



RESEARCH AND DEVELOPMENT ECOSYSTEM IN INDIA

HARNESSING INNOVATION FOR GROWTH



**“What is research but a blind date with knowledge?
-Will Harvey”**

INTRODUCTION

As the world continues to grapple with the pernicious Covid-19 pandemic, the role of innovation has regained importance. The pandemic was dealt with rigorous research and development (R&D) in the health domain with COVID-19 vaccines being developed, clinically tested and manufactured at unprecedented speed. Likewise, technological advancements enabled by R&D have transformed health, transportation, communication, energy, and manufacturing industries across the globe.

As R&D emerges globally as one of the major drivers of socio-economic development, it will play a major role in achieving India's aspirations and goals. So, let us first understand what does R&D entail and why is a robust R&D ecosystem pivotal for the sustainable progress of India? What measures have been taken to boost its R&D ecosystem in India? How far has India progressed in the field of R&D? What holds back India in realizing its growth potential in the R&D sector? What more can be done to make India a global R&D hub?

WHAT DOES R&D ENTAIL AND WHY IS A ROBUST R&D ECOSYSTEM PIVOTAL FOR THE SUSTAINABLE PROGRESS OF INDIA?

R&D activities can be defined as any systematic and creative work undertaken in order to increase the stock of knowledge and use of this knowledge to devise new applications. R&D activities include one or more of the categories of research such as-

Basic Research	<ul style="list-style-type: none"> Experimental or theoretical work undertaken primarily to acquire new knowledge about the underlying foundation of varied phenomena and observable facts, without any particular application or use in view. <ul style="list-style-type: none"> For instance, research in pure mathematics, which may take the form of exploratory, descriptive or explanatory research.
Applied Research	<ul style="list-style-type: none"> Largely the same as basic research, but it is undertaken with a specific practical aim or objective in mind. It is an approach used in diverse fields ranging from business to medicine to education and beyond.
Development Research	<ul style="list-style-type: none"> Unlike the other two forms which are focused on the acquisition of new knowledge, development research takes into consideration existing knowledge and employs it towards producing new materials, products or devices, installing new processes, systems and services, or improving existing ones substantially.

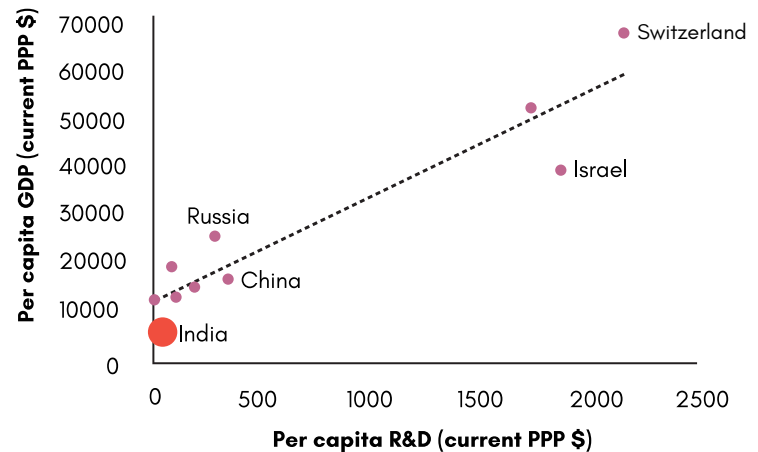
SIGNIFICANCE OF R&D FOR INDIA'S NATIONAL GROWTH

- Achieving sustained economic growth:** It has been seen that R&D has been a major determinant of economic growth in developed countries around the world. R&D facilitates long term economic growth by **bringing industrial transformation, increasing productivity, expanding the markets, creating employment and generating wealth and capital**.
 - The Intellectual Property generated from R&D also brings in revenue to the economy in the form of copy rights and patents.
- Creating a knowledge based economy:** As India emerges as one of the world's largest economies, it needs to gradually move from being a net consumer of knowledge to becoming a net producer. Innovation enabled by R&D fosters **positive knowledge spill overs**, encouraging future technological change and other innovation activities.



- **Solving socio-economic challenges for sustainable growth:** In developing countries, innovation is not only associated with economic growth but also with poverty alleviation, reduction in inequality, increase in social mobility and improvements in standard of living.
 - R & D and innovation play a significant role in **addressing urgent developmental challenges** such as providing access to clean drinking water, low cost renewable energy solutions, eradicating neglected diseases, reducing hunger, etc.
- **Fundamental to India's security:** R&D helps in ensuring security of its populations by **developing the resilience needed to address the multiple uncertainties** stemming from climate change to global meltdown and the national security challenges arising from cyberwarfare to autonomous military systems such as drones.
- **Facilitating future preparedness in emerging domains:** R&D is pivotal for keeping pace with rapidly changing and disruptive global technology landscape.
 - Maturing technologies including Artificial Intelligence (AI), the Internet of Things (IOT), robotics, Big Data Analysis, Precision Medicine, Genomics etc. are expected to enter into every industry and across all societal segments.
- **Attracting foreign investments:** Access to technical competencies is one of the significant factors for attracting investments in India to expand manufacturing and production operations under the ambitious 'Make in India'.
- **Promoting self-reliance and resolving trade imbalances:** Development of indigenous technologies is crucial for fulfilling the dream of Atma-Nirbhar Bharat (Self-reliant India) and strengthening India's trade profile which has been substantially impacted by the increasing imports and decreasing exports in the hi-tech sector.
 - E.g., R&D in the defence sector can help reduce import dependence, whereby **India accounts for 11% of global arms imports**, according to the Stockholm International Peace Research Institute (SIPRI).

Correlation between Per Capita R&D Expenditure and Per Capita GDP across countries



HISTORICAL TRADITION OF RESEARCH & DEVELOPMENT IN ANCIENT INDIA



IN CONVERSATION!



Vini: Hey Vinay! How was your trip to Delhi?

Vinay: It was great Vini. I visited all the historical sites. You know there is an Iron pillar in the Qutub complex which was constructed about 1500 years ago but has never rusted.

Vini: Really! To achieve this feat India must have scientists working in the field of metallurgy back then.

Vinay: Not only metallurgy, but India also has a long tradition of conducting research in other scientific fields like mathematics, medicine and astronomy. Universities like Takshashila and Nalanda were globally famous as centres of knowledge.

Vini: Fascinating! Even I have read about the Indian mathematician Baudhayana in 800 BCE who calculated the value of pi and discovered what is now known as the Pythagoras' theorem. Do you know more about such discoveries from ancient India?

Vinay: Yes. In the field of medicine, mentions of plastic surgery and cataract removal have been found in Sushruta Samhita. It is one of the oldest medical book of the world which was written in 6th century BC by Sushruta who is widely regarded as the 'Father of Indian Medicine'.

Vini: Wow! Scientific knowledge was at a highly advanced stage in ancient India.



WHAT MEASURES HAVE BEEN TAKEN TO BOOST ITS R&D ECOSYSTEM IN INDIA?

○ **Building Institutional framework:** Since independence, India has established a wide network of institutions working towards research and development in varied fields -

□ **Governmental ministries, departments and agencies like** Ministry of Earth Sciences (MoES), Department of Science and Technology (DST), Department of Scientific and Industrial Research (DSIR), Office of the Principal

Scientific Adviser, Prime Minister's Science, Technology and Innovation Advisory Council (PM-STIAC), Science & Engineering Research Board (SERB), Department of Biotechnology (DBT) etc.,

□ **Publicly funded autonomous/semi-autonomous institutions, research councils and research centres** such as Bhabha Atomic Research Centre, ISRO, CSIR, ICAR, BARC etc.

□ **Public Sector Enterprises** like Biotechnology Industry Research Assistance Council (BIRAC).

○ **Streamlining regulatory processes:**

□ **Employing digital technologies in the processing of the research proposals** involving online receipt and online processing of the proposals for review and approvals and digital transfer of the research grants.

□ **Strengthening intellectual property rights (IPR) regime** by establishing dedicated body-Cell for IPR Promotion and Management (CIPAM); ensuring compliance to TRIPS (Trade Related Aspects of Intellectual Property Rights); providing incentives such as 10% rebate on online filing, 80% fee concession for Start-ups, Small Entities and educational institutions etc.; raising IPR awareness etc.

○ **Facilitating private investment in R&D:** through measures like-

□ **Fiscal Incentives for Scientific Research** such as 100% write-off of revenue expenditure on R&D.

□ **Permitting FDI under 100% automatic route** in R&D sector subject to applicable laws/regulations, security and other conditionalities.

□ Allowing corporate sector to make R&D investments under the provision of **Corporate Social Responsibility (CSR)**.

○ **Promoting research and innovation through Start up and entrepreneurship:** Schemes like Start-up India, NIDHI (National Initiative for Developing & Harnessing Innovations), Atal Innovation Mission's Atal Tinkering Labs and Atal Incubation Centres, Innovations for Defence Excellence (iDEX) etc. are primarily aimed at promoting and supporting innovative ideas and successfully transforming them into commercial R&D ventures.

○ **Providing infrastructural support to researchers** through schemes like- SATHI (Sophisticated Analytical & Technical Help Institutes), SAIF (Sophisticated Analytical Instrument Facilities), FIST (Fund for Improvement of S&T Infrastructure in Universities and Higher Educational Institutions), Indian Science Technology and Engineering facilities Map (I-STEM) etc.

○ **Enhancing participation of women researchers:** Schemes like KIRAN, SERB-POWER (Promoting Opportunities for Women in Exploratory Research) etc. aim to mitigate gender disparity in science and engineering research funding in Indian academic institutions and R&D laboratories.

○ **Reversing brain drain to brain gain** through initiatives like-

□ **'VAJRA'** which aims to bring the best of global science and scientists to India, including NRIs.

□ **National Post-Doctoral Fellowship Programme** to encourage PhD recipients to stay in India.

Research Councils of India	
They were established and made responsible for cutting edge Research & Development activities / knowledge base in diverse areas or fields. Some prominent research councils include-	
Space	Indian Space Research Organization (ISRO)
Defence	Defence Research and Development Organization (DRDO)
Nuclear energy	Department of Atomic energy (DAE)
Industrial research	Council of Scientific and Industrial Research (CSIR)
Agriculture	Indian Council of Agricultural Research (ICAR)
Medicine	Indian Council of Medical research (ICMR)

SCIENCE POLICIES PROPELLING INDIA'S S&T GROWTH

SCIENCE POLICY RESOLUTION 1958

- Largely emphasised **basic research in almost every field of science.**
- **Provided the required directions to set up organisations** like DRDO (1958), DST (1971), Department of Space (1972) etc.

SCIENCE AND TECHNOLOGY POLICY STATEMENT OF 1983

- Majorly focused on **achieving technological competence and self-reliance.**
- **Technology Development Fund (TDB)** established to provide financial assistance to Indian industries.
- **Technology Information Forecasting and Assessment Council (TIFAC)** established for continuous and systematic forecasting and assessment studies of emerging technologies.

SCIENCE AND TECHNOLOGY POLICY OF 2003

- Majorly focused on **achieving technological competence and self-reliance.**
- **Technology Development Fund (TDB)** established to provide financial assistance to Indian industries.
- **Technology Information Forecasting and Assessment Council (TIFAC)** established for continuous and systematic forecasting and assessment studies of emerging technologies

SCIENCE TECHNOLOGY & INNOVATION POLICY 2013

- Laid emphasis on creating a robust environment for **enhanced private sector participation in R&D.**
- **India streamlined its efforts by launching several flagship initiatives** including Make in India, Atal Innovation Mission (AIM), Start-Up India, Stand-Up India, Fund of Funds for Start-ups (FFS), introduction of the Patent Box Regime, Regulatory Sandbox, etc.
- **India increased her participation in global mega-science projects**, including the Laser Interferometer Gravitational Wave Observatory (LIGO), the Large Hadron Collider (LHC-CERN), the International Thermonuclear Experimental Reactor (ITER) etc.

- **Policy framework:** The government is currently in the process of drafting its **5th Science, Technology and Innovation Policy, 2020**. The policy by way of its decentralized, bottom-up, and inclusive design process aims to strategize priorities, sectoral focus, and methods of research and technology development for larger socio-economic welfare.
 - Further, Union Budget FY 2021-22 proposed an outlay of **Rs 50,000 crore**, spread over five years, for **National Research Foundation** envisioned under the **National Education Policy, 2020** to enable a culture of research to permeate through our universities.
- **Attracting youth to research through Scholarships/grants/fellowships** under schemes like Prime Minister's Research Fellowship (PMRF) scheme, Innovation of Science Pursuit for Inspire Research (INSPIRE) etc.
- **Dedicated Technological missions** to direct R&D efforts in emerging fields, e.g., National Supercomputing Mission, National Mission on Quantum Technologies and Applications, National Mission for Deep Ocean Exploration (DOE), National Mission for BioScience for human Health, National Mission for Artificial Intelligence, etc.
- **International cooperation:** India cooperates bilaterally with several nations such France, USA, Israel and Germany in the field of R&D. Further, India is partnering in various international programs such as International Solar Alliance, Mission Innovation, International AIDS Vaccine Initiative etc.



Other prominent schemes:

- **Manthan platform** to drive collaboration between the industry and research institutes to implement technology-based social impact innovations and solutions in the country.
- **AGNi** scheme to support the national efforts to boost the innovation ecosystem in the country by connecting innovators across industry, individuals, and the grassroots to the market and helping commercialize innovative solutions.
- **Impacting Research Innovation and Technology (IMPRINT) programme** to address the most socially relevant challenges in the field of engineering, technology, and self-reliance for translating research knowledge into viable technology products and processes.

HOW FAR HAS INDIA PROGRESSED IN THE FIELD OF R&D?

In the recent decades, India has shown considerable progress in the field of R&D which is evident by its performance in the **Global Innovation Index (GII) 2021 released by World Intellectual Property Organization (WIPO)**, where India ranked **46th** among 132 economies, quite an improvement from 81st in 2015-16.

- India's innovation ecosystem stood **2nd** among 34 lower middle-income economies and 1st among 10 Central and Southern Asian economies.

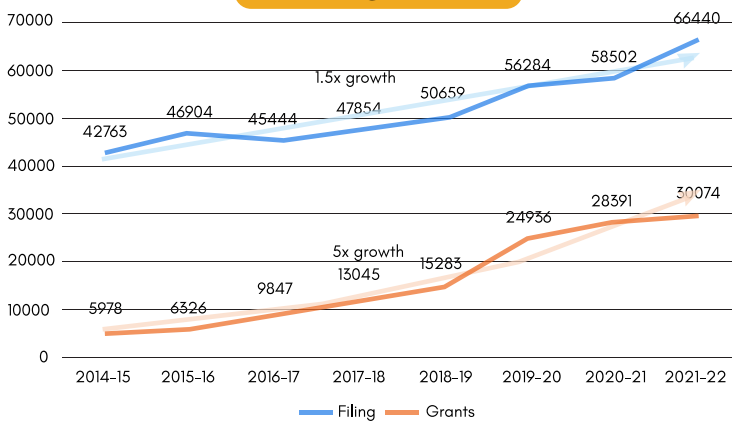
Further, there have been **several positive trends** pointing towards growth in India's R&D sector-

- **R&D expenditure:** India's Gross Expenditure on R&D (GERD) that nearly tripled between 2007-08 to 2017-18 and per capita R&D expenditure increased 1.5 times.

INDIA'S GLOBAL PERFORMANCE ON OTHER PARAMETER

3RD in Number of PhDs awarded in Science and Engineering (after the USA and China).	3RD in Number of publications (from 6 th in 2013) based on National Science Foundation database, USA.	9TH in Resident Patent Filing activity in the world. (WIPO report)
9TH in the Quality of research publications (from 13 th in 2013) in the world's reputed and recognised SCI Journals.	5TH largest office for trademark filing activity overtaking Japan. (WIPO report)	3RD in Start-Up ecosystem and in terms of number of Unicorns. (Economic Survey of India 2021-22)

PATENTS IN INDIA






Patents:

- ◆ **Filing of patents have increased more than 50%** in a span of 7 years from (42763 in 2014-15 to 66440 in 2021-22).
- ◆ **Grant of patents has increased nearly five times** in 2021-22 (30,074) as compared to 2014-15 (5978).
- ◆ **Reduction in Time of patent examination** from 72 months in Dec 2016 to 5-23 months at present, for different technological areas.
- ◆ **For the first time in the last 11 years, the number of domestic patent filing has surpassed the number of international patent filing** at Indian patent office in the Quarter Jan-Mar 2022.

◆ **Foreign Investment:** India attracted USD 343.64 million FDI equity inflow in R&D sector during C.Y. 2021 (Calendar Year) which is 516% higher as compared to previous C.Y. 2020 (USD 55.77 million).

◆ **Researchers:** The number of researchers per million population has more than doubled since 2000.

SIGNIFICANT ACHIEVEMENTS OF INDIA'S R&D ECOSYSTEM

SECTOR	NOTABLE ACHIEVEMENTS
 Space Technology	<ul style="list-style-type: none">● Mars Orbiter Mission (MOM) made India the first nation in the world to reach the Martian orbit in its maiden attempt.● Successfully developed indigenous Cryogenic Upper Stage engine.● Launched 2 missions to the moon- Chandrayaan-1 and Chandrayaan-2.● Successfully established and operationalised the Navigation with Indian Constellation (NavIC).● Polar Satellite Launch Vehicle (PSLV) emerged as the reliable and versatile workhorse launch vehicle of India used by multiple foreign nations.● Successfully tested new technologies such as Supersonic Combustion Ramjet (SCRAMJET) engine, Reusable Launch Vehicle Technology etc.● Future endeavours: Human Space Flight mission- Gaganyaan Programme, mission to study the Sun- Aditya L-1, 3rd mission to moon-Chandrayaan-3 to attempt to 'soft land' on the moon.
 Medicine	<ul style="list-style-type: none">● Global supplier: In the global market, India is the largest supplier of generic medicines, accounting for 20% of the worldwide supply. India also caters to 60% of the global vaccine demand.● Indigenously developed vaccines: ROTAVAC against rotavirus, CERVAVAC against Human Papilloma Virus (HPV), COVAXIN for Corona virus etc.
 Defence	<ul style="list-style-type: none">● Major products developed for defence use by the DRDO: Light Combat Aircraft (LCA) Tejas; Airborne Early Warning and Control (AEW&C) System; Weapon Locating Radar (WLR) Swati; High Speed Heavy Weight Ship Launched Torpedo (Varunastra); Akash Weapon System; Abhay Sonar etc.● With Mission Shakti, India became the fourth nation in the world to have demonstrated anti-satellite capability based on indigenous technology.● India is the 5th country in the world to have developed an indigenous ballistic missile defence programme.

Despite, considerable progress and numerous achievements, India's R&D ecosystem still lags behind major global economies and perform inadequately on key R&D parameters. For instance, Indian residents contribute only 36% of patents filed in India as compared to 62% on average in the top ten economies.

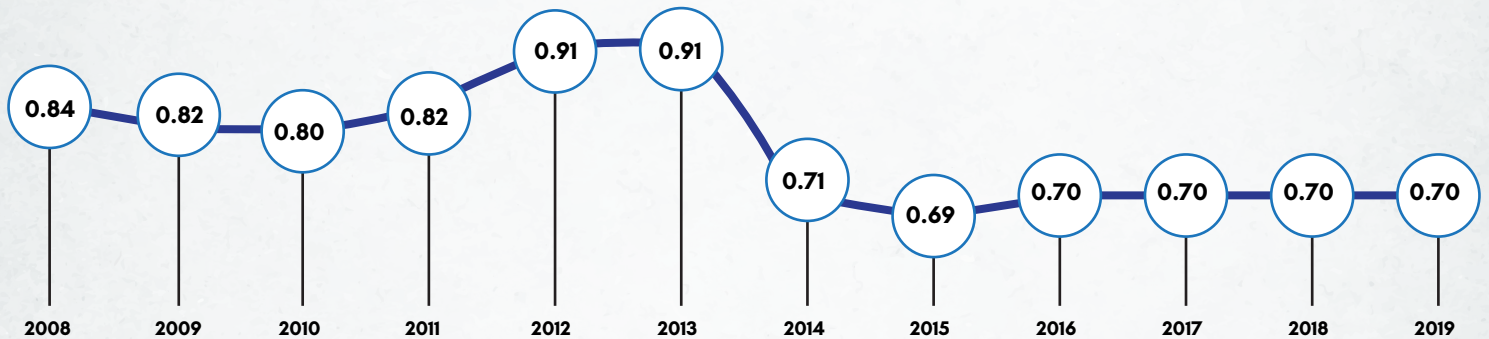




WHAT HOLDS BACK INDIA IN REALIZING ITS GROWTH POTENTIAL IN THE R&D SECTOR?

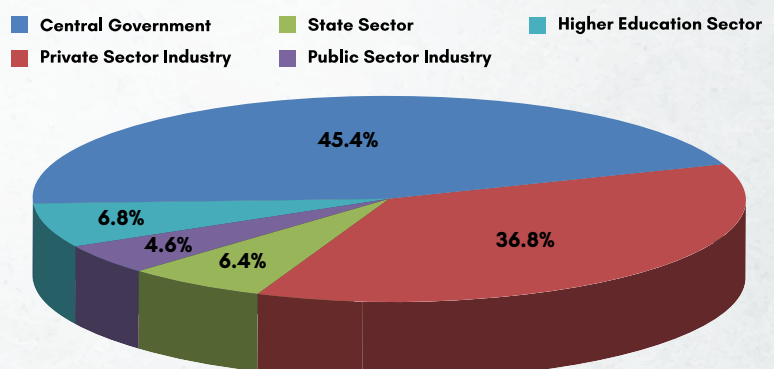
- Financial constraints: Overall share of gross expenditure on R&D (GERD) as a percentage of GDP has been stagnant at around 0.7% of GDP** over the past few years. It is well below major nations such as the US (2.8%), Israel (4.3%) and Korea (4.2%) and lowest among BRICS countries- Brazil (1.3%), Russian Federation (1.1%), China (2.1%) and South Africa (0.8%). Factors responsible-
 - Fiscal limitations of public exchequer** due to other socio-economic priorities—such as hunger, poverty, disease control, etc.
 - Inadequate private sector investment into R&D:** Unlike other advanced countries where more than 70% contribution of GERD comes from the private sector, in India the private sector contribution to GERD is less than 40%. This is primarily because of the high-risk nature of R&D activities, which are capital intensive and have long gestation period for any returns.

GERD as a share of GDP in India, 2008-2019(%)



- Shortage of qualified human resource: Researchers per million inhabitants in India was only 253 in 2018**, in comparison to 1,225 in China. The measure of researcher intensity is important because it determines the number of patents filed, contribution to scientific journals, and industrial trademarks registered. Factors responsible-
 - Persistent issues in India's educational system:**
 - Shortage of institutions offering research opportunities:** Only 2.7% Colleges run Ph.D. programme and 35.04% Colleges run Post Graduate Level programmes.
 - Outdated curriculum and pedagogy** which falls short in inculcating an innovation mindset among Indian students.
 - Lack of systematic monitoring or evaluation of R&D projects** in educational institutes.
 - Absence of formal or informal mentorship and career development support** at institutions for researchers.
 - Bureaucratization of Indian public institutions:** Education in India is highly centralized and there exists very limited autonomy for most institutions. Excessive government interference hinders scientific progress and forges more disincentives in an already straggling environment.
 - Other issues:** Varying quality of education in STEM subjects leading to poor employability of Indian graduates in R&D, limited availability of qualified staff, limited access to state-of-the-art research facilities etc.

NATIONAL R&D EXPENDITURE BY SECTOR, 2017-18



■ Socio-cultural issues:

◆ **Risk-Averse Ecosystem:** Risk taking is fundamental to a successful R&D ecosystem. However, in India, career choices are mostly based on quick returns on the investments made and is tied to a fear of and intolerance for failure, making it difficult to generate innovative ideas or promote existing ones.

◆ **Brain Drain:** Skilled human resource including R&D personnel migrate out of India due to lack of innovative opportunities and to seek better living conditions.

◆ **Lack of inclusivity:** Socio cultural norms and hurdles deter many sections of the society including women from actively participating in R&D activities, shrinking the talent pool. E.g., share of female researchers in India was only 18.7% in 2018.

○ Challenges in translating research into successful technologies, due to factors like-

■ **Skewed focus towards basic research in comparison to application-oriented R&D:** More than 25% of investment is directed at basic research, against China's 5% and U.S.'s 17%. This implies that few ideas translate to a commercial success.

■ **Low Industry-academia connect** leading to academia set-up of India traditionally being largely focused on research publications than business commercialization.

■ **Wasteful expenditure due to absence of a clear-cut guidance and vision on commercialization** of R&D in many scientific departments.

○ Structural issues:

■ **Fragmented R&D ecosystem** highlighted by lack of synergy between the Government, the public and the private institutions engaged in R&D. This leads to duplication of efforts, wasteful expenditure and loss of opportunities for interdisciplinary research.

◆ Further, State governments and universities play a relatively small role in the research activities and every state designs its own separate policies rather than within the national framework.

■ **Narrow focus:** More than one-third of the total national expenditure on R&D is spent on health and defence. While these two sectors are crucial, India also needs to focus on other sectors including social sciences for all-encompassing growth.

■ **Vacuum in planning/strategizing:** Due to lack of a vision or a plan or a target, major stakeholders pursue their individual agenda without a concerted, coordinated plan of action.

Public vs Private sector investment: Role in R&D?

○ While R&D activities in India have always been propelled majorly through Government funding, in exemplars such as the **U.S. and Japan private sector has been a major driver behind R&D and innovation.**

○ Both public and private funding have significant role to play in boosting a Nation's R&D activities.

○ Although for a resilient R&D ecosystem, the role of **public fundings should be to complement and hence stimulate private R&D expenditures.** Significant roles in this regard have been stated below-

○ Role of Public Expenditure in R&D-

- Invest in public education system for development of human resource.
- Put in place research infrastructure.
- Support deployment of socially relevant technologies.
- Provision of incentives to promote R&D.

○ Role of Private Expenditure R&D-

- **Invest in setting quality standards** for technological interventions.
- **Strengthen sector-wise R&D and innovation.**
- **Financially support scientists and academia** in their ongoing research.
- **Invest in upcoming enterprises** in emerging technologies.



WHAT MORE CAN BE DONE TO MAKE INDIA A GLOBAL R&D HUB?

○ **Increase R&D investments:** India as a nation should invest at least 2% of GDP in R&D by 2030. This necessitates encouraging investment from the private sector. For the purpose, following measures can be undertaken-

□ **De-risking mechanisms for joint investments by industry and government,** particularly for high-risk and high-investment projects and for open-ended research on various sectoral or technology verticals.

□ **Establishment of public private partnership (PPP) based incubators.**

□ **Provision of incentives** such as tax concessions with a sunset clause patent related incentive, etc.

□ **Creation of R&D parks** on the lines of a SEZ to offer incentives to investors thereby attracting both domestic and foreign investment.

□ **Government funding of the research being done by the start-ups** would help them raise funds from the open market as the vetting process reduces the information cost and provides credibility to the firms' research.

○ **Reforms in educational system:**

□ **Developing efficient governance mechanisms** which ensures functional autonomy, transparency, accountability and adaptability by strengthening interlinkages to **create a conducive research environment.**

□ **Fostering innovation mindset:** Programs and activities at school level can be encouraged for development innovative thinking and problem solving, e.g., via design thinking or project-based learning.

□ **Promote research as an attractive career option** through incentives such as increasing scholarships and research grants, development of a unique Research Career ladder, Institution of Excellence Awards for accomplishments in the form of impactful quality research and/ or research-based teaching etc.

□ **Update curriculums** for skilling in emerging and futuristic technologies.

□ **Inclusivity:** A concrete action plan to re-energize and encourage women participation right from the elementary stage of school education will help unlock creativity and innovation.

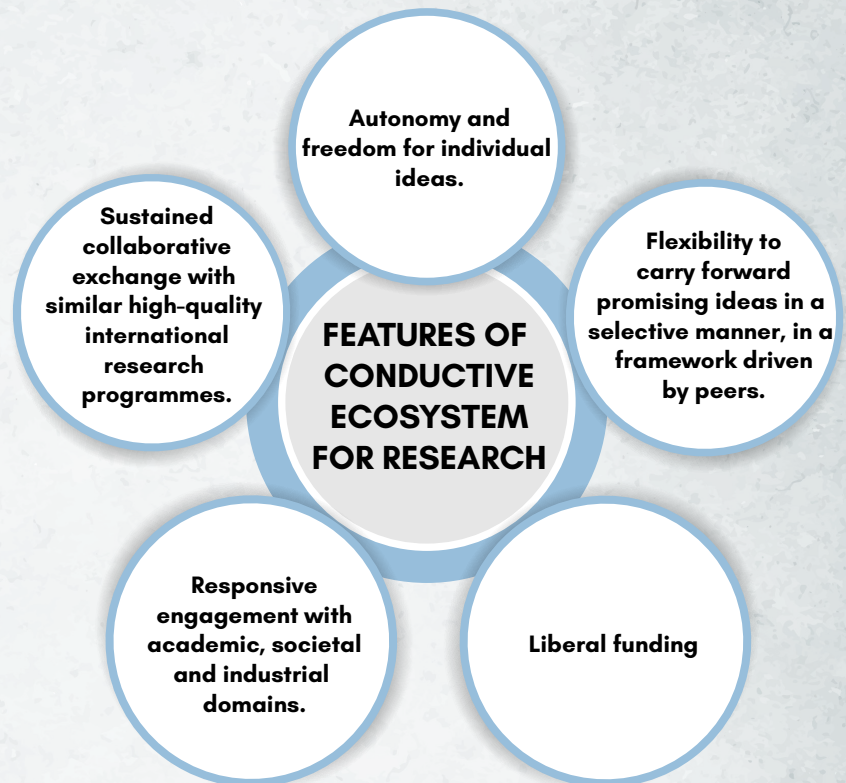
○ **Commercialization of research activities:**

□ **Enhancing industry academia connect:** Strategic partnerships and innovation clusters can be developed with multiple stakeholders including industry players, research organizations, institutions, associations, NGOs, government bodies.

□ **Enhance focus and expenditure on application-oriented R&D activities,** especially in social sector.

○ **Strategizing R&D activities:**

□ **Institutions like the Office of Principal Scientific Adviser and NITI Aayog can act as the top national coordinators** for R&D to connect with all R&D spending stakeholders including CPSEs, Universities, domestic and international R&D institutions and State Governments as well as for preparing a blueprint in monitoring the R&D pathways for the future.





- **Enhancing international collaboration:** Government can partner with countries that have truly been trail-blazers in R&D in specific sectors using platforms like GITA (Global Innovation & Technology Alliance). These collaborations will give an access to global best practices which can then be customized to suit the Indian context.
- **Aligning research promotion activities** with the mandates of various National Missions, SDGs, Start-up India leading to a Self-Reliant India (Atma-Nirbhar Bharat).
- **Expand scope of research by identifying futuristic S&T areas:** Emerging disruptive technologies that will be essential for global competitiveness of Indian sector include big data, automation, AI, IoT, Blockchain, Cyber Security, Nanotechnology, Biotechnology, Energy Storage, Genetics, 3-D printing, etc.

Opportunities for India: Utilizing India's unique strengths for a resonant R&D ecosystem

- **Frugal innovation:** India already excels at creating low-cost high-quality products using existing technologies and has played a crucial role in bringing a range of affordable products like medicines, vaccines etc. to developing countries.
 - These innovative tendencies need to be further extended to development of **new simple, affordable, and accessible solutions for the global market**, e.g., developing treatments for range of neglected tropical diseases.
- **Talent pool:** According to the projections, India is expected to continue having one of the youngest populations in the World until 2030.
 - If skilled and trained efficiently, India will have access to one of the largest R&D talent pools across various mechanical, embedded, and digital domains.
- **Traditional knowledge (TK):** Indian TK like traditional systems of medicines, sustainable agricultural practices etc. offers immense potential to serve national and global needs.
 - Investing in R&D for validating and patenting India's traditional knowledge will propel new manufacturers and innovators to gainfully build enterprises and facilitate societal benefits as well as economic growth.
- **Large and rapidly growing market for products:** India is on the path to becoming a significant consumption economy driven by the middle-class, with 80% of households forming the middle class by 2030.
 - Leveraging India's vibrant start-up culture can help develop India-specific business models to suit India's unique challenges and demands.

CONCLUSION

The experiences of successful countries show that science, technology and innovation policies that are integrated into national development strategies can help raise productivity, improve competitiveness, and foster economic growth. Frontier technologies can bring enormous benefits to the lives of poor people with immense prospects in agriculture, health, education, energy and other areas of development. To reap these benefits, strategic efforts are required for stimulating the R&D ecosystem and encouraging ambidextrous, multipolar and disruptive innovations to meet the dynamic market conditions, developmental needs, and environmental sustainability.



Today's progress is the result of past innovations; today's innovations, in turn, sow the seeds for progress in the years to come.



TOPIC AT A GLANCE

RESEARCH AND DEVELOPMENT (R&D)

- Entails any **systematic and creative work undertaken in order to increase the stock of knowledge and use of this knowledge to devise new applications.**
- Include one or more of the categories of **Basic research, Applied research and Development research.**



SIGNIFICANCE FOR NATIONAL GROWTH

- Sustaining economic growth** by bringing industrial transformation, increasing productivity, expanding the markets, and creating employment and generating wealth and capital.
- Creating a knowledge based economy.**
- Solving socio-economic challenges for sustainable growth** and ensuring **India's security.**
- Facilitating future preparedness in emerging domains** like Artificial Intelligence (AI), the Internet of Things (IOT), robotics, Big Data Analysis, etc.
- Attracting foreign investments.**
- Promoting self-reliance and resolving trade imbalances**

GOVERNMENT MEASURES TO BOOST R&D

- Building Institutional framework:** Governmental ministries, departments and agencies like DST, Publicly funded autonomous/semi-autonomous institutions like CSIR, DRDO etc.
- Streamlining regulatory processes** related to patent filing and research proposals.
- Facilitating private investment in R&D:** through Fiscal Incentives for Scientific Research, Permitting FDI under 100% automatic route etc.
- Providing infrastructural support to researchers** through schemes like- SATHI, SAIF etc.
- Reversing brain drain to brain gain** through 'VAJRA' etc.
- Policy framework:** Thrust under Science, Technology and Innovation Policies and National Education Policy, 2020.
- Attracting youth to research through Scholarships/grants/fellowships.**
- Dedicated Technological missions** in fields like Supercomputing, AI, Quantum, Biotech etc.
- International cooperation:** Bilateral agreements with USA, Israel etc.; International Solar Alliance; Mission Innovation; International AIDS Vaccine Initiative etc.
- Other:** Manthan platform; AGNli scheme; IMPRINT programme

PROGRESS OF INDIA IN R&D

GLOBAL RANKINGS:

- Global Innovation Index (GII) 2021, WIPO:** Ranked 46th, leap from 81st in 2015-16.
- 3rd in Number of PhDs awarded in Science and Engineering, in Number of publications, and in Start-Up ecosystem.**
- 9th in Resident Patent Filing activity** and in the **Quality of research publications.**
- 5th largest office for trademark filing activity**

INVESTMENT:

- GERD nearly tripled** between 2007-08 to 2017-18.
- FDI equity inflow in R&D sector during C.Y. 2021** (Calendar Year) was **516% higher** as compared to C.Y. 2020.

PATENTS AND RESEARCHERS:

- More than 50% increase in Filing of patents** from 2014-15 to 2021-22.
- About 5 times Increase in Grant of patents** in 2021-22 as compared to 2014-15.
- Reduction in Time of patent examination from 72 months in 2016 to 5-23 months at present.**
- Number of researchers per million population more than doubled** since 2000.

IMPEDIMENTS IN R&D SECTOR

- Financial constraints:** Stagnant GERD to GDP ratio and Inadequate private sector investment into R&D.
- Persistent issues in India's educational system:** Shortage of institutions offering research opportunities; Outdated curriculum and pedagogy; Lack of systematic monitoring or evaluation of R&D projects; Bureaucratization of Indian public institutions etc.
- Socio-cultural issues:** Risk-Averse Ecosystem; Brain Drain and Lack of inclusivity.
- Challenges in translating research into successful technologies** due to Skewed focus towards basic research and Low Industry-academia connect.
- Structural issues:** Fragmented R&D ecosystem; Narrow focus; Vacuum in planning/strategizing etc.

WAY FORWARD: MAKING INDIA GLOBAL R&D HUB

- Increase R&D investments** by encouraging investment from the private sector through measures like De-risking mechanisms for joint investments; Provision of incentives etc.
- Reforms in educational system:** Develop efficient governance mechanisms; Foster innovation mindset; Promote research as an attractive career option; Update curriculums; Ensure inclusivity; Create a conducive ecosystem for research.
- Commercialization of research activities** by enhancing Industry academia connect and investing in application-oriented R&D activities.
- Strategizing R&D activities** by using Institutions like the Office of Principal Scientific Adviser and NITI Aayog; Aligning research promotion activities with National Missions; expanding scope of research by identifying futuristic S&T areas etc.