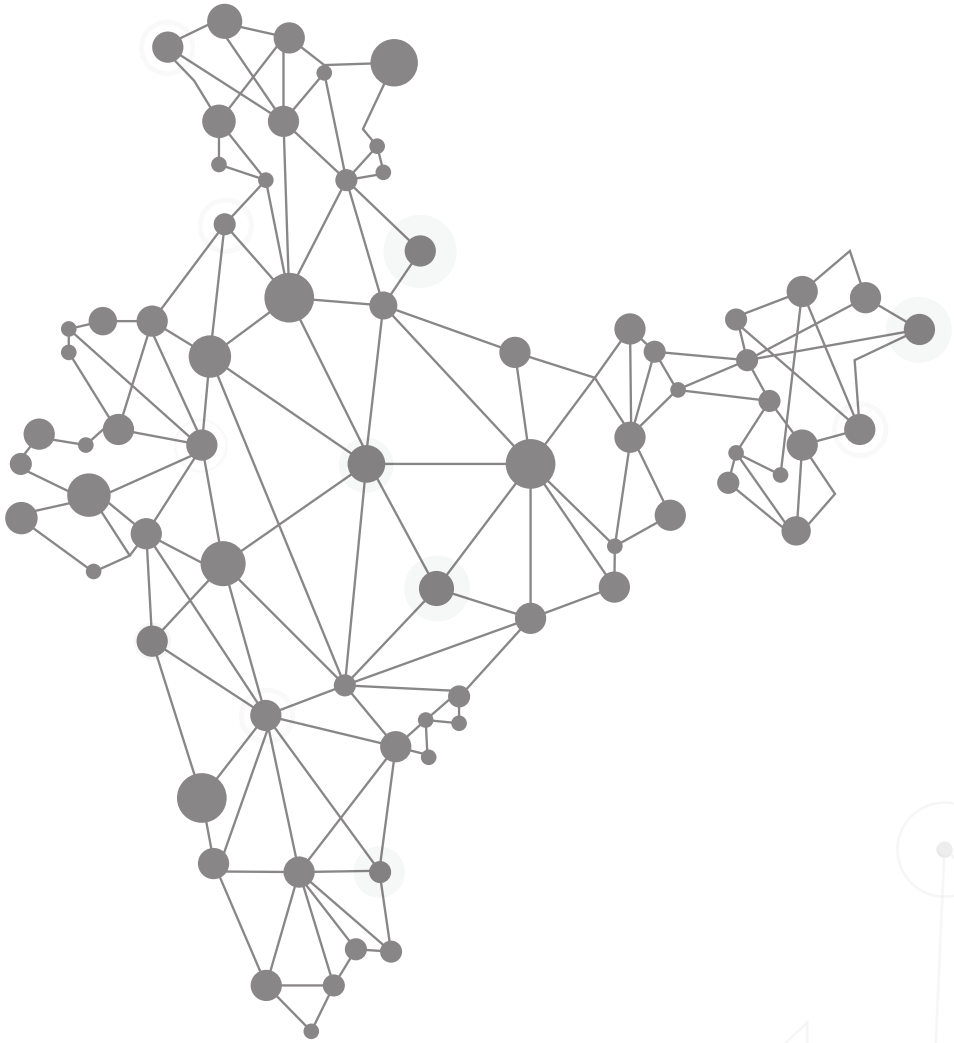
SANGAM 2019

Reimagining India in 2030



This report 'Reimagining India in 2030' proposes 38 Recommendations and 8 Grand Challenges across the five pillars in order to meet 22 specific national objectives to envision a new India by 2030.

IIT Madras Alumni Association
Reconnect • Engage • Impact
SANGAM 2019
REIMAGINING INDIA IN 2030

itihaasa
Research and Digital

Message

IIT Madras Alumni Association (IITMAA), represents around 50,000 alumni of IIT Madras across the world. Our Association's motto is: **'Reconnect... Engage... Impact'**.

- Reconnect with our alma mater, with our faculty and friends.
- Engage through active participation through Chapters, Special Interest Groups but online and virtually.
- Impact through giving back to our Country, our Society, our alma mater, and our association.

IIT Madras is celebrating its diamond jubilee this year. 'Sangam 2018 – A confluence for Impact' was launched to mark the beginning of the celebrations of the Diamond Jubilee Year. Our flagship event was attended last year by around 2500 people from over 125 cities and 25 countries in person and via live streaming.

To increase the scale of impact, Sangam 2019 has taken on a bold and ambitious theme: 'Reimagining India in 2030'. IIT Madras alumni will enable inclusive and insightful discussions, conduct surveys and interviews that provide thought leadership, propose specific recommendations and identify Grand Challenges that could help transform our country.

We aim to continue this journey and bring together our alumni, students and faculty at IIT Madras as well as experts, academics, and corporates around the globe to collaborate in implementing these recommendations to transform India!

Shuba Kumar

President, IIT Madras Alumni Association

Preface

We are delighted and honoured to chair Sangam 2019. As we brainstormed the theme for the event, we were clear that the following guiding principles should govern Sangam 2019 – it should be relevant and significant at an India level; it should provide inspiration to alumni and attendees; and it should be inclusive, especially of the women and the youth in India.

We chose to deliberate the theme "Reimagining India in 2030". India is a growing superpower among the comity of nations and has a powerful voice in the state of global affairs today. World Bank data for India over the last thirty years suggests a 54% growth in population that has witnessed a 726% increase in GDP, achieved a 470% enhancement of per-capita income and realized over 50% reduction in poverty levels in the country.

Where will we be by the next decade? At Sangam 2019, we examined how we could shape and envision a new India. As the late Prof. C.K. Prahalad suggested, we explored ways in which India could assert its economic, technological and moral leadership in the world. This report is an output of this deliberation process.

The report covers the following themes –

- Asserting leadership in **Business, Economy and Technology** – How do we build global excellence in our businesses and technology?
- Nurturing a **Global Innovation and Entrepreneurship Ecosystem** – How do we build in India for the world?
- Harnessing technology for **Agriculture and Sustainable Living** – How do we transform agriculture and achieve a blueprint for sustainable growth in India in the next decade?
- Leveraging **Technology for All** and **delivering Societal Impact** – How can we effectively harness technology to meet the needs and aspirations of the society, especially the under-served and the next billion users in India?
- Achieving **Human Enablement** –How can we provide Education and Skill development for Jobs in the future

The report captures through a survey the Voice of **IIT Madras alumni** and also the **Voice of Youth** (college students) and the **Voice of Women**. The report also contains a summary of the outcomes from the **Machine Learning Hackathon** we conducted as part of the event. It also contains the **I4India@2030 Pledge** that several thousands of alumni and citizens took towards contributing their time for nation building. We are thankful to the different teams that helped with the Surveys and Hackathons.

We received valuable insights through the research process from the following and we are deeply indebted to them.

1. Prof. Bhaskar Ramamurthi, *alumnus and Director of IIT Madras*
2. Prof. Mahesh Panchagnula, *alumnus and Dean of International & Alumni Relations, IIT Madras*
3. Kris Gopalakrishnan, *distinguished alumnus of IIT Madras and co-founder of Infosys*
4. Gururaj 'Desh' Deshpande, *distinguished alumnus of IIT Madras and founder of Deshpande Foundation*
5. M.G. 'Ambi' Parameswaran, *distinguished alumnus of IIT Madras and founder Brand-Building*
6. B. Santhanam, *distinguished alumnus of IIT Madras and Managing Director of Saint Gobain India*
7. D. Chandrasekhar, *distinguished alumnus of IIT Madras and President, Madras Dyslexia Association.*

We are also thankful to other alumni who generously shared their inputs as an expert contributor to the report. We are thankful to itihaasa Research and Digital for being a knowledge partner in preparing this report.

This report provides a pathway to a reimagined India in 2030. It proposes 38 Recommendations and 8 Grand Challenges across 5 Pillars in order to meet 22 specific national objectives to envision a new India by 2030. The report includes some long-term solutions and directional recommendations that provide an arc of transformation for the country as well as our alma mater, IIT Madras.

Happy reading!

Sriram Viji
Alumnus, IIT Madras
Program Chair, IITMAA Sangam

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We are thankful to the following people for their invaluable contributions to the Sangam 2019 Report.

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Voice of Youth Survey – Sarvesh Agrawal, Deepak Sahoo, Subbu Subramanian & Ravi Venkatraman, *Pan IIT Leadership Series*

Foreword

सिद्धिर्भवति कर्मजा || Success is born out of action

Chapter 4, Verse 12 of the Bhagavad Gita and the moto of IIT Madras

Human knowledge is at an exciting cusp today. In the book Critical Path, futurist and inventor Buckminster Fuller estimated that if we took all the knowledge that mankind had accumulated and transmitted by the year one CE as equal to one unit of information, it probably took about 1500 years until the 16th century for that amount of knowledge to double. The next doubling of knowledge from two to four units was completed in 250 years by the mid 18th century. By the turn of the 20th century, 150 years later, human knowledge had doubled again to eight units. The speed at which knowledge doubled is getting faster and faster. The doubling speed is now estimated between one and two years. Action based on this knowledge that will propel humanity to a developed, equitable and sustainable future.

It is in this civilizational backdrop that we are Reimagining India in 2030. It is clear that the foundation of this transformation rests on us, the people of India. Our scientific and technical knowledge are the true engines powering our economy and business. We have to create jobs to ensure that all Indians contribute in this journey to a new India. We need to continuously create new technologies and spawn an ecosystem of innovation and entrepreneurship. The waves of incumbent and new technologies will take us to a higher orbit of development. While this happens, we need to ensure that the basic needs of Indians for food and a sustainable living is well taken care. Given our current context, we need to ensure that all Indians are taken along and contribute to the reimagining of a new India.

We have identified five pillars to reimagine India in the coming decade. These are

- Asserting leadership in economy, business and technology
- Nurturing an innovation and entrepreneurship ecosystem
- Harnessing technology for agriculture and sustainable living
- Leveraging technology for all and delivering social impact
- Human Enablement– Education and skill development for jobs

This report Reimagining India in 2030 analyzes each of these five pillars in detail. We propose 38 Recommendations and 8 Grand Challenges across the five pillars in order to meet 22 specific national objectives to envision a new India by 2030. In this backdrop, we believe that IIT Madras has a pivotal role to play in reimagining India.

itihaasa Research and Digital and IITMAA partnered to undertake this study. This report is an outcome of extensive research. We are thankful to the IIT Madras alumni and other experts who shared their perspectives on Reimagining India in 2030. We are thankful to Nabila Khan, Gopinath Krishnan, Rudramoorthi Thangaraj, and Ramesh Krishnan, PhD students in the Department of Management Studies, IIT Madras who assisted us in the research for the report.

Finally, as IIT Madras alumni, we feel privileged to author the report and contribute to Sangam 2019 in the Diamond Jubilee year of IIT Madras.

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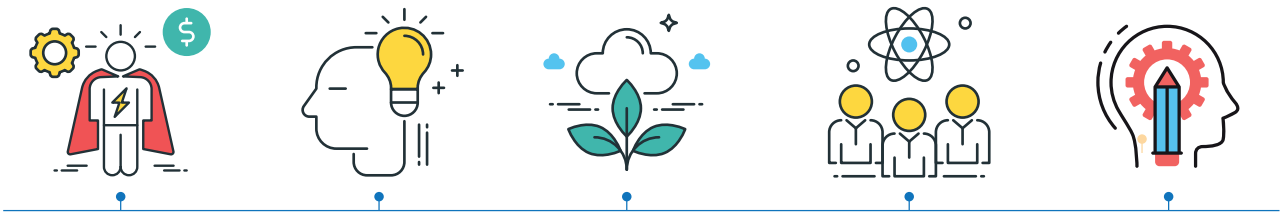
1. Introduction

India is a growing superpower among the comity of nations and has a powerful voice in the state of global affairs today. Data over the last thirty years suggests a 54% growth in population that has witnessed a 726% increase in GDP, achieved a 470% enhancement of per-capita income and realized over 50% reduction in poverty levels in the country. Across other parameters like FDI inflows, life expectancy, and digital readiness, India has taken a giant leap. We have the potential to reach greater heights. Where will India be by 2030?

	1990	2017	% Change
Population (Millions)	870	1339	54
GDP (USD Billions)	321	2651	726
GNI per capita PPP ($)	1220	6950	470
Poverty headcount (% of population)	45	22	-51
FDI (Millions USD)	237	39966	16763
Life expectancy (years)	58	69	19
Electric power consumption (kWh per capita)	273	806	195
Mobile cellular subscriptions (per 100 people)	0	87	
Individuals using the internet (% of population)	0	35	

Source: World Bank Data on India (1990 – 2017)[1]



1 https://databank.worldbank.org/data/views/reports/reportwidget.aspx?Report_Name=CountryProfile&Id=b450fd57&tbar=y&dd=y&inf=n&zm=n&country=IND

This report examines how we can shape and envision a new India in the next decade. It studies five pillars for Reimagining India in 2030. The key considerations and questions that we examine include:

- India is forecast to become the world's fifth largest economy in 2019, reaching a total GDP size exceeding USD 3 trillion. Where will India reach in the next decade? Experts have articulated an aspiration for India to become the third largest economy in the world by 2030 with GDP touching USD 10 trillion. How do we assert our leadership in economy, business and technology, and get there?

- India has the 2rd largest startup ecosystem in the world with over 20,000 startups. 3-4 tech startups are born every day! If India is to achieve its aspiration of becoming a 10 trillion-dollar economy in 2030, then these startups, an innovation mindset and social and micro-entrepreneurship will play a significant role. How can India nurture a global innovation and entrepreneurship ecosystem?

- Around the world, development has come at extreme ecological cost. According to estimates, countries that have achieved a Human Development Index (HDI) of over 9 have done so at an Ecological Footprint (EF) of over 10 hectares of equivalent resource consumption per capita – far above the global sustainable average of 2.5 hectares per capita. How can India adopt a more sustainable approach of development – not just of its business, but also of its agriculture?

- If India is to establish its economic and moral leadership in the world by 2030, then it has to seek inclusive growth for all. How can we effectively harness technology to meet the needs and aspirations of the society, especially the under-served and the next billion users in India?

- People are our nation's biggest assets. In this age of automation and a state of flux, how can India transform its education and skill development strategies, bolster investments in its human capital to ensure sustainable long-term economic growth?

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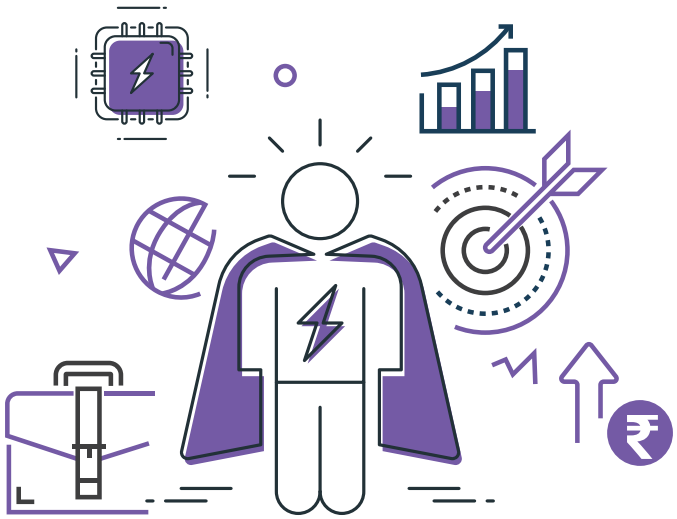

Asserting Leadership in Economy, Business and Technology

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India's objective to reach about USD 10 trillion GDP by 2030 will be powered by how it manages growth in sectors like Agriculture, Services, Infrastructure and Manufacturing – 1) it has to leverage and build on its traditional strengths in services and manufacturing while boosting its focus on big-employment generating industries like textiles; 2) In Infrastructure, sectors like power transmission, roads & highways, housing for all and renewable energy Infra for EVs is not necessarily renewable energy. Electric Vehicles(EVs) will power growth in the coming years; 3) India needs to transform agriculture by leveraging next farming practices and Artificial Intelligence(AI) & digital technologies and build a robust and sustainable farming & non-farming ecosystem in Indian villages; 4) India needs to increase the female workforce not just to empower women but also to increase productivity within the country.

On the technology front, 1) India needs to increase its spending on research and development and develop institutional mechanisms to build horizontal and vertical technology capability; 2) How India ramps up on its manufacturing and technology capabilities like Industry 4.0, AI in the next decade will determine its growth trajectory; 3) India needs to build its technology capability in Electric Vehicles with the aim of shifting the transportation sector to renewable energy.

Objectives

- The nominal GDP of India in 2018 according to the IMF is about USD 2.7 trillion[1]. India's objective should be to reach about USD 10 trillion GDP by 2030.
- Manufacturing industry's contribution is currently about 16% of India's GDP and is about USD 450 billion[2]. India should aspire for a USD 2.5 trillion contribution from manufacturing by 2030 which is 25% of targeted GDP for 2030. This should facilitate India to create more than 120 million jobs in the coming decade.
- Increase Female Labour Force Participation rate in India to add around USD 3 trillion to the GDP by 2025[3].
- India currently spends about 0.7% of its GDP on R&D[4]. India should spend about 3% of its GDP on R&D by 2030.
- India should become a superpower in emerging technologies along with the global leaders by 2030.

1 http://statisticstimes.com/economy/gdp-of-india.php
2 https://niti.gov.in/writereaddata/files/document_publication/Strategy_for_New_India.pdf
3 McKinsey and Company (2015), How advancing women's equality can add $12 trillion to global growth
4 https://niti.gov.in/writereaddata/files/document_publication/Strategy_for_New_India.pdf

Current context

Economy and Business

India's objective to reach about USD 10 trillion Gross Domestic Product (GDP) by 2030 will be powered by how it manages growth in sectors like Agriculture, Services, Infrastructure and Manufacturing

Composition of India's GDP	15% Agriculture	60% Services	25% Industry	16% Manufacturing

Assuming that India continues on a path of macroeconomic stability through prudent fiscal and monetary policies, a steady high GDP growth rate is expected to be the norm. India's current nominal GDP is about USD 2.7 trillion. Agriculture contributes to about 15% of India's GDP, and services about 60%, and industry about 25% including manufacturing about 16%[5].

Agriculture is a development priority for India. Agriculture is important to India since 1.3 billion citizens need to be fed. This apart, agriculture employs about 45% of India's employed population especially those at the bottom of the pyramid[6]. While agriculture is important, it is inefficient. India's yields of rice, maize, and other major crops that are one-half to one-fifth those of Brazil, China, Russia, and other developing economies[7]. An important factor among others that leads to the inefficiency of Indian agriculture is the lack of investment in farm equipment and other technology led modern farm practices. This is coupled by the fact that the agriculture produce is taken to customers using inefficient supply chains resulting in about 40% of produce going waste even before reaching the consumers. There is definitely a role for technology to improve the state of Indian agriculture to improve its contribution to GDP. The section on Harnessing Technology for Agriculture and Sustainable Living will detail how Indian agriculture can become more effective and efficient using technology.

Infrastructure comprises eight core industries of coal, crude oil, natural gas, refinery products, fertilisers, steel, cement and electricity. In 2018-19, growth in the index was led by cement (13.3%), coal (7.3%), and electricity (5.1%). It has given a massive push in the Union Budget 2019-20, with an allocation of INR 4.56 trillion for the sector. From a policy perspective, the Government has announced initiatives like Housing for All, Smart Cities Mission, Regional Connectivity Scheme UDAN and 100 per cent FDI route which will provide fillip to the infrastructure sector[8]. The Indian Railways is an important player in terms of employment and impact on the national economy. Today 60% of goods in India are transported by road and only 35% goes by rail, while in developed countries like USA it is 30% by roadways.

Services are the largest sector of the Indian economy. It employs about 33% of India's workforce. The services sector is also an export powerhouse. India exported USD 196 billion worth in 2018[9] which is about 40% of total exports from India[10]. The IT and BPO sector stand out as probably the only world-class and world-scale industry in India with exports worth USD 126 billion[11]. This is impressive considering the fact that India is among the best in the world in terms of competitiveness of IT and BPO. The total FDI in the services sector including computer hardware and software, and telecom is 35% of total FDI into India between 2000 and 2019[12]. The services sector is probably the largest employer of college educated Indians[13].

Manufacturing flatters to deceive. Realizing the true potential of manufacturing to increase the pace of GDP and jobs growth seems elusive. In fact, the share of manufacturing in India's GDP has been constant or shown a dip from 17% to 18% of GDP a decade back to about 16% now[14]. At the core of this conundrum is the competitiveness of Indian manufacturing. Industry employs about 25% of the workforce[15].

5 http://statisticstimes.com/economy/sectorwise-gdp-contribution-of-india.php
6 https://data.worldbank.org/indicator/SL.AGR.EMPL.ZS
7 Agricultural Policies in India (OECD Food and Agricultural Reviews) by OECD/ICRIER, OECD Publishing 2018
8 https://www.ibef.org/download/Infrastructure-June-2019.pdf
9 https://www.indiaservices.in/Service-Trade-Data
10 https://data.worldbank.org/indicator/NE.EXP.GNFS.CD
11 https://www.indiaservices.in/it-ites
12 https://dipp.gov.in/sites/default/files/FDI_Factsheet_27May2019.pdf
13 https://www.statista.com/statistics/271320/distribution-of-the-workforce-across-economic-sectors-in-india/
14 https://www.cnbctv18.com/economy/share-of-manufacturing-in-indias-gdp-falling-despite-make-in-india-360521.htm
15 https://www.statista.com/statistics/271320/distribution-of-the-workforce-across-economic-sectors-in-india/

India also has a sizeable Micro Small and Medium Enterprises (MSME) segment in manufacturing. According to the MSME Ministry, there are about 20 million MSMEs in the manufacturing sector in India with a workforce of about 36 million[16] . MSMEs contribute to about 38% of India's GDP. They have a share of 45% share of manufacturing output, and play an important role in this sector[17]. One of the important trends that are affecting both MSMEs and larger companies alike is the impact of information technologies in every aspect of manufacturing. Let us take a status check on capital, policies, labour and technology, and the resultant competitiveness of Indian manufacturing.

Foreign Direct Investment (FDI) in the manufacturing sector between 2000 and 2019 stood at 38% of total FDI in this period[18]. While FDI in manufacturing is comparable to that of services, the GDP contribution is only about 25% that of services. Manufacturing employs about 25% of India's workforce. The silver-lining in FDI seems to be the fact that in 2018 India had about USD38 billion of FDI compared with China's USD32 billion. It is for the first time in two decades that India's FDI was more than that of China's[19]. This trend may be beneficial to improve Indian manufacturing's competitiveness. An allied factor is the current geopolitical trade war between the USA and China. This may nudge Multinational Corporations (MNCs) to shift some of the manufacturing activities away from China[20]. It may not be easy though.

India should aim to take advantage of global trends towards geo-political trade rebalancing.

Across the US and European Union, we are witnessing a push towards 'balanced trade'. EU has an overall balanced trade now, with a huge trade surplus with USA (USD 119 billion) and huge deficit with China (USD 178 billion). We can expect US to balance the trade with EU and EU to balance the trade with China. Many US and European companies will be compelled to leave China. Some of them may go back to their own countries and some may set up facilities in countries like Vietnam, Philippines and Thailand. India should aim to take advantage of such geo-political trade rebalancing.

USD 165 billion

India's overall merchandise trade deficit for 2018-19

According to Ministry of Commerce and Industry, India's overall merchandise trade deficit for 2018-19 is about USD 165 billion21. Manufacturing is an important component of India's international trade. The move from many countries and trade blocks towards balanced trade has implications on Indian manufacturing. India needs to pick and choose manufacturing sectors for export focus where it has an inherent competitiveness, textiles industry for example.

The textile industry in India traditionally, after agriculture, is the only industry that has generated huge employment for both skilled and unskilled labour in textiles. The textile industry is the second-largest employment generating sector in India. India is first in global jute production and shares 63% of the global textile and garment market. India is second in global textile manufacturing and also second in silk and cotton production. 100% FDI is allowed via automatic route in textile sector.[22]

India should improve on its ease of doing business and better skill its labour force

77th Rank

Among 190 countries in the Ease of Doing Business

India is now ranked 77 among 190 countries in the Ease of Doing Business by the World Bank[23]. India ranks 166 under the category Registering Property. This refers to the procedures necessary for a business to purchase a property from another business and to transfer the property title to the buyer's name. Basic requirements like getting construction permits, enforcing contracts, paying taxes, starting a business and trading across borders are arduous in India. India should aim to quickly move to a rank under 30. China is currently ranked 46 in Ease of Doing Business.

16 https://msme.gov.in/sites/default/files/MSME-AR-2017-18-Eng.pdf
17 http://www.makeinindia.com/article/-/v/nurturing-a-manufacturing-culture
18 https://dipp.gov.in/sites/default/files/FDI_Factsheet_27May2019.pdf
19 https://economictimes.indiatimes.com/news/economy/indicators/india-pips-china-in-fdi-inflows-for-the-firsttime-in-20-years/articleshow/67281263.cms
20 https://www.livemint.com/politics/policy/india-plans-to-offer-incentives-to-companies-moving-from-china-1561437267139.html
21 https://www.business-standard.com/article/economy-policy/exports-climb-but-trade-deficit-hits-a-record-highof-176-bn-in-fy19-119041501203_1.html
22 https://en.wikipedia.org/wiki/Textile_industry_in_India
23 http://www.doingbusiness.org/en/rankings

One argument is that competitiveness will pick-up in the formal sector if existing labour laws are rationalized. This is also likely to encourage industry to increase employment. At present India has 38 central labour laws[24]. These need to be simplified for manufacturing to become competitive. According to the ILO, the output per worker for 2017 was about USD 5,000 in India and about USD 13,000 in China[25]. While annual wages according to Natixis and JETRO are approximately USD 3,100 for India and USD 5,700[26] for China. A Chinese worker produces 2.6 times more value than an Indian worker for only 1.8 times more wages.

One inference is that the skills levels of an Indian worker are probably not up to the mark. According to a study supported by Confederation of Indian Industry (CII), All India Council for Technical Education (AICTE) and United Nations Development Programme (UNDP), only 47% of Indian students graduating with a college are employable in 2018[27]. Competitiveness of Indian manufacturing is likely to be sub-par when labour quality is not up to the mark. We need to push this ratio to more than 80% by the end of this decade to meet our ambitious goals for increasing contribution of manufacturing industry's contribution to GDP. The section on Human Enablement - Education and Skill Development for Jobs in the Future will elucidate how India can overcome these challenges.

We need to increase the female workforce not just to empower women but also to increase productivity within the country.

According to a McKinsey study, India could boost 2025 GDP by 60% if women participated in the economy at par with men[28].Increasing female labour force participation is a pressing concern for us and needs to be looked at immediately.

26% in 2018

Female labour force participation in India

It is concerning to note that the female labour force participation in India has fallen to 26% in 2018 from 36.7% in 2005. Further, a Deloitte report adds that 95% or 195 million women are employed in the unorganised sector or are in unpaid work[29].One reason assumed for the decline in FLFP is the rise in educational attainment levels amongst women. However, as per a World Bank Report[30], 62% of women in rural India who quit jobs did it for reasons other than education. Another report the United Nations Development Programme indicated that 68.3% of women who are undergraduates don't have paid jobs[31].

The government has launched various initiatives including creating a skills ministry and revamping India's apprenticeship regime. These steps, even though in the right direction, have had limited impact on the female employment rate.

The situation with respect to women in leadership roles in even more stark. India ranks fifth lowest in having women in leadership roles and only 20% of leadership roles are held by women in India[32].Another study shows that just 6% of the most powerful leaders across the USA, China, Russia and India are women with children[33].

24 https://niti.gov.in/writereaddata/files/document_publication/Strategy_for_New_India.pdf
25 https://www.businesstoday.in/from-the-mag/indias-coming-productivity-crisis/story/275891.html
26 https://timesofindia.indiatimes.com/business/china-has-highest-manufacturing-wages-in-emergingmarkets/articleshow/67431978.cms
27 https://wheebox.com/static/wheebox_pdf/india-skills-report-2018.pdf
28 https://www.business-standard.com/article/economy-policy/india-could-boost-2025-gdp-by-60-by-promotinggender-diversity-at-work-mckinsey-report-115092401091_1.html
29 https://www.thehindu.com/business/female-labour-force-participation-in-india-fell-to-26-in-2018-report/article26467857.ece
30 World Bank (2017), Precarious Drop: Reassessing Patterns of Female Labour Force Participation in India
31 United Nations Development Programme (2015), Women's Voices, Employment and Entrepreneurship in India
32 Grant Thornton's Women in business: Beyond policy to progress, 2018
33 http://justactions.org/campaign/motherhood-public-power-index-2018/

Technology

India should increase its spending on research and development and develop institutional mechanisms to build horizontal and vertical technology capability.

0.8% of GDP

India currently spends of its GDP on research

India currently spends only 0.8% of its GDP on research. In comparison, China spends 2% of its GDP on research and the USA spends 2.7%. Compared to our success in some strategic domains like space technology, India still needs to catch-up in other important technologies impacting the lives of its citizens. Apart from technologies driving Industry 4.0, technologies like semiconductors and integrated circuits, nanotechnology, and genetic engineering are important for a country like India with a sizeable population of 1.2 billion. Not catching-up has significant costs implications. According to one study, Indian electronics imports are likely to touch USD 400 billion in 2020[34]. Our recent electronics policy forecasts a domestic electronics production of USD 400 billion in 2025 when the demand is likely to be much higher[35].

India has traditionally not had a capability in a horizontal family of related technologies and applications that are spread across different organizations (universities, government labs and departments, industry, and startups). This implies that India needs a strong capability in Pasteur's quadrant which is application inspired basic research[36]. Pasteur's quadrant is a classification of scientific research projects that seek fundamental understanding of scientific problems, while also having immediate use for society. India has traditionally had a limited success in developing a capability in a horizontal family of technologies and applications. In the past these technologies include biotechnology, aerospace, supercomputing, telecom equipment, etc. India has the second largest number of STEM graduates in the world at 2.6 million next only to China at 4.7 million to power the ramp up required in building a technology capability[37].

34 https://timesofindia.indiatimes.com/business/india-business/indian-electronics-market-expected-to-reach-400- billion-by-2020-study/articleshow/59108734.cms
35 https://www.indiatimes.com/news/india/govt-aims-to-create-1-crore-jobs-generate-400-billion-by-2025-withnew-electronic-policy-362488.html
36 Pasteur's Quadrant: Basic Science and Technological Innovation, Donald E Stokes, Brookings Institution, 1996
37 https://www.statista.com/chart/7913/the-countries-with-the-most-stem-graduates/

How India ramps up on its manufacturing and technology capabilities like Industry 4.0 including AI in the next decade will determine its growth trajectory.

Let's analyse the case of Industry 4.0 technologies. There is a disruption in manufacturing powered by Industry 4.0 technologies. This is much more than just robotics. Figure 1 illustrates the themes, value drivers, and technology drivers for industry 4.0.

Figure 1[38]: Industry 4.0

Key themes of Industry 4.0	Description of themes	Value drivers	Important technology levers
Interoperability	Cyber-physical systems allow humans and smart organizations to connect and communicate with each other.	Improve process and reduce resource consumption Improve asset utilization Improve labour productivity Optimize inventories Improve quality Reduce time to market Match demand and supply Improve service/aftersales	IoT AI Big data and Analytics Simulation AR/VR Wearables Cyber security Cloud computing Blockchain IT platforms Robotics 3D printing / Additive manufacturing Drones Green and energy efficient technologies
Virtualization	A virtual copy of the smart organization is created by linking sensor data with virtual models and simulation models.		
Decentralization	Ability of cyber-physical systems to make decisions of their own and to produce or service locally.		
Real-time capability	The capability to collect and analyze data and provide the derived insights immediately.		
Modularity	Flexible adaptation of smart organizations to changing requirements by replacing or expanding individual modules.		

38 Industry 4.0 , Directorate of Internal Policies, European Parliament, Feb. 2016. Based on the original German INDUSTRIE 4.0 framework.

China's Made in China 2025 is an Industry 4.0 led goal is to comprehensively upgrade Chinese industry, making it more efficient and integrated so that it can occupy the highest parts of global production chains. According to the United Nations Industrial Development Organization (UNIDO), for a smooth transition to 4.0, manufacturing industry needs to enhance existing standards and procedures across their entire production cycle[39].

At the heart of Industry 4.0 are horizontal emerging information technologies. Till now India has been adept in applying technologies once they are mature, but has not been successful in creating a capability in these technologies along with the global leaders. Let us take the case of AI. According to the World Intellectual Property Organization (WIPO), the USA and China are the dominant force in building AI capability[40]. India is third in AI research behind China and the USA[41]. Catching up with the global leaders requires investments in research and development in science and technology.

India has a solid foundation in terms of its macroeconomic stability, strong services economy, and a sizeable talent pool that can be channelled into Science Technology Engineering Math (STEM) disciplines. How India leverages these strengths and overcomes constraints in ramping up manufacturing and technology capability in the next decade will determine its growth trajectory.
India should build its technology capability in Electric Vehicles with the aim of shifting the transportation sector to renewable energy.

>35%

Reduce carbon emissions

As per an analysis by the NITI Aayog, India can save over 60% of the anticipated road-based passenger mobility-related energy demand in 2030 by pursuing a shared, electric, and connected mobility future. This would potentially help reduce more than 35% of the carbon emissions from the sector[42].

The biggest cost element of an EV is the electric battery. Looking at the battery manufacturing stages from a value generation (costs) perspective – 1) Cell manufacturing takes 25–30% of the pie; 2) Battery chemicals have a value of about 35–40% of the total cost of the battery pack; 3) Cell-to-battery-pack manufacturing has a value addition of 30–40%[43].

With a host of incentives unveiled in the Union budget and subsequently for electric vehicles, India has backed the development of the nascent EV industry by offering extensive fiscal incentives and a favourable regulatory environment[44].

Constraints

Economy and Business

The immediate dark cloud for a growing economy like India is the current tension between globalization and localization that are leading to trade wars.

Exports were so far seen as a sure shot strategy to grow the economy. There are already indications of India and the USA engaging in a mini one-upmanship with respect to import duties. The USA withdrew the benefits under the Generalized System of Preferences (GSP) to India. This will end the duty-free status available to 3,500 Indian goods exported to the USA. This is seen as USA's retaliation to the fact that India is not providing equitable market access to imports from the USA. The USA has a USD 24 billion trade deficit in both goods and services with India in 2018 and wants to bring this down[45]. A soft measure that the USA is reportedly working on is to cap the number of H1B work visas available for Indian professionals[46]. This will impact the quantum of services exports from India to the USA, and is reported to be in retaliation to the proposed data localization laws that India is in the process of finalizing.

39 https://economictimes.indiatimes.com/small-biz/sme-sector/made-in-india-made-for-india-version-of-industry-4-0-needed-unidos-ren-van-berkel/articleshow/69852491.cms
40 https://www.wipo.int/edocs/pubdocs/en/wipo_pub_1055_exec_summary.pdf
41 http://www.itihaasa.com/pdf/itihaasa_AI_Research_Report.pdf
42 https://niti.gov.in/writereaddata/files/document_publication/NITI-RMI_India_Report_web-v2.pdf
43 https://niti.gov.in/writereaddata/files/document_publication/EV_report.pdf
44 https://www.livemint.com/budget/news/india-looks-to-lead-electric-vehicle-race-with-latest-push-in-budget-1562523548797.html
45 https://ustr.gov/countries-regions/south-central-asia/india
46 https://timesofindia.indiatimes.com/india/us-mulling-15-cap-on-h-1b-visa-forindians/articleshow/69867049.cms

It should be noted that in the context of manufacturing that the trade deficit that the USA has in goods trade with India is about USD 21 billion that is about 88% of total trade deficit. It appears that any push by India to increase manufacturing export to the USA can be met with some resistance in the current context. The silver lining is that the goods trade between India and EU is balanced with each side exporting about USD 51 billion in 2018[47].

Trade wars not only have a direct impact on exports and hence an economy's growth but also affect an economy indirectly by inhibiting cost effective technology transfers. While technology transfers have not yet impacted India, there are lessons to learn from the US Government preventing its information technology platform companies to transfer or license technology to Chinese companies after a trade blacklist[48].

Another aspect to consider is the Free Trade Agreement (FTA) India signs with other countries. A NITI Aayog committee studied the impact of FTAs on India's trade found that overall trade deficit got almost doubled to USD 24 billion in 2017 against USD 15 billion in 2011 (before the FTA).The committee's conclusion was that FTAs have to be signed keeping two things in mind, mutually reciprocal terms and focusing on products and services with maximum export potential.

There is also an opportunity now to ramp-up manufacturing for exports since China's high real wages are making manufacturers explore cheaper options in other countries. According to the International Labour Organization (ILO), China's manufacturing wages doubled between 2008 and 2017[49].The challenge for India now is that it is not in an immediate position to attract large manufacturing to India. India has a large friction in terms of ease of doing business to attract manufacturers looking to diversify from China. These include regulatory uncertainty, availability of capital to industry, and difficulties in land acquisition for new projects[50]. While increasing the share of manufacturing in India's economy looks attractive, it has a fair share of challenges.

MSMEs that form a substantial part of India's manufacturing sector face challenges like unavailability of timely credit and shortage of skilled labour.

30% and 40%

Employability of Indian students

The main challenge for MSMEs is access to timely credit. India's Non-Banking Financial Companies (NBFC) are a dominant source of credit to MSMEs[51]. The Non-Performing Assets (NPA) issue plaguing the NBFCs has resulted in a decrease in credit offered to MSMEs. With the Goods and Services Tax (GST) regime kicking-in, MSMEs have found it difficult to manage working capital cycles given the delays in obtaining input credit. According to CII, the other big challenges for MSMEs are the technological obsolescence and availability of a skilled workforce[52]. Employability of Indian students completing a diploma in an Industrial Training Institute (ITI) or a polytechnic which powers employment in the manufacturing sector is only between 30% and 40%[53].

All these factors lead to a vicious cycle. Thanks to a perennial shortage of credit, MSMEs employ lower skilled labour and do not have the ability to invest in appropriate technologies. The lower skill levels imply a lower preparedness to absorb new technologies. The capacity to invest in new technologies including Industry 4.0 technologies is low since all the cash generated is required to sustain operations.

47 http://ec.europa.eu/trade/policy/countries-and-regions/countries/india/
48 https://www.livemint.com/technology/tech-news/after-us-ban-google-restricts-huawei-from-using-androidapps-and-updates-report-1558323520752.html
49 https://www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/---publ/documents/publication/wcms_650553.pdf
50 https://niti.gov.in/writereaddata/files/document_publication/Strategy_for_New_India.pdf
51 https://niti.gov.in/writereaddata/files/document_publication/Strategy_for_New_India.pdf
52 https://www.cii.in/uploads/PolicyWatchMSMEJan2017922.pdf
53 https://wheebox.com/static/wheebox_pdf/india-skills-report-2018.pdf

Infrastructure development faces significant challenges in aspects like land availability, financial resources and private sector participation.

In case of large-scale infrastructure projects in India, land acquisition has been contributing to significant delays in execution as well as increase in overall projects costs. The sector has also witnessed challenges with respect to availability of equity and long-term debt funding options to large scale projects. Although the latest budget has talked about tapping into the global financial system, the details need to be worked out. The PPP model in infrastructure projects in India have had a patchy record and the private participation models need to be revitalized[54].

Women face legal, normative, societal and economic constraints to work.

Multiple studies have identified the following indicators leading to gender gaps – Education, Unmet need for family planning, maternal mortality, lack of financial and digital inclusion, and unpaid care work.

95%

of Indian women age 25 and older are married

Marriage is a major cause of low FLFP (95% of Indian women age 25 and older are married). Indian households require that women prioritize housework and may even explicitly constrain work by married women. Women have more trouble matching to jobs than men. Women without vocational training are less likely to work than those with training. Lack of 'peer effects' i.e. lack of female role models in jobs have an impact on women's participation.

A World Bank study[55] found that conventional approaches (focusing on education, skills, legal provisions) are not sufficient for increasing FLFP. Policies should center on promoting acceptability of female employment and investing in growing economic sectors that are more attractive to female employment.

Technology

Access to good indigenous technology is critical for both larger companies and MSMEs in the Indian industry.

218 per million

Scientific R&D professionals in India

Either this technology capability needs to come from within the organizations or it needs to come from public funded research. One of India's challenges is that there are not enough people in R&D to ensure a capability in emerging technologies. The number of scientific R&D professionals in India at 218 per million of population. It is alarmingly low compared to China's 1,113 and the USA's 4,019[56]. This apart, public funded research in India is either not focusing on solutions that can be commercialized or not amenable for commercialization. USD 73 million was the revenue generated by Council of Scientific & Industrial Research (CSIR) from licensing its technologies to private companies[57]. While these numbers may be impressive from a historical perspective, it does not seem commensurate to the USD 675 billion contribution of industry to India's GDP. A real possible scenario in the near future is that technology transfer especially from the USA in emerging technologies may not be as easy as it used to be. This makes it imperative for India to strengthen the indigenous lab to market cycle especially in emerging technologies.

54 https://www.moneycontrol.com/news/business/markets/budget-2019-infrastructure-development-takescentre-stage-in-push-towards-5-trillion-economy-4177541.html
55 Precarious Drop: Reassessing Patterns of Female Labour Force Participation in India, World Bank Report, 2017,https://elibrary.worldbank.org/doi/abs/10.1596/1813-9450-8024
56 https://niti.gov.in/writereaddata/files/document_publication/Strategy_for_New_India.pdf
57 https://www.hindustantimes.com/india-news/increase-in-csir-earnings-through-licensing-tech/storyaRabrvvuOWtYRNZ0CmNIfJ.html

In order to truly achieve world-wide impact in critical technologies like AI / Machine Learning (ML), India has to overcome challenges in terms of quantity and quality of researchers, computing infrastructure and institutional mechanisms for research.

We take the example of AI/ML research in India as a specific instance to illustrate the challenges India faces with respect to achieve world-wide impact.

A report by NITI Aayog[58] suggests that the challenges are concentrated across common themes of: 1) Lack of enabling data ecosystems 2) Low intensity of AI research – core research and transforming core research into market applications 3) Inadequate availability of AI expertise, manpower and skilling opportunities 4) High resource cost and low awareness for adopting AI in business processes 5) Unclear privacy, security and ethical regulations 6) Unattractive Intellectual Property regime to incentivise research and adoption of AI

Another study[59] identified the following key challenges that the AI research ecosystem in India faces: 1) quantity and quality of students entering AI/ML research in India, 2) computing infrastructure, 3) resources and administrative bottlenecks, 4) lack of good quality labelled data sets and 5) a siloed research approach within a university.

The key challenges with respect to Electric Vehicles in India pertain to the battery technology and user adoption.

Predominantly, EVs use lithium-ion batteries (LIBs). LIBs are expensive and do not support long distance travel. Worse, raw materials needed to make LIBs are in short supply.

From a user's perspective, there are four main deterrents[60]: the high upfront cost of EVs (primarily due to battery costs), long charging time, range anxiety and lack of charging infrastructure.

Way forward

Economy and Business

1. Focus on competitiveness of the Indian industry, attracting more domestic and foreign investment capital, streamlining labour and land acquisition laws, and quickly adopting emerging technologies.

- India should feature among the top ten ranked countries in terms of ease of doing business by 2030. Labour laws must be streamlined in the next decade and there should no more than one set of labour laws by 2030.
- India needs to build on strengths in services and take up a focus on a couple of domains like healthcare and tourism that can cater to both domestic and international demand.
- India should build an indigenous technology capability especially around Industry 4.0 and AI through the coming decade. IIT Madras has a leadership opportunity to make this dream of developing cutting edge Industry 4.0 and AI related technologies a reality. By 2030, indigenous technology should power most of Indian industry.

58 https://niti.gov.in/writereaddata/files/document_publication/NationalStrategy-for-AI-Discussion-Paper.pdf
59 http://www.itihaasa.com/pdf/itihaasa_AI_Research_Report.pdf
60 https://www.industr.com/en/ev-manufacturing-in-india-opportunities-challenges-2343489

2. Identify and focus on strategic manufacturing sectors – 1) On products that have a large domestic market and are currently being imported 2) Products where India seems to have traditional strengths to be an exporter.

There are two kinds of products that India can focus on immediately.

- One, focus on products that have a large domestic market and are currently being imported. Good examples are mobile phone and telecom equipment. The targets need to more aggressive, and the aim should be to assemble all of India's mobile phone handsets by 2025. Once India has a large assembly base, backward integration into electronics components can be taken up. India should proactively seek to attract electronics manufacturers moving away from China, given the current geo-political context. The aim should be to build a horizontal capability in consumer electronics manufacturing by 2030.

- Second, products where India seems to have traditional strengths to be an exporter. Cotton and man-made textiles are examples where India has traditional strengths. India should look to boost competitiveness and reclaim the space vacated to countries like Vietnam, Sri Lanka and Bangladesh. Different sub-segments of the textile sector have opportunity for MSMEs, and can provide employment opportunities for Indians.

3. In Infrastructure, sectors like power transmission, roads & highways, housing for all and renewable energy will power growth in the coming years.

- Take forward existing Government programs like Bharatmala, Sagarmala, Pradhan Mantri Gram Sadak Yojana, Jal Marg Vikas and UDAN, as well as a focus on newer themes like Electric Vehicles and charging infrastructure, Maintenance, Repair and Overhaul (MRO) of commercial aircraft, transformation of discoms, and technology for affordable housing. We should consider creating freight corridors having dedicated solar-powered electric rail lines exclusively for movement of goods trains will make a significant impact on economy of India. IIT Madras should create specific Research Centres of Excellence to address these emerging themes.

4. Professionally strengthen the MSME sector by offering training programs and fine-tuning curriculum in it is and polytechnics in India.

While many schemes to provide credit to the MSMEs are being promoted, it is imperative to bring in a professional and rigorous system of project appraisals. This requires a strong techno-business capability.

More important, by 2030 100% of Indian students completing a diploma in an ITI or a polytechnic should be ready for employment.

- IIT Madras and IIMs should partner to offer short term programs including Massive Open Online Courses (MOOCS) to nurture this capability.

- IIT Madras can play a big role in fine-tuning the curriculum in ITIs and polytechnics to make it industry relevant. IIT Madras can train the ITI and polytechnic teachers in new emerging technology domains. IIT Madras can also champion a dedicated SWAYAM / NPTEL channel for the students in ITIs and polytechnics. Last but not the least, IIT Madras can consciously increase the number of MSME licensable technologies developed by its faculty and graduates in the coming decade.

Refer to Section on 'Nurturing a global innovation and entrepreneurship ecosystem' for other specific interventions to promote MSME / Social / Micro Entrepreneurs.

5. Augment women participation in labour-force by providing 1) Financial Incentives and Support 2) Technology and infrastructure support 3) Creation of economic opportunity 4) Capacity building 5) Advocacy and 6) Appropriate laws, policies and regulations.

There are a number of interventions that Governments can undertake to narrow gender gap in work and society[61].

- Financial Incentives and Support: For example, cash & asset transfers to female-headed households where recipients survive on less than 2 dollars per day benefits women. Under Mahatma Gandhi National Rural Employment Guarantee Act (MNREGA), when money was transferred to a woman's bank account rather than that of the household head, it led to better outcomes.
- Technology and infrastructure like access to safe and affordable transportation (e.g., to work, for high-risk pregnancies) and telecommuting work options. It has been seen that Indian states which have better road infrastructure and lower transmission and distribution losses of state power utilities have higher FLPFP.
- Creation of economic opportunity like providing business and financial training, mentoring support to female entrepreneurs, financial products and banks only for women. Some studies have shown that there exists a higher elasticity of female labour supply to wages i.e. women choose work only if the earnings sufficiently make up for the lost home production (and costs including caring for children)
- Capacity building like agricultural extension services for women and digital & financial literacy programs. Studies have shown that education accounts for a third of the increase in female employment.
- Advocacy and shaping attitudes at workplace and society through mass and social media-based awareness campaigns. Strategies to communicate the importance of women's work should take into account the roles of women, men and in-laws in decisions related to FLFP.
- Laws, policies and regulations like legislation to protect women at work, compliance requirements to publish diversity efforts. Flexibility in labour market (higher EPL index) leads to higher FLFP. Key legislations in India that should be amended include the Industrial Disputes Act, Factories Act, Shops Act, Contract Labour Act.

Technology

6. We should increase research spending to 3% of GDP; 1.5% from Government and 1.5% from private sources.

- An urgent priority for India is to increase Research and Development (R&D) professionals per capita from current levels to a level that China has by 2030. We should increase research spending to 3% of GDP; 1.5% from Government and 1.5% from private sources. Private funding has played an important role in the transformation of emerging nations. For example, in the mid-2000s about 65% of Taiwan's R&D was from private sector funding up from about 30% in the past. India is at a point in history where private funding can supplement government funding in research, and this includes philanthropy. This may also be the time to tweak the current rules on the current rules on corporate social responsibility that mandates that2% of average net profit be spent on specified social activities and mandate 1% of such funds be used to fund science and technology research[62].

7. India should develop an indigenous model to create a world-class capability in emerging technologies.

- This has to be coupled with a national strategy that pulls together multiple stakeholders like Government organizations and labs, academia, industry, startups, and citizens to develop an indigenous model to build a world-class capability in emerging technologies along with the rest of the world. The office of the Principal Scientific Advisor to the Government of India has identified emerging domains. These include AI, Natural Language Translation, Quantum Frontier (Quantum Computing), Bio Science for Human Health, Deep Sea Exploration, and Electric Vehicles etc[63]. IIT Madras should take lead in driving some of these national technology missions.

61 McKinsey and Company (2015), How advancing women's equality can add $12 trillion to global growth
62 http://www.itihaasa.com/pdf/itihaasa_AI_Research_Report.pdf
63 http://psa.gov.in/pmstiac-missions

- The NITI Aayog report[64] makes the following recommendations for enhancing the AI capability in India: 1) Focus on turbocharging both core and applied research. 2) Focus on reskilling of existing workforce and preparing students for developing applied set of skills for the changing world of technology 3) Develop large foundational annotated data sets to democratise data and multi-stakeholder marketplaces across the AI value chain 4) Ensure adequate privacy, security and Intellectual Property (IP) related concerns and balancing ethical considerations with need for innovation. Further the itihaasa report makes six recommendations as a way forward for furthering AI/ML research in India[65]. Three of the recommendations pertain to augmenting our resources / infrastructure namely 1) Increasing the number of AI PhD students in India 2) Augment computing infrastructure for AI/ML research 3) Create India-specific AI challenges, tools and data-sets. The other three recommendations suggest institutional mechanisms to be adopted namely 4) Set up Centers of Excellence (CoEs) for AI/ML research 5) Adopt an AI Grand Challenges approach 6) Link institutional mechanisms to start-up ecosystem

- We expect India to continue its leadership role in terms of global IT services and 'digitalization' of the world. Hence it becomes critical for India to develop 'deep-tech digital' capabilities. IIT Madras will play an important role in such a national program. By 2030, India needs to be at the forefront of building a capability in a few important emerging technologies of the next decade.

    - Healthcare – Scale the efforts at the Healthcare Technology Innovation Centre (HTIC)[66] at IIT Madras and aim for 50X increase in delivering impact

    - Distributed energy infrastructure – leverage solar energy, DC distribution and develop multi-village microgrid models for efficient, green power supply[67,68]

    - Combine MOOCs with Digital learning through NPTEL[69]

    - Technology enabling construction industry – Continue research in mass-produced, pre-fabricated building solutions, lean construction principles, and emerging digital technologies in construction industry[70]

8. India should establish strong institutional mechanisms to build such a technology capability.

- We need to evolve strong institutional mechanisms for taking an idea from the research lab to market, a cycle which focuses on both basic and translational research.

    - The IIT Madras Research Park model should be replicated across India to translate basic research in our universities into commercial applications.

    - IIT Madras' Centre for Computational Brain Research (CCBR) set up with a philanthropic investment is an interesting model to build an India capability in the emerging domain at the intersection of brain research and computer science. CCBR is an example of one model to build emerging technology capability in India. This model can be replicated across other Indian institutions in other emerging domains like genetic engineering, smart materials, green technologies, etc.

- IIT Madras and the IITs and have done well for the country in terms of technology development & capability building. Keeping in mind the future of science and technology India, especially in the context global research & thinking, we need to undertake significant efforts. IITMAA envisages an initiative to bring together a set of leading alumni, professors and other knowledge experts to deliberate the topic of "Emerging Technologies for India by 2030 & beyond". The initiative is expected to be in existence for one year and will produce a "living" document i.e. the framework will be useful for IIT Madras alumni as well as others to contribute their ideas. A report is planned by next edition of Sangam and will be published by the Indian Academy of Sciences.

64 https://niti.gov.in/writereaddata/files/document_publication/NationalStrategy-for-AI-Discussion-Paper.pdf
65 www.itihaasa.com/pdf/itihaasa_AI_Research_Report.pdf
66 https://www.iitm.ac.in/htic
67 http://www.ee.iitm.ac.in/~ashok/Solar_Energy.pdf
68 https://timesofindia.indiatimes.com/business/india-business/IIT-Madras-to-develop-multi-village-microgridmodels-for-efficient-green-power-supply/articleshow/55538932.cms
69 https://nptel.ac.in/
70 https://timesofindia.indiatimes.com/city/chennai/iit-madras-collabourates-with-university-of-technologysydney-for-manufacturing-solutions-to-indian-houses/articleshow/69145863.cms

Grand Challenge

1. Ramping up India's competitiveness in the textile industry to make it the number one in the world by 2030

China's share of global apparel exports has come down in recent years. However, India has not yet capitalized on this opportunity. A point intervention of rebates on state levies was introduced by the Government in 2016. According to the Economic Survey 2018[71], over the next couple of years, this improved the exports of ready-made garment from man-made fibers in a year by about 16% over other comparable industry sectors. The government has implemented the Technology Up-gradation Fund Scheme and initiatives focusing on khadi. India has word-class capabilities in the textile industry. There is a good base of technology expertise and fashion design expertise in India which can be built upon. Textiles have a domestic market with the Indian population at 1.3 billion and growing. There is also an opportunity for India to capture a larger share of the international market.

Experts are of the view that USD 150 million investments in petroleum sector creates about 10 jobs, while USD 150,000 investment in garment sector creates about 100 jobs. The textiles and apparel sector present significant employment opportunities, especially to the labour force exiting agriculture. A focus on man-made fibres, through removal of the inverted duty structure, is a first step. India also needs to focus on scale. Nearly 95% of our fabric is produced in small-scale industries, leading to a loss in competitiveness in destination markets. Largescale textile parks, providing common infrastructure and plug-and-play facilities to entrepreneurs, would make this sector competitive. The textile industry is one appropriate industry sector for India to focus its collective attention, and create a grand challenge to become the number one in the world by 2030.

2. Make India a global hub for battery technology

We should consider this grand challenge in the context of making India a global electric vehicle hub. IIT Madras, having expertise in battery technology through centres like Centre for Battery Engineering[72] and Electric Vehicles and Centre of Battery Engineering, should take lead in setting up a multi-disciplinary centre with cross-functional teams to promote long-term R&D and commercialization in various aspects of EV technologies.

- We need to invest in basic research, tools, and processes in multi-disciplinary areas such as chemistry, nanostructures, atomic layer depositions, microscopy, electrochemical reactions at micro or even nano-level, cell construction design for safety, life, cost, thermal management, hydrogen fuel-cells, new battery-chemistries (with higher specific energy and energy densities), battery materials and power-electronics etc.
- From a battery technology perspective, the strategy would be to use battery chemistry with optimized cost and performance at Indian temperatures and conditions of dust, flooding, humidity, etc. We need to build on initiatives like the transfer of Indian Space Research Organization (ISRO) lithium-ion technology to industries for development of electric vehicles. We also need to work on Ultra Capacitors, new designs which will have lower-life and hence lower cost, offer higher charge rates, and higher energy densities.
- While it is important to secure mines which produce materials like lithium, manganese, nickel, cobalt and graphite, India must also obtain these battery materials through recycling of used batteries and should aim to become a leader in "urban mining" of used batteries and set up a thriving Lithium-ion battery recycling industry[73].
- The centre should also research into the demand-side management including dynamic electricity pricing, and vehicle-to-grid technology for use of EVs.
- The centre should create data – by testing cells from all sources and maintaining a database, similar to what National Renewable Energy Laboratory (NREL)[74] does. Such data will help in creating better algorithms for prognostics, increasing battery life / performance.
- Motors & power conversion devices (DC-DC(direct current) converter / inverter) that provide uniformly high efficiency over the entire operating region.
- Target building a Lab where 40%-50% of its instruments and machines are built by the Lab itself.

71 http://mofapp.nic.in:8080/economicsurvey/pdf/001-031_Chapter_01_ENGLISH_Vol_01_2017-18.pdf
72 http://www.cbeev.in/
73 https://niti.gov.in/writereaddata/files/document_publication/EV_report.pdf
74 https://www.nrel.gov/transportation/blast.html

SANGAM 2019

Reimagining India in 2030

Nurturing a Global Innovation and Entrepreneurship Ecosystem

IIT Madras Alumni Association
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REIMAGINING INDIA IN 2030

itihaasa
Research and Digital

India needs to enable technology-led innovation in all sectors of its economy and scale-up its entrepreneurial spirit in order to achieve its aspiration of becoming a 10 trillion-dollar economy by 2030.[1]) Innovations especially in emerging technologies that the industry can create and absorb. India must focus on developing indigenous national innovation capability (intent, investment and innovation infrastructure); 2) Entrepreneurial activity that builds solutions and products based on these innovations is an important engine of growth. While we have managed to nurture an active start-up ecosystem, we need to create more deep-tech startups in the country, that are built in India for the world. We also need to create more startups that solve India-specific challenges helping the next billion users and the under-served in India; 3) Despite all its potential, the Indian start-up ecosystem only employs a million people. In order to provide massive employment opportunities, we need to focus on nurturing social and micro-entrepreneurship in the hinterlands of India.

Objectives

- India should move up from the current 52th position to top 10 in the global innovation index by 2030[1]. India must focus on developing indigenous national innovation capability, especially to leverage emerging technologies.
- With more than 20,000 startups, India has become the third largest entrepreneurship ecosystem[2]. India should aim to become the world's largest startup ecosystem by 2030.
- Create 12 to 15 million jobs each year for the next decade, with a special focus on social and micro-entrepreneurship

1 https://www.globalinnovationindex.org/gii-2019-report
2 https://home.kpmg/in/en/home/insights/2019/01/startup-landscape-ecosystem-growing-mature.html

Current Situation

Innovation

India requires technology led innovation in all sectors of its economy to achieve its aspiration of becoming a 10 trillion-dollar economy by 2030.

52

Rank in Global Innovation Index Delete (GII)

For India to become 10 trillion USD economy by 2030, while the current GDP is 2.7 trillion USD[3], is possible only through massive technology led innovation in all sectors of the Indian economy. Investments made in R&D may have a positive correlation with the innovation and creation of new technologies. India spends 0.88% of the GDP for R&D, which is much less, compared to China which spends2%. Not surprisingly, annual GDP growth rate of China averaged 9.5% for the past three decades from 1989 to 2019[4]. China sets an exemplar in showing higher growth possibilities for heavily populous economies[5]. China is ranked 14 among 129 countries in the Global Innovativeness Index (GII)[6]. India is ranked 52. India's rank has been improved from 81 in 2015 to 52 in 2019.

India has undertaken several key innovation initiatives in this "Decade of Innovations".

India has realized the importance of innovation and declared 2010-2020 as the "Decade of Innovations"[7].The government, public and private sector organizations are increasingly adopting innovation led models. There are various initiatives to spread the innovation mind-set across all key sectors for continued growth. These include the Atal Innovation Mission from NITI Aayog and National Innovation Foundation – India by Department of Science and Technology[8,9]. Let us look at some specific sectors

3rd

India is currently a distant third globally in AI research

Artificial Intelligence (AI) has emerged as the leading technology in software today. China – one the current leaders in AI – has a total spending of USD 12 billion on AI systems in 2017. It is estimated that it will grow to at least USD 70 billion by 2020[10]. According to a White House report, China publishes more journal articles on deep learning (a cutting-edge domain of Machine Learning the powers AI) than the US and has increased its number of AI patents by 200%[11]. China is determined to be the world leader in AI by 2030. There is almost a war like scenario between the USA and China on the AI turf. India is currently a distant third in AI research[12]. We are now in the midst of trying to develop a horizontal capability in AI that has so far been dominated by the USA and China.

3 https://www.indiabudget.gov.in/budgetspeech.php
4 https://tradingeconomics.com/china/gdp-growth-annual
5 https://www.pwc.in/assets/pdfs/publications/2015/innovation_driven_growth_in_india_final.pdf
6 https://www.globalinnovationindex.org/gii-2019-report
7 http://nif.org.in/foin-2017
8 https://niti.gov.in/content/atal-innovation-mission-aim
9 http://nif.org.in/
10 https://www.forbes.com/sites/steveandriole/2018/11/09/artificial-intelligence-china-and-the-us-how-the-us-is-losing-the-technology-war/#387225086195
11 https://obamawhitehouse.archives.gov/sites/default/files/whitehouse_files/microsites/ostp/NSTC/preparing_for_the_future_of_ai.pdf
12 http://www.itihaasa.com/pdf/itihaasa_AI_Research_Report.pdf

Biotechnology is an important technology domain that many policy experts believe is the technology for the 21st century. Among scientific departments, the Department of Biotechnology (DBT) already had a good track record of supporting innovation and changing its innovation strategy to match the evolution of the domain[13]. In its initial years in the 1980s, the DBT supported creation of infrastructure and research capabilities by sponsoring the formation of biotech departments in leading universities given that biotechnology is research intensive. In the 1990s, there was a focus on industrial research and commercialization, and creating the foundation for a strong industrial base in biotechnology. The DBT adopted proactive practices that have improved its success in creating and adopting emerging technologies in the biotechnology domain. These are (1) providing researchers' incentives to experiment (2) supporting a diverse the talent pool for product innovation (3) encouraging bi-directional knowledge flows between R&D and production / market (4) integrated policy making and coordination between all Government organizations.

New Millennium Indian Technology Leadership Initiative (NMITLI) was launched in 2000 and administered by CSIR[14]. The objective was a by-invitation research funding for projects in areas that are relevant to India and where India had some demonstrated research capabilities. One success from NMITLI in the 2000s was Bharat Biotech International Ltd.'s molecule targeted at methicillin-resistant staphylococcus aureus bacterium that causes difficult-to-treat infections.

Innovations for the next billion – India has had some good success stories in innovation that benefits all its citizens including the next billion and the under-served. In healthcare, Aravind Eye Hospital and Narayana Health provide excellent services comparable to that of developed countries at a fraction of the cost. The Jaipur Foot is a product innovation in the healthcare domain. This is again a solution comparable to the best in the world at a fraction of the cost. Jan Dhan Aadhar and Mobile are being used innovatively by the Government to empower the next billion in India. NPTEL/SWAYAM is an India wide revolution in Massive Open Online Courses (MOOCs) that aims to bring higher education literally to the hands of all Indians.

13 http://jugaadtoinnovation.blogspot.com/2013/01/policy-makers-can-influence-climate-for.html
14 https://www.livemint.com/Companies/4NQHz5XgOZ96PRAJq7dxmM/India8217s-top-innovation-fund-slated-for-expansion-make.html

Table 1: Innovation, Universities, Government and Startups

Category	Innovation	Value
Healthcare	Arvind Eye Hospital: Process innovation	World's largest and most productive eye care facility. Standardized operations and patient care. High quality and low cost. Savings of 40 to 60x compared to similar solutions in the USA[15].
	Narayana Health: Process innovation	Achieved operations excellence in cardiac care through process innovation and economies of scale. Ultra low-cost frugal innovation. Savings of 8 to 100x based on similar solutions in the USA[16].
	Jaipur foot: Prosthetic knee: Product innovation	Inexpensive high-performance artificial knee. Cost of prosthetic foot cost is 400x cheaper than that of a similar solution in the USA[17].
Governance	Jan Dhan, Aadhaar and Mobile (JAM): Direct Benefit Transfer	1.2 bilion bank accounts. 1 billion Aadhaar and 900 million phones[18].Curbing leaks in public programs saved INR 830billion[19].
	Passport Seva: Digitization	Digitization of passport application process has significantly reduced the processing time. By 2017, 82% of the passports are issued within one week and 97% within 3 weeks.
Biotech	CSIR NMITLI Bharat Biotech: Drug targeting methicillin resistant bacterium	Molecule targeted at staphylococcus aureus bacterium that causes difficult-to-treat infections.
Education	NPTEL/SWAYAM: Largest repository of online courses	Online courses on Engineering, basic science and humanities. High quality content delivered by IIT and IISc faculties bridge the knowledge gap.
Deep technology	Centre For Innovation IIT Madras: Agricopter	Spraying pesticides ten times faster and with 100% precision at the same cost as manual spraying[20]. Farmers do not need to touch the pesticides. Multispectral camera for assessing crop health.
Transport	Ather: First indigenously built smart e-scooter	IIT-M incubated[21]; High capacity, fast charging e-scooter; Innovation combines mechanical, computer science and battery technologies.

15 https://iovs.arvojournals.org/article.aspx?articleid=2266507
16 https://www.businesstoday.in/magazine/cover-story/biggest-india-innovation-narayana-health/story/205823.html
17 https://news.stanford.edu/pr/2009/pr-limbs-041509.html
18 https://www.livemint.com/Politics/PRmaclHkzL6fGJEUIVLo3H/India-has-started-linking-Jan-Dhan-scheme-Aadhaar-and-mobil.html
19 https://economictimes.indiatimes.com/industry/banking/finance/banking/savings-from-direct-benefit-transfer-pegged-at-rs-83000-crore/articleshow/63423528.cms
20 https://www.livemint.com/education/news/iit-students-develop-agricopter-to-eliminate-manual-spraying-of-pesticides-1563803706161.html
21 http://www.incubation.iitm.ac.in/portfolio/all-startups

Research Parks have emerged as a new innovation capability nurturing mechanism.

India is also witnessing the emergence of a new innovation capability nurturing research parks situated in an academic institution like the IIT Madras Research Park[22]. This is modelled on successful similar organizations like the famous Stanford Research Institute. The main objectives of the IIT Madras Research Park are to develop an innovation capability and to transfer basic research into applications that can be commercialized. IIT Madras Research Park creates a collaborative environment between industry and academia through joint research projects and consulting assignments. It nurtures a self-sustaining and technologically fertile environment that aligns R&D to potential needs of the industry. The IIT Madras Research Park also facilitates the development of high quality and technology competent workforce. This is by providing opportunities for their students to work in the companies in the park and encouraging the employees of the companies in the park to enrol in part time Masters and PhD Programs.

Entrepreneurship Ecosystem

India has a vibrant startup ecosystem comprising 20,000 startups, 270 incubators and accelerators, 200 venture capital firms, 231 angel investors and 8 angel networks.

The current startup ecosystem comprises 20,000[23] startups, 270 incubators and accelerators, 200 venture capital firms, 231 angel investors and 8 angel networks[24]. The number of startups in India grew by 12-15% annually between 2013 and 2018[25].

Startups are widely recognized as the new wave of innovation and entrepreneurship in India[26]. Startups are one constituent of the entrepreneurship ecosystem. Essential components of the startup ecosystem includes, availability of funding organizations to support startups at different stage of life-cycle such as angel investors, and venture capitalists; availability of supporting organizations such as incubators, accelerators and mentors, entrepreneur friendly Government policies and regulation.

Government has launched Startup India initiative in 2016 to promote growth in entrepreneurship by nurturing innovation. As part of the startup action plan in 2016, Government established INR 100 billion in funds under Small Industries Development Bank of India (SIDBI). A targeted focus towards the development of innovative infrastructure, reduction in regulatory barriers and creation of funding sources, has registered an impressive growth in startup ecosystem. India ranked as third largest startup ecosystem in the world[27].

Startups are also seen as an engine of job growth in India. As per Department for Promotion of Industry and Internal Trade (DPIIT), startups have created about 180,000 direct jobs in India[28] and about 40,000 jobs in 2018. Indian startups have created highly efficient jobs and by shifting the jobs to formal sector startups have tried to reduce the vulnerabilities and risks present in the informal sector[29].

82%

Tier-1 and Tier-2 cities account for 82% of the startups

Two-thirds of the startups are concentrated in the metro cities. Tier-1 and Tier-2 cities account for 82% of the startups[30]. Bangalore continued to be the leader in terms of number of startups. With the presence of global technology talent pool, strong investor base Bangalore has become the hub for innovation. Bangalore was also the home for successful tech startups. Other metro cities New Delhi and Mumbai also started gaining traction in the recent years. As per a 2018 CB Insights report titled “Global Tech Hubs” recognized Bangalore, Mumbai, New Delhi among the top 25 global tech hubs[31]. Due to the high concentration of startups and funding organizations in the metros and state capitals, funding opportunities are limited to larger cities. Proportion of funded startups in smaller cities is very low[32].

22 http://respark.iitm.ac.in/
23 https://home.kpmg/in/en/home/insights/2019/01/startup-landscape-ecosystem-growing-mature.html
24 https://www.startupindia.gov.in/content/dam/invest-india/compendium/Startup%20India%20-%20National%20report_Final%20Version_web.pdf
25 https://www.nasscom.in/knowledge-center/publications/indian-tech-start-ecosystem-2018-approaching-escape-velocity
26 https://www.indiainnovates.in/pdfs/SecondImpactAnalysisReportIIGP.pdf
27 https://niti.gov.in/writereaddata/files/Strategy_for_New_India.pdf
28 https://economictimes.indiatimes.com/small-biz/startups/newsbuzz/one-startup-recognised-every-hour-in-may-dpiit-secretary/articleshow/69654419.cms
29 Inspiration and Momentum for the Gladiators, Ynos 2016, https://www.ynos.in/thought-leadership#!#1
30 https://www.startupindia.gov.in/content/dam/invest-india/compendium/Startup%20India%20-%20National%20report_Final%20Version_web.pdf
31 https://www.cbinsights.com/research/report/global-tech-hubs/
32 https://www.thehindubusinessline.com/specials/emerging-entrepreneurs/the-home-run-from-venture-launch-to-exit/article26176333.ece

However, India has only few deep-tech startups.

The number of information technology powered startups is more than 50% of the total startups in India[33]. The information technology domains include e commerce, enterprise software, fintech, healthtech, etc. Deep information technology startups offer advanced engineering innovation, substantial scientific advancements and discoveries. Deep information technology startups use advanced technologies such as AI, Machine Learning (ML), robotics, big data, Augmented Reality / Virtual Reality (AR/VR), blockchain technologies, etc. As of 2018, Over 1200 advanced technology startups were operating in India, including AI[34]. These startups have started penetrating into smaller Indian towns and developing innovative solutions to solve the problems that are unique to the Indian context[35].

1.45%

Deep information technology startups received 1.45 % of the total startup funding received during first quarter of 2019

Deep information technology startups need specialized capabilities, larger seed capital, and longer time period to commercial success. Despite the strategic importance of India to build a capability in emerging technologies, deep information technology startups in India are not adequately funded. Deep information technology startups received 1.45 percentage of the total startup funding received during first quarter of 2019[36]. Lack of availability of a high-skilled workforce is one of the main reasons why there are few deep tech startups in India.

The VCs, incubators, accelerators and academic incubators play a critical role in nurturing the entrepreneurial ecosystem.

USD 4billion

Startup funding in 2018 almost doubled to USD 4billion

Increase in the number of startups coupled with attractive return has fuelled the growth of VC firms and angel investors. Startup funding in 2018 almost doubled to USD 4billion from USD 2.1 billion in 2017[37].Despite the high growth, the number of funded startups remains to be low. Foreign capital dominated the total investment received by Indian startups. Based on estimates, about 90% of VC funds in India are of foreign origin[38]. Till about 2012, this used to be as high as 98%.

Incubators play vital role in the development of startup ecosystem by providing business, technology and infrastructure support. Accelerators on the other hand are mentorship driven which facilitate the startups to move from concept stage to prototype development, fundraising and attaining consumer growth. Incubators and accelerators are predominantly managed by academic institutions, government, and large companies both Indian and MNC. About 50% of India's incubators are run by academic institutions and are of strategic importance[39].

Academic incubators identify entrepreneurs early on in their careers and also provide a fostering environment to build indigenous technology capability. A good example is the IIT Madras Incubation Cell (IITMIC) is a technology business incubator fostering excellence in innovation and entrepreneurship at IIT Madras. IITMIC focuses on startups in Biotech, Healthtech, Hardware and Software domains. IITMIC provides support for students, faculties, alumni of IIT Madras and external R&D partners of IIT Madras in successfully creating deep tech startups and disruptive industries. IITMIC is the India's leading deep tech startup hub, 186 deep tech startups incubated from IIT Madras[40]. Rural Technology Business Incubator is part of the IITMIC ecosystem, which leverages the world class R&D infrastructure to solve the complex rural problems related to power, water and education[41].

33 https://www.nasscom.in/knowledge-center/publications/indian-tech-start-ecosystem-2018-approaching-escape-velocity
34 https://home.kpmg/in/en/home/insights/2019/01/startup-landscape-ecosystem-growing-mature.html
35 https://yourstory.com/2019/04/these-deep-tech-startups-are-penetrating-deep-and-
36 https://inc42.com/datalab/can-innovation-alone-fund-deeptech-startups/
37 https://www.ynos.in/thought-leadership#!#1
38 https://www.thehindubusinessline.com/specials/emerging-entrepreneurs/the-look-and-feel-of-the-indian-vc-fund/article9844564.ece
39 https://www.nasscom.in/knowledge-centre/publications/incubators-accelerators-driving-growth-indian-start-ecosystem-2017
40 http://www.incubation.iitm.ac.in/home
41 http://www.incubation.iitm.ac.in/about-us/ecosystem

Micro and Social Entrepreneurship

MSMEs are a significant employment generator in India.

38%

Micro Small Medium Enterprises (MSME) sector 38% of the country's GDP

The Micro Small Medium Enterprises (MSME) sector in India employs nearly 120 million people with 58 million entrepreneurs and entities - like small entrepreneurs, small manufacturing units, shopkeepers, fruits and vegetable sellers, hair salon, beauty parlours, truck operators, hawkers, artisans in rural and urban areas. This sector contributes 38% of the country's GDP, 45% of the manufactured output and 40 % of its exports[42].

If India is to achieve its aspiration of becoming a 10 trillion-dollar economy by 2030, it needs to create about 12 million jobs each year for the next decade, with a special focus on social and micro-entrepreneurship. MSMEs in India provide employment mostly in the rural areas of the country, making it the largest source of employment after the agricultural sector. They develop economies at the local level– especially providing jobs and livelihood opportunities to the lower economic strata of the society.

MSMEs create societal impact and value-addition at the local level.

MSMEs bring maximum value addition at the local level. In this way, MSMEs directly contribute to various socio-economic Sustainable Development Goals (SDGs), like SDG 1 (No poverty), SDG 8 (Jobs and growth)and SDG 10 (Reduce inequalities).By developing basic needs service delivery models in rural areas, MSMEs have the potential to contribute to SDG 6 (Water for all) and SDG 7(Energy for all), among others[43].

120 million

MUDRA Yojana beneficiaries

It was in this context that the Government launched Micro Units Development & Refinance Agency Limited (MUDRA) and Pradhan Mantri MUDRA Yojana (PMMY) on 08 April 2015. The guidelines of PMMY issued by Department of Financial Services (DFS), indicated that all banks are required to lend to micro enterprises engaged in manufacturing, processing, trading and service sector activities, for a loan upto INR 1 million. According to government estimates, MUDRA Yojana has given INR 6000 billion to 120 million beneficiaries since April 2015. Out of the 120 beneficiaries, 28 per cent or INR 32.5 million are first-time entrepreneurs; about 74 per cent or 90 million borrowers are women and 55% belong to the SC/ST and OBC category[44].

42 Performance of MUDRA Bank: A Study of Financial Assistance to MS
43 MSMEs: Engines to Achieve Sustainable Development Goals https://www.devalt.org/images/L2_ProjectPdfs/MSME_Policy_Brief.pdf
44 Economic Times, May 2018, http://bit.ly/2Zh416GME Sector, 2015, http://euroasiapub.org/wp-content/uploads/2016/09/22ESSJuly-2446-1.pdf

Constraints

Innovation

India suffers from low R&D spending.

0.7%

R&D spend to India's GDP

Low R&D spending in India is a major challenge faced by innovation ecosystem. India's investment in R&D has shown a consistent increasing trend over the years. However, it is a fraction of India's GDP, it has remained constant at around 0.6% to 0.7% of India's GDP[45]. This is below the expenditure of countries like the US 2.8%, China 2.1%, Israel 4.3% and South Korea 4.2%. Government expenditure, is the driving force of R&D in India which is in contrast to the advanced countries where private sector is the dominant and driving force of R&D spends. There is a need for greater participation of private sector and philanthropy in overall R&D spending in India especially in innovation and application-oriented R&D[46].

Horizontal and advanced technology development is difficult for India

Apart from increased R&D spend, India needs to answer two fundamental questions on innovation especially with respect to emerging technologies. (1) Are current Indian organization structures and processes for creating and adopting emerging technologies inimical to advanced technology development? (2) Is India intrinsically better in vertically integrated mission mode technology projects compared to developing a horizontal capability in technologies?

Vertically integrated projects are run as a national priority, top-down from the highest levels in the government with committed and generous funding. Usually one dominant government technology organization is responsible the end to end delivery of vertically integrated programs. Most often, the technology developed in these programs are not for mass production. Some examples of vertically integrated projects include satellites for remote sensing and communications, nuclear energy, missiles technology, etc.

On the other hand, developing a capability in a horizontal family of related technologies and applications is spread across different organizations (universities, government labs and departments, industry, and startups). This implies that India needs a strong capability in Pasteur's quadrant which is application inspired basic research[47]. India has traditionally had a limited success in developing a capability in a horizontal family of technologies and applications.

Entrepreneurship Ecosystem

A study on "Entrepreneurial India" by IBM institute and Oxford Economics found that more than 90% of the Indian startups fail within the first five years[48]. The report highlighted lack of innovation as the major reason for the failure of startups. There is a strong need to promote technical innovation, ease of regulatory policies to address these challenges.

45 http://pib.nic.in/PressReleaseIframePage.aspx?PRID=1580049
46 https://tech.economictimes.indiatimes.com/news/technology/india-needs-to-budget-for-research-funding/56903468
47 Pasteur's Quadrant: Basic Science and Technological Innovation, Donald E Stokes, Brookings Institution, 1996
48 https://www-03.ibm.com/press/in/en/pressrelease/52424.wss

India faces challenges with the lack of depth and foreign-capital nature of venture funding available, and geographic concentration of startups present in the country.

Availability of funding is a challenge for Indian startups. A large proportion of startups in India are still struggling to find seed and venture capital partners[49] [50]. Foreign capital dominates the total investment made in the Indian startups. While foreign capital is good to have, over-reliance on foreign capital poses challenges to the startup ecosystem where technologies and solutions relevant for India's next billion may not find favour. Funding especially seed funding can be cyclical, like the decline in the seed funding from 2016 to 2018[51] in India.

The foreign funds tend to focus more on Indian consumption story which is largely urban India focused. Indian startups focused on the next billion or indigenous technology innovations often find it difficult to raise funds from VCs. Only Indian funds with a deep understanding on nurturing Indian technology and innovation capability will be willing to bet on the next billion and indigenous innovations. The silver lining is that Indian HNIs, Indian family offices, and Indian entrepreneurs are turning VCs. India needs to develop Government regulations and financial intermediaries to channel investments from domestic markets to fund the startups. The INR 100 billion Fund of Fund for Startups program by the government in association with SIDBI is in the right direction[52].However, it has failed to achieve its targets for fund allocation by 10 billion in 2018-19[53]. This points to gaps in the ecosystem between the government, investors, incubators/accelerators and entrepreneurs. One significant gap is the inability of incubators to produce startups that will be attractive to investors.

The funding is largely skewed towards the metro cities, where there is a better chance of obtaining funding. Startups from major metros Bangalore, NCR and Mumbai have a significant chunk of funding[54]. Startups in rural areas also need to get a good startup ecosystem in including funding options so that India fosters inclusive growth in the entrepreneurship ecosystem.

5-8%

investability of startups coming out from incubators in emerging markets

Further, incubators are being setup indiscriminately without actually being equipped to provide the right kind of support needed. Incubation in India needs to move from a mentor-driven approach to a process-driven approach, if it needs to flourish in Tier 2/3 cities where mentors are few and far between, and if it wishes to scale. The current rate of 'investability' of startups coming out from incubators in emerging markets is 5-8% as compared to the global best of 50-80%[55].

Startups in India predominantly focus on problems that cater to the urban customers and do not focus on India-specific problems especially for the next billion users and the under-served in India.

According to the Economic Survey 2019, majority of the Indian startups are concentrated in the e-commerce, food tech and services domains[56]. Startups in these sectors are predominantly serving an Indian urban customer base. Studies suggest that tens of e-commerce companies are enough to serve the Indian market while there are more than 800 startups in online retailing[57]. Too many startups mushrooming in the same sector will create hyper competition, makes them unattractive to investors and result in market saturation. There is a need to create vibrant startup ecosystem, diversified into various sectors.

49 https://www.thehindubusinessline.com/companies/low-proportion-of-startups-get-funding-in-india-report/article9310193.ece
50 https://economictimes.indiatimes.com/small-biz/startups/newsbuzz/problem-of-plenty-only-for-big-startups-rest-still-struggling-for-funding/articleshow/63497367.cms?from=mdr
51 https://www.nasscom.in/knowledge-center/publications/indian-tech-start-ecosystem-2018-approaching-escape-velocity
52 https://economictimes.indiatimes.com/small-biz/startups/newsbuzz/254-startups-get-rs-1700-crore-investment-from-afi/articleshow/70361038.cms
53 https://timesofindia.indiatimes.com/business/india-business/startup-india-fund-falls-short-of-allocation-target-by-over-rs-1000cr/articleshow/69920174.cms
54 https://www.yesbank.in/pdf/indias_startup_landscape.pdf
55 https://www.unitus.vc/wp-content/uploads/2015/10/Unitus-Seed-Fund-2015-Global-Best-Practices-Survey-of-Incubators-and-Accelerators.pdf
56 https://www.indiabudget.gov.in/economicsurvey/
57 https://www.entrepreneur.com/article/334044

Startups should address the real problems faced by India and promote indigenous innovation rather than only copying business models and technologies from elsewhere. There link between research in universities and startup companies is just emerging in India. A strong link between the research and startups to commercialize the research is imperative to develop indigenous innovation. This is also an area where incubators and accelerators can play a more important role. There should be a better geographical spread of incubators and accelerators in India, and not concentrated in the metro cities. This will make the startup ecosystem become more inclusive.

Another challenge faced by India is the slow pace of growth in number and funding received by deep technology startups in India. This has strategic importance for India. For example, robotics is another area where India has a negligible presence. There are also India specific robotic applications like cleaning septic tanks. The SEPoy Septic Tank Robot from IIT Madras is one such deep technology innovation[58]. China on the other hand, accounts for 40% of the global robotics market[59]. The demand for industrial and consumer robots will increase significantly in the next decade.

Micro and Social Entrepreneurship

MSMEs suffer from lack of skilled labour and affordable financing.

4%

small business units have access to bank loans

Most of these micro-entrepreneurs work in unorganized sectors and lack in business, marketing and technological skills, and easily available & affordable finance to start and scale their business. Just 4% of the 58 million small business units have access to bank loans and rely on informal lenders for costly credit. Due to inadequate capital and knowledge, entrepreneurs in rural and semi-urban areas have limited market access and often unable to take risks.

The MUDRA loan program faces the challenges of low loan ticket-size, geographic exclusion and a relaxed NPA monitoring mechanism.

70%

70% of the total disbursals under the MUDRA scheme is concentrated in 10 states

An analysis of the MUDRA loans disbursement reveals the following challenges: 1) 80 per cent of MUDRA loans by PSBs fall in the Shishu category (< INR 5,000). Small ticket business loans are a relatively high-risk category and typically a bank would not lend to this segment at base rate, as governed by an RBI mandate2) Over 70 per cent of the total disbursals under the MUDRA scheme is concentrated in 10 states, while the backward states, especially North Eastern states lag far behind. Economically backward states need such schemes the most. 3) According to different estimates, gross non-performing assets arising out of Mudra loans vary between 4 and 15 per cent and a strict monitoring of NPAs is required

58 https://www.thehindu.com/news/cities/chennai/coming-soon-a-robot-to-clean-septic-tanks/article26649772.ece
59 https://economictimes.indiatimes.com/small-biz/startups/newsbuzz/the-policy-hack-whats-stopping-industrialrobots/articleshow/65729206.cms?from=mdr

Way forward

Innovation

1. Increase R&D funding and change its contribution mix.

- In the coming decade, India should develop technologies for all the sectors by promoting indigenous innovation on a massive scale. India should simultaneously pursue indigenous R&D driven innovation. This must be accompanied by ramping up investment in R&D to about 2% of GDP in the next two to three years. The ultimate goal in the decade should be to increase R&D spend to more than 3% of GDP.

- India is at a point in history where private funding can supplement government funding in research, this can come even from philanthropy. For this, government must provide tax incentives to private philanthropic investments in research. This is also a time to tweak the current rules on corporate social responsibility that mandates that 2% of average net profit be spent on specified social activities. Instead, 1% of such funds can be used to fund research that shapes our future.

2. Create new institutional models for managing national innovation capability development.

Creating a capability in emerging technologies involves creating new models for managing this activity in a given institutional context. India has excellent institutions like the IITs and the IISc as well as other national laboratories. We have access to world class talent in technology research both in India and the diaspora. Our technology policy must ensure we chose domains that are at the intersection of our foundational strengths and national priorities. Coupled with a goal-oriented plan for execution, such a model can help create multiple indigenous innovations and least one new world class industry in the next decade.

- The government is placing a greater emphasis on collaborative R&D by the public sector enterprises with focus on partnerships with IITs. The public sector enterprises have been encouraged to set up innovation cells which will work on market-oriented research. The IITM Research Park model[60] enables strong collaboration between industry and research which is the crucial driver for the innovation. This model needs to be replicated in several parts of the country. IIT Madras should provide a mentoring role to these research parks till they reach a critical scale. The government also has plans to set up a National Research Foundation (NRF) with an aim to catalyse and energise research and innovation across all academic disciplines, particularly at the university and college levels[61]. IIT Madras in collaboration with its alumni could also introduce courses on corporate innovation.

- India should learn from and contextualize from the best practices elsewhere like the ARPANET project in the USA. Perhaps the most exemplar project that innovated with emerging technologies is the ARPANET project of ARPA (Advanced Research Projects Agency) which was an organization in the USA's Defense Department. ARPANET exists today as the Internet, the technology that has impacted the world like no other in the 20th and 21st century. The original objective of ARPANET was to provide the US military a robust fault tolerant computer network that would survive an attack. The team of organizations in universities, government and industry came together and develop a technology that survived for more than half a century and still going strong. It provided the USA with a competitive advantage in information technology sector and all other industrial sectors that were disrupted by information technology.

Entrepreneurship Ecosystem

Developing a more vibrant entrepreneurship ecosystem is ecosystem is essential to become the largest. All actors in the entrepreneurship ecosystem need to act in synergy with one another. This is essential to deepen and broaden the entrepreneurship ecosystem.

60 IITM Research Park, http://respark.iitm.ac.in/
61 National Research Foundation to boost research, innovation, The Hindu Business Line, Jul 2019, http://bit.ly/2LJZzKE

3. Create a culture of contribution, creating public goods and paying forward.

This includes common assets, shared infrastructure, common know-how, advocacy and creating common capabilities. Common assets include physical assets such as workshop and co-working spaces and financial assets like new savings and loan funds for innovators. Shared infrastructure includes communication infrastructure, relationship infrastructure such as new networks and linkages between actors in the ecosystem. Common knowhow includes new information on technology, products and markets, training a workforce with enhanced skills specific to certain industry and innovation niches and capacity building for startups and incubators and accelerators. Advocacy for local innovation - including changes in norms and rules, and policies to create a more level playing field. New capacities within the system include scaling production and distribution, and training a large pool of workforce. The various programs already started in India should be smoothly connected and training to the managers of the programs should be institutionalized, possibly with trainers with entrepreneurial/investor backgrounds.

4. Adopt an incubator and accelerator led funding model in the seed stage.

Startups giving good financial returns lead to an increased availability of funding. India probably needs an incubator and accelerator led funding model in the seed stage. Investors should support incubators and accelerators especially those not in the Indian metros. Incubators and accelerators in India will provide technical support and facilities for the creation of more startups and more startups that meet the criteria for funding by angels and VCs. This has led to the creation of 'virtuous cycle' in the Indian startup ecosystem. This cycle needs to be continuously expanded and sustained for India to become the world's largest ecosystem by 2030.

5. The IIT Madras Alumni Association should enable Indian entrepreneurship ecosystem to work closely with other global ecosystems.

It should be easy for startups to leverage talent and technology from across the globe. The Indian startup ecosystem should learn from the best practices from other global entrepreneurship ecosystems. The IIT Madras Alumni Association and other leading Indian alumni associations can play a catalyst role to connect the Indian ecosystem with the Silicon Valley ecosystem including access to the global support community/network for startups, investors and incubators/accelerators that make it easy for our startups to expand to global markets for growth. Some of the best practices that the Indian entrepreneurial ecosystem can imbibe, over a long period of time, from the Silicon Valley ecosystem include nurturing world-class technology capability, managing hyper growth, deep product management expertise, connect with global markets, strong culture of mentorship, angels and VCs who have a wide range interest, etc. The IIT Madras alumni have an opportunity to help create such an environment in India & establish a global entrepreneurship bridge.

6. Government of India should develop procurement mechanisms for accepting single-vendors in specialized cases.

In case of disruptive technology, coming out of cutting-edge research from the IITs, typically we have only one vendor or startup coming from the IITs that provides the technology. Examples from IIT Madras include startups in the space of arsenic removal using nanotechnology, and off-grid electrification. Government is an important buyer for such technologies. But their processes typically require more than one vendor. Government should consider alternate mechanisms to procure from such vendors and startups with unique technology. Further the Government should develop mechanisms to interface directly with such startups rather than engaging with the IITs from which the startups originate.

7. IIT Madras should set up a 'Women in Science & Tech' Entrepreneurship Program.

This program should provide specialized and structured incubation and mentorship support to women scientists and engineers in building and taking to market deep-tech solutions. This program will have a pan-India focus and will be hybrid (online and a strong offline support mechanism). IIT Madras is uniquely well positioned to run such a program and will leverage its expertise in groups like the IIT Madras Incubation Cell, National Programme on Technology Enhanced Learning (NPTEL) and Gopalakrishnan-Deshpande Centre.

Micro and Social Entrepreneurship

In rural communities, a huge mismatch exists between demand (targeted beneficiaries) and supply (formal banking system) side which leads to poor credit services. The reasons could be unavailability of quality

human resources, poor asset availability, lack of skills, etc. An infrastructure in the form of institutions working solely on entrepreneurial skill development of small industries/enterprises and infrastructure for enterprise development should be setup address this demand-supply gap.

8. Establish 100 Micro-entrepreneurship Centres over the next 3-5 years.

The centres should nurture entrepreneurs from rural and peri-urban areas at the bottom of the pyramid. It should be localized – support 5 to 6 districts surrounding a centre with each centre supporting 0.8 million to 1 million entrepreneurs. The centre assists with managing local distribution of online content, and providing mentorship, marketing and business advice in order to scale up – like how to improve business by regularly maintaining accounts, file tax, how a margin can be set, how to approach a client, set targets, workmanship, costing etc. We could model this infrastructure on the Navodyami[62] program of the Deshpande Foundation. Global Alliance for Mass Entrepreneurship (GAME) is another model aiming to create 50 million jobs (micro and social entrepreneurship) by 2030[63].

9. Encourage women social and micro-entrepreneurship especially in the light of the falling Female Labour Force Participation (FLPR) rates in India.

As of January 2018, 106 million loans had been sanctioned under the MUDRA scheme and nearly 75% of all the loans under MUDRA were to women. In order to encourage women entrepreneurs, the financing banks / Microfinance Institution (MFI) may consider extending additional facilities, including interest reduction on their loans (e.g. extending MUDRA loans Women Enterprise Program).

In multiple studies, it has been found that cash and asset transfers to female-headed households where recipients survive on less than USD 2 per day benefits women when such transfers are accompanied with training[64]. Offline and online content for training women entrepreneurs in villages, Tier 3 and Tier 2 towns should be available all Indian languages.

Since 2016, IIT Madras has been involved in a unique effort[65] to nurture micro women entrepreneurs. The objective of this exercise is to use education and training to enhance the credit worthiness of women entrepreneurs. In three batches, close to 250 micro women entrepreneurs from Kanchipuram and nearby villages have participated in the program. About 50% of the participants have been able to successfully secure credit from banks and financial institutions for the growth of the businesses.

10. A growth in 'platform' players leads to growth of micro-entrepreneurship.

The Government should view the new platform ecosystem as the new 'mass-manufacturing' engine of the 21st century66. The platforms are in the form of e-Commerce marketplaces (like Amazon, Flipkart), transport (like Ola, Uber), food delivery (like Swiggy), logistics (like Delhivery) and other areas. These platforms provide common services like customer acquisition, logistics, and payments and reduce barriers like significant capital investments for small enterprises. Platforms thus create an ecosystem for self-employment, leading to more job creators rather than only job-seekers. The Government should frame policies in such a context of such platforms bringing a multiplier effect to jobs creation, while balancing the potential impact these platforms may have on stand-alone MSME businesses.

Grand Challenge

Build for Bharat – Nurture 1000 startups focusing on India-specific opportunities especially in the space of healthcare, agriculture and water.

Indian entrepreneurs should create innovative business models and solutions for the next billion in India. Anytime anywhere access to affordable healthcare, improve the efficiency and effectiveness of technology interventions in agriculture, and water conservation and management are critical focus areas for India in the coming decade. India needs to encourage startups in agriculture management, healthcare management and water management in the next decade. Startups operating in these domains have the difficult responsibility in developing innovative products using multidisciplinary technologies. The Government needs to provide special support to these startups in the early phase of their existence. Indian startups have the opportunity to become the world leaders in these domains given the Indian context and scale.

62 http://navodyami.org/
63 Global Alliance for Mass Entrepreneurship, Times of India, Aug 2018, http://bit.ly/2Y4Vqay
64 Women and Work in India: Descriptive Evidence and a Review of Potential Policies, Harvard University Working Paper, 2017
65 Muscle to the Mind program https://www.youtube.com/watch?v=BHCUzx7MP3E&t=11s.

SANGAM 2019

Reimagining India in 2030

Harnessing technology for Agriculture and Sustainable Living

IIT Madras Alumni Association
Reconnect • Engage • Impact

SANGAM 2019
REIMAGINING INDIA IN 2030

itihaasa
Research and Digital

Under this pillar, the report discusses the current context, constraints and suggests national objectives and technology enabled solutions to 1) Improve the efficiency of agriculture and its entire value-chain to achieve food security in India by leveraging next farming practices and Artificial Intelligence (AI) & digital technologies and 2) Harness with care the resources of water, air, & energy and manage urbanization to ensure robust economic growth with ecologically sustainable development. In both the areas of agriculture and sustainable living, we believe that it is unlikely that we can supplant Western solutions directly and we need to develop uniquely Indian solutions that carry forward both urban and rural India.

Objectives

- Adopt low cost technologies at the farm and supply chain level to transform agricultural productivity.
- Achieve universal and equitable access to safe and affordable drinking water for all
- Substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity
- Bring down particulate matter 10 and 2.5 levels in Indian cities by 30% by 2024
- Achieve economic objectives of USD 10 trillion GDP by 2030 in a sustainable manner and carrying along both rural and urban India
- Target a per capita energy consumption of around 2500 to 3000 kWh by 2030. Aim for a 40% of installed energy capacity from renewable sources.

Current Situation

Agriculture

Agriculture is the backbone of Indian economy creating job opportunities for more than 42.74% of India's population while meeting food and nutritional requirements of its 1.3 billion population.

86.2%

of total farmers are small and marginal farmers

India holds 12% of world arable land for agriculture purpose. According to the World Bank 179.7 million hectares of land is being used for agriculture purpose in India[1]. In India, 86.2% of total farmers are small and marginal farmers with land holdings of less than 1.5 hectares, accounting for owning 47.3% of total cultivable area. Globally India ranks second in farm output. India is the world's largest producer of fresh fruits and vegetables, buffalo milk, castor oil seeds, millets, major spices and various other crops. It is also the world's second largest producer of wheat, rice, sugarcane, tea, groundnuts and various other crops[2].

In India 40% of the food produced is wasted or lost annually and food waste is a big challenge to our food security.

40%

of the food produced in India is wasted or lost

Food waste is the wholesome edible material intended for human consumption, arising at any point in the food supply chain that is instead discarded, lost or degraded[3]. According to the Food and Agriculture Organisation (FAO), globally one-third of the food produced is wasted or lost annually, which is 1.3 billion tons of food, amounts to USD 680 billion in developed countries and USD 310 billion in developing countries[4]. In developed countries, 70 to 80% of food waste happens at post-harvest stages of food supply chain due to changing customer preferences and quality requirements. In India, the food wastage is even higher and it is estimated by the UN that nearly 40% of the food produced in India is wasted or lost. And this costs India one trillion rupees every year[5].

From an economic sustainability perspective, a huge amount of value is lost with food waste. There is a cost to disposal of food waste and managing the disposed waste. From environmental sustainability perspective, release of greenhouse gases such as methane from food wastes is significantly impacting the environment in addition to creating waste land and altering soil property. From social sustainability perspective, food waste reduces farmers income, labour productivity and wages, causing severe health impacts to the surrounding population when food wastes are left untreated and food availability and nutrient supply to the consumers are affected[6].

Water & Air

India is suffering from a severe water crisis and about 600 million people suffer from high to severe water stress.

45%

of the Indian population suffer from high to severe water stress

NITI Aayog acknowledged in a report[7] that the country was suffering from a severe water crisis and about 45% of the Indian population suffer from high to severe water stress. 17% of world's population lives in India, whereas it has only 4% world's freshwater resources and out of which 80% of fresh water is used for agriculture purpose. Water is one of the critical inputs for cultivation of agriculture crops, with lack of water, the crops will not yield to its full potential[8]. This is the same situation for animal husbandry as well.

1 https://data.worldbank.org/indicator/AG.LND.AGRI.K2?end=2016&locations=IN&start=1961&view=chart
2 http://www.fao.org/faostat/en/#home
3 http://www.fao.org/3/a-i2697e.pdf
4 http://www.fao.org/faostat/en/#data/QC
5 https://thecsrjournal.in/food-wastage-india/
6 https://doi.org/10.1016/j.jclepro.2017.09.028
7 "Composite Water Management Index (CWMI) a National Tool for Water Measurement, Management & Improvement", 2018, NITI Aayog
8 https://www.oav.de/fileadmin/user_upload/5_Publikationen/5_Studien/170118_Study_Water_Agriculture_India.pdf

During the 2011 census, India is listed under water deficient nations list with water availability of 1,545 m3 per person. A nation is said to be water deficient if the water availability per person goes below 1,700 m3. In India, the water consumption rate is more than its replenishment rate resulting in decreasing of ground water levels. For agriculture alone more than 80% of water is consumed, however there is no significant action towards managing this water consumption in agriculture. Though, there are actions taken in industries and utility sectors to conserve the water consumption, only a small percentage of water is saved as they consume only 5% of the India's water.

With the kind of uncertainty present in rainfall and failure of seasonal rainfall, farmers are facing severe water issue. Out of 4 trillion m3 of precipitation received per year, India stores only 48% of it in surface and groundwater bodies and the rest are directly goes to the sea due to lack of storage and infrastructure facilities and poor water management system. Also, 75% India's annual rainfall is received in short span of four months of time between July to September, resulting in flooding and run off during monsoon. This is also the result of lack of facilities and water management system[9].

The atmospheric pollution of Indian cities is another matter of concern posing environmental risk to health and contributing to premature deaths every year.

1.2 million

deaths of Indians in 2017 could be attributed to air pollution

The Lancet, in December 2018 said that 1.2 million deaths of Indians in 2017 could be attributed to air pollution. The pollution is mostly on account of particles, NO2, SO2, CO and ground level ozone. The sources of atmospheric pollution in Indian cities are automobiles with unsafe emission levels, power plants, burning of municipal waste, burning of agricultural waste, use of firewood for cooking and heating, construction activities, road dust on account of poor surface conditions of the roads etc. All these matters would need simultaneous actions for bringing down the levels of TSPM (total suspended particulate matter) in the atmosphere as well the concentration of hazardous gases.

According to the IQAir AirVisual 2018 World Air Quality Report[10],India's national capital region (NCR) emerged as the most polluted region in the world. Gurugram was the worst affected followed by Ghaziabad, Faridabad and Noida and they are amongst the top six worst-affected cities. In terms of the average annual levels of PM2.5 particles, India was nearly 9 times and over 1.75 times as polluted as USA and China respectively.

The National Clean Air Policy 2019 lays down the road map for Indian cities to clean up their act in the next five years.

Energy

India existing average per capita energy consumption is just over 1,000 kWh and renewable energy generated is 17% of total generation of electricity.

37%

installed capacity for all renewable energy

India's total installed capacity as on March 2019 was 356,100 MW. Hydro and other renewable energy represented 131,640 MW[11]. India's installed capacity for all renewable energy was 37% of the total installed capacity and this corresponded to 17% of the total generation of electricity.

Global forecasts suggest that fossil fuel will continue to be the major source for power generation in 2030 with a contribution of 59% of all energy produced. The renewable sources including large hydro power are expected to provide about 28%[12].

Electricity generation in 2040 could be 36.5 trillion kWh in comparison to 21.56 trillion kWh in 2012. This increase of around 15 trillion kWh from 2012 to 2040 will be happening mostly in the developing world. It is likely that China and India together could represent around 10 trillion kWh. The average per capita consumption of electricity in the World may go up from 2,674 kWh in 2016 to around 4000 kWh in 2040.

9 https://www.oav.de/fileadmin/user_upload/5_Publikationen/5_Studien/170118_Study_Water_Agriculture_India.pdf
10 https://www.iqair.com/blog/press-releases/IQAir-AirVisual-2018-World-Air-Quality-Report-Reveals-Worlds-Most-Polluted-Cities
11 CEA, Ministry of Power, Government of India
12 Statistica

Urban and Rural Development

Although urbanization is a global trend, India has to achieve economic growth with social justice that carries forward both rural and urban India.

While urbanization is a world-wide trend, it is often associated with increased wealth-creation, higher levels of education, better health care, integrated public transport, access to social services, better facilities for cultural activities and sports activities etc.

69%

of India lives in its villages

A UN document titled "World Urbanization prospects 2014" gives the following information on the evolution of urbanization[13]. Urban population in the world increased from 30% in 1950 to 54% in 2014. It is expected to increase to 66% by 2050.In 2014, North America had an urbanization level of 82%, Europe 73%, Asia 48 % and Africa 40%. In 2014, there were 28 megacities with population over 10 million and this is expected to go up to 41 million by 2030. About 69% of India lives in its villages according to the Indian census 2011.

China is a nation comparable to India in population and it has a very successful model of economic development through massive urbanization through megacities. China's labour policy for bringing millions of workers from the rural China to the cities with questionable working conditions is not a model for India. With large scale closure of factories in China, thousands of workers are now being sent back to the villages without any jobs at all.

The German model may offer some interesting options. As per an article published in *ZEIT ONLINE* on 20/9/2017, 69% German population lives in villages and towns. A large number of small and medium enterprises (the famed German Mittelstand) are also operating from these communities. Not surprisingly, rural and intermediary communities generate around 80% of per capita GDP in comparison to the per capita GDP of urban communities. Around 33% of Germany's GDP comes from small towns and villages of population less than 20,000 and around 55% from communities with a population of less than 100,000.

Constraints

Agriculture

Agriculture in India suffers from low productivity and inefficiencies in the entire farming cycle including pre-planting, planting, harvesting, selling and financing.

1.1 hectares

average size of an India farm is around 1.1 hectares

The increase in agricultural production is often at the cost of unsustainable practices such as excessive utilization of natural resources, fertilizers, pesticides and hybrid seeds, etc.[14]. There is a lack of advance farm machineries with Indian farmers and relatively less data on weather, soil condition and other information, resulting in poor agricultural crop and inputs planning. The land holdings in India are fragmented. The average size of an India farm is around 1.1 hectares[15]compared to 0.6 hectares[16] in China and 434 hectares in the USA[17]. Given the pre-dominance of small and marginal farmers in Indian agriculture, affordability becomes a significant constraint on technology adoption by farmers. There is a lack of information sharing and transparency among the food supply chain entities. For example, the demand information at the retailer end are not shared with farmers to plan their agricultural produces in the subsequent years.

13 World Urbanization prospects 2014
14 http://www.academicjournals.org/app/webroot/article/article1406278581_Parwez.pdf
15 https://www.thehindubusinessline.com/economy/agri-business/average-farm-landholding-size-shrinks-to-11-ha/article24719240.ece
16 https://www.livemint.com/Opinion/bORKeOM7iNCRvi4nNse8gO/What-India-can-learn-from-Chinese-agriculture.html
17 http://www.fooddialogues.com/agriculture-101/

Further, the presence of many intermediaries in the supply chain substantially reduces the margin realised by the farmers and hence making agriculture a low profitable business and making farmers to think of giving up farming. In fact, a good number of farmers pledge the entire farm-output to moneylenders or traders in advance at very low prices. There is no nation-wide robust direct online access to national and international markets through an e-marketing platform facilitating direct deliveries from farmers through logistics companies.

India has not aggressively adopted agriculture product differentiation as a marketing technique for selected products. For example, the French wine industry dominated by farmers with small holdings operating through cooperatives could be taken as a model and customized to the Indian context for several farm products. India should also be proactive in geographical identification as a marketing technique to get higher selling prices for selected products especially in global markets.

India has not followed the strategy of using the appropriate technology in agriculture based on local contexts. Simply put, appropriate technology can be a new hi-tech solution or a small modification over a conventional practice, but it is the best fit for the local context. Sometimes, the appropriate technologies emerge from the farmers themselves. However, India does not have a program to teach essentials of relevant agriculture technology in schools located in rural areas.

Given the importance of sustainability, India has not yet explored technology enabled vertical farming, redirecting agriculture from the present large-area model exposed to the elements, to compact vertical farming modules surrounded by large tree forests.

India lacks the appropriate level of facilities for food-waste recycling, cold storage of perishable foods, and processing of excess food products during peak season.

67 million tons

67 million tons of food products are wasted every year

Around 67 million tons of food products are wasted every year, valued at USD 14 billion. In spite of India being the world's second largest producer of fruits, around 72% of harvested fruits are wasted before it reaches the final customers due to the lack of cold storage facilities, lack of skilled labours, poor selection of packaging materials and oversupply/pushing of fruits to the market in the short period of time instead of processing the fruits to get pulp/puree that can avoid wastage of fresh fruits.

India has around 6,300 cold storage facilities which can store up to 30.11 million tons of food products. Only 10 to 11% of fruits and vegetables produced in India are stored in these facilities. Also, majority of these facilities (80%) are used only for storing potatoes. Thus, lack of cold storage facilities and improper handling of food products during transportation process results in more than 30% of food losses[18].

Further, India lags in terms of processing of food products for value addition and differentiation due to small land holdings of farmers and its low yield. Landholding of farmers are averaging around 1.1 hectares and with inefficient practices, the farm yields are 50% to 90% of those in China, Brazil and other developing countries[19]. China's farm yields are higher inspite of its average farm size being 60% of that of an average Indian farm.

Water & Air

Unless remedial steps are taken, India will not be able to meet its growing water demand.

Though a substantial portion of Government's budget is allocated for irrigation projects in the water stressed districts of India, all these budgets are mainly used for construction of irrigation canals, which are wasteful when compared with other potential actions that could have been taken[20]. The water delivered to the fields from these irrigation canals are one fourth of what it draws from rivers. Also, due to lack of nationwide regulation for water consumption and sharing, the fields in the places where there are more irrigation canals present draws more water and leaving very less or no water in the river to the rest of the states.

18 Sachan, A., Sahay, B.S., Sharma, D., 2005. Developing Indian grain supply chain cost model: a system dynamics approach. Int. J. Product. Perform. Manag. 54, 187–205. https://doi.org/10.1108/17410400510584901

19 India's technology opportunity: Transforming work, empowering people, McKinsey Global Institute, December 2014. https://mck.co/2XS6IxX

20 https://www.orfonline.org/expert-speak/if-80-water-consumption-in-india-is-for-agriculture-why-is-it-unregulated-and-inefficient/

197%

more domestic water demand in 2050 compared to consumption in 2000

The government has announced in 2019 an ambitious target of providing piped clean drinking water to all rural households by 2024. According to estimates by the Food & Agriculture Organization, the water demand in 2050 has been estimated to be 197% more for the domestic sector, 287% more for industrial sector than the year 2000 levels, while the agricultural sector may need 5% more at the 2014 levels. All these estimates indicate that India will not be able to meet the growing water demand[21].

Any attempt to develop a sustainable solution to the problems of air pollution should take into account multifarious aspects.

As an example of a recommendation to address air pollution, a Supreme court order dated 10/10/2018 had instructed the Delhi administration to take concrete actions for reducing emissions from automobiles and power plants. An IIT Kanpur study[22] of pollution in Delhi and NCR summarized the source of pollution as Road dust - 35 %; Vehicles - 25%; Domestic cooking - 22%; Power plants and large industrial plants – 22%. The overall pollution level went up in winter because of additional biomass burning for cooking as well as stubble burning in neighbouring states. Any attempt to have a sustainable solution to the problems of particle pollution should take into account all these aspects and work out remedial measures to bring down the pollution to acceptable limits in a time bound manner. While we have a national policy for clean air, it is non-binding and suffers from a lack of stringent implementation framework.

Energy

Electricity distribution and transmission in India is highly inefficient and the cost of power generation from renewable sources is higher than from fossil fuel.

20%

20% of total energy generated is lost

Around 20% of total energy generated is lost before it reaches the end customer. This electricity loss in India is twice that of world average and thrice that of losses in the USA[23]. Electricity losses occurs as a result of technical losses due to inefficiency of distribution and transmission systems. Resistance of wires and equipment causes significant electricity losses. The other major reason for electricity loss is commercial losses - theft. In this case, electricity is stolen by tampering with the meter or by bribing utility meter readers or billing agents[24].

Moving towards renewable for new power generation is being seen as an environmentally conscious decision. However, the cost associated with power is considerably higher compared with cost of power generation from fossil fuels such as coal. Nevertheless, the efforts are being taken to reduce the cost make it consistent with fossil fuels[25]. International Renewable Energy Agency's 2017 report states that, the cost of power generation from wind schemes are on an average USD 0.06 per kWh and for solar it is 0.1 per kWh when compared with power generation from fossil fuels costing USD 0.05 per kWh.

21 https://www.indiatoday.in/india-today-insight/story/india-water-crisis-new-ministry-1541181-2019-06-03
22 https://economictimes.indiatimes.com/news/politics-and-nation/iit-kanpur-study-says-trucks-and-road-dust-are-bigger-pollutants-than-cars-in-delhi/articleshow/50115310.cms
23 https://www.eia.gov/todayinenergy/detail.php?id=23452
24 https://www.electricalindia.in/transmission-losses-in-india/
25 https://www.forbes.com/sites/dominicdudley/2018/01/13/renewable-energy-cost-effective-fossil-fuels-2020/#2e4e752a4ff2

Urban and Rural Development

Urbanization has brought its own challenges, especially the growth of urban slums with the challenges of inadequate shelter and environmental infrastructure.

50%

Mumbai and Delhi have around 50% of the population falling under the category of slum-dwellers

The UN defines a slum as a dwelling place which does not have one or more of the following facilities; improved water, sanitation, sufficient living space, durable housing. It is estimated that Mumbai and Delhi have around 50% of the population falling under the category of slum-dwellers as per UN definition.

Urbanization has been a major issue dealt by UN in its document "New Urban Agenda" published in 2017[26]. Many of the issues listed are relevant for India. Providing adequate shelter and improving human settlements management for all living in urban areas is a challenge. Shelter alone is not adequate. There needs to be an integrated provision of environmental infrastructure: water, sanitation, drainage and solid waste management, sustainable energy, and integrated transport systems.

Way forward

1. Adopt appropriate technology in agriculture

Practise water management and soil nutrient management

- 1. We should leverage India's expertise on satellite imaging to create a master data of every single land holding. This can be used to determine the nutrition requirement based on soil health and crop targets.
- 2. Generally domestic wastewater is discharged untreated into lakes, rivers and other local water bodies, which is around 40,000 million litres of water per day from 300 odd cities. Treating this water and using for agriculture will reduce the freshwater consumption for agriculture purpose[27]. Further, crops act as bio-filters while absorbing the nutrients present in the wastewater.

Adopt innovative and next farming practices

- 1. Create model farms in every taluka: These model farms will be maintained by local farmers. It is to test and demonstrate appropriate technologies that are suitable for that local region.
- 2. Next Green and Blue Revolution: Replicate the success of green revolution in oil seeds, spices, internationally exportable horticulture. Adopt sustainable fishing and aquaculture with international markets in mind. We have one of the largest coast lines, in tropical oceans, with negligible presence in global trade of sea food.
- 3. Modernize the agricultural supply chain: Implement nationwide integrated supply chain solutions for all major agricultural produce with international quality standards. The focus should be the customer and farmer rather than the middleman. Develop appropriate sustainable technologies like top quality, eco-friendly, yet cost effective packaging.

Leverage AI and digital technologies to transform Indian Agriculture

- Creating wealth and jobs in the rural India with the adoption of appropriate AI and digital technologies. Specific areas where AI technologies can be put into use are weather prediction, intelligent environment control, intelligent driverless tractors and drones, etc.
- 2. Enhancing farmer's awareness on digital technologies will help them to sell their products in online markets such as electronic National Agriculture Market, or eNAM, which has the potential to increase the farmer's margin by 15%[28].

26 New Urban Agenda, UN
27 https://www.orfonline.org/expert-speak/if-80-water-consumption-in-india-is-for-agriculture-why-is-it-unregulated-and-inefficient/
28 Digital transformation initiative: Unlocking $100 trillion for business and society from digital transformation, World Economic Forum, January 2017; Rapid introduction and market development for urea deep placement

- As the McKinsey Global Institute report suggests, digital technologies can transform agriculture in India in the following manner[29]
  - Raise farm productivity and create new opportunity for farmers
  - Advise farmers on which crops to grow and the right amount of fertilizer to use
  - Enable farmers to engage in precision agriculture
  - Enable financial services firms to offer lending and insurance products to farmers who are underserved today
  - Revamp farm financing and crop insurance pay-out(s) in the future

Create inter-disciplinary centers for Agriculture in the IITs

These centers must be in association with agriculture universities in the region. These centers will be multidisciplinary and should house researchers from agricultural universities on a rotation basis. These centers should take up specific initiatives like creating a one-year train the teacher program to train people further.

Achieve Food and Nutritional Security through innovative technologies

In addition to the above suggestions to address agriculture, there are other ideas to ensure food and nutritional security for India's population. Technology Information Forecasting and Assessment Council (TIFAC) has identified a number of relevant technologies in various stages of maturity[30] (see adjacent table).

TECHNOLOGIES RELATED TO FOOD AND NUTRITIONAL SECURITY

	ARE READILY DEPLOYABLE	TO MOVE FROM LAB TO FIELD	REQUIRE TARGETED RESEARCH	IN IMAGINATION STAGE
VERTICAL FARMING	●	●		
DEVELOPMENT OF PERENNIAL CEREAL CROPS			●	
CONVERSION OF NON-EDIBLE PLANTS INCLUDING SEA FLORA INTO FOOD			●	
BIO FORTIFICATION(BOTH CONVENTIONAL AND GENETIC)	●	●	●	
GENOMICS AND PHENOMICS	●	●	●	
TRANSGENIC CROP PLANTS AND ANIMALS	●	●	●	
RAPID DIAGNOSTIC TOOLS FOR DETECTION OF ZOONOTIC DISEASES		●	●	
TECHNOLOGIES FOR INCREASING SHELF-LIFE OF PERISHABLE FOODS		●	●	
ELECTRON BEAM FOOD IRRADIATION	●			
OIL TO POWDER TECHNOLOGIES FOR FOOD		●	●	
HIGH VALUE NEUTRACEUTICALS AND PHARMACEUTICAL PRODUCTS FROM AQUATIC ORGANISMS AND ALGAE	●	●	●	
REAL TIME MONITORING OF QUALITY AND BIO TRACEBILITY RELATED TECHNOLOGIES		●	●	
CLIMATE SMART AGRICULTURE	●	●	●	
CONVERSION OF C3 PLANTS TO C4 PLANTS			●	
NANO FORMULATIONS OF PESTICIDES AND FERTILIZERS		●	●	
INTERACTIVE FOODS				●
SMART FOODS				●
3D PRINTING OF FOOD			●	
EXPLOITING MICROGRAVITY AND SEA FOR CULTIVATION OF CROP PLANTS				●

2. Effectively manage supply-side and demand-side of water

Implement a Water Conservation Campaign

- 1. Government of India has launched 'Jal Shakti Abhiyan'[31], a water conservation campaign that will focus on five aspects — water harvesting, renovation of traditional and other water bodies, reuse of water and recharging of structures, watershed development, and intensive afforestation. Quick runoffs of rainwater results in depletion of its availability as a source of fresh water. This can be prevented by taking adequate harvesting measures including facilitating percolation to supplement subterranean water tables.
- 2. If we take the example of water deficient desert nation Israel, though they are living in extreme climatic conditions, they are one of the water surplus nation in the world. This has become possible because of their nation-wide action to address the water scarcity issue. Water rationing, changing the method of irrigation, rainwater harvesting and recycling of wastewater for agriculture use are some of the immediate measure that Israel took in 2008. They instituted a nationwide strict regulation and educational campaign explaining the impact of the water crisis and the proposed reduction measure

29 https://www.mckinsey.com/business-functions/digital-mckinsey/our-insights/digital-india-technology-to-transform-a-connected-nation
30 http://planning.kar.nic.in/docs/SDG/Technology%20Vision%202035.pdf, pg 50-51
31 https://timesofindia.indiatimes.com/india/jal-shakti-abhiyan-govt-launches-water-conservation-campaign/articleshow/70026830.cms

3. Manage water for agriculture

Since agriculture consumes over 80% of India's water, water management should focus on the management of agricultural irrigation. Again, there are significant learnings from Israel in this aspect

- 1. Today, in Israel, 80% of wastewater is recycled at lower cost and used for agriculture purpose. Investment on drip irrigation instead of flood irrigation has reduced water consumption as well as increased the yield by 15% as compared with flood irrigation. Also, today, Israel is at the highest position in the world in-terms of its crop yield per m3 of its water consumption. These measures could be benchmarked for our nation, India and the water crisis issues could be reduced and eradicated completely in the long term.

- 2. In addition, India should encourage and provide incentives to farmers to shift from water-intensive crops like rice, wheat and sugarcane to less water-intensive crops like pulses, millets and oilseeds[32].

4. Implement solutions for clean air and potable water

1. Aggressive implementation of green manufacturing, transportation and mining technologies would be required for improving air quality.

2. Replacing biomass as an energy source with gas including bio-methane and deployment of smokeless 'chulha' is a solution for ensuring better air quality.

3. In addition to the above suggestions, there are other ideas to ensure availability of clean air and potable water for India's population. TIFAC has identified a number of relevant technologies in various stages of maturity[33] (see adjacent table).

TECHNOLOGIES RELATED TO CLEAN AIR AND POTABLE WATER

ADVANCED CLEAN COAL TECHNOLOGIES		●	●	●
ALTERNATE FUEL BASED TRANSPORTATION	●	●	●	
NOVEL PROPULSION TECHNOLOGIES			●	●
GREEN MANUFACTURING	●			
INTELLIGENT TRANSPORTATION SYSTEM	●			
LOW DUST CONSTRUCTION TECHNOLOGIES	●	●		
REAL TIME DENSE SPATIAL AIR QUALITY MONITORING		●	●	
REAL TIME AQUIFER MONITORING INCLUDING SALINITY INGRESS		●	●	
INSTANT PORTABLE WATER QUALITY TESTING	●	●	●	
AFFORDABLE DESALINATION TECHNOLOGY		●	●	
MEMBRANE BASED WASTE WATER TREATMENT	●			
AFFORDABLE DE-SILTING OF WATER BODIES		●	●	
TECHNOLOGY FOR RUN-OFF CONTROL	●	●	●	
SCALABLE-POINT-OF-USE WATER TREATMENT TECHNOLOGY		●	●	
DEW HARVESTING		●	●	
IN-SITU WATER PURIFICATION IN PIPELINE			●	
SELF HEALING PIPELINES			●	●

ARE READILY DEPLOYABLE
TO MOVE FROM LAB TO FIELD
REQUIRE TARGETED RESEARCH
IN IMAGINATION STAGE

Increase the contribution of renewable energy and focus on energy conservation.

5. Implement policies that provide a push towards Green Energy

India is well on target to achieve its target of an installed capacity of 175,000 MW installed capacity from renewable resources by 2022. India must keep up with this pace.

- The Government should pass a law similar to EU directive for making energy neutral buildings compulsory over the next decade.

- The business plan for any industrial activity or commercial activity should provide for such capital investment in renewable and work out the Return on Investment (ROI) based on the total investment and depreciation of up to 25% on the investment for renewable energy.

- The Indian power grid should be suitably modified for having bidirectional flow of current. The consumer should be able to pump in the additional quantities generated during daytime to the grid and draw the energy from the grid in the night.

- One other way for India to increase the contribution of green energy will be to popularize off-grid installations in India. Solar lanterns, streetlights, water heaters, refrigerators and cold storage, pumps, water purifiers etc. could be widely used in India.

32 https://www.orfonline.org/expert-speak/india-water-crisis-permanent-problem-which-needs-permanent-solutions-52896/
33 http://planning.kar.nic.in/docs/SDG/Technology%20Vision%202035.pdf, pg 48-49

- Shifting the transportation sector to renewable electricity: Electric vehicles (EVs) are cheaper per mile and require less maintenance. With a host of incentives unveiled in the Union budget and subsequently for electric vehicles, India has backed the development of the nascent EV industry by offering extensive fiscal incentives and a favourable regulatory environment[34].

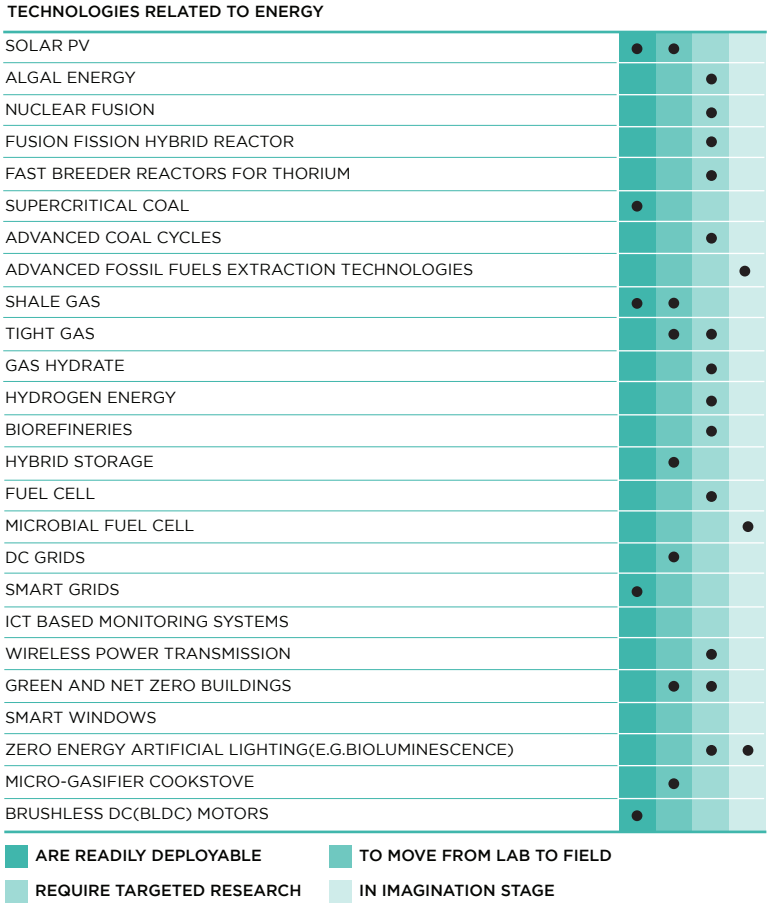
- The report Mission Possible: Reaching net-zero carbon emissions from harder-to-abate sectors by mid-century outlines the possible routes to fully decarbonize cement, steel, plastics, trucking, shipping and aviation – which together represent 30% of energy emissions today and could increase to 60% by mid-century as other sectors lower their emissions[35].

6. Develop and adopt novel renewable technology solutions for power generation

1. IITs should be at the forefront to help India assess the use of novel renewable technology solutions for power generation. These include recycling CO2 into hydrocarbons which will make fossil fuel a source of renewable energy, manufacturing of hydrogen at reasonable prices to make it a source of energy, furthering thorium-based energy via. sub-critical molten salt reactor power plants.

2. TIFAC has identified a number of relevant technologies in various stages of maturity[36] (see adjacent table).

3. India should also develop technologies for generation power from sewage treatment plants. The sewage-sludge could be used for generation of electricity. This will be two birds in one shot, disposal of sewage waste and generation of electricity. The IITs should take a lead in developing the technology solutions required for generating power from sewage treatment plants in an effective and efficient manner.



34 https://www.livemint.com/budget/news/india-looks-to-lead-electric-vehicle-race-with-latest-push-in-budget-1562523548797.html
35 http://www.energy-transitions.org/mission-possible
36 http://planning.kar.nic.in/docs/SDG/Technology%20Vision%202035.pdf, pg 56-57

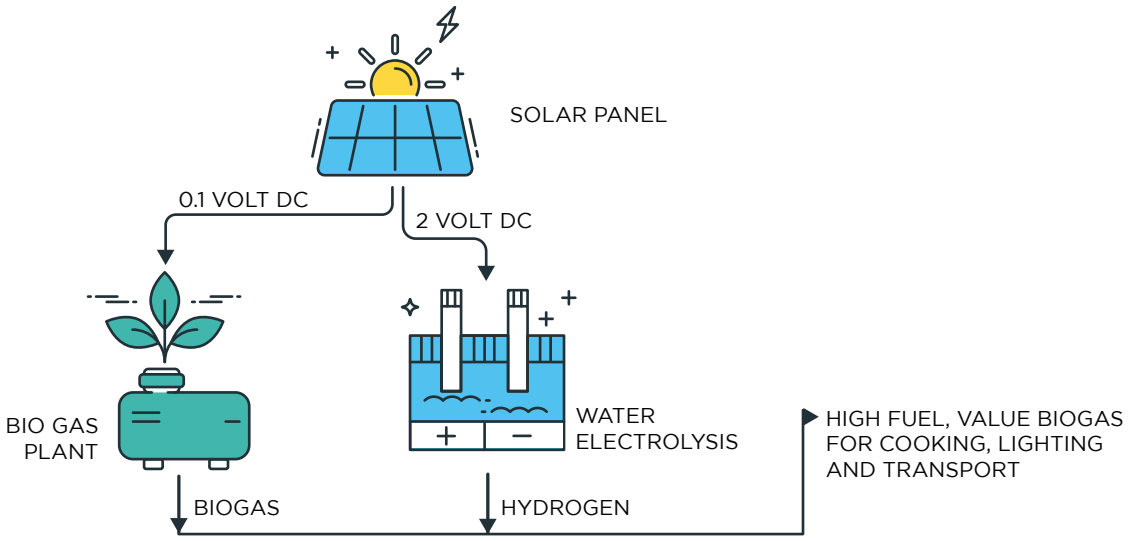
Grand Challenge

Design and demonstrate a working model for PURA (Providing Urban amenities in Rural Areas).

One of the models for India is to go for smaller cities with "human dimension" with a population of less than 100,000 by providing urban amenities in rural areas, as proposed by our former president Abdul Kalam. The basic objective should be to create intermediary cities as growth centers with excellent physical, electronic, technological and economic connectivity with the whole of India. Bigger villages should be developed as small towns with a population of less than 100,000 and smaller villages should be developed as interconnected cluster of villages. The aim is to design and run a model sustainable town with a population of about 100,000 by 2025. This model should integrate, agriculture and agriculture-based Micro Small Medium Enterprises (MSMEs), renewable energy generation, healthcare and education facilities, waste management, etc. with the use of appropriate technology. The Government should take the winning models and solutions and start implementing them across the country by the end of the decade.

Design and implement a Solar Hydrogen Biogas Village

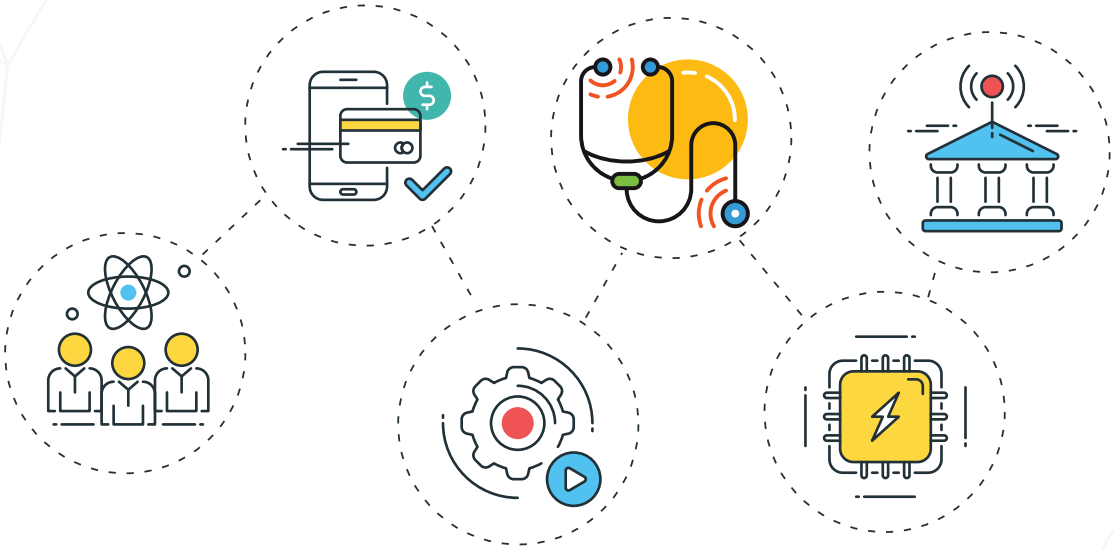
Villages are the back bone of India and they could be made prosperous and healthy by developing them into hydrogen-biogas energy economic centers. Indian Villages have a good supply of gobar and other biomass, whose utilization has been attempted for producing biogas. Due to a high variability in the microbial digestion, the success of the household biogas plants has been limited. Recent advancements in & lower cost of solar electricity can help transform the biogas use. The solar electricity can be directly used in the digesters to significantly enhance the microbial conversion and separately to split water to produce hydrogen. The hydrogen enrichment significantly increases the fuel value of the biogas. The solar hydrogen biogas can help overcome the fuel bottleneck of the rural India and help accelerate development.



Further, the generated electricity by the solar panels will also help to provide pumping of water to the agricultural fields, offer controlled climate comforts as well as help in reducing the wastage of food and agricultural products. The well-established IC engine technology which can burn hydrogen biogas will provide the necessary transportation needs of the village folks and also electricity generation during night times and when it is cloudy.

SANGAM 2019

Reimagining India in 2030



Leveraging Technology for All and delivering Societal Impact

IIT Madras Alumni Association
Reconnect • Engage • Impact

SANGAM 2019
REIMAGINING INDIA IN 2030

itihaasa
Research and Digital

As India marches towards becoming an economic super-power by 2030, it should continuously focus on equitable, inclusive growth and on bridging income inequalities in the country. How can India effectively harness technology to meet the needs and aspirations of the society, especially the under-served and the next billion users in India? 1) India should strive for Digital Inclusion, with a focus on affordable access and adoption of internet and mobile, access to a range of digital services in multiple local Indian languages and help reduce the digital divide between rural and urban India. 2) For technology to have maximum impact on all Indians in the coming decade it should aid in improving how public services like healthcare, financial inclusion and e-governance are delivered more effectively and efficiently in India. 3) Artificial Intelligence (AI) and digital technologies have the potential to transform rural India, and we should make fairness and ethics central to AI implementations to ensure that there is no bias or discrimination in decisions that AI systems may recommend for services that affect the next billion users in India.

Objectives

- Close to 40% of Indians are accessing the Internet and there is a digital divide between rural and urban populations[1]. India should increase internet accessibility to 100% of the population by 2030 in order to increase the societal impact of Digital India.
- Leverage transformative technologies like Artificial Intelligence for Good, but keep in mind the principles of fairness, ethics, transparency and explainability while developing the AI solutions.
- Leverage technology in healthcare to part make-up for the deficiency in number of doctors per thousand and number of hospital beds per thousand in India in the coming decade.
- Achieve 100% coverage of bank accounts and a 50% financial literacy among adults in India by 2030
- Leverage technology to get a 90 plus score for government effectiveness in the World Governance Indicators score by 2030 up from the current score of 57[2].

1 https://cms.iamai.in/Content/ResearchPapers/15c3c84c-128a-4ea9-9cf2-a50a6d18f21c.pdf
2 http://info.worldbank.org/governance/wgi/pdf/WGI.pdf

Current Situation

Digital Inclusion

India should strive for digital inclusion and focus on affordable access, adoption and application including healthcare, financial inclusion and e-governance.

Digital inclusion addresses issues of opportunity, access, knowledge, and skill at the level of policy. While digital divide tends to focus on the access available to individuals, digital inclusion is meant to signal a focus on a practical, policy-driven approach that addresses the needs of communities as a whole[3]. The importance of the Internet today poses challenges and opportunities for one billion Indians – called the next billion who can get excluded from development since they are unable to access the Internet.

India should focus on (1) Access: availability, affordability, design for inclusion, and public access (2) Adoption: Relevance, digital literacy, and consumer safety and (3) Application: Including healthcare, financial inclusion and e-governance.

89%

tele-density in India

India launched Digital India in 2015 to digitally empower every citizen. As per telecom data released by Telecom Regulatory Authority of India (TRAI), tele-density in India was 89%, with an urban tele-density of 160% and a rural tele-density of only 56%[4].

Artificial Intelligence (AI) and digital technologies have the potential to transform rural India and the lives of the next billion.

2.8 million

jobs in rural India would be generated By AI and IoT apps by 2029

Let's examine the role of AI as a special tool under Digital inclusion and its potential to transform India. While the popular applications of AI in e-Commerce and fashion recommendation are visible and seemingly impact the urban India, AI has the potential to significantly impact rural India and the lives of the next billion in the country. According to a recent study[5], 2.8 million jobs in rural India would be generated By AI and IoT apps by 2029.

AI is being leveraged by innovative startups to solve a variety of India-specific problems – NextWealth and iMerit provide 'AI in the loop' and data-enabled services jobs for the next billion; Vassar Labs and Nanopix leverage AI for agriculture and water management; Wadhwani AI and Forus Health for healthcare; and several more companies in these areas.

Healthcare

The Indian healthcare context is characterized by a shortage of qualified doctors and nurses and poor healthcare infrastructure.

Healthcare is important for improving societal well-being. The Indian healthcare context is characterized by a shortage of qualified doctors and nurses and a poor healthcare infrastructure is insufficient towards meeting the demands of the growing population.

There are only 0.76 doctors and 2.09 nurses/1,000 population in India, compared to WHO recommendations of 1 doctor and 2.5 nurses/1,000 population. In Infrastructure, there are 1.3 hospital beds/1,000 population, a far cry from the mandated 3.5 hospital beds/1,000 population[6].

3 https://digitalinclusion.umd.edu/content/what-digital-inclusion
4 https://main.trai.gov.in/sites/default/files/PR_No.49of2019.pdf
5 https://dazeinfo.com/2019/07/04/2-8-million-jobs-in-rural-india-ai-iot-apps-2029/
6 https://www.pwc.in/assets/pdfs/publications/2017/funding-indian-healthcare-catalysing-the-next-wave-of-growth.pdf

70%

India's healthcare infrastructure is concentrated in the top 20 cities

Adding to the woes is the fact that healthcare facilities are not uniformly accessible across India. There is an urban-rural divide: 67% of doctors are in the cities, where only 34% of the country's population resides[7]. Furthermore, according to a NATHEALTH-PwC report released in 2017, 50% of beneficiaries travel more than 100 km to access quality medical care, as about 70% of India's healthcare infrastructure is concentrated in the top 20 cities[8]. This apart, there is lack of affordable and consistent quality in the healthcare sector across the nation—less than 2% of hospitals in India are accredited[9].

Technology enabled innovations, digital healthcare solutions and models have the potential to transform healthcare in India.

4 to 5 billion

digital technology could save USD 4 billion to USD 5 billion in 2025

At present, technology enabled systems are being utilized in resolving the problems in healthcare in India. It has been estimated that digital technology could save USD 4 billion to USD 5 billion in 2025[10]. For instance; telemedicine is playing a key role in bridging the rural-urban divide by providing affordable consultation and diagnostic facilities in the hinterlands via. telecommunication and 3G/4G internet services. Further, telemedicine-based models have the capability to handle up to half of in-person outpatient consultations. Such initiatives globally have shown that virtual doctor visits cost about 30% less than in-person visits[11].

There are various success stories that are inspiring scaling up of innovative healthcare solutions and models. Paving the way for low-cost and efficient business models that effectively utilize technology, Aravind Eye Hospital has pioneered in developing a self-funded healthcare delivery model; which provides free or low priced service par excellence to about 50% to 60% of patients who are not well-off financially by utilizing the revenue made from 40% to 50% of patients who are able to pay. This model has been successful in bringing down the cost of cataract surgery to 1.67% of the cost (i.e. USD 50, a sharp contrast from USD 3000 charged in the USA)[12]. This is based on bringing down fixed costs through efficiency; illustrated by the fact that they perform 60% of total surgeries done in the UK health system, but at 1/100th of the cost[13]. All of this has been possible through constant innovation of technology by Aravind and its strong research division.

Rapid developments in information communications technologies followed by subsequent integration with medical products and services (for diagnostics and treatment), is increasing the accessibility of affordable and quality healthcare from the comfort of homes. Narayana Health has been working towards making quality healthcare accessible and non-discriminatory. His hospital on the outskirts of Bangalore provides heart surgeries at a small fraction of the cost incurred in developed countries, (USD 2,000 for open-heart surgery, compared with USD 20,000 to 100,000 in the USA[14]).

There are also a few successful applied research collaborations and innovative startups in India that are charting new territory in healthcare.

Healthcare Technology Innovation Centre (HTIC), a joint initiative of Indian Institute of Technology Madras and Department of Biotechnology (DBT), Government of India is developing healthcare technologies for the country[15]. HTIC has developed various innovative products and solutions improving healthcare. Eye-PAC, which empowers healthcare professionals perform eye screening at places where a qualified ophthalmologist might not be available, and Mobile Eye Surgical Unit, a self-contained and sterile surgical facility that can be transported to remote locations for performing cataract surgery on-site. There are other products that are capable of reading multiple test kits along with wearable devices that monitor blood oxygen saturation, stress and even perform wireless ECGs.

7 https://m.dailyhunt.in/news/india/english/qrius-epaper-qrius/5+ways+technology+is+helping+improve+governance+in+asia-newsid-101088703
8 https://www.pwc.in/assets/pdfs/publications/2017/funding-indian-healthcare-catalysing-the-next-wave-of-growth.pdf
9 https://www.pwc.in/assets/pdfs/publications/2018/reimagining-the-possible-in-the-indian-healthcare-ecosystem-with-emerging-technologies.pdf
10 https://www.mckinsey.com/business-functions/digital-mckinsey/our-insights/digital-india-technology-to-transform-a-connected-nation
11 https://www.mckinsey.com/business-functions/digital-mckinsey/our-insights/digital-india-technology-to-transform-a-connected-nation
12 https://digital.hbs.edu/platform-rctom/submission/aravind-eye-care-system-mcdonaldization-of-eye-care/#
13 https://digital.hbs.edu/platform-rctom/submission/aravind-eye-care-system-mcdonaldization-of-eye-care/#
14 https://www.sciencedirect.com/science/article/pii/S0970389617305384
15 https://www.hticiitm.org/

Additionally, varied startups have entered into the field of advanced technological healthcare. For example, Niramai, a healthcare technology startup that has developed a low cost, portable, radiation free cancer screening device which uses artificial intelligence based thermal image processing and machine learning algorithms for reliable and accurate breast cancer screening[16].

While AI and ML are making waves in the healthcare industry, 3D and bio-printing are being employed for producing dental implants (crown of teeth), prosthetic limbs, and even human organs, thus reducing the time taken to manufacture these products (for instance, it takes only an hour to create a crown as opposed to two weeks using the traditional process[17]).

Indian government has set Electronic Health Records (EHR) standards but they have been adopted only in a few urban medical pockets.

The Indian government set standards in 2016 for the effective use and interoperability of EHR, which gather patients' entire medical history; including test results, diagnostic images, surgical procedures, and prescription drugs take in one file. This is meant to provide accurate, up-to-date, and complete information about patients regardless of whether they are being treated by their regular doctor, a specialist they have never seen before, or an emergency room surgeon. EHRs can help providers make more effective diagnoses, reduce the risk of medical errors, and provide safer care[18]. However, India's medical professionals outside of a few urban pockets have not yet embraced EHRs[19].

Financial Inclusion

India has taken massive strides towards financial inclusion by implementing relevant policy and regulation, and leveraging innovative digital technologies.

Over the 1980-2014 period in India, the top 0.1% of earners captured a higher share of total growth than the bottom 50%, while the top 1% received a higher share of total growth than the middle 40%[20]. There is clearly a for need more inclusive growth in India.

Banks began to implement financial inclusion as part of their business policy after the RBI directed them to adopt a three-year board-approved financial inclusion policy (FIP) that began in 2010. It laid a firm roadmap for opening brick-and-mortar branches and spread of alternative modes of banking[21].

80%

adult Indians having bank accounts

The number of adult Indians having bank accounts doubled in 7 years and stands at 80%, according to the Global Findex Database published in April 2018[22]. Powering this dramatic rise has been a series of financial inclusion measures launched by the government like the Aadhar, Jan Dhan Yojana bank accounts, Micro Units Development and Refinance Agency (MUDRA) loans, Direct Benefits Transfers, and digital payment infrastructure like, RuPay, Bharat Interface for Money (BHIM) and United Payment Interface (UPI).

A Reserve Bank of India (RBI) study found a positive and statistically significant impact of financial outreach on per capita income growth[23]. Global research has already linked poverty alleviation to financial inclusion brought about through financial awareness[24].

16 https://www.niramai.com/
17 https://www.wipro.com/en-IN/blogs/wipro-insights/3d-printing--revolutionizing-healthcare/
18 https://www.healthit.gov/
19 https://pdfs.semanticscholar.org/3fb5/1e43abdf632766dfe9e1fbba1f48153a3089.pdf
20 Chancel, Lucas and Piketty, Thomas, Indian Income Inequality, 1922-2014: From British Raj to Billionaire Raj? (October 2017). CEPR Discussion Paper No. DP12409. Available at SSRN: https://ssrn.com/abstract=3066021
21 https://www.rbi.org.in/scripts/PublicationsView.aspx?id=13937
22 https://www.weforum.org/agenda/2019/01/financial-inclusion-in-india-is-soaring-heres-what-must-happen-next/
23 Financial Outreach and Growth in India: Interactions at the Sub-National Level, Sunil Kumar et al., Reserve Bank of India
24 Financial Inclusion, Poverty Reduction and the Millennium Development Goals, Michael Chibba, 2009

Governance

Appropriate applications of ICT in government can help build trust by enabling citizen engagement in the policy process and promoting accountable plus open governance.

In a developing country like India, while the health of citizens is of paramount importance, another aspect that equally important is governance. Building trust between governments and citizens is fundamental to good governance. Citizens of a democratic country are entitled to three key aspects of governance – accountability, transparency and efficacy. In order to achieve these, Information and Communication Technology (ICT) is being globally recognized for promoting effective-governance.

At present, the government is progressing towards enhancing its relationship with multiple stakeholders by incorporating relevant technological measures. In Government to citizen relationship, the government is liable to provide services ranging over the domains like healthcare, transportation, education, telecommunications and much more. Towards this, a key initiative is Common Service Centres (CSCs), which are the access points for delivery of essential public utility services, social welfare schemes, healthcare, financial, education and agriculture services, along with host of diverse B2C services to citizens in rural and remote areas of the country. Through e-governance, government services can be made available to citizens in a convenient, efficient and transparent manner. It can help in improving efficiency in mass processing tasks and public administration operations.

India is progressing well in the field of e-Governance and has created some innovative Government to Citizen (G2C) and government to Government (G2G) solutions.

107

India is ranked at 107 on e-Government Development Index (EGDI)

From making use of ICT for elections, census, computerizing all the government offices, to digital lockers, e-kranthi portals, e-panchaayat, Jeevan Praman programme and e-seva kendras, the new India is making its mark in the world of e-Governance. India is ranked at 107 on e-Government Development Index (EGDI) published by United Nations for the year 2016. Due to consistent efforts by all stakeholders, ranking of the country has improved by 11 positions in comparison with the year 2014 when it was 118[25].

This can be illustrated by the 100% benefit transfer that has been achieved by the successful implementation of Direct Benefit Transfer (DBT). Models like JAM involving integration of Jan Dhan Yojana, Aadhar and mobile technology, enable the Government in implementation of DBT on a large scale. Additionally, to engage citizens, My Gov platform has been established to exchange ideas and suggestions with the government. Through this initiative, the government receives feedback, inputs and ideas from people regarding policy decisions and new initiatives like Digital India, Swachh Bharat, Make in India, among others[26]. Apart from maintaining relationship with citizens, a dedicated and much-insightful G2G relationship will enable better communication and exchange of sensitive information between the Central and the State Government.

Another important aspect of e-governance where ICT can make a huge difference is in quickening the pace of the judicial process many-fold. In order to achieve this, courts, prisons and police stations would need to be interconnected. This would necessitate computerisation and real time updating of all citizen/court/police records as well as proceedings. Once online databases of such sensitive information have been created, guaranteed security, safety and integrity of all national databases will be mandated. India also needs to leverage technologies that help translating judicial documents from a regional language to Hindi or English and vice versa.

While India is making great strides in ICT for governance, indigenous space technology is also proving to be highly beneficial as inputs derived from this technology are helping central and state governments in planning, monitoring, reviewing, mid-course correction and assessment of development activities. Owing to high susceptibility of India to cyclones, floods, droughts etc., and satellites are being relied on to provide observational data at periodic intervals that help in better planning and management of disasters. This apart, satellite communication is also becoming ubiquitous for its widespread applications in mass media and other communication paradigms.

25 https://www.jagranjosh.com/current-affairs/india-breaks-into-top-100-in-uns-egovernment-index-1533032106-1
26 https://mygov.in

Constraints

Digital Inclusion

While the potential benefits of Digital India initiative are unquestionable, challenges remain, including delayed infrastructure development, bandwidth availability, personal computer penetration and the capacity to scale.

150,000

connecting the remaining 150,000 gram-panchayats

The single biggest constraint in India achieving digital inclusion is broadband infrastructure. The government has completed laying optical fiber cables across more than 100,000 gram-panchayats in the first phase of the BharatNet program[27]. While the plan was to complete connecting the remaining 150,000 gram-panchayats by March 2019, according to reports, it has not progressed much beyond the first phase.

The Indian government should be pragmatic and look to monetize completed and work in progress BharatNet network via. leasing arrangements to private players who can complete and operate this fiber network. If required, the Indian government can try to subsidize the services provided by these operators to villages. This is the only way to boost connectivity in Indian villages and digitally include them. But in the current low telecom tariff context in India, it is not very clear if private players will be interested in BharatNet.

There are experts who believe that it is difficult to foresee fiber infrastructure being the backbone to solve India's digital inclusion. They argue that India is not conducive for laying fiber like countries like USA and China. For these experts, wireless technologies like 4G and 5G are the answer to increasing digital inclusion in India. Current statistics also seem to support this view. According to TRAI India has 563.06 million mobile broadband subscribers but just 18.45 million wired broadband subscribers[28].

The challenges with leveraging AI for good include availability of good quality and labelled data in the problem domain, public computing infrastructure for processing big-data and ensuring digital solutions are designed keeping in mind the next billion users, who typically are not digitally savvy.

The other big digital inclusion challenge in India is digital gender divide.

29%

Only 29% of India's current internet users are women

Only 29% of India's current internet users are women, according to a recent UNICEF report[29]. This may also be connected to the lack of broadband penetration in India. If the cost of wired broadband comes down, there may be women who are predominantly at home to access the Internet. There is still a social taboo in parts of India to provide women with smart phones. There is a call for BharatNet to act as a beachhead and reach community paces that are frequented by women in a rural context. Finally, even if all Indians get access to the Internet, they may not be digitally savvy. This requires an active India wide digital literacy and digital inclusion training which may have to be on the scale of the national literacy mission.

27 http://bbnl.nic.in/
28 https://main.trai.gov.in/sites/default/files/PR_No.49of2019.pdf
29 https://economictimes.indiatimes.com/tech/internet/only-29-female-internet-users-in-india-unicef-report/articleshow/62027590.cms?from=mdr

Healthcare

India is saddled by inadequate and ageing public healthcare infrastructure, inequalities in healthcare distribution, insufficient advanced diagnostic equipment, along with a lack of well-trained health workforce and a weak healthcare delivery mechanism.

With regard to leveraging technology for enhancing well-being of society, we are experiencing a paradoxical situation today. While one of the most developed and efficient low-cost healthcare systems is available in India, making it a much sought after medical tourism destination, the country's own residents who are poor or reside in rural areas are deprived of the world-class healthcare (for treatment and diagnostics) available in the country. A potential cause of this conundrum could be the high cost of healthcare procedures and equipment in private hospitals coupled with the low quality and inadequate infrastructure in government hospitals. To resolve this issue, we require rapid indigenisation of affordable technology like telemedicine along with its integration in existing healthcare infrastructure.

INR 957

Per capita government expenditure every year on health is INR 957 is among the lowest globally.

A challenge for healthcare in India is low percentage expenditure by the government on healthcare and associated technology. India spent the equivalent of 4.2% of its GDP on healthcare in 2000, but only 3.66 % in 2016. Over the same period, China's healthcare spending rose from 4.5 % of its GDP to 4.98 %[30]. Per capita government expenditure every year on health is INR 957 is among the lowest globally. Not only is the government expenditure inadequate, it is also insufficient towards performing the role of primary healthcare provider. Additionally, health insurance has a low penetration in India, with only 34% of Indians subscribing to health insurance in 2017; high premiums generally tend to put insurance out of reach for many people. This in turn has a huge impact on out of pocket expenditure for the people. Access to healthcare in India is affected with the 70:70 paradox; with 70% of expenses incurred as out of pocket expense, out of which 70% is only on medicines, consequently increasing the burden on financially weaker section of the society[31].

A cause for concern is the lack of awareness among Indians about diseases, care and services available. Although government initiatives are in place, currently, they are not marshalled effectively to optimise healthcare delivery in India. Indians do not have access to information about availability of healthcare doctors in their area, and they are often cannot be sure if a medical practitioner will be available and where.

ICT based healthcare services are already in use to a certain extent. AI based solutions possess the potential to leapfrog several other technologies. The challenge associated with implementing AI on a large scale is that digitisation of content is a mandatory requirement. Though various technology-based healthcare pilot projects in those using AI are being executed in India, the challenge is usually with scaling up and distributing technology - even technology that has been proven to be cost-effective and useful. While several pilots of public-private partnerships have been successful, hardly any of them have been scaled up to meet India's health challenges.

The lack of government spending on healthcare means that public health programmes are still largely funded from outside the country. This sometimes results in importing technology rather than fostering the development of indigenously developed locally appropriate inventions. Medical education in India does not place enough emphasis on research and on keeping up with new developments. Combined with an overburdened system, this results in generations of practicing clinicians with little motivation to innovate or to understand and adopt technology.

30 Global health expenditure database, World Health Organization, 2016.
31 https://www.sciencedirect.com/science/article/pii/S0970389617305384

Financial Inclusion

While India has established policy and infrastructure for financial inclusion (FI), the utilization of its FI infrastructure and the financial literacy of its citizens are low.

13%

only 13% of Indian adults borrow through formal channels

According to the World Bank, 48% of the country's Jan Dhan bank accounts have had no transactions in the last one-year. Globally, the percentage of inoperative accounts stands at 25[32]. An IMF study indicates that only 13% of Indian adults borrow through formal channels. Despite priority sector lending norms, hardly 35% of Indian farmers utilise institutional loans.

According to Standard & Poor's 'Global Financial Literacy Survey – 2014', 3.5 billion adults across the globe, most of them from developing economies, do not have any understanding of financial products and services. The average financial literacy rate is 24% of adults in India. While digital channels are able to provide most of the banking services, they are unable to popularise loan products through digital platform due to lack of digital literacy.

Governance

The key challenges in e-governance projects in India include the sheer scale of operations, the resistance to new technologies, the need for seamless, transparent operations at all levels and change management for both Indian citizens and government officials.

Governance is a challenge in a country as large and diverse as India. As India gears up for an era of rapid digitalization, the issue of holistic and inclusive economic growth is also a concern. This is where technologies can intervene and enable large scale transformation and help in the implementation of ambitious government plans ensuring Indians are empowered like never before.

40%

about 40% of Indians are accessing the Internet

Though significant progress has been made in e-Governance, a worrying impediment could be the digital divide in the country. Based on the IAMAI (Internet and Mobile Association of India) report, about 40% of Indians are accessing the Internet[33]. This has to be much higher for e-governance to become a universal success in India. A recent report by the Digital Empowerment Foundation indicates that 30% of our population lags on basic literacy and thrice that for digital literacy.

Improving digital literacy will only be half the battle won, the other half will require training of personnel and staff at all levels to operate the new systems. While there are already multiple e-governance services in place, there needs to be a consolidated platform for all such services (one-stop portal for all services). This will require ensuring interoperability of these services on one platform. Owing to the multitude of languages and dialects spoken across the country, the services offered by the Government will have to be provided in all the 22 official languages and English. This will require end-to-end translation by language experts.

At present, there is inadequate capacity at the centre spanning across all levels of government. There is a lack of targeted training programmes for building digital capacity and combating resistance to change initiatives, such training programmes can help officials in municipal corporations and ministries build capability and capacity to successfully implement smart, intervention-based projects at local government level. Additionally, there is insufficient impetus towards collaboration in digital interventions across the country. This leads to inefficiencies and siloed digital infrastructure over time. All Indian states and the central government should push for utilizing their capabilities in combination for maximum impact. Only then can we successfully tap digital technologies for societal well-being.

32 https://www.thehindubusinessline.com/opinion/financial-inclusion-is-fast-losing-steam/article26071996.ece
33 https://cms.iamai.in/Content/ResearchPapers/15c3c84c-128a-4ea9-9cf2-a50a6d18f21c.pdf

Way Forward

Digital Inclusion

Strive to bring about digital inclusion for the next billion users in India.

- 1. Infrastructure providing the foundation for digital inclusion in India needs to be a mix of mobile and fixed infrastructure. Even the current low telecom tariffs may be perceived as high by those who are currently in the next billion in India. It will be worthwhile to explore what the next billion in India see as real value-added digital services and price the services rather than the infrastructure. This may be the only way to co-create with those at the bottom of the digital pyramid who stay stretched to make both ends meet on a daily basis. Be it more effective and efficient critical healthcare services, e-governance or even entertainment. Some of the Indian telcos seem to be implementing this value-based strategy very well.

- 2. India needs a slew of measures to bring about digital inclusion. These include but are not limited to providing public access to devices that can help connect to the Internet, access to a range of digital services in multiple local Indian languages, and providing digital literacy services that assist individuals navigate, understand, evaluate, create digital content using a range of information and communications technologies, and creating digital public services in healthcare, governance etc. Experts in the IIT Madras RBCDSAI and itihaasa colloquium on AI: A Priority of India were unanimous that India has the opportunity to leapfrog and adopt emerging technologies like AI to serve the next billion users and bring about digital inclusion[34].

- 3. As we increasingly adopt AI for good, 1) India should take up initiatives to create India-specific data-sets on a war-footing. Take the case of genomics – while India accounts for more than one-sixth of the world's population, the DNA sequences of its people contribute a meagre 0.2% of the global genetic databases. Hence the need for initiatives by the Centre for Brain Research at IISc which is collecting one-of-a-kind Indian data related to healthcare and DNA sequencing, and which would be used to develop, say unique markers for early detection of Alzheimer's in Indians[35]; 2) make fairness and ethics central to AI implementations to ensure that there is no bias or discrimination in decisions that AI systems may recommend for services that affect the next billion users in India.

- 4. Digital literacy programs should be taken up on a war footing. National Programme on Technology Enhanced Learning (NPTEL) can be used as a channel to beam digital literacy programs in multiple Indian languages. A 'digital citizenship' education should be offered at every Indian school. More important, there should be an army of trained intermediaries who should be provided the training to convince all Indians to become digitally savvy. The model of intermediaries to facilitate digital literacy can be borrowed and scaled-up from the Deshpande Foundation's model of training intermediaries in rural and semi-urban areas.

Healthcare

Focus on affordability and quality of service of technology solutions in healthcare.

- 1. Technology can make healthcare more affordable. But the choice of technology should be such that it fits the Indian healthcare use cases at Indian costs. There needs to be a judicious mix of indigenous and imported technology solutions. Adoption of technology has a long-term impact on cost, and hence there needs to be more intended effort to invest in technology and adopt this up-front. Ideally this means investing upfront in training and hiring manpower, implementation, and running costs at the healthcare facilities, which can pay for themselves in the long term. The government should encourage Indian companies; large, Micro Small Medium Enterprises (MSME), and startups to provide healthcare solutions for India.

- 2. Development of affordable technology aided non-invasive diagnostics and surgical procedures, inexpensive drugs and targeted delivery mechanisms would have to be on top of the list of priorities. India should also focus on clinical transformation, which involves assessing and continually improving the way patient care is delivered. Given that Indian healthcare is under stress from an ever-increasing demand, there may be a natural tendency to resist change. Incentives to adopt technology at an individual level are limited. There needs to continuous training for professionals in healthcare on the longer-term benefits of technology solutions that improve patient care in terms of quality and cost.

34 https://rbc-dsai.iitm.ac.in/2019/01/19/IIT-Madras-Colloquium-videos.html
35 https://factordaily.com/longform/indias-big-data-huntfor-cures-mental-ageing-related-diseases/

- 3. The government has given a push to enhancing the healthcare system of the nation by launching the Ayushman Bharat, which will provide insurance cover to 100 million families in India[36]. Under the guidance of NITI Aayog, allocations to the tune of INR 30 billion have been set for creating a digital economy with emerging technologies like AI, the Internet of things, block chain and 3D printing[37]. These are all building block modern technologies for improving healthcare delivery. NITI Aayog has also indicated that one of the focus domains for applying AI in India is healthcare[38].

- 4. We believe that COEs in Indian universities should focus on developing technologies for healthcare. COEs like HTIC in IITM must continuously collaborate with clinical practitioners and healthcare providers. Given that healthcare is of paramount importance to India, there may be merit in collocation a medical school with some of the IITs or IISc and collocating a technology school with some of AIIMS.

Financial Inclusion

Expand on adoption of digital technologies to augment financial inclusion and disseminate financial and digital awareness in the society.

- 1. The next big agenda should be to bring about a mindset shift among newly connected financial beneficiaries. They should be taught and encouraged to derive benefits from the formal financial system and building a traceable credit history. Financial inclusion may also be made a mandatory subject at different educational levels, from school to higher levels of education.

- 2. The Government should explore digital technologies like mobile computing, AI and block-chain to develop newer innovative financial inclusion solutions – to close small business credit gap, remittances, and include unbanked adults into the formal financial system[39]. Another example may be for India to develop a mobile app to help more micro units across the country avail MUDRA loans for their operations. This mobile app is the front-end, while Small Industries Development Bank of India (SIDBI) in stead of SIDBI's 'Udyamimitra' could be the backend. The proposed app would not only focus on making it easier for micro units to apply and avail loans, but also use analytics and AI so that lenders also get more information about the borrowers.

Governance

Build an integrated approach to E-Governance.

An India wide-governance platform that gives Indians access to central, state and local governments should become another proverbial "steel frame" of India. This will drive-governance efficiencies and breaking down silos for Indians. And also reduce the overall cost of e-governance.

- 1. The impact of high-potential solutions can be maximized by sharing best practices. Project implementation can be accelerated and India can have a steep learning curve by sharing and pooling knowledge across central, state and local governments. Shareable Application Programming Interfaces (APIs) and digital tools can be hosted to facilitate usage by local bodies with some customisation. E-Governance platforms need the flexibility to allow users to customize in terms of language they prefer, multiple access points – devices and seva kendras are some of the key enablers for wider adoption. For example, the government's internal e-office initiative gives departments the ability to customise the tool to suit their specific requirements. Consequently, it is used across 367 departments of the central and state governments.

- 2. There are also important but difficult arms of the government that can be evaluated for E-Governance. These are parts of judicial and police processes. It will be a challenging but will be revolutionary and of immense benefit to Indians if this is brought under E-Governance as e-police, e-courts. Reducing the time for service delivery even by a few percentage points in these domains will be of immense benefit to the country. A blueprint of these types of new services will need experts from IITs, the National Law Schools, public policy schools, Lal Bahadur Shastri National Academy etc. to work on a framework for such a program.

36 https://www.pmjay.gov.in/
37 https://inc42.com/buzz/budget-2018-ai-ml/
38 https://niti.gov.in/writereaddata/files/document_publication/NationalStrategy-for-AI-Discussion-Paper.pdf
39 https://www2.deloitte.com/content/dam/Deloitte/lu/Documents/technology/lu-blockchain-accelerate-financial-inclusion.pdf

Grand Challenge

Machine translation for Indian languages

One of the tricky elements in providing a pan India E-Governance platform is the fact that India has 22 official languages and many more that are spoken. The aim should be to provide a robust machine translation solution to seamlessly translate between these 22 official languages and English. While there are commercially available solutions available from the large platform Multinational Corporations (MNCs), it is worthwhile to use a domestic solution that is free to use and where the government of India is in charge of the data that is used in the machine learning. The objective of the grand challenge will be two-fold. First, increase the accuracy of translation between languages. Second, cover as many languages as possible. It must be possible to use the machine translation platform in a real time mode like in a personal digital assistant or chatbot. Or offline to translate existing documents.

NITI Aayog has already realized the importance of machine translation. It has announced a project that creates a machine learning system that is conceptual dictionary to help decipher correct meaning of words in 18 Indian languages. The objective is to help in translation, dialogue generation, question-answering and information retrieval.

SANGAM 2019

Reimagining India in 2030

Human Enablement – Education and Skill development for Jobs in the future

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SANGAM 2019
REIMAGINING INDIA IN 2030

itihaasa
Research and Digital

People and their knowledge, skills and capability are one of the most invaluable assets of India. The world is in a state of flux, where automation and digital innovations are changing the fundamental nature of work and could potentially cause imbalance in the labour-market opportunities leading to challenges of unemployment and underemployment. This is where India needs to transform its education and skill development strategies, bolster investments in its human capital and reap the benefits of demographic dividend and ensure sustainable long-term economic growth. 1) Use an effective bouquet of vocational skills training programs that are multilingual and delivered online 2) School education in India has to be transformed to include skill education, nurturing children with learning disabilities and leveraging the power of digital learning. 3) Adapt the higher education system to prepare young Indians in emerging multidisciplinary Science, Technology, Engineering, Art and Mathematics (STEAM) disciplines.

Objectives

- Skill and re-skill India's workforce to keep up with the change in demand. Many of the jobs in existence today will become redundant with 47% of the jobs disappearing in the next 25 years[1]. 40% of the Indian population in the working age should be skilled by 2030[2] using effective bouquet of vocational skills training programs that are multilingual and delivered online.
- By 2030, all Indians especially those under 30 years of age should be literate[3].
- Increase Gross Enrolment Ratio in undergraduate programs to at least 40% by 2030 and 50% by 2035[4]. Adapt the higher education system to prepare young Indians in emerging multidisciplinary STEAM disciplines that will emerge in the next decade and beyond.

1 https://bigthink.com/philip-perry/47-of-jobs-in-the-next-25-years-will-disappear-according-to-oxford-university
2 https://www.mckinsey.com/~/media/McKinsey/Featured%20Insights/Employment%20and%20Growth/Technology%20jobs%20and%20the%20future%20of%20work/MGI-Future-of-Work-Briefing-note-May-2017.ashx
3 https://mhrd.gov.in/sites/upload_files/mhrd/files/nep/English1.pdf
4 https://mhrd.gov.in/sites/upload_files/mhrd/files/Draft_NEP_2019_EN_Revised.pdf

Current Situation

Skill Development

India should improve its Human Development Index and place greater emphasis on human enablement.

0.640

India's Human Development Index for 2017

India is on the verge of a transformation that can lead to unparalleled economic growth along with drastic improvements in the country's Human Development Index (HDI). India's HDI value for 2017 is 0.640[5], which put the country in the medium human development category. In order to improve HDI, India should lay greater emphasis on human enablement. This implies strengthening skill development, school education, higher education and research.

Industry 4.0 indicates that the rise of modern technologies will alter the job landscape resulting in displacement of the workforce. Such upheavals are a part of the creative destruction process that impact employment, job roles and skilling requirements. What is inevitable, however, is the requirement to generate new and inclusive employment opportunities for India's growing youth and women.

India has to train and impart skill development to the estimated 12 million people entering the workforce every year.

12 million

people entering the workforce every year

Approximately 62% of the Indian population are of working age (15 to 59 years), 65% of whom are under the age of 35. The result is an estimated 12 million people entering the workforce every year[6]. There are multiple initiatives by the Ministry of Skill Development to improve the skills of Indian workforce, notable being the Pradhan Mantri Kaushal Vikas Yojana[7]. India has to confront the dual challenge of a continued increase in number of citizens entering the job market and the impact of Industry 4.0 and technology intensive farming. According to the National Skill Development Mission, it is estimated that only 4.69% of the total workforce in India has undergone formal skill training as compared to 68% in UK, 75% in Germany, 52% in USA, 80% in Japan and 96% in South Korea[8]. In China, skilled workers account for 24% of the workforce[9].

India needs to remodel the vocational skills training sector which includes the ITIs and polytechnics.

2.8 million

total capacity to train 2.8 million Indians in 126 trades

Owing to the significant change in nature of job requirements, the skills and competencies required of workers are also undergoing tremendous change. At this juncture, India needs to remodel the vocational skills training sector which includes the ITIs and polytechnics to be able to meet future skill requirements, while also catering to the education needs of a burgeoning population. Furthermore, the informal sector will have to be brought into the purview of the skill development programs. According to the Ministry of Skill Development and Entrepreneurship, in 2016 a network of 13,350 Government and private ITIs located all over the country have a total capacity to train 2.8 million Indians in 126 trades[10]. There is scope for multiplying the reach of Government and private Industrial Training Institutes (ITI) using Massive Open Online Courses (MOOCs) and online simulations.

5 http://www.in.undp.org/content/india/en/home/sustainable-development/successstories/india-ranks-130-on-2018-human-development-index.html
6 https://www.orfonline.org/research/43609-conceptualising-an-inclusive-future-of-work-in-india/
7 https://www.msde.gov.in/pmkvy.html
8 http://pib.nic.in/newsite/PrintRelease.aspx?relid=122929
9 https://counterview.org/2018/07/03/bridging-the-skills-gap-less-than-5-of-workforce-in-india-has-undergone-formal-skill-training/
10 https://www.msde.gov.in/assets/images/annual%20report/Annual%20Report%202016-2017%20-%20English.pdf

Education

School education in India has to be transformed to include skill education, nurturing children with learning disabilities and leveraging the power of digital learning.

The New Education Policy draft shows the direction making skill education an integral part of all education and covering to at least 50% of all learners by 2025[11]. Skill development and hands-on-learning can also start young. This is one of the rationales for setting up the Atal Innovation Mission[12]. School education is not only important for imparting skills-based education to all Indians but also responsible to achieve 100% literacy goals.

73%

of all Indian children enrolled in grade 8, only about 73% can read at least a grade 2 level text

Indian school children are not acquiring the basic literacy. By grade 8, the last year of compulsory schooling in India, children are expected to be not only to have mastered foundational skills but to have proceeded well beyond the basic stage. This is not the reality. Annual State of Education Rural 2018 report indicates that of all Indian children enrolled in grade 8, only about 73% can read at least a grade 2 level text[13]. The flat learning curve of students over several years in foundational literacy and numeracy is linked to students not attending or dropping out of school. Schools and teachers are under pressure to cover the prescribed curriculum while also attending to students who are unable to catch up in the previous years. Another aspect that merits attention is that of children with learning disabilities (like dyslexia) – 1 in every 6 school going children face this challenge. Early detection and providing multi-sensory (visual, auditory, kinaesthetic, tactile) teaching can provide effective remediation for the children with disabilities.

The rise in Internet penetration has increased the number of online users in India has surpassed the number of people who have completed primary education. This characterizes the growing influence of digital economy. According to Ministry of Electronics and Information Technology (MeitY), Indian Internet subscriptions stood at 560 million in 2018[14]. In comparison, the number of Indians who are studying in school and university is about 435 million and the number of Indians studying in elementary school up to standard 8 is about 202 million[15]. The prevalence of the Internet in India implies that is has a role in augmenting school education. While increase in enrolments and opening new schools may provide a linear increase in literacy, the proliferation of knowledge through use of Internet and digital technologies power an exponential increase in literacy.

Higher education must capitalize on current expertise and build the new capabilities required for the next decade.

While school education and literacy are part of a fundamental foundation to build on, it is higher education that provides India the catapult to meet its economic aspirations. Countries across the globe are addressing this challenge by embedding the curriculum of STEAM (Science, Technology, Engineering, Arts, and Mathematics) in their education architecture. The focus worldwide is on developing an interdisciplinary and applied approach instead of the regular tendency of studying subjects in silos. In order to cultivate the much sought after STEAM skills, India must also incorporate this approach in its educational set up across all levels. The future workplace will demand the hard-critical thinking and problem-solving skills along with the soft communication, creativity skills. Single-skill and single-discipline jobs are likely to become automated over in the 21st century, and it will be imperative to get multidisciplinary expertise in higher education. By focusing on such broad based, flexible, individualised, innovative, and multidisciplinary learning, higher education must aim to prepare its students not just for their first jobs - but also to learn continuously for their second, third, and all future jobs over their lifetimes. In particular, the higher education system must prepare the leaders for Industry 4.0.

11 https://mhrd.gov.in/sites/upload_files/mhrd/files/nep/English1.pdf
12 https://niti.gov.in/content/atal-innovation-mission-aim
13 http://img.asercentre.org/docs/ASER%202018/Release%20Material/aserreport2018.pdf
14 https://www.meity.gov.in/writereaddata/files/india_trillion-dollar_digital_opportunity.pdf
15 https://mhrd.gov.in/sites/upload_files/mhrd/files/statistics-new/ESAG-2018.pdf

40%

of all colleges in the country run only a single programme

India has over 800 universities and approximately 39,000 colleges, reflecting the overall severe fragmentation of higher education[16]. Over 40% of all colleges in the country run only a single programme, far from the multidisciplinary style of higher education that will be required in the 21st century. In fact, over 20% of colleges have enrolment below 100, while only 4% of colleges have enrolment over 3000[17]. Thousands of the small colleges hardly have any teaching faculty at all, and there is little or no education taking place - thus affecting severely the integrity of the higher education system in India. Another interesting aspect of Indian university education is that distance mode of education has a majority of total enrolments at about 55%[18].

The quality of higher education in India also impacts the quality of its research.

Based on analysis of the SCImago database, between 1996 and 2017 Indian research publications have been cited 12.6 million times compared to China's 39.2 million times and the USA's 267.6 million times[19]. This provides a measure of the impact of Indian research compared to other countries. There are about 24,000 PhDs that India graduated in 2015-16[20]. There are about 160,000 students currently enrolled in a PhD program in India[21]. About 88,000 of them are in STEM (Science Technology Engineering Mathematics) streams. While the quality of Indian research is a mixed bag, there is a silver lining is that in some emerging STEAM domains like AI where India is third in the world in terms of citable publications[22].

While India has the basic foundation, it needs to ramp up skill development programs and match supply with demand. The supply-demand matching needs to be both in terms of numbers as well as in terms of hot skills required. There should be robust mechanisms to ensure that the supply and demand are in equilibrium. The primary focus of Indian school education should be to achieve 100% literacy and nudge students to pursue interests in either higher education or vocational skill development. Higher education in India should create the science, technology and leadership capability for India to become a USD 10 trillion economy in 2030.

Constraints

Skill Development

Skill development initiatives in India suffer from the challenges of small scale, poor employment outcomes, and mismatched supply & demand.

40%

less than 40% of India's ITI and polytechnics' students find employment on graduation

The key requirement for India to enable a robust workforce is inextricably linked to skill development. Skills training has to come into the main stream education to ensure Indians are skilled for the jobs that open up in the coming decade. While there is a growing demand for a skilled workforce, the skills education stream in India is still very small in scale. Only around 3% of students are enrolled in vocational streams at the upper secondary level and less than 40% of India's ITI and polytechnics' students find employment on graduation[23]. This apart, the skills education is largely unresponsive to the labour market requirements. Inadequate involvement of the industry in skills education leads to a mismatch of skills that are required as opposed to the skills that are generated.

16 https://mhrd.gov.in/sites/upload_files/mhrd/files/statistics-new/ESAG-2018.pdf
17 https://mhrd.gov.in/sites/upload_files/mhrd/files/nep/English1.pdf
18 http://aishe.nic.in/aishe/viewDocument.action?documentId=245
19 https://www.livemint.com/Education/GP0k0R7jySJvdUQcoyxMAN/What-India-can-learn-from-Chinas-rise-in-higher-education.html
20 https://mhrd.gov.in/sites/upload_files/mhrd/files/statistics-new/ESAG-2018.pdf
21 http://aishe.nic.in/aishe/viewDocument.action?documentId=245
22 http://www.itihaasa.com/pdf/itihaasa_AI_Research_Report.pdf
23 http://web.worldbank.org/archive/website01291/WEB/0__CO-41.HTM

There also appears to be teething issues in the implementation of various skilling initiatives of the Government[24]. The National Skill Development Council, through its partner training providers, has trained around 600,000 in 2016-17, and could place only about 73,000 of those trained. This is a placement rate of about 12%[25]. One of the challenges appears that employers are not satisfied with the focus on short term training by private trainers and seem to prefer a mix of long-term and short-term training by ITIs and polytechnics. At present, there is no standardized process of mapping skill requirements across sectors and across the country geographically. There is no process to match demand and supply of skills in a timely manner. Though there are plans, India does not have a vocational skills program in school.

Education

Education in schools faces the primary challenges of misplaced infrastructure-learning outcome priorities, attendance and lack of appropriate teacher guidance.

One of the main challenges currently plaguing the education sector is inadequate public funding and disproportionate focus on school infrastructure as opposed to learning outcomes. There also seems to be a lack of mechanisms to monitor learning outcomes compounded by insufficient training of teachers. This is accentuated in the case of providing training for teachers to handle disability (like dyslexia).

There are more basic challenges in Indian school education as well. Keeping children in school is a key issue that needs to be addressed. A related aspect is increasing the average number of years of schooling from 7 to 10 in the coming decade. But then using a quantitative measure like average number of years of schooling for the evaluation of improvement in education is not enough. It has to be supplemented with the evaluation of education quality that is received in the corresponding period. If there is no emphasis on the quality of education, a mere increase in the number of years of schooling will not serve the purpose. Rural school education needs to become robust. The enrolment of children in schools across rural India, in the age group 6-14 is over 96% and attendance between 70-74%. The percentage of girls staying out of school in rural India in the age group of 15 to 16 is a high 13.5%[26].

Higher education in India is suboptimal on various fronts including access, resource utilisation, teacher shortage, range and number of programmes and disciplines.

Higher education in India is suboptimal on various fronts including resource utilisation, range and number of programmes and disciplines, and the ability to introduce high-quality multidisciplinary programs in emerging STEAM disciplines. From a focus perspective, there is too much early specialisation and streaming of students into disciplines. Indian higher education has developed rigid boundaries of disciplines and fields, along with a narrow view of what constitutes education. For example, there are thousands of stand-alone teacher education institutions, and most engineering and medical colleges are also stand-alone institutions.

Even in universities that offer programmes across more than one discipline, there are silos that separate disciplines within these institutions. For example, students in engineering are generally not encouraged or even allowed to take courses outside of their single programmes (e.g. in the arts, humanities, social sciences, or even in the pure sciences). India produces undergraduates with identical education rather than true individuals and humans exercising their own creativity, and developing their own talents and interests. All these challenges imply that India takes more time than other global leaders to ramp up its capability to build expertise in emerging multidisciplinary domains. Some of these multidisciplinary domains like brain science is critical for India in the coming decade.

25%

Gross Enrolment Ratio (GER) of higher education has risen over the last several years

Access in higher education has significantly improved in the past few decades, but is still not sufficient to reach all our young citizens; equity in and quality of education still remain a big challenge. The Gross Enrolment Ratio (GER) of higher education has risen over the last several years, to around 25%[27], but this is inadequate given India's socio-economic aspirations.

24 https://www.thehindu.com/opinion/lead/skill-india-urgently-needs-reforms/article23447258.ece
25 https://www.business-standard.com/article/economy-policy/why-india-s-skill-mission-has-failed-117090200098_1.html
26 http://img.asercentre.org/docs/ASER%202018/Release%20Material/aserreport2018.pdf
27 http://aishe.nic.in/aishe/viewDocument.action?documentId=245

Teacher shortage is also a challenge in Indian higher education. Besides, there are a large number of faculty posts lying vacant, for example in central universities, nearly 33% of teacher posts were vacant in March 2018 and faculty training is inadequate[28]. When it comes to development of teachers, there are inadequate in-service training programmes as well as lack of public funding support. The eligibility tests for teachers and facilitators are insufficient in their efficacy. There a lack of system for managing and adequately addressing the demand and supply of teachers at the regional, state and national level.

Way Forward

Skill Development

1. For jobs in the future, we will see a skill-sets trifurcation model in play and India needs to gear for this scenario.

Many white-collar jobs considered safe from erosion due to automation, are under threat of extinction in near future. As machines evolve into smart systems (a combination of hardware and software) every function involving routine cognitive tasks stands exposed for transfer from humans to machines. Autonomous Vehicles would not need any drivers, Offices can do away with the accountants providing routine accounting services, factories can be run with minimal need for human presence and even interpretation of X-rays and other health care data and images be handed over to sophisticated AI systems. It is projected that nearly 400 million jobs that exist today worldwide, will not be there in two decades.

Studies by World Bank, leading consulting firms of the world and economists affirm the emergence of this trend already. Employment and GDP Data collected from the developed countries seem to show jobless growth phenomena since year 2000. Apart from the projected job losses in coming years, they are also predicting a tectonic shift in nature of surviving jobs and the need for massive retraining of employees. As many as 375 million jobs face this threat over next two decades.

Yet there is a silver lining here. The new economy demands higher order skills as well as newer category of jobs that may not have existed so far. the experts project the emergence of at least 800 million new jobs during the same time horizon of three decades. They are calling for major structural changes and curriculum redesign in the educational sector (both early education and subsequent on the job learning) to gear up to this challenge. India is no exception to this scenario even though the magnitude of impact may be less severe.

The skills demanded in future can be represented as shown below in the Skill Sets Trifurcation Model (SSTM).

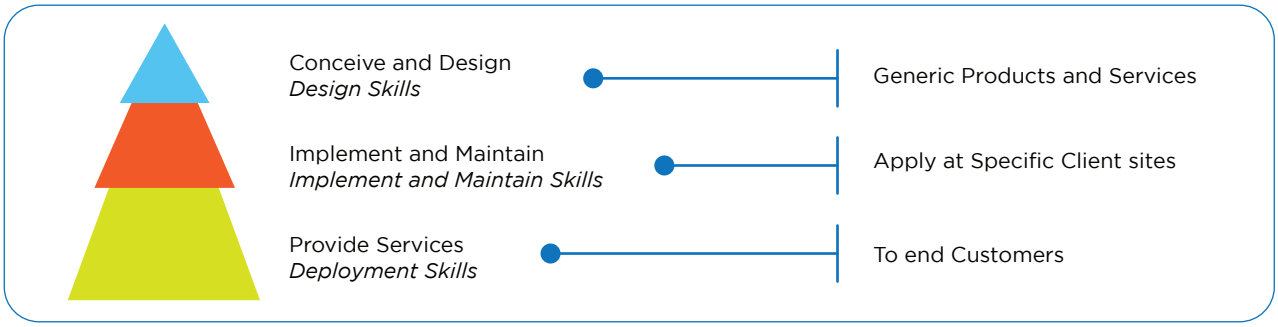
1. Smart systems of the future demand optimization of features and functionality distributed between hardware and software and periodic enhancement. Products and Services need to be conceived and designed to cater to the emerging demands in the market place. This would be a premium skill in demand albeit the percentage of population required to be skilled may be less than 2%

2. An entirely different but allied set of skills are needed to take these products and implement them at millions of customer sites around the world. The product functionality needs to be tweaked and tuned to local requirements just as say a Generic Billing System would need adjustments or changes depending on the vertical or geographic domain of the customer. Further, the number of people needed with these skills will be a scale factor of the order of 20 and more in comparison to the design skilled personnel.

3. The employees at the customer firm also require additional skills to use these products and serve their end customers. The deployment (of the system) calls for retraining existing employees on an ongoing basis. Again, the number of people to be retrained will be a multiple factor of people needed for implementation.

Since most of the new jobs are expected to be created with these skill sets, the educational sector has to be adequately geared with capacity to meet demand.

28 https://www.business-standard.com/article/current-affairs/with-33-teaching-posts-vacant-indian-varsities-continue-to-lag-globally-1180816001 00_1.html



The Skill Sets described above pertain to the new economy jobs expected to be created in the next three decades. Populace need to build these skills on top of the traditional skill sets of Domain & Technical, Interaction & Communication and Supervisory & Leadership skills towards which the existing curricula are focused.

2. Continuously align demand and supply in vocational skills training.

- By 2035, TIFAC forecasts that 30% of Indians are still likely to be in the Left Out or Left Behind category, 20% are Rooted and Remote, and 55% being Beehives and Production Lines[29]. With the advent of Industry 4.0, bringing vocational training in to main stream education to improve employability of students is essential. India may need to seriously consider having a separate stream for vocational skills education from secondary school. This is like China where after nine years of schooling there is an option to take vocational skills stream. This is chosen by about 50% of Chinese school students[30]. Skills training will become more appealing if there is quality content is vernacular language. This can be achieved by leveraging e learning modules and MOOCs.

- While short term courses may be appropriate for those who are already employed and looking to upgrade their skills, long term courses with certifications from it and polytechnics may be required for the unemployed. A continuous mapping of skills demand and courses required to fulfil the demand is also essential to increase the placement ratio post skills education. Out of the box thinking is required to identify new skills that are likely to be in demand in the next decade for self-employment. Some in-demand skill development programs in the near future are likely to include electronics (including repair of mobile phones), optics fabrication (for making spectacles), sustainable technology and waste management (like making pulverising units for kitchen sinks), etc. For people with disabilities, a multiple-intelligence skill development program should be considered.

- India should also explore an apprentice model in engineering skills post school just like that for Charted Accountants (CA). This will address the challenge of that engineering graduates are not industry ready today and provide an industry ready workforce in engineering disciplines. There should be a well-defined process of credit transfer where students in the apprentice stream can shift into a full-time engineering course and also to apply to graduate and doctoral courses in engineering.

- While the apprentice model is one way forward, India should improve the quality of the existing model of skill education. Focus on training the trainers is essential to infuse quality and it is time for India to have a BEd and MEd program for teachers in ITIs and polytechnics. There is merit in creating centers of excellence in different skills. These centers can include an advisory board from industry, IITs and IIMs.

- Models like the Deshpande Foundation's in-campus program for skill development for youth from rural and semi-urban areas can be adopted pan-India. It empowers young graduates from small towns and villages across India by increasing their capabilities to meet changing skill requirements of the industry, ensuring effective personality development and awakening their leadership spirit. The placement rate of 70% to 80% achieved by the Deshpande Foundation's in-campus skill development program is about 6 times that of current short-term Government enabled skill development programs. The Deshpande Foundation also has the Elevate skilling program that is conducted in various college campuses in rural and semi-urban areas to provide them employment opportunities right after their graduation in minimal cost and time. The program focuses on creating motivated employees and entrepreneurs who imbibe high levels of leadership and professional experience. This program also has modules in professional English, use of ICT and soft skills.

29 http://planning.kar.nic.in/docs/SDG/Technology%20Vision%202035.pdf
30 https://www.thehindu.com/opinion/lead/skill-india-urgently-needs-reforms/article23447258.ece

Education

1. Ensure children are functionally literate and proficient in basic skills before they leave school.

- The draft recommendations in the New Education Policy are spot on in terms of its focus on creating functionally literate children[31]. India must aim to achieve 100% Gross Enrolment Ratio for all school education by 2030. No child loses any opportunity to learn and excel because of the circumstances of birth or background. Special attention paid to early language and mathematics in grades 1 to 5.

- Ensure that every student in Grade 5 and beyond must achieve foundational literacy and numeracy by 2025. The proposed new developmentally-appropriate curriculum and pedagogical structure for school education based on principles of brain development and learning has been developed based on a 5 + 3 + 3 + 4 design must be implemented.

- A structured multi-modal teaching program is required in regular schools to address children with learning disabilities.

2. Teachers are central to achieving these goals and we need to create and implement programs and platforms that addresses teacher competency gaps.

- Teachers will be recruited through robust, transparent processes, promotions will be merit-based, multi-source periodic performance appraisals will happen and progression paths to become educational administrators or teacher educators will be available.

- The Ministry of Human Resource Development and the National Council for Teacher Education launched the National Teacher Platform or Diksha in 2017, in collaboration with non-government stakeholders such as the Central Square Foundation and EkStep[32]. Diksha addresses teacher competency gaps through courses that plug their skill gaps.

- IIT Madras in collaboration with Madras Dyslexia Association (MDA) launched 'e-Shikshanam,' a free online teacher training programme to 'Provide Remedial Support to Children with Specific Learning Difficulties'[33]. The Government should provide wide publicity and encourage wider adoption for initiatives like these.

3. We can learn from the best and next practices in school education from other parts of the world.

- Considering the poor quality of primary school education across most schools in India, it is worthwhile to study Finland's educational system which is considered to be the best in the world. Finland has evolved a world class system of education by ensuring high competency of teachers and autonomy to schools.

- The curriculum highlights the importance STEAM. Finland lays emphasis on the importance of a multi-disciplinary approach to education and utilizes the concept of "phenomenon-based" teaching[34], which includes classroom discussion on a broad and relevant range of social issues. Such a teaching methodology inculcates the habit of applying skills across disciplines in a single class. This methodology simulates real-life approach to solving problems and provides insight into the everyday complexity of the world.

- An interesting aspect of phenomenon-based curriculum is that students are involved in planning their classes and assessing their learning outcomes from such classes. This has resulted in Finnish students performing much better than their counterparts on global assessments.

31 https://mhrd.gov.in/sites/upload_files/mhrd/files/nep/English1.pdf
32 https://www.hindustantimes.com/education/the-urgent-need-for-spotlight-on-training-teachers-in-india/story-5hQCvJEYu9Mi9r0C0RbtQM.html
33 https://www.indiatoday.in/education-today/news/story/iit-madras-madras-dyslexia-association-launch-free-online-programme-to-train-primary-school-teachers-1510640-2019-04-26
34 https://bigthink.com/design-for-good/the-latest-school-reform-in-finland-introduces-a-new-way-to-look-at-subjects

4. Increase higher education GER and focus on emerging multidisciplinary STEAM disciplines

- India should aim for GER to reach 40% by 2030 and 50% by 2035, in order to fulfil the aspirations of our youth and to form the basis for a vibrant society and economy. This implies more than doubling enrolment, from the present base of 35 million students, and including increased opportunities and access for students from socio-economically disadvantaged backgrounds and women.

- GER can be improved with flexible curricular structures will enable creative combinations of disciplines of study, and offer multiple useful exit and entry points for students, thus demolishing currently prevalent rigid boundaries and creating possibilities for lifelong learning. One of the important changes that are envisaged by the New Education policy is that the undergraduate degree may offer multiple exit options with appropriate certification. An advanced diploma in a discipline or field (including vocational skills and professional areas) after completing 2 years of study or a certificate after completing 1 year.

- Open and distance learning needs to expanded, thus playing a significant role in increasing the GER. Given the existing large footprint of distance learning in India, MOOCs will have an important role to play in the coming decade. IITM's pioneering work with NPTEL will be one of the important pillars to ensure that MOOCs scale up with the highest quality comparable to in-class programs.

- Apart from digital mediums, India should also explore how we can contextualize the concept of community colleges that are popular in countries like the USA. These colleges can become another path to obtain both certified skills as well as credits for a university course. These colleges can also serve as a lateral entry feeder to universities.

- The focus of the New Education Policy on higher education policy is on multidisciplinary STEAM education[35]. A broad-based liberal arts education at the undergraduate level for integrated, rigorous exposure to science, arts, humanities, mathematics and professional fields is in the plan. Along with flexible curricular structures, creative combinations of study, integration of vocational education and multiple entry/exit points presents a good architecture for higher education in the coming decade. IITs will have to focus on multidisciplinary undergraduate and graduate programs in domains like Industry 4.0 technologies, brain science, computational biology, sustainability technology, etc. This is easier said than done since departmental silos need to be broken. Another change that will create impact is to introduce practice stream faculty in engineering colleges who can bring in the latest industry practices into the classrooms. The practice stream will also ensure that the students are more job ready than they are today. The success of the practice stream of faculty will depend on creating a different set of performance metrics vis. a vis. research faculty and maintain a parity among the two streams.

- There is also a pressing need for integrating humanities as a second specialization along with technology in the IITs. For example, an MS program in AI and Ethics can be offered in IITM jointly by the departments of computer science and engineering, humanities and social science and management studies. AI and ethics are becoming important across the world, and will become even more important in a country like India when AI technologies increasingly pervade everyday lives of the one billion who may not be digitally savvy. It is also imperative that multidisciplinary graduate level education provides rigorous research-based specialization on par with the best of the world in the institutes of eminence and national importance.

35 https://mhrd.gov.in/sites/upload_files/mhrd/files/nep/English1.pdf

Grand challenge

1. Integrated digital platform SWAYAM 2.0 to bring together learning material from KG to PG in English and multiple Indian languages for Indians.

While India has a good start in the SWAYAM platform of the Government that is designed to achieve the three cardinal principles education that is access, equity and quality[36]. SWAYAM takes the best teaching learning resources to all, including the most disadvantaged. SWAYAM seeks to bridge the digital divide for students who have hitherto remained untouched by the digital revolution and have not been able to join the mainstream of the knowledge economy.

SWAYAM is focused on undergraduate and post graduate education. While there are content providers for schools like National Council of Educational Research and Training (NCERT) and National Institute of Open Schooling (NIOS) are part of SWAYAM there is no content for students in school. SWAYAM 2.0 needs to have content starting from KG. Apart from videos, there should also be an emphasis to have more quality text books and activity/problem sheets in SWAYAM 2.0. Perhaps the most important feature of SWAYAM 2.0 will be an ability to accurately translate material in English to any Indian language and vice versa. This is important to reach many more Indians. The ability to store and transfer SWAYAM 2.0 credits must be made easy. There should also be links to financial services providers who can offer micro loans to students who want to take up a SWAYAM 2.0 credit but cannot afford one. Most important, there should be a special focus in SWAYAM 2.0 on helping Indians functionally literate in whatever Indian language they choose.

2. Develop a model for a National Skill Development Framework

A National Skill Development Framework (NSDM) has to be developed with equal focus on the demand and supply side factors. This is in response to the job creation challenge, building appropriate skill sets in working age populace to meet market demand and optimal capacity creation.
Why is there a need for a NSDM?

Government of India has recognized the need and urgency to revamp the education sector and to create the ecosystem for continuous skill building, in this context. It has set up the National Skill Development Corporation (NSDC) and embarked on new initiatives such as Skill India, Digital India, Smart Cities and Make-In-India. It has chosen to standardize the curriculum, testing and admission procedures and upgrade the competencies of many institutions.

Yet numerous studies of independent agencies have recorded that the results achieved are still far below the targets set (for NSDC and key programs such as PMKVY) and show that the nation faces an up-hill task. Numerous gaps have been identified in structuring the institutions, planning initiatives and their implementation. Some of the major shortcomings are

- Between the studies done to ascertain the current status (the descriptive) and the goals set by policy makers and the new initiatives (the prescriptive), there is no visible connect. Neither the cause and effects of forces that move the current state to a desired future state have been identified nor reflected in the path chosen to move to the goals set.
- The lack of assurance that these are the best means by which the nation can reach the goals efficiently. Measures of efficacy are conspicuously absent.
- Another major shortcoming is the disconnect between the demand and supply side initiatives. Investments in improving the educational and skill building institutions have no validation-ready link to the demand side.
- The initiatives and the institutions entrusted to implement them sit in silos. They are not effectively interlinked within themselves and to the functional departments of the government at state and central levels.

36 https://swayam.gov.in/

Hence the need for a comprehensive model at the national level which is quantifiable, actionable, envelops all stakeholder institutions, reflect all major cause and effect linkages, and above all provide the logical link between the supply side and demand side initiatives.

Such a National Skill Development Model can be built along the following steps:

1. Skill supply side segmentation plan: Define supply segments with adequate granularity for the purpose in mind. For example, it can be correlated to the educational attainment level such as K10 students, +2 level students, college students, vocationally trained students, blue and white-collar workers, volunteers etc. Sub segments can be defined to any depth as needed.

2. Develop Work Population Count Table: Estimate number of working population, in 5-year intervals for a 30-year period, for different supply segments defined earlier. It has to recognize population age-specific growth trends , migration patterns etc.

3. Demand side segmentation plan: The demand-side for skills consists of traditional sectors like agriculture, factory floor, MSMEs, government services, military services and futuristic AI-impacted new products and services that will be defined in coming decades.

a. The skills categories required by these different sectors range from basic skills, domain / technical skills, interaction/communication skills, managerial skills, AI-impacted skills trifurcation (of design, implementation and deployment as defined in the SST Model).

b. For example, in the sector of Agriculture, the following skills may be required in the future:

i. Basic skills of tilling

ii. Domain skills of next farming practices, micro-irrigation

iii. Communication skills of interacting with market intermediaries

iv. AI-impacted skills of handling AI enabled farm advisory systems

4. Skills Demand Matrix: A Skills Demand Matrix (SDM) needs to be developed combining the Demand Side Segments identified earlier and the Skill Categories defined. SDM cells are to be reviewed for existing curricula and to be revised to measure up to the desired new curricula.

5. Desired Employee Count Table (DECT): Across the defined demand side segments one has to determine the desired count of the population with appropriate skill sets. This has to take into account the national aspirations for equitable economic growth, income distribution, job dispersal etc. They have been expressed in terms of goals to be achieved in various policy documents. In other words, status quo has to be changed to the desired levels of population to be engaged in different work segments within the society. The role of technology as the job creator and destroyer has to be duly recognized as well.

6. Skill Generators Identification: Schools, Colleges, Polytechnics, Diploma Institutions et al exist at present with the capability to generate required skills. They are supplemented by in-house training programs, government certified third party trainers and more. The information age has created on line systems (such as MOOCs) as well. A given set of skills can be imparted by one or more of them. Hence Skill Generators need to be classified and defined with adequate partitions.

7. Capacity Augmentation: The current capacity that exists in the country is determined by the capacities of different skill-generators with the focus on SDM defined earlier. The desired capacity is derived by mapping the SDM with the demand side count derived through DECT. The gap between the two represents the capacity augmentation needed in the country.

8. Capacity Augmentation Plan: It is apparent that the capability to deliver the training program may exist in many skill-generators and a strategy has to be developed as to which one or more of the generators is best positioned to provide the service to a given Demand Segment.

a. Based on existing reach, ability to reach to a demand segment with ease, ability to scale quickly, ability to provide service of consistent quality and being cost effective, one skill-generator may score over others

b. Hence evolving the Efficacy Matrix [EM]for the skill-generators is an exercise needed to be undertaken. This will guide allocation of additional capacity to a particular skill-generator category.

9. National Investment Plan: Capacity Augmentation is a resource and time-consuming process. The resources demanded would include Land, Capital, Trainers, Training materials and more. Procurement and supply of each of these resources can also be a time-consuming activity, Hence the planning process for capacity augmentation need to recognize resource-requirements explicitly.

Since the Model needs to be quantifiable, all cause effect relationships can be expressed in mathematical terms. Further it has to serve the purpose of efficient resource allocation in a dynamic mode. Hence a computer-based Simulation/Optimization Model has to be developed. It is likely that instead of one comprehensive (and hence too complex) model, it can be an assemblage of sub models that can be linked in a logical framework.

It should be amenable for action. Hence existing and proposed initiatives and institutions need be represented in the model and be able to be analyzed for resource consumption, program efficacy etc.

The grand challenge is to develop it with wide consultation within a given time frame (6 months) and pilot it within a year. Numerous policy changes may need to be effected with respect to creation and working of nodal agencies, fixing responsibility and accountability, empowerment, inter agency coordination, role of public sector versus private sector, testing and certification institutions, data and decision distribution between human and machines etc. They can be undertaken in parallel to the development and piloting of the NSDM.

About IIT Madras Alumni Association (IITMAA)
www.iitmaa.org

IIT Madras Alumni Association (IITMAA) was founded in 1964, after the graduation of its very first batch. IITMAA represents around 50,000 alumni of IIT Madras across the world. Its motto is: 'Reconnect... Engage... Impact'.

- Reconnect with our alma mater, with our faculty and friends.
- Engage through active participation through Chapters, Special Interest Groups but online and virtually.
- Impact through giving back to our Country, our Society, our alma mater, and our association.

About itihaasa Research and Digital
(www.itihaasa.com)

itihaasa Research and Digital is a not-for-profit, Section 8 company that studies the history and evolution of technology and business domains in India. Kris Gopalakrishnan, co-founder of Infosys, is its founder and Chairman.

itihaasa's flagship project is chronicling the six decades of the evolution of the history of Indian IT – a digital chronicle that is available as a mobile app on Apple & Google and as a chatbot.

itihaasa published in 2019 reports on the Landscape of AI/ML Research and Brain Research in India.