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REVIEW ARTICLE

Trends in Agricultural Research and Development in India

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ABSTRACT

There has been a significant transformation in the agricultural research and development scenario in India since the dawn of Green Revolution. Agricultural research has dramatically broadened its scale and scope, becoming multidisciplinary and more inclusive and integrative. One of the main reasons for low productivity in India is low investment on Agricultural research. The economic survey also noted that Agricultural R&D is the main source of innovation, which is needed to sustain agricultural productivity growth in the long-term. The Survey says that the actual expenditure of Department of Agricultural Research and Education/Indian Council of Agricultural Research (ICAR) has increased from Rs 5,393 crore in 2010-11 to Rs.6800 crore during 2017-18. The compound annual growth rate of expenditure has been 4.2% over the years and in recent years' expenditure has been on higher side. ICAR is allocated Rs 4,599 crore for the year 2018-19. This is 0.6% greater than the revised estimate in 2017-18. In 2017-18, the allocation under ICAR increased from the actual expenditure of Rs 319 crore in 2016-17. This is due to regrouping of salaries, pensions, and office expenditure from all schemes under ICAR. India's GERD has tripled in the last decade to Rs 85,326 crores in 2014-15 from Rs 24,117 crore of 2004-05. It is estimated at Rs 1,04,864 crore in 2016-17. Although India's investment in science, which is measured in terms of Gross Expenditure on R&D (GERD), has tripled in the last decade, the ratio was stagnant at 0.6 to 0.7 per cent of the GDP. Most of the developed countries spent more than 2% of their Gross Domestic Product (GDP) on R&D. India also should increase its spending on R&D to fulfil its objective of doubling farm incomes by 2022, the govt must hike R&D spend and facilitate private investments. Rapid increase in population followed by fragmentation of land has created a situation which urges the improving in productivity which is possible by focusing on agricultural research and development.

Key words: *Agriculture, Research, Development, Investment, Expenditure.*

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INTRODUCTION

India is an agrarian economy where agriculture and its allied activities act as a main source of livelihood for more than 80 per cent of the rural population. The primary sector provides employment for approximately 52 per cent of the total working force and contributes 16.6 per cent to total GDP of the country. Besides, agriculture sector is one of the important sectors which assist in ensuring food security, employment generation and ultimately economic development.

Research and Development in agriculture has a wide scope in addressing key issues in the society such as, achieving sustainability in production, ensuring nutritional security of the rural population, adoption and mitigation of climate change and also energy conservation. Agricultural research has dramatically broadened its scale and scope, becoming multidisciplinary and more inclusive and integrative. The Total Factor Productivity (TFP) growth, which was the main driving force for the overall growth of agricultural output during 1980s in India, has started slowing down in recent years. Various authors have estimated growth in TFP of agriculture in India [1,2,7].

India has one of the largest and institutionally most complex agricultural research systems in the world. Historically, the Indian agricultural research system is the zenith of a process which started in the 19th century and which resulted in the establishment of the Imperial (now Indian) Council of Agricultural Research (ICAR) on the recommendation of a Royal Commission on Agriculture in 1929. India also saw the beginning of scientific farming with the establishment of Department of Agriculture in each Indian province in 1880 under the British rule. Next step was to establish Imperial Agricultural Research Institute to foster agricultural research and education and decentralization of agricultural developmental activities to the Provincial Governments in response to Montague–Chelmsford Reform (1919). This led to

co-evolution of research and education [9]. Since then there was a stupendous evolution of agricultural research in India. The ICAR is an autonomous apex national organization which plans, conducts and promotes research, education, training and transfer of technology for advancement of agriculture and allied sciences. Over the years, it has developed a large research and training infrastructure to work on the production and other emerging problems confronted in agriculture to meet the growing demands for food, fodder, fibre and fuel. It coordinates agricultural research and development programmes and develops linkages amongst national and international organizations to enhance the quality of life of the India population, particularly of farming community. First, there is no clear concept of budgetary support to agricultural R&D by the government administration though it is accepted that one per cent of agricultural GDP may be allocated for agricultural research. An examination of data reveals that research intensity was hovering between 0.48 and 0.73 during 1999-00 to 2006-07 [5]. In the case of allocation of research resources across commodities, the relative value of the commodity in total value of agricultural production was used as a major criterion. Nearly 40 per cent of the resources found the way for research on food grains and horticultural crops [6].

As a percentage of Agricultural GDP, India spends 0.5% of its Ag GDP on agricultural research in 2011, which was lesser than the share invested by China (0.62%). It is also considerably less than the 2.6% spent by Brazil. However, in terms of researchers, India employs more than double than what Brazil does, with 12,750 people employed in this sector (excluding the private research industry), compared to 5,800 in Brazil. However, given the very different populations and structure of the farming industry, this represents a ratio of only 4.6 per 100,000 farmers in India, compared to 57 per 100,000 in Brazil. This paper highlights the investment and expenditure on Agriculture research and education in country by various departments. PPP in agricultural R&D is increasingly emerging as an effective means of conducting research in frontline areas of science and technology, commercializing new technologies, and deploying new products for the benefit of small-scale farmers, food-insecure consumers and other marginalized groups [8].

RESEARCH AND DEVELOPMENT

Research and Development (R&D) is the term commonly used to describe the activities undertaken by firms and other entities such as individual entrepreneurs in order to create new or improved products and processes. R&D defines as "creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications." R&D is generally thought to consist of three main activities: basic research, applied research, and development. Basic research is research undertaken primarily to acquire new knowledge without a view as to its application. Applied research is research directed towards a specific objective and development is work drawing on existing research results and directed specifically towards the creation of new and improved products and processes. In general, more than two-thirds of R&D spending by firms or countries is directed toward development rather than research.

Definition: Research and development (R&D) is to any activity associated with creating new innovations in existing products, services, or procedures or the discovery of new innovations that lead to the creation new products. In other words, it's an ongoing process of investigation that looks forward to create new things.

Objective of research and development in Indian agriculture.

- Increased returns to factors of production by reduced costs or increased output
- Improved product quality
- Introduction of new production
- Lower vulnerability through production control.
- Transform agricultural production into a modern science-based market oriented agriculture capable of greater efficiency, profitability and of sustaining growth in the agricultural sector while contributing to poverty eradication
- Promote agriculture and related industry for the purposes of contributing to the improvement of the quality of life and livelihoods of the people, having regard to the protection of the environment
- Support the development and implementation of national policy with relevant information and knowledge.

The Need for Agricultural Research

- To ensure food safety for the people under poverty line
- Improving the quality and safety of agricultural products
- Protecting crops and livestock from pest and diseases

- Determining the best nutrition for people of all ages
- Sustaining soil and other natural resources
- Ensuring profitability for farmers and processors
- Keeping costs down for consumers

RESEARCH AND DEVELOPMENT STATISTICS

Table 1: Research and development expenditure (% of GDP)

Country Name	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Brazil	0.99	1.08	1.13	1.12	1.16	1.14	1.13	1.20	1.27	1.28	-
China	1.37	1.37	1.44	1.66	1.71	1.78	1.91	1.99	2.02	2.06	2.11
India	0.82	0.82	0.87	0.84	0.82	0.83	-	-	-	0.62	-
Israel	4.14	4.43	4.35	4.13	3.94	4.01	4.16	4.15	4.20	4.27	4.25
Japan	3.28	3.34	3.34	3.23	3.14	3.24	3.21	3.31	3.40	3.29	3.15
United States	2.55	2.63	2.77	2.82	2.74	2.77	2.69	2.72	2.74	2.74	2.74
World	2.00	1.96	2.02	2.06	2.04	2.03	2.10	2.06	2.14	2.13	2.31

Source: OECD iLibrary

Table 1 depicts the R & D expenditure by different country's from 2006 to 2016 expressed in percentage of GDP. The total R&D expenditure in India as percentage of GDP has been stagnant at 0.6 to 0.7 per cent in the last two decades much lower than the US (2.8 per cent), China (2.1 per cent) and Israel (4.2 per cent). To keep the numbers in perspective, one must keep in mind that GDPs of the US and China are around seven and four times bigger than that of India. So when Ramesh Chand implicitly puts India's R&D spend on par with China, it calls for a reality check.

Table 2: AgGERD as a Share of AgGDP

	1980	1990	2000	2005	2010	2011	CAGR (%)
USA	3.8	4.7	8.3	8	7.3	6.9	2
Japan	5.3	7.8	11.4	14.4	14.3	14.5	3
China	0.2	0.1	0.2	0.4	0.7	0.8	5
Brazil	1.4	1.5	2.4	2.3	2.7	2.6	2
India	0.3	0.3	0.5	0.5	0.5	0.5	2

Source: InSTePP R&D Accounts, version 3.5

Table 2 portrays the share of agriculture GERD as a share of agriculture GDP. It is evident from the table that, developed countries like USA and Japan spend about 6.9 per cent and 14.5 per cent of their agriculture GDP on agriculture R&D respectively. On the other hand, developing countries have spent less than 1 per cent of their agriculture GDP on agriculture R&D. India had spent about 0.3 per cent of its agriculture GDP on R&D which was increased to 0.5 per cent in 2011 with a CAGR of 2 per cent. The growth rate was at maximum in case of China (5 %), followed by Japan (3%).

Table 3: Share of Total Global R&D Spending (in percentage)

Share of Total Global R&D Spending	2015	2016	2017	2018
North America (12 countries)	27.9	27.52	27.60	27.36
United States	25.8	25.36	25.60	25.25
South America (10 countries)	2.7	2.44	2.40	2.28
Europe (34 countries)	21.6	21.16	21.00	20.52
Germany	5.8	5.60	5.50	5.32
Asia (24 countries)	41.3	42.72	42.67	43.62
Japan	8.5	9.00	8.80	8.52
China	19.4	20.70	21.20	21.68
South Korea	3.9	4.00	4.10	4.03
India	3.5	3.60	3.70	3.80
Africa (18 countries)	1.0	0.88	0.90	0.92
Middle East (13 countries)	2.5	2.43	2.50	2.51
Russia/CAS (5 countries)	3.0	2.86	2.90	2.80

Source: *R&D Magazine* Survey (www.rdmag.com)

As noted in the Table 3, U.S. and European R&D investments as shares of the total global R&D spending have been declining over the past ten years, while Asian investments in R&D, especially that of China, have been increasing such that this country's share is now more than 43% of the global total. China's continuing large annual R&D investments with increases of 7% per year or more have been the driving

force in this trend, which is expected to continue for at least the next five years, as stated in China's current five-year plan. Small R&D regions, including Africa, the Middle East and Russia/CIS are not increasing their R&D at substantial rates and are expected to maintain their comparatively small shares of the overall global R&D.

Table 4: Country's R&D Investment

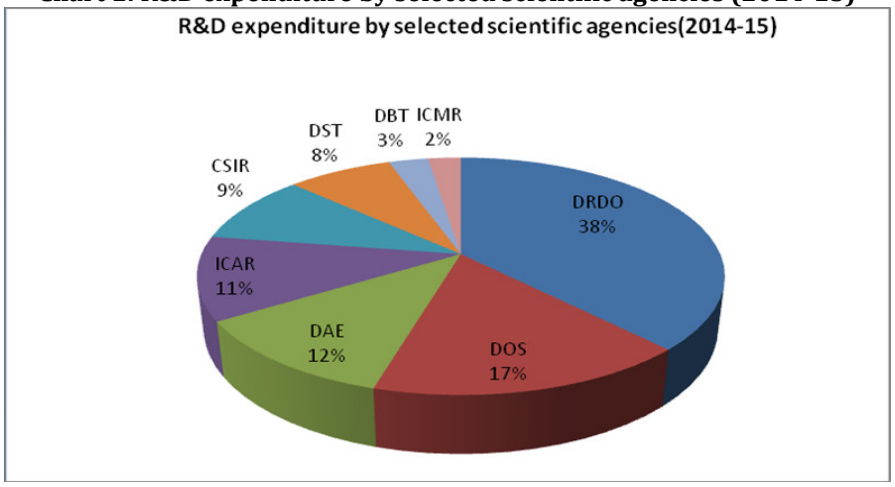
Global rank	Country name	2017		2018	
		GDP BIL USD	R&D BIL USD	GDP BIL USD	R&D BIL USD
1	US	$18,996.0	$537.59	$19,471.0	$552.98
2	China	22,695.00	444.82	24,102.00	474.81
3	Japan	5,300.90	185.53	5,332.70	186.64
4	Germany	4,043.70	114.84	4,104.40	116.56
5	South Korea	1,986.70	85.43	2,042.30	88.23
6	India	9,155.70	76.91	9,796.60	83.27
7	France	2,761.30	62.13	2,805.50	63.12
8	Russia	3,803.5	57.81	3,856.7	58.62
9	United Kingdom	2,841.7	49.16	2,884.3	49.61
10	Brazil	3,147.3	37.14	3,200.8	37.45

Source: *R&D Magazine* Survey

India is ranked sixth in terms of global R&D investments, increasing its R&D by 8.3% in 2018 to $83.3 billion. By increasing its R&D above the global average, India also improved its share of the global R&D total ($2.19 trillion in 2018) from 3.7% in 2017 to 3.8% in 2018. India is the world's seventh largest economy, but growing faster than any other country except for China. And by 2050, India is expected to be the world's second largest economy behind China. India has a population of 1.34 billion and will overtake China as the most populous country in just six years by 2024. And by 2050, India is expected to be the world's second largest economy behind China. India has 25 innovation canters throughout the country and has been ranked as the top innovation destination in Asia. A pool of low-cost, highly skilled, English-speaking workers has attracted massive flows of foreign direct investment (FDI) into the country. The outsourcing of knowledge-intensive activities

Indian Scenario

Chart 1: R&D expenditure by selected scientific agencies (2014-15)



Source: Department of Science and Technology, Government of India, Jan 2018

Amongst the 8 Central Government major scientific agencies, Defence Research and Development Organisation (DRDO) accounted for the maximum share of 37.8% of R&D expenditure followed by Department of Space (16.6%), Department of Atomic Energy (11.6%), Indian Council of Agricultural Research (11.4%), Council of Scientific and Industrial Research (9.5%), Department of Science and Technology (7.7 %), Department of Biotechnology (2.9%) and Indian Council of Medical Research (2.4%) during 2014-15.

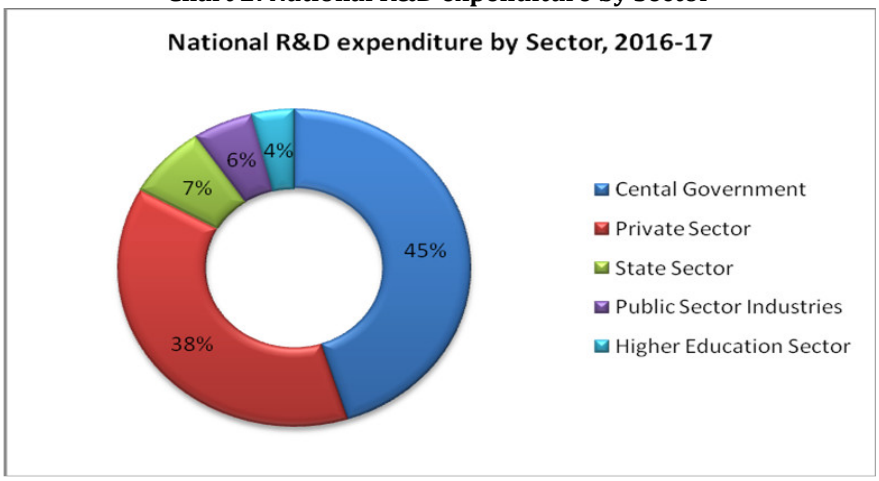
Table 5: Number of Researchers (FTE) in India and Brazil (1996-2013)

Year	India			Brazil		
	Researchers (Total FTE)	FTEs per 100,000 Farmers	FTEs per million population	Researchers (Total FTE)	FTEs per 100,000 Farmers	FTEs per million population
1996	12,516.6	5.5	12.9	5,098.6	37.4	31.0
1999	12,865.5	5.5	12.6	4,775.7	35.4	27.8
2002	12,643.9	5.2	11.7	4,936.3	37.9	27.5
2005	12,391.1	4.9	11.0	5,227.9	42.0	28.1
2008	11,811.3	4.5	10.1	5,296.7	45.5	27.6
2011	12,311.6	4.6	10.1	5,714.0	53.0	29.0
2013	12,784.2	4.7	10.2	5,869.4	57.5	29.3
CAGR (%)	0.1	-1.0	-1.4	0.9	2.7	-0.4

Source: Agricultural Science and Technology Indicators, IFPRI

Table 5 it represents the number of Researchers (Full Time Equivalent) in India and Brazil over the years. The number of researchers in India over the years has almost remained constant over the years with a CAGR of only 0.1 per cent. Whereas, in Brazil, number of researchers has increased with a CAGR of 0.9 per cent. Full time equivalent Researcher per 100,000 farmers in India decreased over the years with CAGR of -1.0% whereas, in Brazil, it has increased over years with a CAGR of 2.7 per cent. Full Time Equivalent Researcher per million populations in India has decreased over the years with a CAGR of -1.4% whereas; in Brazil it has decreased with a CAGR of -0.4%.

Chart 2: National R&D expenditure by Sector



Source: Department of Science and Technology, Government of India

Gross Expenditure on R&D (GERD) is mainly driven by the Government sector comprising of Central Government 45.1%, State Governments 7.4%, Higher Education 3.9% and Public Sector Industries 5.5% with Private Sector Industries contributing 38.1% during 2016-17.

Current status of Agricultural Research

The Indian Council of Agricultural Research (ICAR) is allocated Rs 4,599 crore for the year 2018-19. This is 0.6% greater than the revised estimate in 2017-18. In 2017-18, the allocation under ICAR increased from the actual expenditure of Rs 319 crore in 2016-17. This is due to regrouping of salaries, pensions, and office expenditure from all schemes under ICAR.

Research under crop sciences (including horticulture science), and animal sciences (including fisheries science) is allocated Rs 1,051 crore and Rs 571 crore. Observing that vegetable oils, pulses, cashew are among the major commodities which were imported between 2011 and 2016, the Standing Committee on Agriculture (2017) stated that there is need for enhancing production of these commodities. It also recommended that the central government must allocate additional funds to ICAR for this purpose.

India spent 0.69% of its GDP on R&D in 2014-15, while the same among other developing BRICS countries was Brazil 1.24%, Russian Federation 1.19%, China 2.05% and South Africa 0.73%. This ratio was less than 0.5% for countries like Pakistan (0.29%) and Sri Lanka (0.10%). The country needs to redouble its

efforts to make improvements in science and R&D, said the Economic Survey 2017-18, tabled in Parliament by Finance Minister Arun Jaitley.

India's GERD has tripled in the last decade to Rs 85,326 crores in 2014-15 from Rs 24,117 crore of 2004-05. It is estimated at Rs 1,04,864 crore in 2016-17.

Although India's investment in science, which is measured in terms of Gross Expenditure on R&D (GERD), has tripled in the last decade, the ratio was stagnant at 0.6 to 0.7 per cent of the GDP. Most of the developed countries spent more than 2% of their Gross Domestic Product (GDP) on R&D. India also should increase its spending on R&D to fulfil its objective of doubling farm incomes by 2022, the govt must hike R&D spend and facilitate private investments

India's spending on R&D in terms of percentage of GDP has been stagnant at 0.6 to 0.7 per cent in the last two decades -- much lower than the major nations such as the US (2.8), China (2.1), Israel (4.3) and Korea (4.2)," the survey said.

According to the Survey, East Asian countries like China, Japan and Korea have seen dramatic increases in R&D as a percentage of GDP as they have become richer. "India, on the other hand, has only seen a slight increase. In fact, in 2015, there was a sizable decline in R&D spending even as GDP per capita continued to rise. At its current rate, India would just barely reach GERD of 1 per cent of GDP by the time it was as rich as the USA," it added. Agricultural R&D is the main source of innovation, which is needed to sustain agricultural productivity growth in the long-term.

CONCLUSION

To sum up, India is developing economy with vast proportion of its human resource being employed in un-organized sectors, mostly in rural areas. Though our scientists have achieved in increasing the productivity of many commodities since green revolution, still our standards are far below the global average. Rapid increase in population followed by fragmentation of land has created a situation which urges the improving in productivity which is possible by focusing on agricultural research.

POLICY RECOMMENDATIONS

Public spending on agricultural R&D must be increased as the private sector spending mostly concentrates on post harvest technologies rather than increasing the productivity or decreasing the input cost. Number of researchers availability per farmers must be increased which would help in conducting area specific and region specific agricultural research. As major population of our country have marginal land holdings, adaption of high cost technologies and mechanization of land is highly impossible. So, low cost technologies like IPM, LEISA should be encouraged. Research on water management related studies would have a greater scope in the upcoming decades.

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