Analysis of Outcome of Extramural

R&D Projects

(2010-2015)

Government of India
National Science and Technology Management Information System (NSTMIS) Division

Ministry of Science and Technology
Department of Science and Technology
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ANALYSIS OF OUTCOME OF EXTRAMURAL R&D PROJECTS 2010 – 2015

GOVERNMENT OF INDIA
NATIONAL SCIENCE & TECHNOLOGY MANAGEMENT INFORMATION SYSTEM (NSTMIS) DIVISION

MINISTRY OF SCIENCE & TECHNOLOGY
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Dr. Lalit Mohan
Executive Director
July, 2021 Society for Environment & Development, Delhi

LIST OF ABBREVIATIONS

AICTE	All India Council for Technical Education
AYUSH	Department of Ayurveda, Yoga, Unani, Siddha and Homeopathy
CSIR	Council of Scientific and Industrial Research
DAE	Department of Atomic Energy
DBT	Department of Biotechnology
DOC	Department of Coal
DOD	Department of Ocean Development*
DRDO	Defence Research and Development Organization
DSIR	Department of Scientific and Industrial Research
DST	Department of Science and Technology
ICAR	Indian Council of Agricultural Research
ICMR	Indian Council of Medical Research
ISRO	Indian Space Research Organization
MNES	Ministry of Non-Conventional Energy Sources**
MOCIT	Ministry of Communication and Information Technology
MOEF	Ministry of Environment and Forest
MOFPI	Ministry of Food Processing Industries
MOP	Ministry of Power
MOSJE	Ministry of Social Justice and Empowerment
MOWR	Ministry of Water Resources
PCRA	Petroleum Conservation Research Association
UGC	University Grants Commission

* MOES	Ministry of Earth Sciences (Formerly known as DOD – Department of Ocean Development)
** MNRE	Ministry of New & Renewable Energy (Formerly known as MNES--Ministry of Non-conventional Energy Sources)

EXECUTIVE SUMMARY

Science and Technology have always been an integral part of Indian culture. Natural philosophy, as it was termed in those ancient times, was pursued vigorously at institutions of higher learning. The Indian Renaissance, which coincided with our independence struggle, at the dawn of 1900s witnessed great strides made by Indian scientists. This innate ability to perform creatively in science came to be backed with an institutional setup and strong state support after the country's independence in 1947. Since then, the Government of India has spared no effort to establish a modern S&T infrastructure in the country. One mode of making this investment is by providing funding support to S&T research. A large number of scientific agencies/departments/ministries of the central government provide funding support to S&T research in the form of extramural or sponsored R&D projects, with the aim of building research capability and S&T infrastructure in the country.

The Department of Science and Technology plays a pivotal role in promotion of science and technology in the country. National Science & Technology Management Information System (NSTMIS) division of Department of Science & Technology (DST), GoI has been continuoesly compiling the outcome of extramural research to assess and disseminate the output of these projects supported by various public funding agencies. The division is compiling information on extramural R&D projects annually and also published a 5-year analysis of the funding pattern to study the trend and understanding the dynamic S&T landscape of extramural R&D. With the cooperation of all the R&D funding agencies/departments/organizations, NSTMIS division has already published six reports on the funding pattern of the sponsored research by scientific agencies for the periods 1985-90, 1990-95, 1995-2000, 2000-2005, 2005-2010 and 2010-15. The division has also analysed the outcome of R&D projects funded during 1995-2000, 2000-2005, & 2005-2010 and published the reports. Taking it further, the present study analyses outcome of the extramural R&D projects funded during the period 2010-2015.

The study has analysed the information received from all the R&D projects, funding agency-wise, subject area-wise, year-wise, types of institute-wise, state-wise, city-wise, project cost-wise, PIs age-wise, and PIs gender-wise. The analysis is described in two parts namely-

- Support to extramural R&D projects by S&T agencies

- Outcome of extramural R&D projects

Support to extramural R&D projects:

The support to extramural R&D projects is based upon the information collected from the annual EMR directories published for the five years period. During the period 2010-2015, total amount of Rs. 10,504.27 crore was approved for funding of 27900 projects sanctioned by 21 central government departments and agencies.

During this period, major sponsors of R&D projects were DST (9808), UGC (8175), DBT (2921), ICMR (1913) and CSIR (1778), accounting for more than 88% of the total number of projects sanctioned. In terms of funding support, DST was at top (Rs. 3591.53 crore), followed by DBT (Rs. 2671.79 crore), MOCIT (Rs. 1188.55 crore) and ICMR (Rs. 658.92 crore). These four scientific agencies accounted for 77% of the total extramural R&D funding. An interesting pattern was emerged from these data – in case of UGC, number of projects sanctioned was second largest but in funding support, it was at fifth place while in case of MOCIT, it was at tenth place in number of project but got third place in funding support. This was attributed to high cost per project in MOCIT and low cost per project in UGC.

Among the various subject areas, biological sciences received the maximum support by way of number of projects (29.95%), followed by engineering and technology (18.88%), chemical sciences (14.55%) and medical sciences (14.46%). These subject areas together accounted for 78% of total number of projects sanctioned.

Year-wise analysis of projects supported has **interesting to note that number of project and amount sanctioned are both declining from 2010-11 to 2012-13 with slight increase in after that.** A total of 5855 projects were supported in 2010-11 which were higest in all the five-year period.

The outreach of extramural R&D support confined mainly to the academic sector comprising of universities, colleges and institutes of national importance (80%) while national laboratories had 7% projects and remaining 13% went to others category.

Although colleges & universities awarded maximum number of projects from funding agencies, the average cost per project was only Rs. 20 lakh, while in case of other institutions it was Rs. 70 lakh, national laboratories Rs. 68 lakh, deemed universities Rs. 73 lakh and institutes of national importance Rs.51 lakh.

About 71.66% of the projects were sanctioned to the institutions located in eight states viz. Andhra Pradesh, Delhi, Karnataka, Maharashtra, Tamil Nadu, Uttar Pradesh and West Bengal. These states also received 73% of total funding during the reporting period.

During the reporting period, 630 cities/towns were covered under EMR projects. Among these locations, institutions based in six metro cities received 29% of total projects. 107 cities had 50 or more projects.

The maximum number of projects approved (10748) were in the middle cost range while minimum (868) projects approved were in ultra high-cost range category. **As the cost-range increased, the number of R&D projects decreased**.

Gender-wise analysis of PIs who undertook these R&D projects indicated that the number of R&D projects with women PIs was small as compared to projects carried out by male PIs. 7813 projects had women PIs while 20046 projects had male PIs.

Outcome of extramural R&D projects:

The analysis of outcome of extramural R&D projects is based on the response to the questionnaires received from the 10950 (39.3%) projects out of total 27900 projects sanctioned during the period 2010-2015.

Department/funding agency-wise analysis reveals that 21 scientific department/agencies under central government supported these extramural R&D projects. The highest response rate of around 54% was of projects supported by Department of AYUSH followed by AICTE (46%), MoSJE (44%) and MoCIT (41%). In absolute terms, the highest response was received from the DST-funded projects (3791), followed by UGC-funded (3354), DBT-funded (1084) and ICMR-funded (760) projects. These four funding agencies accounted for nearly 82% of the responded projects under analysis.

The highest number of research papers were published from the projects funded by DST. Among different funding agencies, the share of DST is highest (around 37%) in the total publications/presentations of research papers, followed by UGC (27%), DBT (10%), ICMR (7%) and CSIR (6% papers) funded projects.

The significant revelation from the analysis is that the PIs of the sponsored projects published more papers in foreign journals (25043) than in Indian journals (7596) - almost 3.1 times. This shows that the PIs sent a greater number of quality research papers for publication in foreign journals which were accepted and published by them.

The analysis of 10950 R&D projects shows that these projects resulted in the development of 6358 new products, 2410 new processes, 990 new prototypes, 553 new instruments, 1085 new leads and 728 new principles/theories.

DST leads in almost all fields like new products, new processes, new prototypes developed, intellectual property rights (IPR's) registered, patents filed, patents sealed, new theories and new instruments developed.

A total of 789 patents were filed and 164 patents were obtained. In filing and sealing of patents, the DST-funded projects were on the top with 334 patents filing (283 in India and 51 in foreign countries), and 77 patents sealed (43 in India and 34 in foreign countries) during the period 2011-2015. It was followed by UGC with filing of 168 patents (113 in India and 55 in foreign countries) and CSIR-funded projects with 37 patents granted (9 in India and 28 in foreign countries). **The DST-funded projects obtained highest number (100) of copyrights.**

The specialised manpower generated from all the analysed R&D projects included 6522 PhD, 8 DSc, 869 MPhil, 33 MD and 2826 MTech. The share of DST-funded projects was maximum in almost all categories of manpower generation with 2361 PhD, 1225 MTech and 314 Mphil while ICMR funded projects was at top with 12 MD produced. The second highest number of PhDs were produced by projects funded by UGC (1679) followed by DBT (738) and ICMR (458).

A total of 21786 personnel were employed in different categories by all the projects analysed. The scientific staff (16974) included JRFs (5316), followed by SRFs (1826), RAs (1283), Engineers/Doctors (2125) and other scientific staff (6424). Agency-wise analysis shows that DST-funded projects employed highest number of scientific personnel (8808), followed by UGC (3004), DBT (1362), ICMR (886) and CSIR (794) funded projects.

Among the subject areas, biological sciences (8433 projects), engineering & technology (5240 projects) & chemical sciences (4309 projects) were main recipients of projects as well as funding while mathematics with 1214 projects was at bottom in both number of projects and funding. Although

engineering & technology has lesser number of responses than biological sciences it had more new processes (641), new prototypes (342) and new intruments (178) developed to its credit. **The highest numbers of Patents filed and sealed were in the area of engineering & technology followed by biological sciences and chemical sciences.** As far as research papers are concerned, maximum number of papers were published in the area of biological sciences (17009) followed by engineering & technology (10580), chemical sciences (8401) and physical sciences (7195).

The analysis of Institute-wise outcome revealed that the outreach of the R&D support was confined mainly to the academic sector. As colleges & universities were awarded maximum number of projects by the funding agencies, the outcome has also reflected similar patterns in publication/presentation of research papers, development of new products, processes, instruments, prototypes, principles/theories, varieties, filing & sealing of patents, producing PhDs, employing JRF, SRF & RA etc.

The PIs age-wise analysis of sponsored R&D projects gives an interesting finding that PIs above 55 years of age have outperformed on most of the outcome parameters. This category of PIs gave maximum response to questionnaires (21%), published second highest research papers (11887) and developed highest number of new processes (503), new and new varieties (222).

A look at the cost range-wise analysis indicates that the highest number of JRF (2099) SRF (733), RA (521) and number of engineers & doctors (1600) were employed in middle cost range projects. Employment of scientific personnel was found to be inversely proportional to the cost range of projects. In other words, **as the cost-range of EMR projects increased, number of personnel employed in projects decreased. When very high and ultra high costing projects were further analysed, it was found that infrastructure support (scientific equipments) was major component in these projects which lead to increase in their cost and not the manpower.** In the high-cost range, very high-cost range and ultra high-cost range, the number of persons employed gradually decreased with the increase in the cost range of the projects.

Out of total 789 patents filed and 164 patents obtained at national and foreign levels, the very high-cost range projects (50 lakh to less than 1 crore) obtained 2 patents out of 70 patents filed. The middle cost range projects (10 lakh to 25 lakh) could obtain 93 patents while filed 380 patents.

The gender-wise analysis of R&D projects and their performance is a novel aspect of the report. It is seen that the share of women as PIs in extramural R&D projects was small, only 22.64%. In terms of outcome, the women PIs published 8818 papers in journals (6667 in foreign and 2151 in Indian). They also participated in Indian and foreign conferences and presented 6159 papers. **The performance of female PIs in terms of development of new products, processes, prototypes, varieties, etc. per project has been found quite good and comparable with male PIs. In terms of number of manpower generated per project, the number is comparable in each category of degree/diploma with male PIs**. Thus, projects with women as PIs are in no way behind the men as PIs in terms of performance.

Number of problems were faced by the PIs in carrying out EMR projects and some common one was: **delay in approving the project, curtailment of budget for equipment, delay in the releasing of next instalment of grant, lack of infrastructure facilities, resignation of project staff at crucial time, lack of motivation among students for research** etc. These should be looked into by the funding agencies.

Based on the study, few conclusions and recommendations are made. Prominent among them are **need for central repository of Project Completion Reports (PCRs) in every funding department/agency**, **need for uniformity in project completion report (PCR) of all funding agencies**, **more use of IT in data collection, women participation in extramural R&D needs to be encouraged by funding agencies** and **increasing awareness of R&D schemes in all states to maintain regional balance.**

OUTCOME AT A GLANCE (2005-2010 Vs. 2010-2015)

2005-2010	2010-2015
Total number of EMR Projects	
20497	27900
Total EMR Projects Funding	
Rs. 6331.76 crore	Rs.10504.27 crore
Responses received from EMR Projects	
10337 (50.43%)	10950 (39.30%)
Main sponsors of EMR Projects by number and responses received (in brackets)	
DST 6676 (3921), UGC 4781 (3125) DBT 2349 (675), ICMR 1527 (713) CSIR 1380 (941)	DST 9808 (3791), UGC 8175 (3354) DBT 2921 (1084), ICMR 1913 (760) CSIR 1778 (663)
Number of research papers published	
Total papers 54002 Indian journals 9643 Foreign journals23201 Indian conferences 12065 Foreign conferences 9093	Total papers 55934 Indian journals 7586 Foreign journals 25043 Indian conferences 12326 Foreign conferences 10979
Number of Patents sealed	
Patents filed 701, patents sealed 154	Patents filed 789, patents sealed 164
New Products, Instruments and Prototypes developed	
Products 4449, Instruments 318 Prototypes 527	Products 6358, Instruments 553 Prototypes 990
New Processes and Principles/theories developed	
Processes 1711, Principles/theories 728	Processes 2410, Principles/theories 1085
Manpower generated	
PhDs 6724, DScs 12, MPhils 740 MDs 33 and MTechs 2044	PhDs 6522, DScs 8, MPhils 869 MDs 33 and MTechs 2826
Manpower employed	
JRFs 5339, SRFs 1681, RAs 1293 Engineers/Doctors 563, Technicians 1075 Supporting Staff 2309	JRFs 5316, SRFs 1826, RAs 1283 Engineers/Doctors 2125, Technicians 1726 Supporting Staff 3086

The major outcome of R&D projects in terms of various parameters is as follows:

	About the EMR projects	
1.	No. of funding agencies	21
2.	**No. of R&D projects supported**	**27900**
3.	No. of projects having women PIs	7813 (28.0%)
4.	No. of projects having men PIs	20055 (71.8%)
5.	No. of projects with PIs gender not known	32
6.	**Total amount granted**	**Rs 10,504.27 crore**
7.	Average cost per project	Rs 37.65 lakh
8	**Responses received from R&D projects**	**10950**
9.	No. of projects allocated less than Rs 10 lakh	8680
10.	No. of projects allocated more than Rs 1 crore	868
	Outcome	
	Publications	
1.	Research papers published in Indian journals	7586
2.	Research papers presented in Indian conferences	12326
3.	*Total no. of papers published/presented in Indian journals/conferences*	*19912*
4.	Research papers published in foreign journals	25043
5.	Research papers presented in foreign conference	10979
6.	*Total no. of papers published/presented in foreign journals/conferences*	*36022*
7.	***Total no. of research papers published/presented***	***55934***
	Intellectual Property Rights	
8.	No. of Patents filed	789
9.	No. of Patents Sealed	164
10.	Copyrights obtained	302
11.	Other IPRs registered	30
	Technical Parameters	
12.	New products developed	6358
13.	New instruments developed	553
14.	New Processes developed	2410
15.	New Prototypes developed	990
16.	New Principles and Theories developed	1085
17.	New Varieties (crop) developed	543
	Manpower produced	
18.	a. PhD produced	6522
19.	b. DSc produced	8
20.	c. M Phil produced	869
21.	d. MD produced	33
22.	e. MTech produced	2826
23.	f. Other manpower produced	9665
24.	**Total Manpower produced (a+b+c+d+e+f)**	**19923**
	Manpower employed	
25.	a. JRF employed	5316
26.	b. SRF employed	1826
27.	c. RA employed	1283
28.	d. Engineers/Doctors employed	2125
29.	e. Others scientific staff employed	6424
30.	**f. Total S&T personnel employed (a+b+c+d+e)**	**16974**
31.	g. Technicians employed	1726
32.	h. Other supporting staff employed	3086
37	**i. Total support staff employed (g+h)**	**4812**
38	**j. Total Manpower employed (f+i)**	21786

Chapter 1

About the Study

Introduction

Science and Technology have always been an integral part of Indian culture. Natural philosophy, as it was termed in those ancient times, was pursued vigorously at institutions of higher learning. The Indian Renaissance, which coincided with our independence struggle, at the dawn of 1900s witnessed great strides made by Indian scientists. This innate ability to perform creatively in science came to be backed with an institutional setup and strong state support after the country's independence in 1947. Since then, the Government of India has spared no effort to establish a modern S&T infrastructure in the country. One mode of making this investment is by providing funding support to S&T research.

A large number of scientific agencies/departments/ministries of the central government provide funding support to S&T research in the form of extramural or sponsored R&D projects, with the aim of building research capability and S&T infrastructure in the country.

The National Science & Technology Management Information System (NSTMIS) division of Department of Science & Technology (DST), GoI has been continuoesly compiling the outcome of extramural research to assess and disseminate the output of these projects supported by various public funding agencies. The division is compiling information on extramural R&D projects annually and also published a 5-year analysis of the funding pattern to study the trend and understanding the dynamic S&T landscape of extramural R&D. With the cooperation of all the R&D funding agencies/departments/organizations, NSTMIS division has already published six reports on the funding pattern of the sponsored research by scientific agencies for the periods 1985-90, 1990-95, 1995-2000, 2000-2005, 2005-2010 and 2010-15. The division has also analysed the outcome of R&D projects funded during 1995-2000, 2000-2005, & 2005-2010 and published the reports. Taking it further, the present study analyses outcome of the extramural R&D projects funded during the period 2010-2015.

Scope and Coverage

The support to extramural R&D projects is based upon the information collected from the annual EMR directories published for the five years period. During the period 2010-2015, total amount of Rs. 10,504.27 crore was approved for funding of 27900 projects sanctioned by 21 central government departments and agencies. During this period, major sponsors of R&D projects were DST (9808), UGC (8175), DBT (2921), ICMR (1913) and CSIR (1778). These together accountined for more than 88% of the total number of sponsored projects. In terms of funding support, DST was at top (Rs. 3591.53 crore), followed by DBT (Rs. 2671.79 crore), MOCIT (Rs. 1188.55 crore) and ICMR (Rs. 658.92 crore).

Objectives

The main objectives of the study are:

1. Collection of information on the outcome of extramural R&D projects from principal investigators for the period 2010-2015.
2. Compilation of information/achievements in database form and their analysis/assessment.
3. Publication of findings for wider use among policy and decision makers.

Methodology

The target group for data collection in the study was principal investigators who had undertaken extramural R&D projects with funding support from various central government departments/agencies during 2010-2015. All the 27900 projects were approached for this study.

- **Structuring of questionnaire** - The questionnaire was designed keeping in view the objectives and focus of the project. It had direct questions seeking information on the project supported by the funding agency like project title, duration, major achievements in the form of products, processes, instruments, prototypes developed, research papers published, scientific manpower produced and employed, patents filed & granted etc. The questionnaire was finalized in consultation with the Local Project Advisory Committee (LPAC) constituted for this project.

- **Data collection** - Data was collected from all the principal investigators through a well-designed questionnaire covering various outcome parameters. A reminder was sent to those principal investigators, who did not respond within stipulated time limits. Then,

second reminder was also sent to the non-responding PIs. Questionnaire was also made available on the web-site of the Society for Environment & Development (SED), Delhi. A number of PIs utilized this facility and sent duly filled in questionnaires through email. Every effort was made to get information from the maximum number of PIs.

All questionnaires received were entered manually in the register and also in computer. All the information received through questionnaires was entered in Microsoft Access format for further use and analysis.

- **Processing & analysis of data -** The collected data were stored in physical form in the files. Structured programming was done for entering the data. The information was divided into a number of fields as per requirements of the study. All the information received through questionnaires was stored in the specially designed HTML enabled data-base. Codes were developed to analyse the data directly through software, as per the following parameters:

  - Department/agency-wise outcome
  - Subject area-wise outcome
  - Year-wise outcome
  - Types of institutes-wise outcome
  - State-wise outcome
  - City-wise outcome
  - Project cost range-wise outcome
  - Gender-wise outcome
  - PIs Age group-wise outcome

  Each of the above parameters were analysed in terms of the following outcomes:

  > No. of projects and amount sanctioned

  > Research papers published/presented in Indian and foreign journals/conferences

  > New products/processes developed

  > New instruments developed

  > New prototypes, principles/theories & varieties (crop) developed

  > Number of intellectual property rights (IPRs) obtained includes copyright, patents

filed/granted, trademarks, designs etc.

> Number of human resources developed

> Manpower employed

- **Publication of report** – Based on the data collected, the present report provides an analysis of outcome of the extramural R&D projects supported during the period 2010-2015 by 21 central government funding agencies.

Limitations of the Study

The following points may be kept in view while going through this report on analysis of extramural R&D projects;

- Despite making all efforts to cover all the extramural R&D projects sanctioned (27900) during the period 2010-2015 by the funding agencies, the analysis is based on the 10950 projects, who responded to the questionnaire or data collected from Project Completion Reports (PCR) available with the funding agencies and provided access to these PCRs.
- Since the period under report was from 2010-2015, the PIs of some projects, which were more than 5 years old, had retired/transferred/changed job/expired. This affected the response received.
- Since the projects have been classified into eight broad subject areas (agricultural sciences, biological sciences, chemical sciences, earth sciences, engineering & technology, mathematics, medical sciences and physical sciences), some interdisciplinary projects might have been classified as per their major bias.
- The data mentioned in the report indicates the actual number of different outcomes of a project at the time of submitting the questionnaire by the PIs.

Chapter 2

Funding Agency-wise Analysis of Extramural R&D Projects and their Outcome

Many S&T agencies/departments of Government of India fund EMR projects through various R&D funding schemes. Projects are funded in various subject areas of natural and applied sciences. This chapter deals with analysis of EMR projects outcome by various funding agencies. A list of major agencies which funded projects during 2010-2015 is given in table 2.1.

Table 2.1: Funding agencies that sponsor extramural R&D projects

1. AICTE	All India Council for Technical Education
2. AYUSH	Department of Ayurveda, Yoga, Unani, Siddha and Homeopathy
3. CSIR	Council of Scientific and Industrial Research
4. DAE	Department of Atomic Energy
5. DBT	Department of Biotechnology
6. DOC	Department of Coal
7. DRDO	Defence Research and Development Organization
8. DSIR	Department of Scientific and Industrial Research
9. DST	Department of Science and Technology
10. ICMR	Indian Council of Medical Research
11. ISRO	Indian Space Research Organization
12. MNES	Ministry of Non-Conventional Energy Sources
13. MOCIT	Ministry of Communication and Information Technology
14. MOEF	Ministry of Environment and Forest
15. MOES	Ministry of Earth Sciences
16. MOP	Ministry of Power
17. MOS	Ministry of Steel

18. MOSJE Ministry of Social Justice and Empowerment

19. MOWR Ministry of Water Resources

20. PCRA Petroleum Conservation Research Association

21. UGC University Grants Commission

Agency-wise funding pattern of extramural R & D projects

Although Government of India makes investment on S&T research is several ways, one major mechanism is providing support for extramural or sponsored R&D projects undertaken by experts from various institutions of the country. Since this report covers the period 2011 to 2015, details of support given by various S&T agencies of the Government of India during this 5-year period is provided in table 2.2 along with the number of R&D projects supported and their total approved cost.

Table 2.2: Agency-wise funding to extramural R&D projects during 2005-10

Funding Agency	No. of projects supported	Total cost (Rs. Crore)	Average cost per project (Rs. Lakh)
AICTE	556	64.79	11.65
CSIR	1778	314.68	17.69
DAE	888	335.48	37.78
DBT	2921	2671.79	91.46
DRDO	784	357.31	45.57
DST	9808	3591.53	36.61
DSIR	242	211.71	87.48
ICMR	1913	658.92	34.44
ISRO	148	21.86	14.77
MOCIT	246	1188.55	483.15
MOEF&CC	117	34.19	29.22
MOES	83	82.84	99.81
UGC	8175	412.17	5.04
Other agencies	241	558.32	231.66
All agencies	**27900**	**10504.39**	**37.65**

Other agencies: AYUSH, DOC, MNRE, MOP, MOS, MOSJE, MOWR & PCRA

Table 2.2 shows that DST is the biggest provider of EMR projects support (Rs 3591.53 crore), followed by DBT (Rs 2671.79 crore) and MOCIT (Rs 1188.55 crore). It is interesting to note that the average cost per project was highest for MOCIT funded projects (Rs 483 lakh), followed by MOES (Rs 99 lakh), DBT (Rs 91.46 lakh), DSIR (Rs 87.48 lakh), DAE (Rs 37 lakh) and DST (Rs 36 lakh). The UGC provided smallest amount (Rs 5 lakh) per project. This was attributed to high cost per project in MOCIT and low cost per project in UGC.

Funding agency-wise outcome of extramural R&D projects

As mentioned under the methodology, the study is based on the responses received from the principal investigators (PIs) of 27900 extramural R&D projects supported by a total of 21 funding agencies of the Central Government. The agency-wise response from PIs of these projects is given in Table 2.3.

The maximum number of projects was supported by DST (9808) followed by UGC (8175) and DBT (2921). The highest response rate of around 46% was of AICTE followed by MOCIT & UGC (41%), ICMR & DRDO (39%) and (DST (39%).

Table 2.3: Funding agency-wise response received of extramural R&D projects

Funding agency	No. of projects supported	Responses received from projects	Percentage of response (%)
AICTE	556	255	45.86
CSIR	1778	663	37.28
DAE	888	357	40.20
DBT	2921	1084	37.11
DRDO	784	306	39.03
DST	9808	3791	38.65
DSIR	242	84	34.71
ICMR	1913	760	39.72
ISRO	148	54	36.48
MOCIT	246	101	41.05
MOEF&CC	117	37	31.62
MOES	83	26	31.32
UGC	8175	3354	41.02
Other agencies	241	78	32.36
All agencies	**27900**	**10950**	**39.25**

Other agencies: AYUSH, DOC, MNRE, MOP, MOS, MOSJE, MOWR & PCRA

Types of projects

Analysis has been made on the basis of types of EMR project. Projects have been classified into four categories using the following standard definitions:

1. **Basic research:** The basic research may be defined as any experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundations of phenomena and observable facts, without any particular or specific application or use in view.

2. **Applied research:** Applied research may be defined as any original investigation undertaken to acquire new knowledge and is directed primarily towards a specific practical aim or objective.
3. **Experimental development:** Experimental development may be defined as any systematic work, drawing on existing knowledge gained from research and / or practical experience that is directed to produce new material, products and devices, to install new processes, systems and services, and to improve substantially those already produced or installed.
4. **Other activities:** Other activities would include S&T services provided by libraries, information and documentation centre, data banks and information processing institutions.

Table 2.4: Funding agency-wise break-up of type of extramural R&D projects

Funding agency	Basic research	Applied research	Experimental development	Others
AICTE	126	83	39	11
CSIR	384	233	60	8
DAE	163	156	38	6
DBT	559	445	121	15
DRDO	130	139	38	7
DST	2044	1390	462	72
DSIR	36	31	8	4
ICMR	432	275	59	21
ISRO	28	22	4	0
MOCIT	37	52	12	2
MOEF&CC	25	12	1	1
MOES	13	13	0	0
UGC	1841	1226	351	50
Other agencies	30	36	10	1
All agencies*	**5848**	**4113**	**1203**	**198**

Other agencies: AYUSH, DOC, MNRE, MOP, MOS, MOSJE, MOWR & PCRA

Among the funding agencies, DST sponsored projects outperformed in all the categories, followed by UGC. At the third position was projects sponsored by ICMR in all categories except in experimental development where CSIR has more projects.

Actual Expenditure on project and equipments

The analysis on agency wise information on expenditure made on the projects and purchase of equipments by the PIs received is shown in table 2.5. It is evident from the table that MOEF & CC projects made highest expenditure on equipment in percentage terms (46.80) while MOCIT spent a meagre 11.05% out of total expenditure made in the projects. This result when linked with table 2.4 clearly shows that majority of AICTE funded projects fall under basic research category and so equipment intensive projects.

Table 2.5: Funding agency-wise total actual expenditure on EMR projects and equipments

Funding agency	Total expenditure (Rs. Crore)	Expenses on equipments (Rs. Crore)	% of total exp.
AICTE	137.09	54.90	40.04
CSIR	120.25	25.71	21.38
DAE	98.29	22.80	23.20
DBT	503.72	72.20	14.33
DRDO	124.69	18.12	14.53
DST	1121.41	281.29	25.08
DSIR	105.93	22.34	21.08
ICMR	201.14	42.44	21.10
ISRO	7.51	0.95	12.61
MOCIT	219.97	24.31	11.05
MOEF&CC	12.16	5.69	46.80
MOES	6.98	2.74	39.30
UGC	375.09	112.19	29.91
Other agencies	28.90	7.54	22.63
All agencies	**3063.19**	**693.25**	**34.65**

Other agencies: AYUSH, DOC, MNRE, MOP, MOS, MOSJE, MOWR & PCRA

Research papers

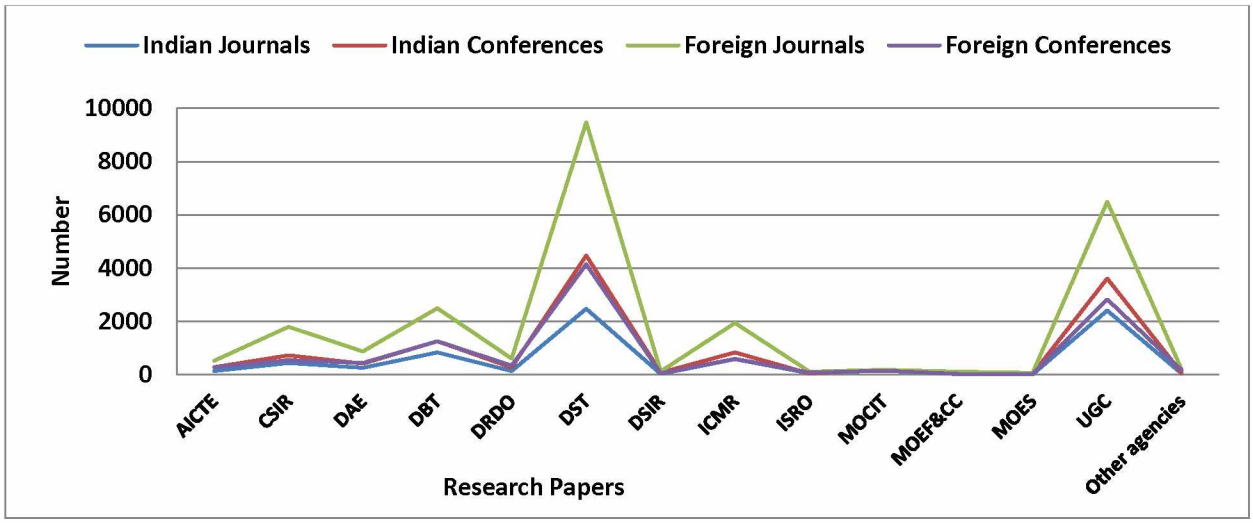
DST funded projects resulted in highest number of research papers published/presented, followed by UGC and DBT. The contribution of MOES, ISRO, MOEF & CC, DAE and DSIR funded projects was marginal in this category of outcome.

Table 2.6: Funding agency-wise research papers emenated from extramural research projects

Funding agency	Indian			Foreign			Total
	Journals	Conferences	Sub-total	Journals	Conferences	Sub-total	
AICTE	145	278	423	522	287	809	1232
CSIR	436	730	1166	1803	549	2352	3518
DAE	257	417	674	872	443	1315	1989
DBT	836	1252	2088	2492	1256	3748	5836
DRDO	140	272	412	606	347	953	1365
DST	2475	4477	6952	9479	4146	13625	20577
DSIR	30	78	108	133	57	190	298
ICMR	578	840	1418	1946	593	2539	3957
ISRO	55	43	98	114	74	188	286
MOCIT	158	187	345	186	157	343	688
MOEF&CC	15	43	58	112	31	143	201
MOES	9	31	40	71	25	96	136
UGC	2409	3617	6026	6502	2838	9340	15366
Other agencies	43	61	104	205	176	381	485
All agencies	**7586**	**12326**	**19912**	**25043**	**10979**	**36022**	**55934**

Other agencies: AYUSH, DOC, MNRE, MOP, MOS, MOSJE, MOWR & PCRA

Figure 2.1: Funding agency-wise research publications arising out of EMR projects



Average number of research papers per project

This parameter indicates average production of research papers from the sponsored projects. Its value was the highest in case of MOCIT (5.45), followed by ISRO (3.88). During the study period, the projects sponsored by CSIR, DAE, ISRO, DST and MOEF &CC produced

on an average three papers per project. The number of papers per project sponsored by UGC, AICTE, MOES and ICMR was relatively small.

Table 2.7: Funding agency-wise average number of research papers per project produced from EMR projects

Funding agency	Average number of paper per project
AICTE	2.60
CSIR	3.48
DAE	3.15
DBT	2.75
DRDO	3.12
DST	3.63
DSIR	
ICMR	2.34
ISRO	3.88
MOCIT	5.45
MOEF&CC	3.12
MOES	2.21
UGC	2.85
Other agencies	3.05
All agencies	**3.21**

Other agencies: AYUSH, DOC, MNRE, MOP, MOS, MOSJE, MOWR & PCRA

Research papers finding place on coverpage of journal

Quality of any research paper can be assessed by number of parameters and finding place on the cover page of journal is an important tool. The table 2.8 depicts funding agency wise break up of research papers finding place on cover page of journals. Maximum number of research papers finding place on coverpage in Indian journals are UGC funded (60) while in case of foreign journals, these were DST funded (267).

Table 2.8: Funding agency-wise distribution of research papers found place on cover page of journal from EMR projects

Funding agency	Coverpage of journal	
	India journal	Foreign journal
AICTE	2	16
CSIR	12	42
DAE	8	7
DBT	33	121
DRDO	2	8
DST	52	267

DSIR	1	3
ICMR	11	20
ISRO	0	2
MOCIT	1	3
MOEF&CC	0	2
MOES	0	0
UGC	60	164
Other agencies	2	1
All agencies	**184**	**656**

Other agencies: AYUSH, DOC, MNRE, MOP, MOS, MOSJE, MOWR & PCRA

New products & processes development and utilization of R&D

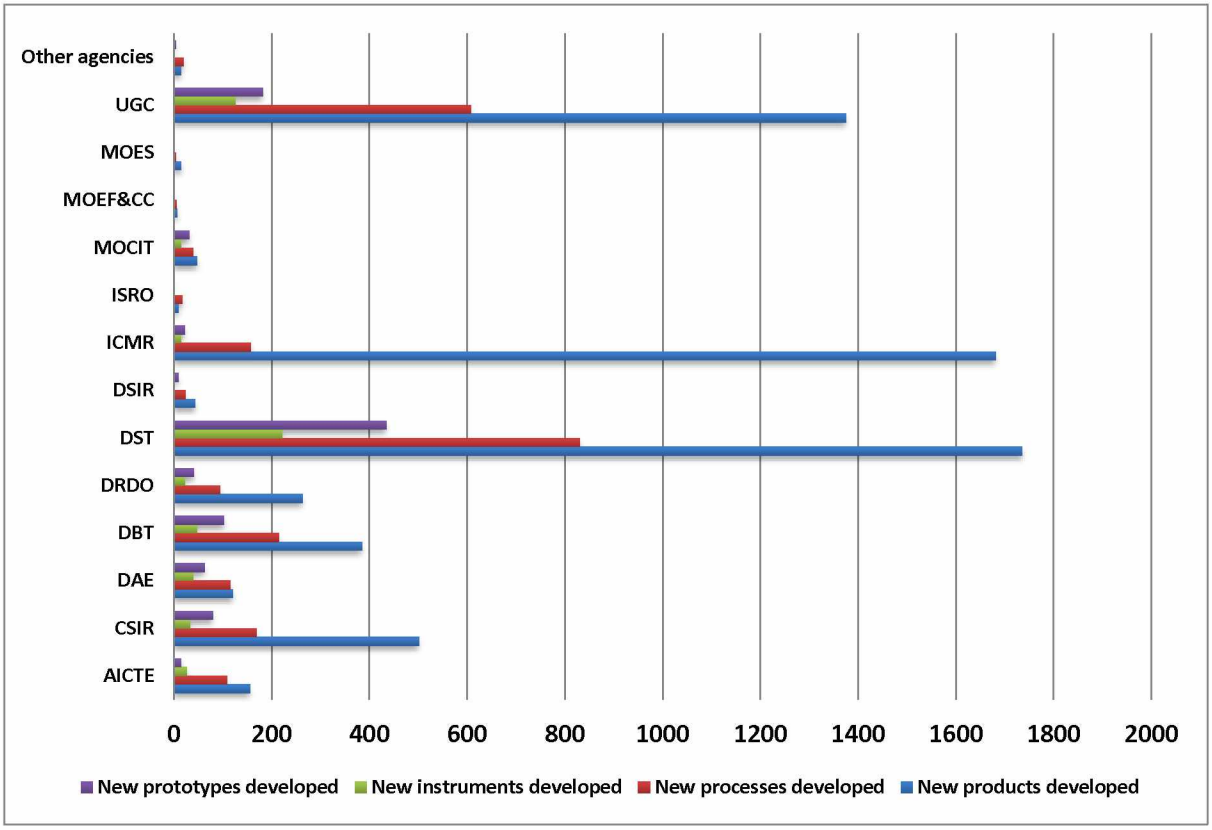
Out of total of 6358 new products, 2410 new processes and 990 new prototypes were developed, the maximum number of new products (1736), new prototypes (435) and new processes (831) were developed in DST funded projects. This was followed by ICMR with 1682 new products and UGC with 608 new processes & 182 new prototypes developed.

Table 2.9: Funding agency-wise development of new prototypes, products and processes from EMR projects

Funding agency	New products developed	New processes developed	New instruments developed	New prototypes developed	New principle/ theory developed	New varieties developed
AICTE	156	109	27	15	19	3
CSIR	502	169	33	80	86	8
DAE	121	116	40	63	48	5
DBT	385	215	47	103	98	46
DRDO	263	95	23	41	42	2
DST	1736	831	222	435	426	196
DSIR	44	24	1	9	8	0
ICMR	1682	157	14	22	51	8
ISRO	10	17	1	2	5	1
MOCIT	48	40	15	32	14	6
MOEF&CC	7	5	1	1	3	0
MOES	15	4	1	1	1	0
UGC	1375	608	126	182	278	268
Other agencies	14	20	2	4	6	0
All agencies	**6358**	**2410**	**553**	**990**	**1085**	**543**

Other agencies: AYUSH, DOC, MNRE, MOP, MOS, MOSJE, MOWR & PCRA

Figure 2.2: Funding agency-wise development of new products & processes from EMR projects



Intellectual Property Rights (IPRs) obtained

The maximum number of patents (326) were filed and sealed (85) came from the DST funded projects. This was followed by DBT, UGC, CSIR, ICMR and MOCIT in that order. Maximum number of other IPRs were registered by the PIs of DST funded projects (16), followed by DBT (4) and DSIR (3).

Table 2.10: Funding agency-wise Intellectual Property Rights (IPRs) obtained from EMR projects

Funding agency	Patent filed		Patent sealed		Copyrights	Other IPR's registered
	India	Foreign	India	Foreign		
AICTE	17	5	1	0	9	0
CSIR	31	4	9	28	34	1
DAE	23	4	0	0	6	0
DBT	76	5	3	3	50	4
DRDO	28	1	1	4	15	0
DST	283	51	43	34	100	16
DSIR	9	1	1	0	0	3

ICMR	29	5	3	2	21	0
ISRO	0	1	0	0	0	0
MOCIT	27	2	1	9	2	0
MOEF&CC	4	4	4	4	0	0
MOES	1	0	0	0	0	0
UGC	113	55	13	1	65	6
Other agencies	5	5	0	0	0	0
All agencies	**646**	**143**	**79**	**85**	**302**	**30**

Other agencies: AYUSH, DOC, MNRE, MOP, MOS, MOSJE, MOWR & PCRA

Manpower generated/employed

a) Manpower generated

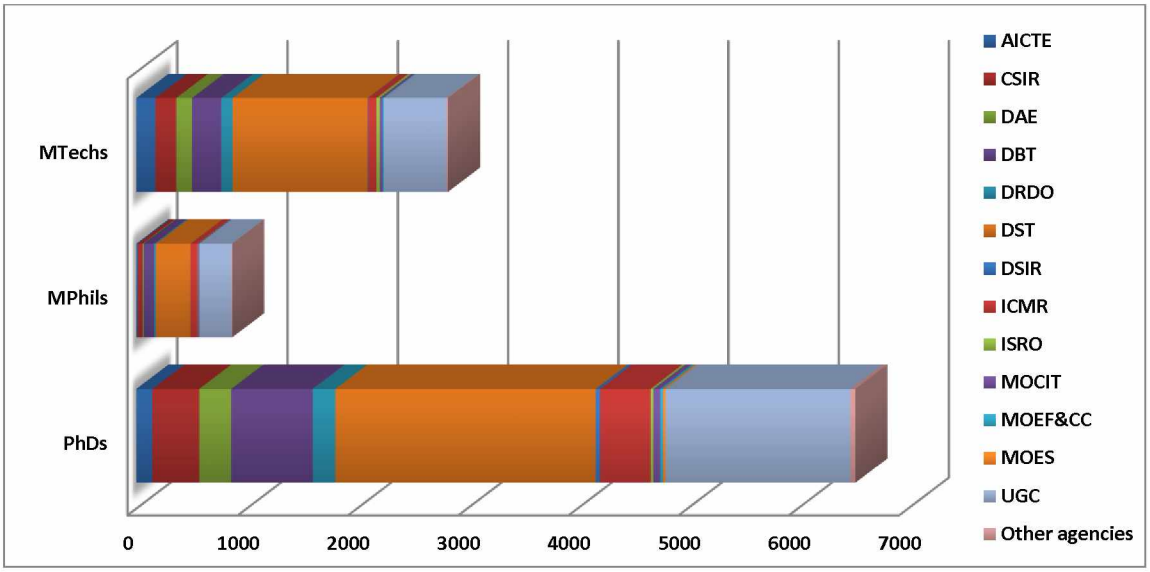
The specialized manpower produced out of sponsored R&D projects was in the form of PhD, DSc, MPhil, MTech and MD. DST funded projects generated the highest number (2361) of PhD followed by UGC (1679), DBT (738) and ICMR (458). Out of the total 19923 specialised manpower produced from the projects sponsored by all agencies, 6522 obtained PhD, 2826 MTech and 869 MPhil while only 8 obtained DSc.

Table 2.11: Funding agency-wise generation of manpower from EMR projects

Funding agency	PhD	DSc	MPhil	MTech	MD	Others	Total
AICTE	145	1	13	170	0	523	852
CSIR	425	1	44	191	0	399	1060
DAE	290	1	8	143	1	224	667
DBT	738	2	97	266	6	694	1803
DRDO	206	0	15	102	1	160	484
DST	2361	1	314	1225	9	3637	7547
DSIR	39	0	2	3	0	17	61
ICMR	458	0	61	76	12	528	1135
ISRO	28	0	3	30	0	13	74
MOCIT	59	0	12	29	0	57	157
MOEF&CC	27	0	2	8	0	13	50
MOES	22	0	1	1	0	10	34
UGC	1679	2	292	569	4	3364	5910
Other agencies	45	0	5	13	0	26	89
All agencies	**6522**	**8**	**869**	**2826**	**33**	**9665**	**19923**

Other agencies: AYUSH, DOC, MNRE, MOP, MOS, MOSJE, MOWR & PCRA

Figure 2.3: Funding agency-wise generation of manpower from EMR projects



b) Manpower employed

The manpower employed to run the project was in the form of JRF, SRF, RA, engineers & doctors, technicians and others. Overall, 21786 personnel were employed in all the categories. The highest number were employed as other professionals (6424) category followed by JRF (5316), others (3086), Engineers & Doctors (2125), SRF (1824), technician (1726) and RA (1283).

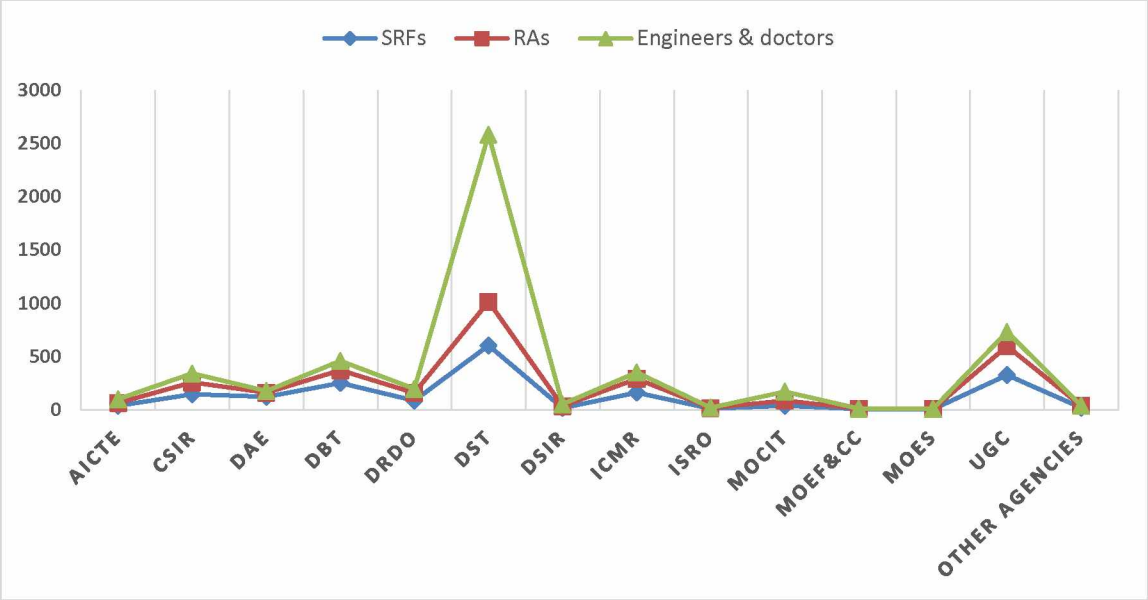
Table 2.12: Funding agency-wise manpower employed in extramural R&D projects

Funding agency	JRF	SRF	RA	Engineer & doctor	Other professionals	Technician	Others	Total
AICTE	86	37	28	34	176	57	89	507
CSIR	351	145	113	83	102	70	104	968
DAE	258	122	40	15	87	92	72	686
DBT	643	251	119	88	261	125	142	1629
DRDO	184	86	73	37	109	66	77	632
DST	1963	604	412	1569	4260	609	1141	10558
DSIR	45	17	18	16	35	88	50	269
ICMR	312	160	129	60	225	167	457	1510
ISRO	30	9	8	2	8	6	6	69
MOCIT	71	38	48	83	129	50	80	499
MOEF&CC	25	6	4	1	10	1	8	55
MOES	15	5	3	0	3	4	1	31
UGC	1296	326	271	134	977	383	669	4056
Other agencies	37	20	17	3	42	8	190	317
All agencies	**5316**	**1826**	**1283**	**2125**	**6424**	**1726**	**3086**	**21786**

Other agencies: AYUSH, DOC, MNRE, MOP, MOS, MOSJE, MOWR & PCRA

Agency-wise analysis shows that DST projects employed highest number of (2610) personnel followed by UGC (1004), ICMR (758) & DBT (739).

Figure 2.4: Funding agency-wise manpower employed in EMR projects



Observations & Conclusions:

The highest number of research papers were published from the projects funded by DST. The significant revelation from the analysis is that the PIs of the sponsored projects published more research papers in foreign journals (25043) than in Indian journals (7586) - almost 3.2 times. This shows that the PIs sent a greater number of quality research papers for publication in foreign journals which were accepted and published by them.

DST leads in almost all fields like new products, new processes, new rototypes developed, intellectual property rights (IPR's) registered, patents filed, patents sealed, new theories and new instruments developed.

Among the specialised manpower generated the share of DST-funded projects was maximum in categories like PhD (2361), MTech (1225), MPhil (314) and DSc (1). Similar is the the case with manpower employed category, where DST-funded projects employed highest number of scientific personnel, followed by UGC, ICMR, DBT and CSIR funded projects.

Funding agency-wise outcome of EMR projects sanctioned during 2010-2015

Outcome parameters	AICTE	CSIR	DAE	DBT	DRDO	DST	DSIR	ICMR	ISRO	MOCIT	MOEF & CC	MOES	UGC	Other agencies
Research papers published/ presented	1232	3518	1989	5836	1365	20577	298	3957	286	688	201	136	15366	485
Res. Paper found place on coverpage of journal	18	54	15	154	10	319	4	31	2	4	2	0	224	3
New products developed	156	502	121	385	263	1736	44	1682	10	48	7	15	1375	14
New processes developed	109	169	116	215	95	831	24	157	17	40	5	4	608	20
New instruments developed	27	33	40	47	23	222	1	14	1	15	1	1	126	2
New prototypes developed	15	80	63	103	41	435	9	22	2	32	1	1	182	4
New principle/ theory developed	19	86	48	98	42	426	8	51	5	14	3	1	278	6
New varieties developed	3	8	5	46	2	196	0	8	1	6	0	0	268	0
Patent filed	22	35	27	81	29	334	10	34	1	29	8	1	168	10
Patent sealed	1	37	0	6	5	77	1	5	0	10	8	0	14	0
Copy rights obtained	9	34	6	50	15	100	0	21	0	2	0	0	65	0
Manpower generated	852	1060	667	1803	484	7547	61	1135	74	157	50	34	5910	89
Manpower employed	507	968	686	1629	632	10558	269	1510	69	499	55	31	4056	317

Other agencies: MoS, AYUSH, CIL, DOC, DOD, DSIR, MNRE, MOP, MOSJE & PCRA

Chapter 3

Subject area-wise Analysis of Extramural R&D Projects and their Outcome

In this chapter, outcome of R&D projects by all the 21 funding agencies has been studied subject area-wise. The outcome emanating from these projects has been analysed in terms of research papers, patents, books & monographs, technical reports, new products, new instruments, new crop vaitites, new lead/potential molecule, new principles/theories developed and manpower generated and employed.

Subject area-wise extramural R&D projects

All the 27900 R&D projects supported by 21 funding agencies have been grouped in to 8 subject areas. The number of projects sponsored in each subject area along with funding support is shown in table 3.1

Table 3.1: Subject area-wise extramural R&D projects sponsored and amount sanctioned during 2010-15

Subject area	No. of projects	Total cost (Rs. Crore)	Average cost per project (Rs. Lakh)
Agricultural sciences	669	294.56	44.03
Biological sciences	8433	2970.35	35.22
Chemical sciences	4309	938.81	21.78
Earth sciences	1472	470.10	31.93
Engineering & technology	5240	3160.64	60.31
Mathematics	1214	110.82	9.13
Medical sciences	3733	1712.44	45.87
Physical sciences	2830	846.65	29.91
All subjects	**27900**	**10504.39**	**37.65**

It is seen from table 3.1 that the number of sponsored projects was highest in biological sciences (8433) while support was highest in the area of engineering & technology (Rs. 3160.64 crore). The next subject-areas in terms of number of projects sponsored were engineering & technology (5240), followed by chemical sciences (4309), medical sciences (3733) and physical sciences (2830). However, in terms of cost, the subject areas were biological sciences, medical sciences, chemical sciences, and physical sciences in that order.

The average cost per project in various subject areas depicted a wide variation ranging from Rs. 9.13 lakh per project in mathematics to more than Rs. 60.31 lakh per project in engineering & technology.

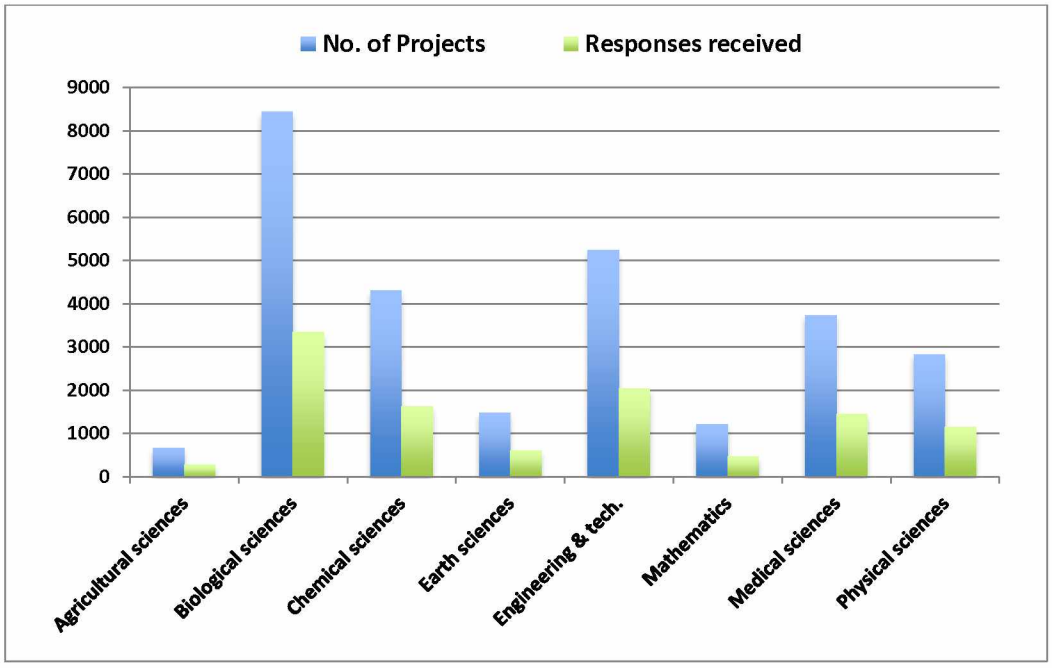
Subject area-wise outcome of extramural R&D projects

The study on outcome of R&D projects is based on the responses received from the 10950 projects out of 27900 projects sponsored by funding agencies. As can be seen in figure 3.1, the maximum response was received from the projects in earth sciences (40.89%), physical sciences (40.74%), agriculture sciences (40.36%) and biological sciences (39.66%). The overall response was 39.25% from total projects.

Table 3.2: Subject area-wise response received from extramural R&D projects

Subject area	No. of projects	Responses received	%age of response
Agricultural sciences	669	270	40.36
Biological sciences	8433	3345	39.66
Chemical sciences	4309	1631	37.85
Earth sciences	1472	602	40.89
Engineering and technology	5240	2034	38.81
Mathematics	1214	465	38.30
Medical sciences	3733	1450	38.84
Physical sciences	2830	1153	40.74
All subjects	**27900**	**10950**	**39.25**

Figure 3.1: Subject area-wise response received from extramural R&D projects



Research papers published

The subject area-wise analysis of research papers reveals that in biological sciences, the highest number of research papers (6454) were published in Indian journals and conferences, out of which 2485 papers were published in journals and 3969 were presented in conferences. The second highest number of research papers published in Indian journals and conferences was in engineering & technology (3341). This was followed by medical sciences (2790) category. Mathematics having a smaller number of total projects (1214), only 736 research papers were published in Indian journals & presented in conferences.

Table 3.3: Subject area-wise research papers published in journals and presented in conferences from EMR projects

(Number)

Subject area	Indian			Foreign		
	Journals	Conferences	Total	Journals	Conferences	Total
Agricultural sciences	245	356	601	546	273	819
Biological sciences	2485	3969	6454	7371	3184	10555
Chemical sciences	939	1798	2737	4091	1573	5664
Earth sciences	375	685	1060	1579	645	2224
Engineering & technology	1239	2102	3341	4676	2563	7239
Mathematics	294	442	736	988	408	1396
Medical sciences	1177	1613	2790	3205	1200	4405
Physical sciences	832	1361	2193	2587	1133	3720
All subjects	**7586**	**12326**	**19912**	**25043**	**10979**	**36022**

Monographs, books and technical reports published

The analysis of data shows that biological sciences category had the highest number of technical reports (496) published, followed by engineering & technology with 372 and chemical sciences with 296 technical reports. The highest number of books were published in biological sciences (90), followed by engineering & technology (68) and medical sciences (43). In case of monographs highest number were produced in mathematics (53).

Table 3.4: Subject area-wise monographs, books and technical reports published from extramural R&D projects

Subject area	Monographs	Books	Technical reports
Agricultural sciences	11	12	49
Biological sciences	24	90	496
Chemical sciences	23	34	296
Earth sciences	8	17	81
Engineering and technology	19	68	372
Mathematics	53	10	72
Medical sciences	18	43	144
Physical sciences	8	24	180
All subjects	**164**	**298**	**1690**

New products & processes developed

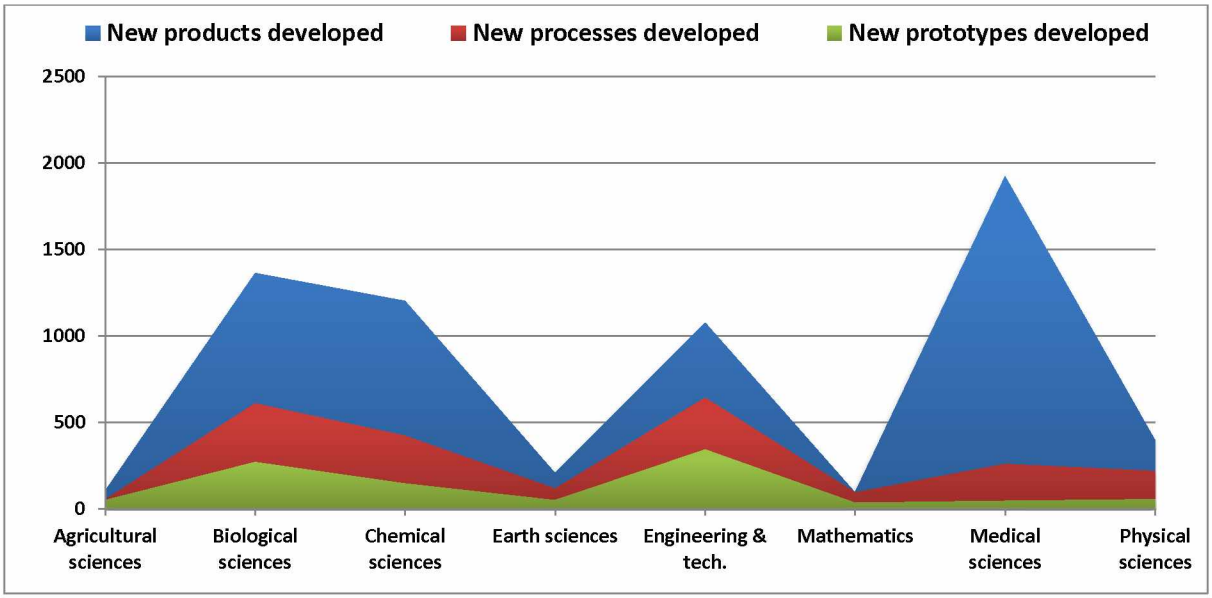
It is evident from the table 3.5 that the highest number of new products were developed in subject area - medical sciences (1922), this was followed by biological sciences (1362), chemical sciences (1202) and engineering & technology (1076).

Table 3.5: Subject area-wise development of new products, processes, instruments, prototypes, principles/theories & varieties under extramural R&D projects

Subject area	New products developed	New processes developed	New instruments developed	New prototypes developed	New principles / theories developed	New varieties developed
Agricultural sciences	103	52	13	49	17	4
Biological sciences	1362	609	135	270	289	247
Chemical sciences	1201	421	97	146	180	87
Earth sciences	205	116	25	49	71	60
Engineering & technology	1076	641	178	342	272	86
Mathematics	94	94	16	34	53	6
Medical sciences	1922	259	34	45	97	45
Physical sciences	395	218	55	55	106	8
All subjects	**6358**	**2410**	**553**	**990**	**1085**	**543**

The highest number of new processes were developed in the field of engineering & technology (641) followed by biological sciences (609), chemical sciences (421) and medical sciences (259). The lowest numbers of new processes (52) were developed in agriculture sciences.

Figure 3.2: Subject area-wise development of new processes, principles/theories & varieties under extramural R&D projects



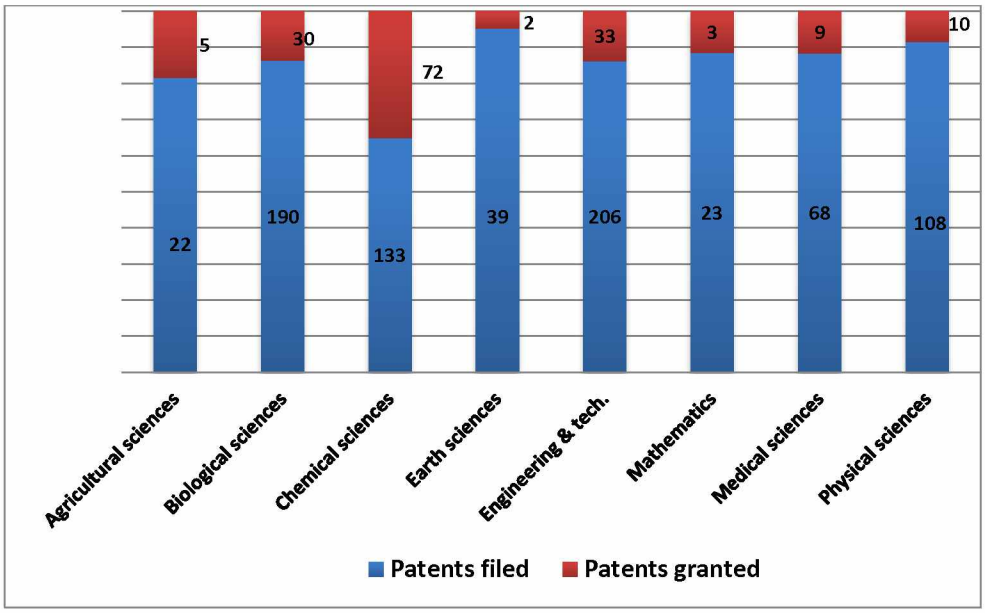
Patents and Intellectual Property Rights (IPRs) obtained

The highest number of patents filed (206) by the PIs were in the field of engineering & technology and sealed (72) by PIs of chemical sciences. This was followed by biological sciences with filing of 190 patents and engineering & technology with sealing 33 patents.

Table 3.7: Subject area-wise Intellectual Property Rights (IPRs) obtained under EMR projects

Subject Area	Patent filed		Patent sealed		Copyrights	Other IPR's registered
	India	Foreign	India	Foreign		
Agricultural sciences	19	3	5	0	6	0
Biological sciences	171	19	20	10	95	9
Chemical sciences	102	31	25	47	37	11
Earth sciences	34	5	2	0	4	3
Engineering and technology	178	28	14	19	83	5
Mathematics	22	1	2	1	12	1
Medical sciences	60	8	6	3	26	1
Physical sciences	60	48	5	5	39	0
All subjects	**646**	**143**	**79**	**85**	**302**	**30**

Figure 3.3: Subject area-wise patents filed & sealed under extramural R&D projects



Manpower generated/employed

a) Manpower generated

The subject area-wise analysis shows that 1922 PhD were produced in biological sciences followed by 1278 in engineering & technology while 1008 and 876 in the field of chemical sciences and medical sciences respectively. 277 students got MPhil degree in biological sciences, which is the highest number in any subject area. Number of MPhil produced in the field of chemical sciences was 135, followed by 115 and 104 in medical sciences and engineering & technology respectively. 15 MD were produced in medical sciences followed by 6 in the field of biological sciences. The highest number of 942 MTech were produced in the field of engineering & technology followed by 660 in biological sciences, 439 in chemical sciences and 284 in physical sciences.

Table 3.8: Subject area-wise manpower generated through extramural R&D projects

Subject area	PhD	DSc	MPhil	MTech	MD	Others
Agricultural sciences	176	0	11	75	1	319
Biological sciences	1922	4	277	660	6	2356
Chemical sciences	1008	1	135	439	5	1681
Earth sciences	334	0	41	154	0	735
Engineering & technology	1278	1	104	942	1	2462
Mathematics	253	0	70	113	2	219
Medical sciences	876	2	115	159	15	795
Physical sciences	675	0	116	284	3	1098

All subjects	**6522**	**8**	**869**	**2826**	**33**	**9665**

b) Manpower employed

The maximum number (1561) of Junior Research Fellows (JRF) were appointed in the field of biological sciences followed by 1023 in the engineering & technology and 841 in chemical sciences. The maximum number of Senior Research Fellows (SRF) were employed in biological sciences (491) while 407 and 298 SRFs were employed in the field of biological sciences and medical sciences respectively. Only 39 SRFs were employed in the field of mathematics.

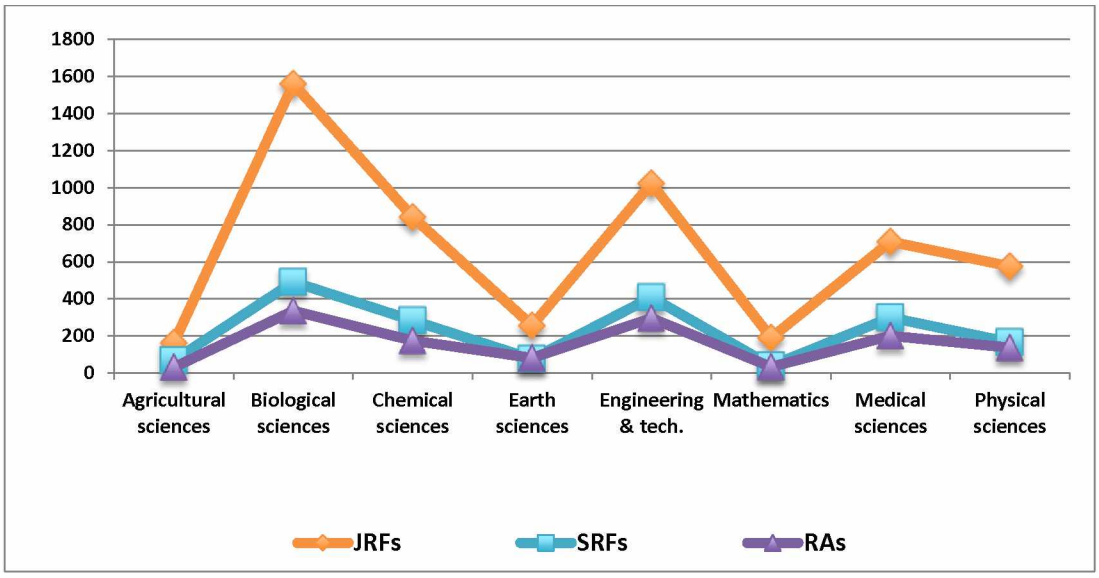
Table 3.9: Subject area-wise manpower employed under extramural R&D projects

(Number)

Subject area	Professional staff					Support staff	
	JRF	SRF	RA	Engineer & doctor	Other professionals	Technicians	Others
Agricultural sciences	162	67	30	10	64	21	28
Biological sciences	1561	491	335	258	1231	382	665
Chemical sciences	841	283	174	1412	2745	288	510
Earth sciences	256	76	80	40	212	75	167
Engineering and technology	1023	407	295	250	1227	496	748
Mathematics	190	39	33	8	219	75	94
Medical sciences	708	298	200	97	418	258	744
Physical sciences	575	165	136	50	308	131	130
All subjects	**5316**	**1826**	**1283**	**2125**	**6424**	**1726**	**3086**

The highest number of Research Associates (RA) were employed in biological sciences (335) followed by engineering & technology (295) and medical sciences (200) fields. Chemical sciences used services of 174 RA. Total 1412 engineers were employed in chemical sciences area.

Figure 3.5: Subject area-wise manpower employed in EMR projects



The highest number of technicians were employed in the subject area of engineering & technology (496) while 382 and 288 technicians were employed in and biological sciences areas chemical sciences respectively.

Observations & Conclusions:

Number of sponsored projects was highest in biological sciences (8433) while support was highest in the area of engineering & technology (Rs. 3160.64 crore). The highest numbers of patents filed were in the area of engineering & technology while sealed in chemical sciences. As far as research papers are concerned, maximum number of papers were published in the area of biological sciences (17009) followed by engineering & technology (10580), chemical sciences (8401) and medical sciences (7195).

Subject area-wise outcome of EMR projects sanctioned during 2010-2015

Outcome parameter	Agricultural sciences	Biological sciences	Chemical sciences	Earth sciences	Engineering & technology	Mathematics	Medical sciences	Physical sciences
Research papers published/ presented	1420	17009	8401	3284	10580	2132	7195	5913
Monographs published	11	24	23	8	19	53	18	8
Books published	12	90	34	17	68	10	43	24
Technical reports published	49	496	296	81	372	72	144	180
New products developed	103	1362	1201	205	1076	94	1922	395
New processes developed	52	609	421	116	641	94	259	218
New instruments developed	13	135	97	25	178	16	34	55
New prototypes developed	49	270	146	49	342	34	45	55
New principle/ theory developed	17	289	180	71	272	53	97	106
New varieties developed	4	247	87	60	86	6	45	8
Patent filed	22	190	133	39	206	23	68	108
Patent sealed	5	30	72	2	33	3	9	10
Copy rights obtained	6	95	37	4	83	12	26	39
Manpower generated	582	5225	3269	1264	4788	657	1962	2176
Manpower employed	382	4923	6253	906	4446	658	2723	1495

Chapter 4

Year-wise Analysis of Extramural R&D Projects and their Outcome

In this chapter, year-wise analysis of outcome emanating from the R&D projects sponsored by all the funding agencies is presented in respect of research papers, intellectual property rights, new products, new instruments, new principles/theories and manpower developed & employed during the 5-year period 2010 to 2015.

The year-wise analysis of the project indicates a slight upward shift in funding of extramural research & development projects from 2010-11 to 2014-2015. During this period total of 27900 projects were approved for funding by 21 central government departments/agencies.

Year-wise extramural R & D projects

The year-wise distribution of total number of projects sponsored by all the major funding agencies of Government of India is shown in Table 4.1.

There has been steady decline in number of sanctioned projects from the year 2010-11 to 2014-15 with exception in 2013-14. Total 10950 responses were received out of 27900 projects. In percentage terms maximum response (48%) has been received for the year 2014-15. The average cost per project declined from Rs. 44.31 lakh in year 2010-11 to Rs. 31.44 lakh in 2012-13. The overall average cost per project in the five years period was Rs. 37.65 lakh.

Table 4.1: Year-wise funding of extramural R&D projects and their responses

Year	Total projects	Total cost (Rs. Crore)	Avg. cost (Rs. Lakh)	Responses received	% Age of response
2010-11	5855	2594.44	44.31	2530	43.21
2011-12	5656	2328.35	41.16	1743	30.81
2012-13	5444	1711.95	31.44	1676	30.78
2013-14	5525	1867.53	33.80	2378	43.04
2014-15	5420	2002.12	36.94	2623	48.39
Total	**27900**	**10504.39**	**37.65**	**10950**	**39.25**

Outcome of R&D projects

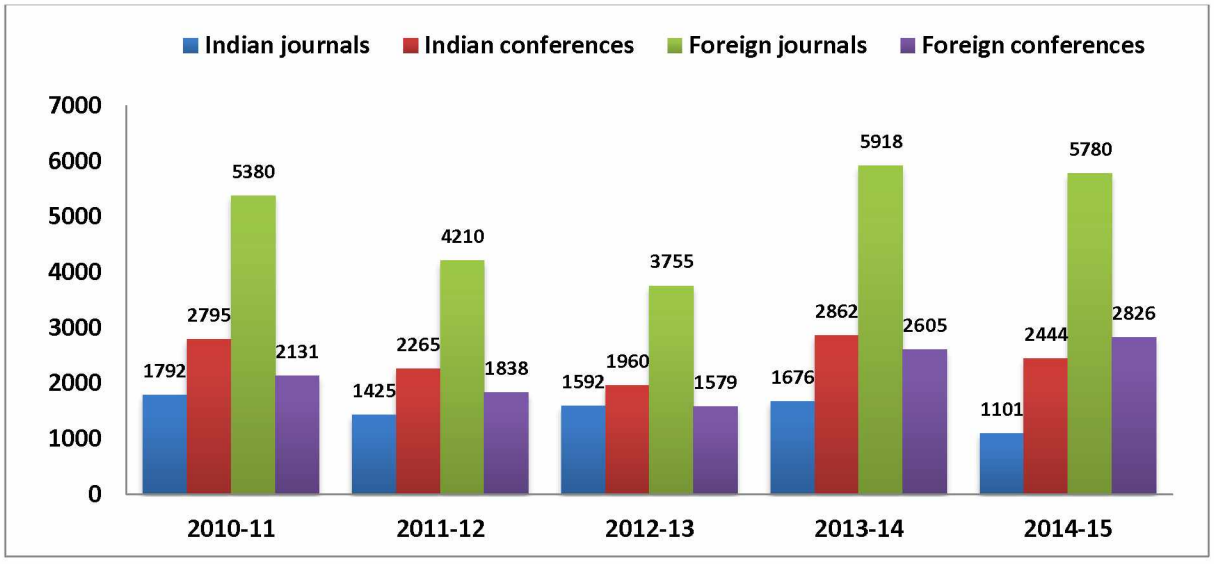
Research papers published

The total number of research papers published in Indian journals and presented in conferences is decreased from 4587 papers in 2010-11 to 3545 papers in 2014-15 except in 2013-14 where it has increased to 4538 papers, while in case of foreign journals and conferences; increase was from 7511 papers in 2010-11 to 8606 papers in 2014-15 except small decline to 6048 and 5334 in the year 2011-12 and 2012-13 respectively.

Table 4.2: Year-wise research papers published in journals and presented in conferences from EMR projects

Year	India			Foreign			Grand total
	Journals	Conferences	Total	Journals	Conferences	Total	
2010-11	1792	2795	4587	5380	2131	7511	12098
2011-12	1425	2265	3690	4210	1838	6048	9738
2012-13	1592	1960	3552	3755	1579	5334	8886
2013-14	1676	2862	4538	5918	2605	8523	13061
2014-15	1101	2444	3545	5780	2826	8606	12151
Total	**7586**	**12326**	**19912**	**25043**	**10979**	**36022**	**55934**

Figure 4.1: Year-wise research papers published under extramural R&D projects



New products, processes & prototypes developed

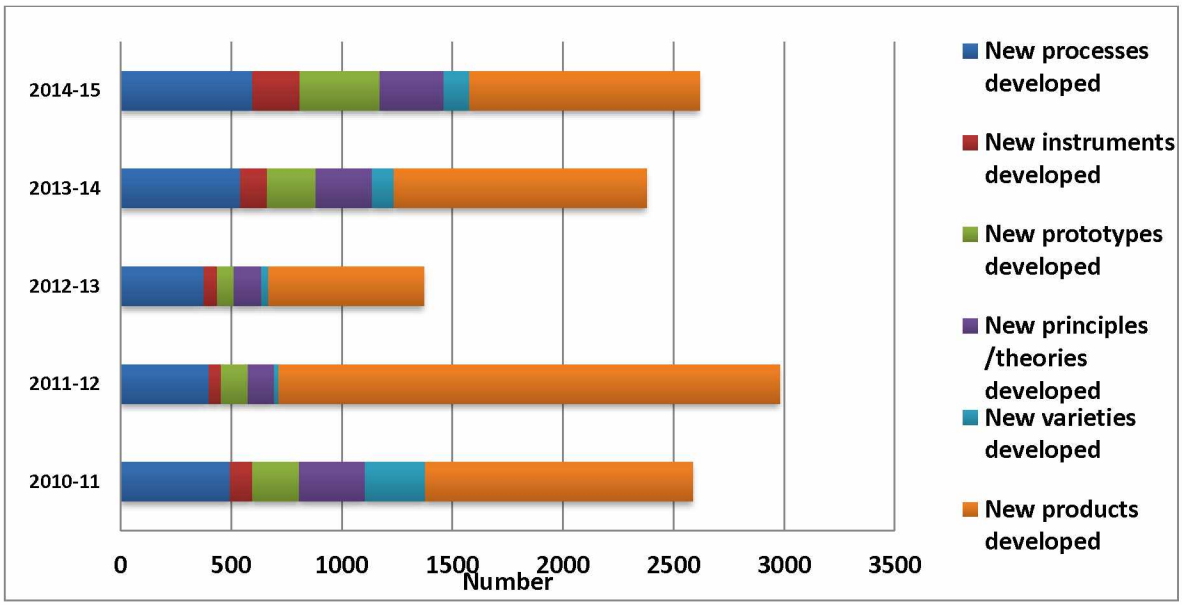
It is evident from the table 4.3 that number of new processes developed, increased from the year 2011-12 to 2014-15, while new crop varieties developed were decreased during the same

period. New products, new prototype, new instrument & new principle/theory developed do not indicate any specific pattern.

Table 4.3: Year-wise development of new prototype, processes and instruments under extramural R&D projects

Year	New products developed	New processes developed	New instruments developed	New prototypes developed	New principles /theories developed	New varieties developed
2010-11	1209	495	101	211	298	274
2011-12	2265	399	55	122	120	20
2012-13	703	376	62	75	124	33
2013-14	1142	543	121	219	255	99
2014-15	1039	597	214	363	288	117
Total	**6358**	**2410**	**553**	**990**	**1085**	**543**

Figure 4.2: Year-wise new prototypes, processes & instruments developed under extramural R&D projects



Patents and Intellectual Property Rights (IPRs) obtained

It is interesting to note that highest number of patents filed and sealed were in the year 2013-14 and lowest in the year 2012-13. The total 302 copyrights and 30 other Intellectual Property Rights (IPRs) were registered during the 5-year period.

Table 4.4: Year-wise Intellectual Property Rights (IPRs) obtained through extramural R&D projects

Year	Patents filed			Patents sealed			Copyrights	Other IPR's registered
	India	Foreign	Total	India	Foreign	Total		
2010-11	120	29	149	26	38	64	54	18
2011-12	122	55	177	10	5	15	32	5
2012-13	72	7	79	6	9	15	36	0
2013-14	164	23	187	27	23	50	100	2
2014-15	168	29	197	10	10	20	80	5
Total	**646**	**143**	**789**	**79**	**85**	**164**	**302**	**30**

Manpower generated/employed

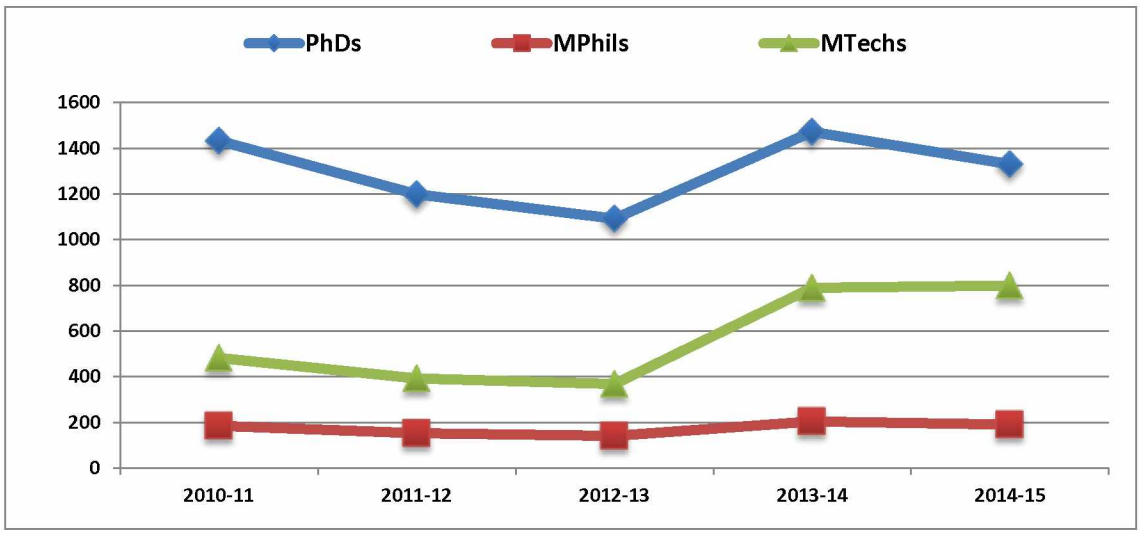
a) Manpower generated

There was steady decline in number of PhD produced from 2010-11 (1432) to 2012-13 (1091) with exception in 2013-14 (1471) while there is no remarkable change in number of DSc, MPhil, MTech and MD produced in these five years.

Table 4.5: Year-wise details of manpower generated in extramural R&D projects

Year	PhD	DSc	MPhil	MTech	MD	Others
2010-11	1432	3	184	481	7	1841
2011-12	1198	1	152	392	12	1209
2012-13	1091	2	140	367	3	1321
2013-14	1471	2	203	788	5	3495
2014-15	1330	0	190	798	6	1799
Total	**6522**	**8**	**869**	**2826**	**33**	**9665**

Figure 4.3: Year-wise generation of manpower through extramural R&D projects



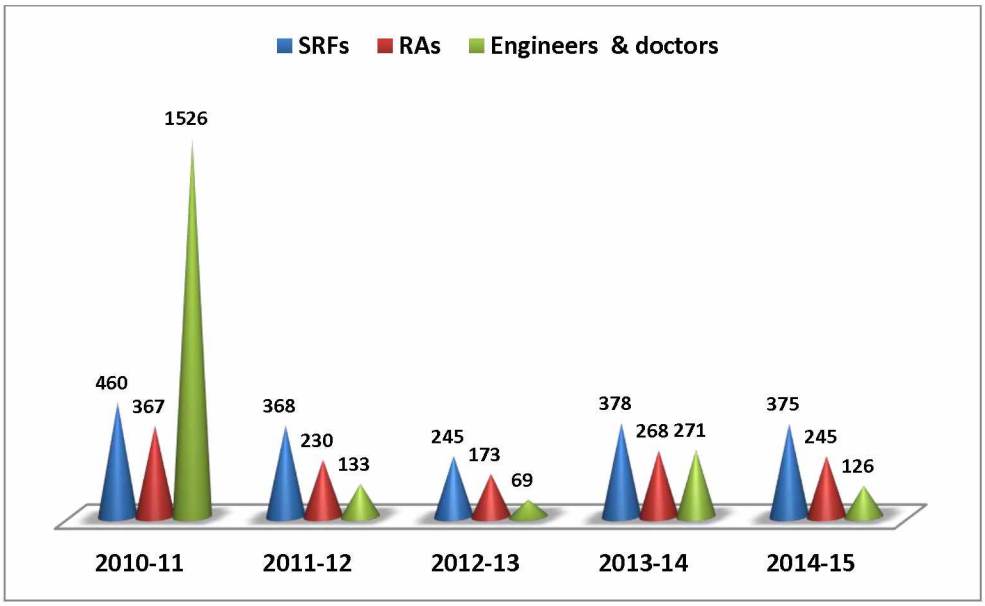
b) Manpower employed

During the five-year period of study, 21786 personnel were employed in 10950 projects for which information was given by the PIs. Out of this, 5316 were JRF, 1826 were SRF, 1283 were RA, 2125 were engineers/doctors, 6424 other scientific personnel, 1726 technicians and 3086 were from other support staff category.

Table 4.6: Year-wise details of manpower employed in extramural R&D projects

Year	Scientific / technical personnel					Support staff	
	JRF	SRF	RA	Engineer & doctors	Other professionals	Technicians	Others
2010-11	1278	460	367	1526	3397	448	511
2011-12	881	368	230	133	460	277	304
2012-13	923	245	173	69	409	218	327
2013-14	1096	378	268	271	1243	420	992
2014-15	1138	375	245	126	915	363	952
Total	**5316**	**1826**	**1283**	**2125**	**6424**	**1726**	**3086**

Figure 4.4: Year-wise details of manpower employed in extramural R&D projects



Observations & Conclusions:

Analysis of year-wise support to projects has revealed a steady decline in number of sanctioned projects from the year 2010-11 to 2014-15 with exception in 2013-14. Total 10950 responses were received out of 27900 projects. Total 5855 projects were supported in 2010-11 which continuously decreased to 5420 in the year 2014-15 with the exception of the year 2013-14 with the increase of 5525

projects. It is interesting to note that highest number of patents filed and sealed were in the year 2013-14 and lowest in the year 2012-13. The total 302 copyrights and 30 other Intellectual Property Rights (IPRs) were registered during the 5-year period.

Year-wise outcome of EMR projects sanctioned during 2010-2015

Outcome parameter	2010-11	2011-12	2012-13	2013-14	2014-15
Research papers published/ presented	12098	9738	8886	13061	12151
New products developed	1209	2265	703	1142	1039
New processes developed	495	399	376	543	597
New instruments developed	101	55	62	121	214
New prototypes developed	211	122	75	219	363
New principle/ theory developed	298	120	124	255	288
New varieties developed	274	20	33	99	117
Patent filed	149	177	79	187	197
Patent sealed	64	15	15	50	20
Copy rights obtained	27	33	15	63	59
Manpower generated	3948	2964	2924	5964	4123
Manpower employed	7987	2653	2364	4668	4114

Chapter 5

Types of Institute-wise Analysis of Extramural R&D Projects and their Outcome

The extramural R &D projects supported by the 21 central government funding agencies was mainly to the academic sector which included universities & deemed universities, colleges, institutes of national importance, etc. In this chapter, type of institute-wise analysis emanating from the sponsored R&D projects is presented in terms of research papers published, new products, new instruments, new principles/theories, new varieties, new processes developed and intellectual property rights obtained during the five years period.

The outreach of the R&D support was confined mainly to the academic sector comprising of universities, colleges and institutes of national importance (80%) while national laboratories had 7% projects and remaining 13% went to others category.

Type of institute-wise extramural R&D projects

Since a large number of institutes were involved with R&D projects sanctioned by funding agencies, these institutes were grouped into four categories:

A. Colleges and universities

B. Deemed Universities

C. Institute of National Importance

- Till date 73 institutes are declared Institutes of National Importance by government of India. Prominent among them are Indian Institute of Technology, National Institutes of Technology, All India Institute of Medical Sciences, Indian Statistical Institute, P.G. Institute of Medical Education & Research and Sree Chitra Tirunal Institute for Medical sciences & Technology etc.

D. National Research Laboratories

- Laboratories under CSIR, ICAR, ICMR, DRDO and autonomous institutions under Central Government Ministries / Departments, Central Public Sector Undertakings

E. Others

- Institutions which are not covered under A, B, C & D above.

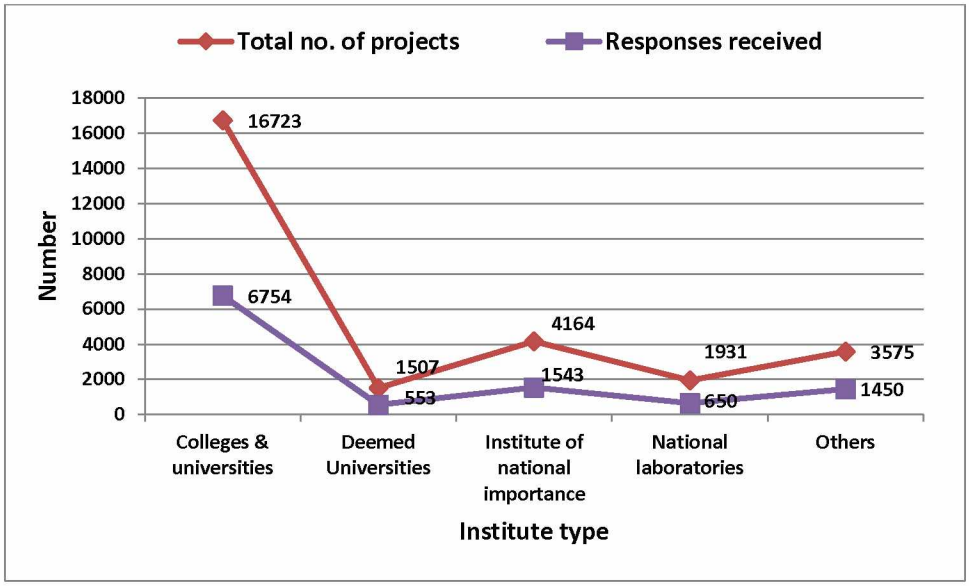
Responses received

A total of 10950 responses were received from 27900 projects. The maximum number of responses (6754) was received from colleges & universities. There were 73 institutes of national importance which submitted 1543 responses while national laboratories and deemed universities submitted 650 and 553 responses respectively. 1450 responses were received from all other institutes.

Table 5.1: Types of institute-wise response received from extramural R&D projects

Type of institutes	Total no. of projects	Total approved cost (Rs. crore)	Avg. funding per project (Rs. Lakh)	Responses	%Age of response
Colleges & universities	16723	3343.12	19.99	6754	40.38
Institutes of national importance	4164	2150.15	51.63	1543	37.05
National laboratories	1931	1315.33	68.11	650	33.66
Deemed universities	1507	1066.33	70.75	553	36.69
Others	3575	2629.44	73.55	1450	41.00
All institutes	**27900**	**10504.39**	**37.65**	**10950**	**39.25**

Figure 5.1: Types of institute-wise response received from extramural R&D projects



Outcome of sponsored R&D projects

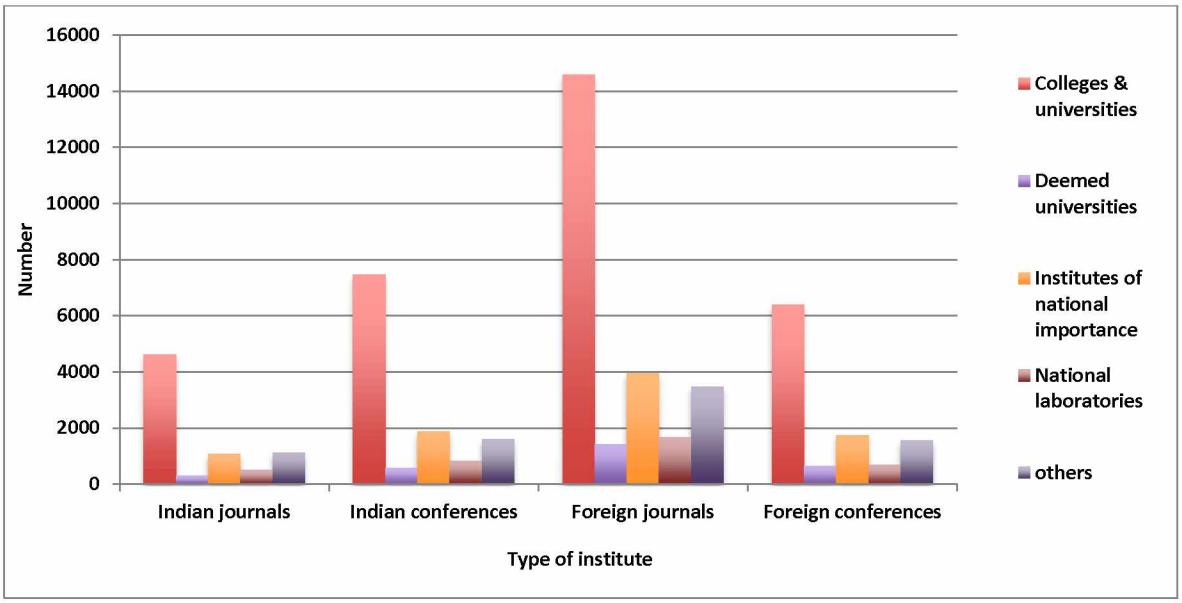
Research papers published

The principal investigators from colleges & universities had the maximum number of research papers published/presented. This includes 4611 papers in Indian and 14576 papers in foreign journals/conferences. Next to it were projects from institutes of national importance (8329 papers) with 2397 papers published in Indian and 5932 papers in foreign journals/conferences. The PIs from national laboratories has published total 5904 research papers comprising 2364 in Indian and 3540 in foreign journals/conferences.

Table 5.2: Types of institute-wise research papers published in journals and presented in conferences under EMR projects

Type of institutes	Indian			Foreign		
	Journals	Conferences	Total	Journals	Conferences	Total
Colleges & universities	4611	7464	12075	14576	6383	20959
Institute of national importance	1074	1878	2952	3937	1736	5673
National laboratories	497	828	1325	1656	680	2336
Deemed universities	284	571	855	1407	636	2043
Others	1120	1585	2705	3467	1544	5011
All institutes	**7586**	**12326**	**19912**	**25043**	**10979**	**36022**

Figure 5.2: Types of institute-wise research papers published & presented under EMR projects



Monographs, books and technical reports

The analysis of data collected, shows that colleges & universities had the highest number of technical reports (1057) books (173) and monograph (90) published, followed by Institutes of national importance with 228 technical reports 48 books and 14 monographs. PIs from national research laboratories have published 98 technical reports, 12 books and 9 monographs.

Type of institutes	Monographs	Books	Technical reports
Universities/Colleges	90	173	1057
Institutes of National Importance	14	48	228
National Laboratories	9	12	98
Deemed Universities	4	15	78
Others	91	175	1060

New products & processes developed

The analysis of data reveals that total 6358 new products and 2410 new processes were developed by the principal investigators out of the 10950 projects. The maximum number of new products (3028) and new processes (1382) were developed by the projects from colleges & universities. This was followed by projects from institutes of national importance in developing 655 new products and national laboratories in 352 new processes. PIs from deemed universities developed 333 new products and 132 new products.

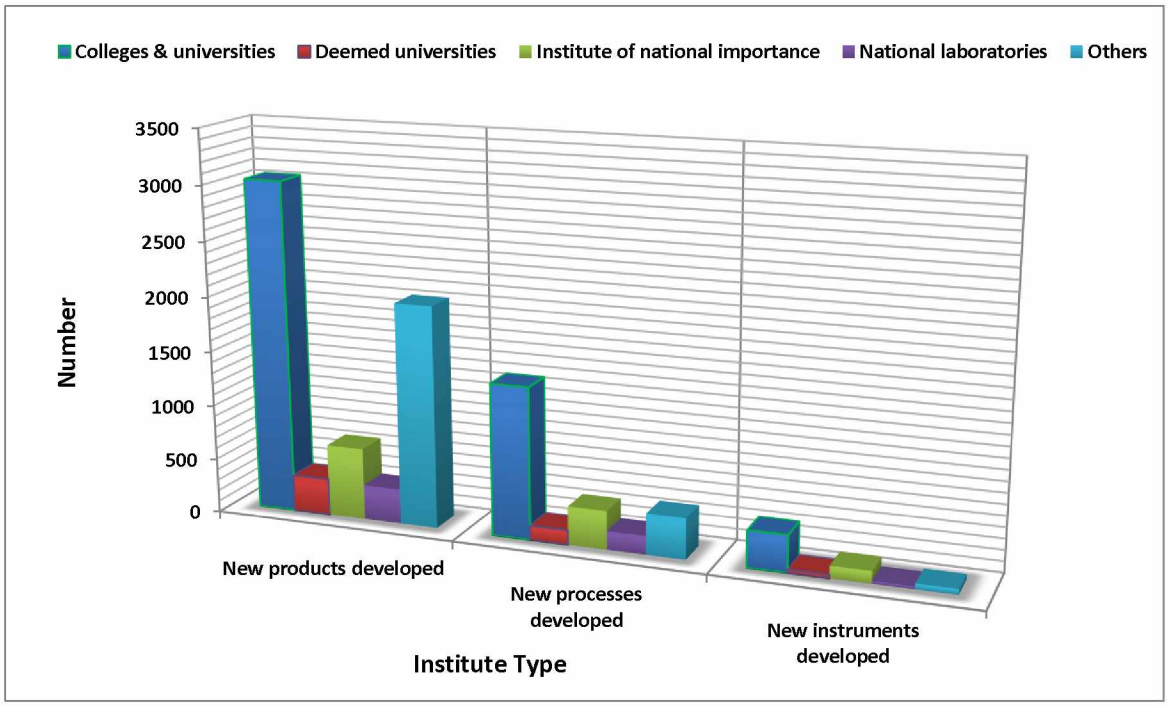
Table 5.3: Types of institute-wise development of new products, processes, instruments, prototypes, principles/theories and varieties through extramural R&D projects

Type of institutes	New products developed	New processes developed	New instruments developed	New prototypes developed	New principles/ theories developed	New varieties developed
Colleges & universities	3028	1382	334	466	636	384
Institute of national importance	655	352	111	141	150	46
National laboratories	319	170	25	119	73	12
Deemed universities	333	132	32	59	76	5
Others	2023	374	51	205	150	96
All institutes	**6358**	**2410**	**553**	**990**	**1085**	**543**

New instruments & prototypes developed

As shown in table 5.3 the maximum number of new instruments (334) and new prototypes (455) were developed by PIs from colleges & universities. This was followed by 111 new instruments and 141 new prototypes from institutes of national importance while 32 new instruments were developed by PIs from deemed universities and 119 new prototypes by national laboratories.

Figure 5.4: Types of institute-wise new products & processes developed through extramural R&D projects



Patents and Intellectual Property Rights (IPRs) obtained

Projects undertaken in colleges & universities filed the maximum number of patents in both India (313) and foreign countries (46), followed by institutes of national importance in India (117) and other institutions in foreign countries (62). The maximum copy rights were obtained by colleges & universities (160) followed by institutes of national importance (64) while lesser number (16) of copy rights was registered by the PIs from national laboratories.

Table 5.4: Types of institute-wise Intellectual Property Rights (IPRs) obtained under EMR projects

Type of institutes	Patent filed		Patent sealed		Copyrights	Other IPR's registered
	India	Foreign	India	Foreign		
Colleges & universities	313	46	23	18	160	16
Institute of national importance	117	19	13	17	64	4
National laboratories	38	10	20	33	16	1
Deemed universities	52	6	7	4	35	0
Others	126	62	16	13	27	9
All institutes	**646**	**143**	**79**	**85**	**302**	**30**

Manpower generated/employed

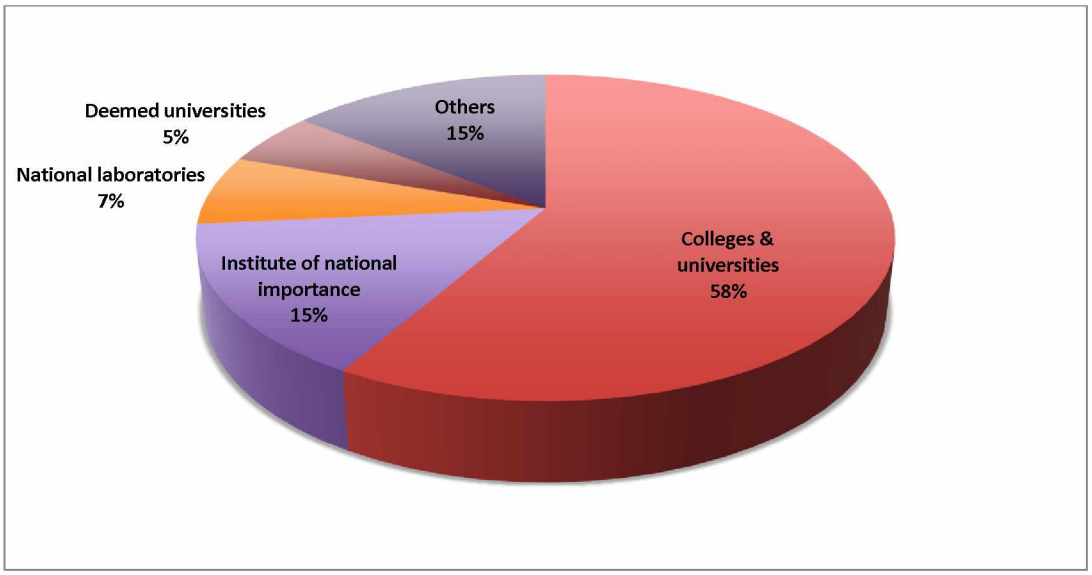
a) Manpower generated

The types of institute-wise analysis shows that colleges & universities generated highest number of manpower in all the categories. The highest number of PhD were produced in colleges & universities (3801), followed by institutes of national importance (991), national research laboratories (451), deemed universities (342) and other institutions (937). The highest number of M Phil awardees was again in colleges & universities (592), followed by institutes of national importance (90) and national laboratories (53).

Table 5.5: Types of institute-wise manpower generated under extramural R&D projects

Type of institutes	PhD	DSc	MPhil	MTech	MD	Others	Total
Colleges & universities	3801	5	592	1519	19	5761	11697
Institute of national importance	991	2	90	626	6	1418	3133
National laboratories	451	0	53	142	3	916	1565
Deemed universities	342	1	29	171	2	401	946
Others	937	0	105	368	3	1169	2582
All institutes	**6522**	**8**	**869**	**2826**	**33**	**9665**	**19923**

Figure 5.5: Types of institutes-wise No. of PhDs produced in extramural R&D projects



b) Manpower employed

As shown in Table 5.6, the maximum number of Junior Research Fellows (JRF) were employed in the projects undertaken by PIs from colleges & universities (3049), followed by other institutions (797), institutes of national importance (790), national laboratories (378) and deemed universities (302). Similarly, the highest number of Senior Research Fellows (SRF) were employed in the projects carried out in colleges & universities (964) while 331 and 298 SRF were employed by the institutes of national importance and other institutions respectively. Although the highest numbers of Research Associates (RA) were employed in colleges & universities (713), institutes of national importance come second (226) followed by national laboratories (60).

Table 5.6: Types of institute-wise manpower employed under extramural R&D projects

Type of institutes	Professional staff					Support staff		Total
	JRF	SRF	RA	Engineer & doctor	Other professionals	Technicians	Others	
Colleges & universities	3049	964	713	473	2389	963	1786	10337
Institute of national importance	790	321	226	161	648	278	372	2796
National laboratories	378	147	60	1336	2360	116	100	4497
Deemed universities	302	96	54	36	222	89	119	918
Others	797	298	230	119	805	280	709	3238
All institutes	**5316**	**1826**	**1283**	**2125**	**6424**	**1726**	**3086**	**21786**

Observations & Conclusions:

The analysis of Institute-wise outcome reveals that the outreach of the R&D support was confined mainly to the academic sector comprising universities, colleges and institutions of national importance (80%) while national laboratories had only 6.92% projects.

Although colleges & universities awarded maximum number of projects from funding agencies, the average cost per project was only Rs. 20 lakh, while in case of other institutions it was Rs. 73 lakh, national laboratories Rs. 68 lakh, deemed universities Rs. 70 lakh and institutes of national importance Rs.51 lakh.

The outcome was highest from projects carried out in colleges & universities in terms of publication/presentation of research papers, development of new products, processes, instruments, prototypes, principles/theories, varieties, filing & sealing of patents, producing PhD, employing JRF, SRF & RA.

Type of institute-wise outcome of EMR projects sanctioned during 2010-2015

Outcome parameter	Colleges & universities	Institute of national importance	National laboratories	Deemed universities	Others
Research papers published/ presented	33034	8625	3661	2898	7716
New products developed	3028	655	319	333	2023
New processes developed	1382	352	170	132	374
New instruments developed	334	111	25	32	51
New prototypes developed	466	141	119	59	205
New principle/ theory developed	636	150	73	76	150
New varieties developed	384	46	12	5	96
Patent filed	359	136	48	58	188
Patent sealed	41	30	53	11	29
Copy rights obtained	160	64	16	35	27
Manpower generated	11697	3133	1565	946	2582
Manpower employed	10337	2796	4497	918	3238

Chapter 6

State-wise Analysis of Extramural R&D Projects and their Outcome

The study of geographical distribution of R&D programmes is very important for a vast country like India. Hence, in this chapter state-wise analysis of the outcome emanating from the R&D projects sponsored by all 21 central government funding agencies during 2010-11 to 2014-15 is presented in respect of research papers published, new products, new instruments, new principles/theories, new varieties, new processes developed, intellectual property rights obtained and scientific manpower generated/employed.

State-wise distribution of extramural R&D projects

The state-wise spread of R&D projects by the central government funding agencies is shown in Table 6.1. It is evident from the data that Tamil Nadu received the highest number of projects (4134), followed by Maharashtra (2995), Karnataka (2772), Delhi (2348), Andhra Pradesh (2066), West Bengal (1925), Uttar Pradesh (1922) and Kerala (1833). These eight states taken together received 71.66% of total number of projects. All the other states received less than one thousand projects each during five years period. The state receiving minimum projects was Bihar (125).

Since the analysis is based on the number of responses received from the sponsored projects, the number of responses received from each state is also listed in Table 6.1.

The highest number of 1811 responses were received from the PIs from state of Tamil Nadu, as it had the highest total number of projects (4134) sanctioned. Next to this was Maharashtra (1298) while PIs from Maharastra responded next with 1128 responses followed by Delhi and Andhra Pradesh with 827 and 800 responses respectively. Whole North-eastern region had 1856 projects sanctioned out of which responses was received from 690 projects while Union Territories had 258 responses from 645 projects sanctioned.

Table 6.1: State-wise distribution of extramural R&D projects and response received

State	No. of projects	Responses received
Andhra Pradesh	2066	800
Bihar	125	50
Chhattisgarh	150	47
Delhi	2348	827
Goa	148	57
Gujarat	672	279
Haryana	403	151
Himachal Pradesh	262	100
Jammu & Kashmir	265	85
Jharkhand	251	91
Karnataka	2772	1128
Kerala	1833	739
Madhya Pradesh	502	166
Maharashtra	2995	1298
North-East states	1856	690
Orissa	568	213
Punjab	674	289
Rajasthan	567	209
Tamil Nadu	4134	1817
Telangana	323	141
Union Territories	645	258
Uttar Pradesh	1922	657
Uttarakhand	494	174
West Bengal	1925	684
Total	**27900**	**10950**

State-wise outcome

Research papers published

As shown in table 6.2, PIs of projects sponsored in the institutions based in Tamil Nadu had published/presented maximum number of research papers (2985) in Indian journals and conferences (5996) in foreign journals and conferences. This was followed by Maharashtra (2491 papers) in Indian journals and conferences and 4367 papers published in foreign journals and presented in conferences.

Table 6.2: State-wise research papers published in journals and presented in conferences from EMR projects

State	Indian			Foreign		
	Journals	Conferences	Total	Journals	Conferences	Total
Andhra Pradesh	618	983	1601	1866	851	2717
Bihar	26	47	73	112	45	157
Chhattisgarh	74	91	165	154	68	222

Delhi	645	861	1506	1713	877	2590
Goa	36	57	93	131	56	187
Gujarat	160	325	485	679	241	920
Haryana	73	130	203	339	149	488
Himachal Pradesh	74	158	232	299	85	384
Jammu & Kashmir	40	116	156	225	106	331
Jharkhand	61	63	124	187	43	230
Karnataka	802	1271	2073	2397	1020	3417
Kerala	509	674	1183	1215	515	1730
Madhya Pradesh	117	192	309	387	154	541
Maharashtra	970	1521	2491	3020	1347	4367
North-east States	443	879	1322	1581	688	2269
Orissa	165	201	366	479	290	769
Punjab	187	375	562	770	314	1084
Rajasthan	96	213	309	561	266	827
Tamil Nadu	1108	1877	2985	4070	1926	5996
Telangana	54	155	209	351	198	549
Union Territories	185	380	565	745	250	995
Uttar Pradesh	491	796	1287	1585	663	2248
Uttarakhand	144	218	362	449	194	643
West Bengal	508	743	1251	1728	633	2361
Total	**7586**	**12326**	**19912**	**25043**	**10979**	**36022**

New products, processes and instruments developed

Principal investigators from Delhi developed the highest new products (1909), followed by Tamil Nadu (847), Maharashtra (639), Karnataka (622) and Andhra Pradesh (381) while Tamil Nadu topped again in developing new processes (372), this was followed by Karnataka (278) and Maharashtra (266). PIs from Tamil Nadu again ranked number one in developing new instruments (99) followed by Karnataka (83) and Andhra Pradesh (53).

Table 6.3: State-wise distribution of new products, processes and instruments developed in EMR projects

State	New products developed	New processes developed	New instruments developed	New prototypes developed	New principle/ theory developed	New varieties developed
Andhra Pradesh	381	173	53	69	100	52
Bihar	15	10	0	5	6	0
Chhattisgarh	62	10	3	0	4	2
Delhi	1909	195	35	78	60	35
Goa	30	19	4	1	4	3
Gujarat	147	51	4	20	27	51
Haryana	75	25	2	39	16	29

Himachal Pradesh	44	14	4	4	19	5
Jammu & Kashmir	83	19	0	8	3	7
Jharkhand	5	8	2	2	6	0
Karnataka	622	278	38	80	129	142
Kerala	186	109	21	38	44	8
Madhya Pradesh	32	23	11	9	23	0
Maharashtra	639	266	83	119	131	72
North-east States	184	146	41	51	66	7
Orissa	48	86	24	14	12	6
Punjab	141	105	18	34	25	11
Rajasthan	98	53	13	11	24	2
Tamil Nadu	847	372	99	256	179	43
Telangana	45	53	16	14	16	2
Union Territories	59	50	8	9	20	2
Uttar Pradesh	350	154	28	42	65	11
Uttarakhand	41	41	7	8	27	2
West Bengal	315	150	39	79	79	51
Total	**6358**	**2410**	**553**	**990**	**1085**	**543**

Intellectual Property Rights (IPRs) obtained

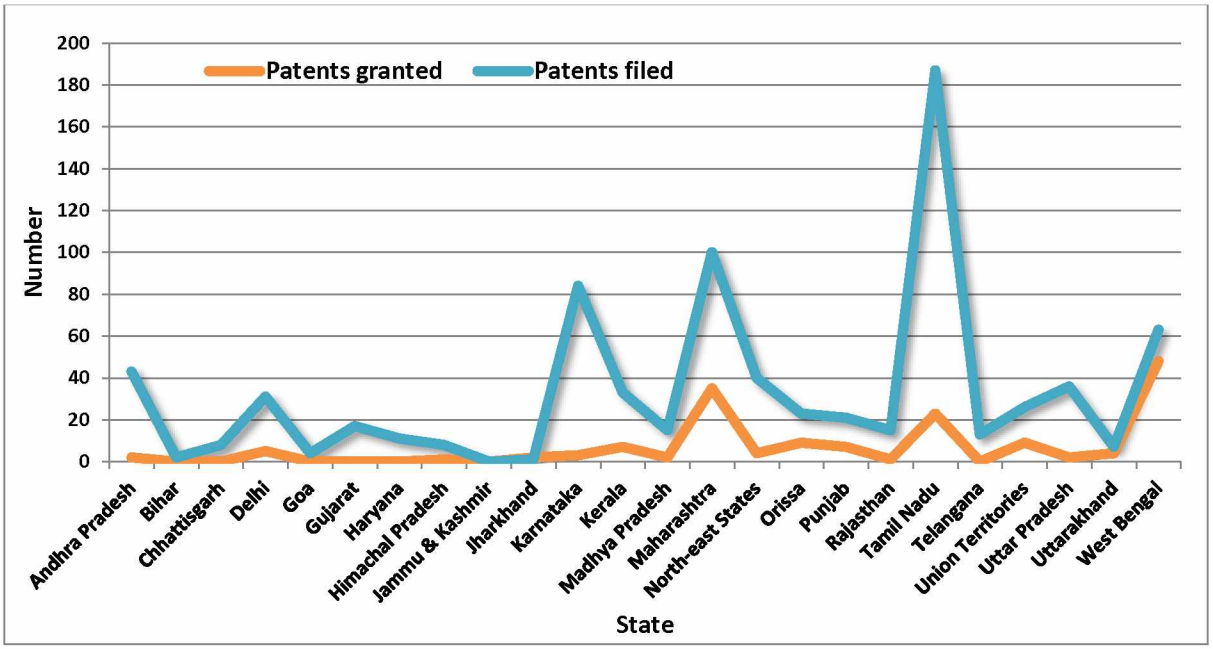
The maximum number of patents were filed by the PIs from Tamil Nadu (187), this was followed by Maharashtra (100), Karnataka (84) and West Bengal (63). The PIs from West Bengal sealed the maximum number of Patents (48). This was followed by Maharastra (35) and Tamil Nadu (23) patents. Principal investigators from Maharastra registered the maximum number of other IPRs (7), followed by 5 each from Punjab and North eastern states.

Table 6.4: State-wise distribution of Intellectual Property Rights (IPRs) obtained in EMR projects

State	Patent filed		Patent sealed		Copyrights	Other IPR's registered
	India	Foreign	India	Foreign		
Andhra Pradesh	31	12	2	0	43	1
Bihar	2	0	0	0	0	0
Chhattisgarh	8	0	0	0	0	0
Delhi	30	1	4	1	32	1
Goa	4	0	0	0	1	0
Gujarat	15	2	0	0	0	0
Haryana	11	0	0	0	2	0
Himachal Pradesh	5	3	0	1	12	0
Jammu & Kashmir	0	0	0	0	2	0
Jharkhand	1	0	2	0	2	0
Karnataka	77	7	3	0	39	4
Kerala	30	3	3	4	20	3
Madhya Pradesh	15	1	0	2	2	0
Maharashtra	79	21	15	20	24	7

North-east States	37	3	4	0	13	5
Orissa	16	7	4	5	2	1
Punjab	17	4	2	5	2	5
Rajasthan	11	4	1	0	8	0
Tamil Nadu	131	56	14	9	57	1
Telangana	12	1	0	0	4	0
Union Territories	18	8	4	5	6	0
Uttar Pradesh	31	5	1	1	13	0
Uttarakhand	7	0	1	3	5	0
West Bengal	58	5	19	29	13	2
Total	**646**	**143**	**79**	**85**	**302**	**30**

Figure 6.1: State-wise distribution of Patents filed & sealed under EMR projects



Manpower generated/employed

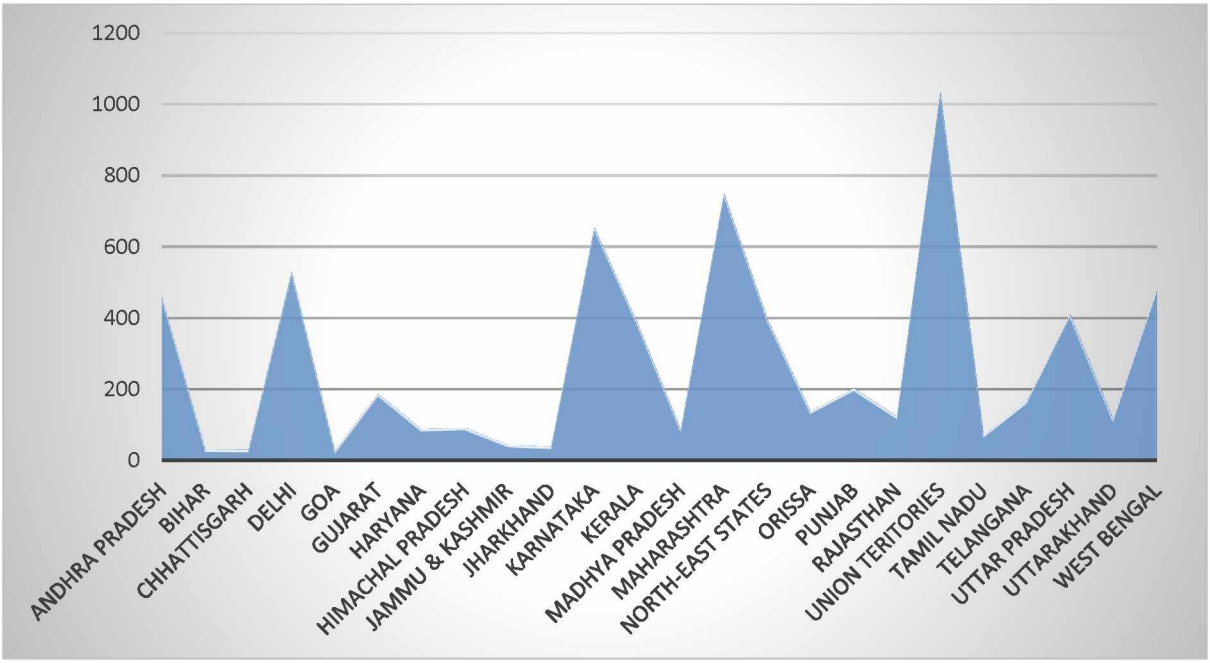
a) Manpower generated

In manpower generation, projects from Tamil Nadu produced maximum number of PhD (1034) followed by Maharashtra (748), Karnataka (653), Delhi (528) and West Bengal (475). PIs from Tamil Nadu again produced the highest number of MPhils (217) followed by Maharashtra (74) and Karnataka (73). Investigators from Tamil Nadu produced the highest number of MTech (510) followed by Maharashtra (359) and Karnataka (246).

Table 6.5: State-wise manpower generated under extramural R&D projects

State	PhD	DSc	MPhil	MTech	MD	Others
Andhra Pradesh	457	3	53	142	4	856
Bihar	31	0	3	43	0	205
Chhattisgarh	29	0	4	6	0	33
Delhi	528	1	60	235	3	462
Goa	26	0	0	18	0	25
Gujarat	187	1	9	66	0	163
Haryana	88	0	14	24	0	57
Himachal Pradesh	92	0	2	15	0	66
Jammu & Kashmir	44	0	2	8	0	224
Jharkhand	38	0	14	27	0	28
Karnataka	653	0	73	246	7	1081
Kerala	384	0	58	124	2	1800
Madhya Pradesh	86	0	9	43	2	84
Maharashtra	748	1	74	359	0	710
North-east States	398	0	70	171	1	483
Orissa	137	0	19	84	0	117
Punjab	202	0	50	123	0	178
Rajasthan	123	0	12	49	2	77
Union Teritories	1034	1	217	510	6	1368
Tamil Nadu	71	0	8	75	0	382
Telangana	166	0	14	36	2	109
Uttar Pradesh	410	1	58	146	0	490
Uttarakhand	115	0	11	73	0	274
West Bengal	475	0	35	203	4	393
Total	**6522**	**8**	**869**	**2826**	**33**	**9665**

Figure 6.3: State-wise distribution of PhDs produced in EMR projects



b) Manpower employed

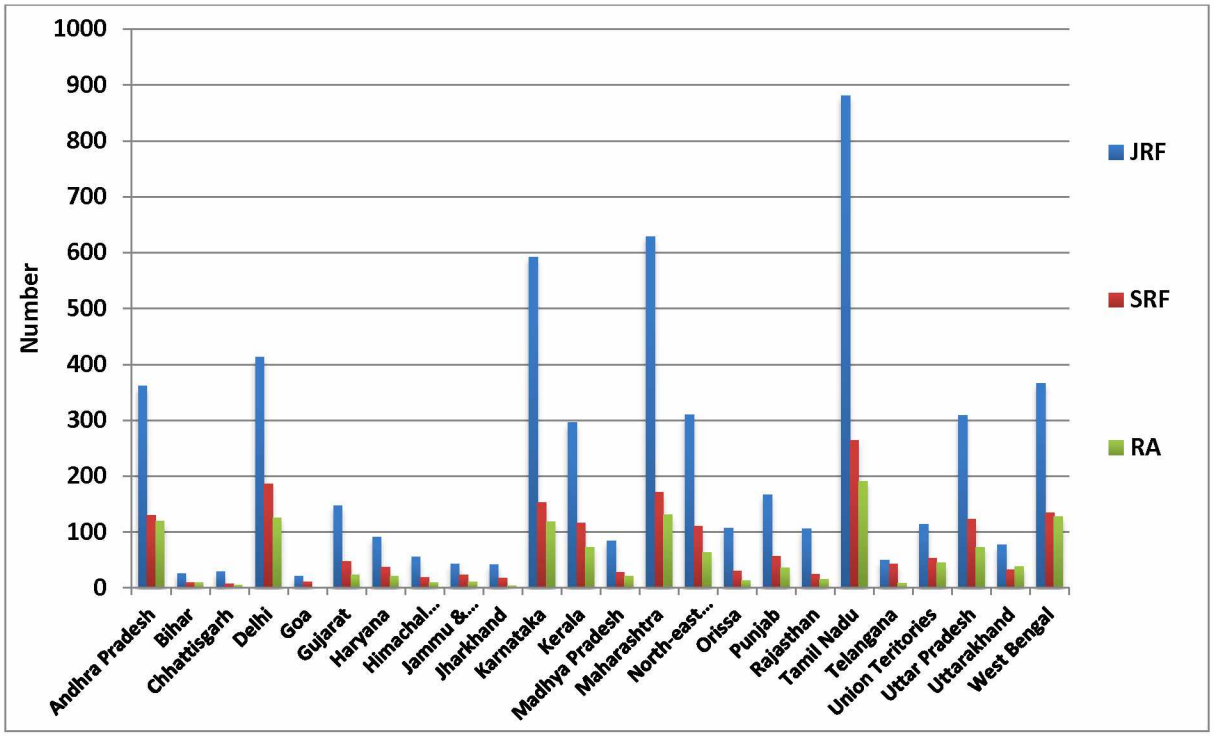
It is evident from the data that PIs from Tamil Nadu employed maximum number of JRF (881), followed by Maharashtra (629), Karnataka (592), Delhi (413) and West Bengal (366). In case of SRF, PIs from Tamil Nadu employed highest number (264), followed by Delhi (186) and Maharashtra (171).

Table 6.6: State-wise distribution of manpower employed under extramural R&D projects

State	JRF	SRF	RA	Engineers & doctors	Other professionals	Technicians	Others	Total
Andhra Pradesh	361	130	120	1321	2478	106	154	4670
Bihar	26	10	9	0	17	7	3	72
Chhattisgarh	29	7	5	14	11	9	7	82
Delhi	413	186	125	120	284	108	165	1401
Goa	21	11	2	4	13	10	3	64
Gujarat	147	47	23	14	342	37	88	698
Haryana	91	37	21	18	39	20	29	255
Himachal Pradesh	55	19	10	2	23	8	16	133
Jammu & Kashmir	43	23	11	8	24	21	41	171
Jharkhand	42	18	4	0	16	10	7	97
Karnataka	592	153	118	73	389	183	220	1728
Kerala	296	116	73	42	243	102	143	1015
Madhya Pradesh	84	28	21	3	134	21	115	406
Maharashtra	629	171	131	132	441	217	327	2048
North-east States	310	110	63	40	366	105	341	1335
Orissa	107	30	13	14	77	26	37	304
Punjab	167	57	36	33	117	52	61	523
Rajasthan	106	24	15	3	64	18	23	253
Tamil Nadu	881	264	191	121	783	361	654	3255
Telangana	50	43	8	6	65	16	15	203
Union Teritories	114	53	45	13	106	40	217	588
Uttar Pradesh	309	123	73	46	152	84	265	1052
Uttarakhand	77	32	38	31	29	34	23	264
West Bengal	366	134	128	67	211	131	132	1169
Total	**5316**	**1826**	**1283**	**2125**	**6424**	**1726**	**3086**	**21786**

The Principal Investigators from Karnataka employed maximum number of RA (191) followed by Delhi (176), Maharashtra (150) and Uttar Pradesh (139).

Figure 6.4: State-wise distribution manpower employed under extramural R&D projects



Observations & Conclusions:

About 71.66% of the projects were sanctioned to the institutions located in eight states viz. Andhra Pradesh, Delhi, Karnataka, Maharashtra, Tamil Nadu, Uttar Pradesh and West Bengal. These states also received 73% of total funding during the reporting period. One reason behind higher number of projects and funding to these states may be due to the location of IITs, IISc and other institutes of national importance in these states. The eight north eastern states accounted for only 6.65% of projects and 3.14% of funding.

As Tamil Nadu received the maximum number of projects, similar trends are visible in outcome parameters.

State-wise outcome of EMR projects sanctioned during 2010-2015

Outcome parameter	Research Papers published/ presented	New products developed	New processes developed	New instruments developed	New prototypes developed	New principle/ theory developed	Patent filed	Patent sealed	Manpower generated	Manpower employed
Andhra Pradesh	4318	381	173	53	69	100	43	2	1515	4670
Bihar	230	15	10	0	5	6	2	0	282	72
Chhattisgarh	387	62	10	3	0	4	8	0	72	82
Delhi	4096	1909	195	35	78	60	31	5	1289	1401
Goa	280	30	19	4	1	4	4	0	69	64
Gujarat	1405	147	51	4	20	27	17	0	426	698
Haryana	691	75	25	2	39	16	11	0	183	255
Himachal Pradesh	616	44	14	4	4	19	8	1	175	133
Jammu & Kashmir	487	83	19	0	8	3	0	0	278	171
Jharkhand	354	5	8	2	2	6	1	2	107	97
Karnataka	5490	622	278	38	80	129	84	3	2060	1728
Kerala	2913	186	109	21	38	44	33	7	2368	1015
Madhya Pradesh	850	32	23	11	9	23	16	2	224	406
Maharashtra	6858	639	266	83	119	131	100	35	1892	2048
North-east States	3591	184	146	41	51	66	40	4	1123	1335
Orissa	1135	48	86	24	14	12	23	9	357	304
Punjab	1646	141	105	18	34	25	21	7	553	523
Rajasthan	1136	98	53	13	11	24	15	1	263	253
Tamil Nadu	8981	847	372	99	256	179	187	23	3136	3255
Telangana	758	45	53	16	14	16	13	0	536	203
Union Territories	1560	59	50	8	9	20	26	9	327	588
Uttar Pradesh	3535	350	154	28	42	65	36	2	1105	1052
Uttarakhand	1005	41	41	7	8	27	7	4	473	264
West Bengal	3612	315	150	39	79	79	63	48	1110	1169

Chapter 7

City-wise Analysis of Extramural R&D Projects and their Outcome

The central government funding agencies sponsored R&D projects largely to recognized academic and research institutions. Most of these institutes are situated in big/medium cities and therefore it is worth-wile to analysis these R&D projects city-wise. The study revealed that a total of 27900 sanctioned projects were spread among 630 cities/towns during the study period. **Since it was a large number for carrying out the study, it was decided to limit the analysis to only those cities which received 200 or more projects. The adoption of this criterion brought down the number of cities to 24 only and therefore, the analysis in this chapter is limited to these 24 cities only.**

City-wise extramural R&D projects

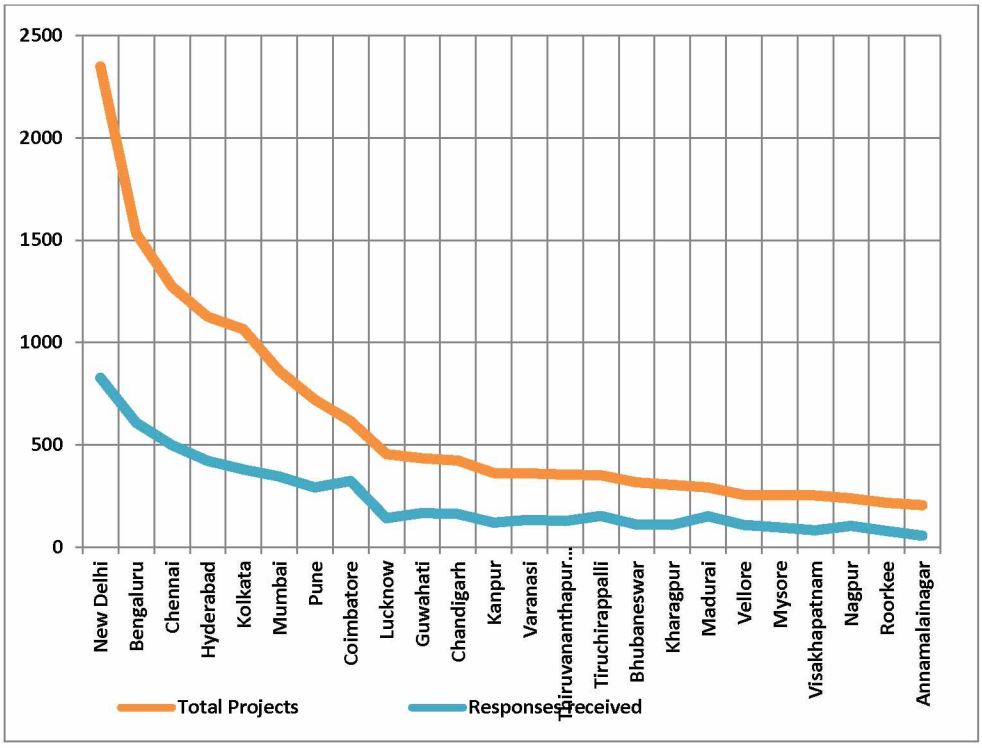
The highest numbers of projects were awarded to the PIs from Delhi (2348), followed by Bengaluru (1532), Chennai (1273) and Hydrabad (1126). Smilarly the highest number of responses (827) were received from the PIs of Delhi followed by Bangalore with 608 responses and Chennai, Hyderabad and Kolkata with 498, 421 and 380 responses respectively. The minimum responses were received from the PIs from Annamalainagar with 56 responses.

Table 7.1: City-wise extramural R&D projects and responses received

City	Total Projects	Responses received
New Delhi	2348	827
Bengaluru	1532	608
Chennai	1273	498
Hyderabad	1126	421
Kolkata	1065	380
Mumbai	861	345
Pune	720	292
Coimbatore	615	323
Lucknow	455	142
Guwahati	434	166
Chandigarh	423	162
Kanpur	362	120
Varanasi	360	134
Thiruvananthapuram	354	127
Tiruchirappalli	352	152

Bhubaneswar	317	110
Kharagpur	304	108
Madurai	292	151
Vellore	256	108
Mysore	254	96
Visakhapatnam	252	82
Nagpur	238	104
Roorkee	216	79
Annamalainagar	205	56
Other cities	13286	5359
Total	**2700**	**10950**

Figure 7.1: City-wise distribution of EMR projects and responses received



City-based outcome

Research papers published

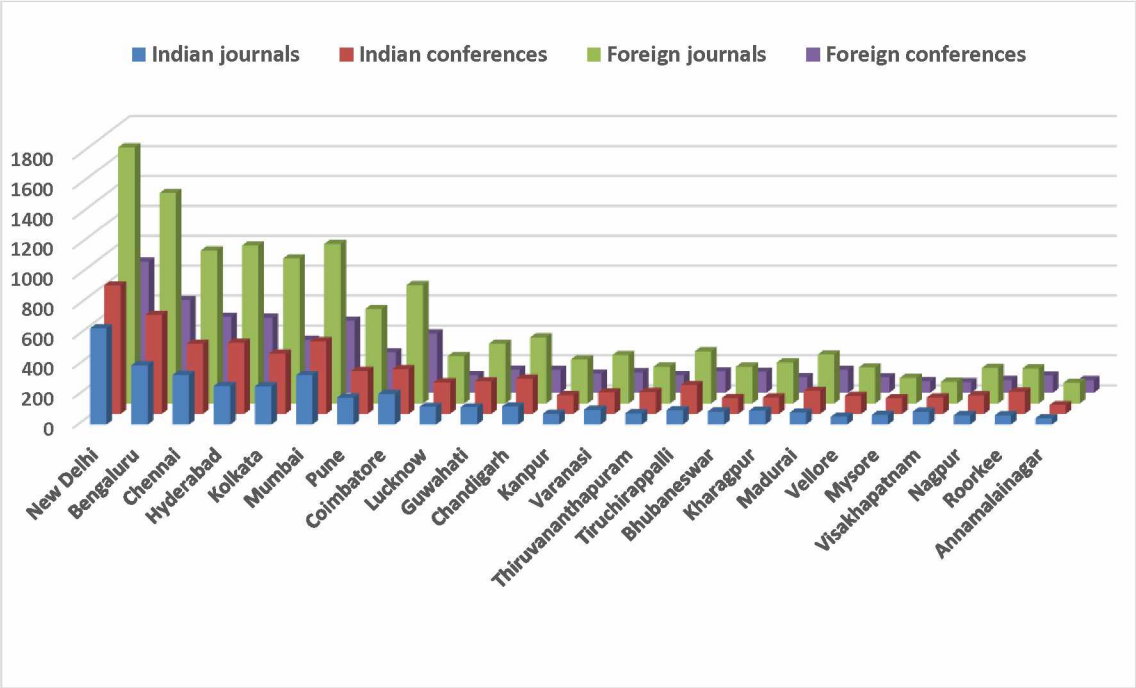
Principal Investigators from Delhi published/presented the maximum number of papers in both Indian (1506) and foreign (2590) journals & conferences. PIs from Bangaluru followed with 1060 papers in Indian journals & conferences and 2025 in foreign journals & conferences. PIs from Chennai published 804 and 1530 papers in Indian journals & conferences and foreign journals & conferences respectively. 736 and 1556 papers were published/presented in Indian journals & conferences and foreign journals & conferences respectively from Hydrabad while 760 papers were

published/presented in Indian journals & conferences and 1325 in foreign journals & conferences from Kolkata.

Table 7.2: City-wise research papers published/presented based on extramural R&D projects

City	Indian			Foreign		
	Journals	Conferences	Total	Journals	Conferences	Total
New Delhi	645	861	1506	1713	877	2590
Bengaluru	397	663	1060	1406	619	2025
Chennai	333	471	804	1022	508	1530
Hyderabad	259	477	736	1055	501	1556
Kolkata	257	403	660	970	355	1325
Mumbai	331	488	819	1065	482	1547
Pune	182	288	470	631	269	900
Coimbatore	206	300	506	792	397	1189
Lucknow	119	212	331	315	118	433
Guwahati	116	218	334	400	153	553
Chandigarh	121	237	358	442	152	594
Kanpur	72	126	198	294	127	421
Varanasi	99	146	245	322	136	458
Thiruvananthapuram	75	148	223	245	118	363
Tiruchirappalli	96	193	289	347	143	490
Bhubaneswar	87	108	195	245	139	384
Kharagpur	92	111	203	273	104	377
Madurai	80	155	235	326	152	478
Vellore	52	122	174	240	103	343
Mysore	64	107	171	170	78	248
Visakhapatnam	86	111	197	144	71	215
Nagpur	62	125	187	236	85	321
Roorkee	61	150	211	233	115	348
Annamalainagar	42	60	102	138	84	222
Other cities	5709	5785	11494	10177	3207	13384
Total	**9643**	**12065**	**21708**	**23201**	**9093**	**32294**

Figure 7.2: City-wise research papers published & presented under EMR projects



New products & processes developed

Projects sanctioned in institutions of New Delhi developed the highest number of new products (1909) followed by projects from Mumbai (299), Bengaluru (260), Hyderabad (258) and Chennai (225). PIs from Kolkata (186) and both Pune and Trichanapalli developed 101 new products each.

Projects from New Delhi based institutions again lead in development of new processes (195) while from Bengaluru 155, Hyderabad 115, Mumbai 92 and Kolkata 88 new processes were developed.

Table 7.3: City-wise development of new products, processes, instruments, prototypes, principles/theories and varieties under extramural R&D projects

City	New products developed	New processes developed	New instruments developed	New prototypes developed	New principles / theories developed	New varieties developed
New Delhi	1909	195	35	78	60	35
Bengaluru	260	155	24	47	76	134
Chennai	225	89	28	165	44	34
Hyderabad	258	115	33	43	38	6
Kolkata	186	88	18	60	54	48
Mumbai	299	92	31	34	38	2
Pune	101	60	6	30	27	10
Coimbatore	87	55	27	20	30	4
Lucknow	80	27	3	11	7	3

Guwahati	42	34	20	22	17	0
Chandigarh	37	34	6	5	11	0
Kanpur	56	26	6	13	15	1
Varanasi	84	32	6	10	12	5
Thiruvananthapuram	61	17	4	14	5	0
Tiruchirappalli	101	31	2	18	15	0
Bhubaneswar	32	68	20	9	9	3
Kharagpur	18	21	12	11	6	1
Madurai	68	28	5	14	16	0
Vellore	27	26	12	6	14	2
Mysore	8	13	2	7	10	1
Visakhapatnam	20	17	4	3	13	0
Nagpur	79	21	11	12	3	51
Roorkee	33	29	4	4	15	2
Annamalainagar	27	15	3	5	2	0
Other cities	2260	1122	231	349	548	201
Total	**6358**	**2410**	**553**	**990**	**1085**	**543**

New instruments & prototypes developed

The highest number of new instruments (25) were developed in the projects implemented in the institutions based in New Delhi followed by Hydrabad (33) Mumbai (31), Chennai (28) while projects from institutions based in Coimbatore (27), Bengaluru (24) and Bhubaneshwar (20) developed new instruments.

The maximum number of 52 new prototypes were developed from projects undertaken in Chennai Bangaluru followed by (165), New Delhi (78) and Kolkata (60).

Intellectual Property Rights (IPRs) obtained

The maximum numbers of patents were filed by the PIs of intutions from Coimbatore (80) and sealed from Chennai (46). It was followed by Bengaluru (58), Chennai (49) and Mumbai 42 patents filed. Kolkata (46) Mumbai (31) and Coimbatore (12) were the other cities in decending order from where patents were sealed.

Table 7.4: City-wise Intellectual Property Rights (IPRs) obtained from EMR projects

City	Patent filed		Patent sealed		Copyrights	Other IPR's registered
	India	Foreign	India	Foreign		
New Delhi	30	1	4	1	32	1
Bengaluru	51	7	3	0	26	4
Chennai	40	9	5	2	13	1
Hyderabad	26	9	2	0	25	1

Kolkata	31	3	18	28	1	0
Mumbai	33	9	11	20	9	2
Pune	18	4	0	0	6	2
Coimbatore	39	41	7	5	21	0
Lucknow	9	1	0	0	2	0
Guwahati	12	1	1	0	4	3
Chandigarh	11	3	0	0	5	0
Kanpur	4	1	0	0	5	0
Varanasi	6	2	1	1	3	0
Thiruvananthapuram	5	0	0	1	2	1
Tiruchirappalli	6	0	1	2	5	0
Bhubaneswar	13	7	4	5	2	0
Kharagpur	9	0	1	0	8	1
Madurai	11	2	0	0	6	0
Vellore	5	0	0	0	0	0
Mysore	1	0	0	0	1	0
Visakhapatnam	6	1	0	0	3	0
Nagpur	5	5	0	0	1	1
Roorkee	5	0	0	0	1	0
Annamalainagar	2	0	0	0	0	0
Other cities	268	37	21	20	121	13
Total	**646**	**143**	**79**	**85**	**302**	**30**

New Delhi is the city, where PIs registered the maximum copyrights (32). Next was Bengaluru (26), Hyderabad (25) and Coimbatore (21) cities in decending order.

Manpower generated/employed

a) Manpower generated

The City-wise analysis of manpower generated under extramural R&D projects shows that the highest number of PhD was produced in New Delhi based projects (528), followed by Bangaluru (382) Chennai (273) and Kolkata (263). Among the major cities, minimum number of PhDs was awarded in the projects carried out in Annamalainagar (29).

Table 7.5: City-wise manpower generated under EMR projects

City	PhD	DSc	MPhil	MTech	MD	Others
New Delhi	528	1	60	235	3	462
Bengaluru	382	0	35	148	4	449
Chennai	273	0	34	89	2	220
Hyderabad	245	2	40	125	2	398

Kolkata	263	0	23	120	3	241
Mumbai	249	0	16	103	0	289
Pune	157	0	22	114	0	95
Coimbatore	186	1	46	136	1	291
Lucknow	67	0	7	18	0	63
Guwahati	102	0	9	55	1	210
Chandigarh	90	0	13	12	2	62
Kanpur	82	0	16	27	0	75
Varanasi	96	0	9	24	0	185
Thiruvananthapuram	70	0	7	16	0	531
Tiruchirappalli	91	0	34	23	0	78
Bhubaneswar	75	0	8	23	0	43
Kharagpur	69	0	7	41	0	33
Madurai	90	0	29	28	1	127
Vellore	61	0	8	16	0	74
Mysore	47	0	0	44	0	153
Visakhapatnam	50	1	0	14	0	47
Nagpur	63	0	13	17	0	70
Roorkee	56	0	10	51	0	220
Annamalainagar	29	0	4	48	0	17
Other cities	3101	3	419	1299	14	5232
Total	**6522**	**8**	**869**	**2826**	**33**	**9665**

b) Manpower employed

It is evident from the data that projects undertaken in New Delhi based institutions employed maximum number of JRF (413), followed by Bangaluru (274), Chennai (265) and Kolkata (205). Similar pattern was followed in SRF as Delhi tops with 186, followed by Bengaluru (97), Kolkata (95) and Hydrabad (89).

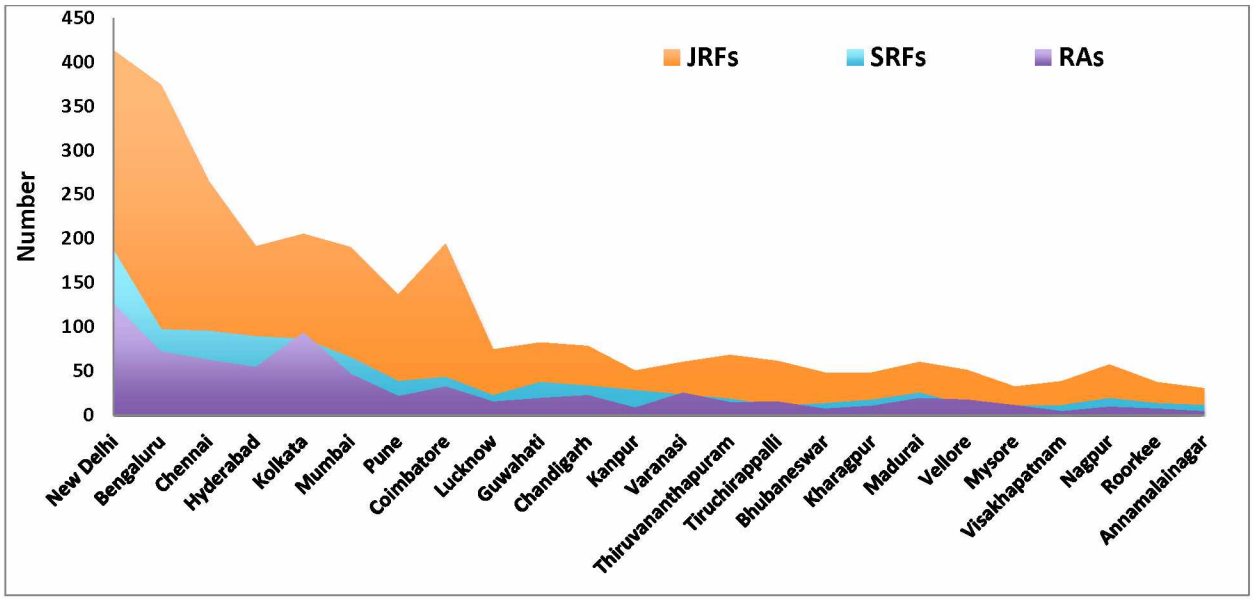
Table 7.6: City-wise distribution of manpower employed under extramural R&D projects

City	Professional staff					Support staff	
	JRF	SRF	RA	Engineer & doctor	Other professionals	Technicians	Others
New Delhi	413	186	125	120	284	108	165
Bengaluru	374	97	72	33	241	99	130
Chennai	265	95	62	44	161	138	264
Hyderabad	191	89	54	1316	2400	64	70
Kolkata	205	86	93	59	147	69	92
Mumbai	190	65	46	93	159	112	172
Pune	136	38	21	6	101	28	53
Coimbatore	194	43	32	37	128	38	38
Lucknow	74	22	15	8	30	21	216
Guwahati	82	37	19	11	86	27	14

Chandigarh	78	33	22	6	79	31	22
Kanpur	50	28	8	14	41	14	9
Varanasi	60	23	25	10	27	13	10
Thiruvananthapuram	68	18	14	8	29	22	9
Tiruchirappalli	61	10	15	3	59	65	23
Bhubaneswar	48	13	7	11	17	13	13
Kharagpur	48	17	10	1	23	38	17
Madurai	60	25	19	14	82	17	14
Vellore	51	11	17	5	45	21	197
Mysore	32	11	11	1	14	11	7
Visakhapatnam	38	11	4	3	22	4	8
Nagpur	57	19	9	6	25	10	13
Roorkee	37	13	7	0	6	9	7
Annamalainagar	30	11	4	0	20	10	44
Other cities	2474	825	572	316	2198	744	1479
Total	**5316**	**1826**	**1283**	**2125**	**6424**	**1726**	**3086**

PIs from Delhi also employed maximum number of RA (125) followed by Kolkata (93), Bangaluru (72) and Chennai (62). The highest numbers of engineer & doctors (1316) were employed in project sanctioned in Hydrabad followed by New Delhi (120) and Mumbai (93).

Figure 7.3: City-wise manpower employed under EMR projects



Observations & Conclusions:

During the reporting period, 630 cities/towns were covered under EMR projects. Among these locations, institutions based in six metro cities received 29% of total projects. 107 cities had 50 or more projects.

Maximum funding Rs. 1354 crore and number of projects 1532 was received by the institutions located in Bengaluru, followed by Rs. 1216 crore funding and 1964 projects by institutions located in New Delhi. The reason behind higher number of projects and funding attributed to the location of IITs, IISc, national laboratories and other institutes of national importance. This trend was observed in almost all outcome parameters.

City-wise outcome of EMR projects sanctioned during 2010-2015

Outcome parameter	Research Papers published/ presented	New products developed	New processes developed	New instruments developed	New prototypes developed	New principle/ theory developed	Patent filed	Patent sealed	Manpower generated	Manpower employed
New Delhi	4096	1909	195	35	78	60	31	5	1289	1401
Bengaluru	3085	260	155	24	47	76	58	3	1018	1046
Chennai	2334	225	89	28	165	44	49	7	618	1029
Hyderabad	2292	258	115	33	43	38	35	2	812	4184
Kolkata	1985	186	88	18	60	54	34	46	650	751
Mumbai	2366	299	92	31	34	38	42	31	657	837
Pune	1370	101	60	6	30	27	22	0	388	383
Coimbatore	1695	87	55	27	20	30	80	12	661	510
Lucknow	764	80	27	3	11	7	10	0	155	386
Guwahati	887	42	34	20	22	17	13	1	377	276
Chandigarh	952	37	34	6	5	11	14	0	179	271
Kanpur	619	56	26	6	13	15	5	0	200	164
Varanasi	703	84	32	6	10	12	8	2	314	168
Thiruvananthapuram	586	61	17	4	14	5	5	1	624	168
Tiruchirappalli	779	101	31	2	18	15	6	3	226	236
Bhubaneswar	579	32	68	20	9	9	20	9	149	122
Kharagpur	580	18	21	12	11	6	9	1	150	154
Madurai	713	68	28	5	14	16	13	0	275	231
Vellore	517	27	26	12	6	14	5	0	159	347
Mysore	419	8	13	2	7	10	1	0	244	87
Visakhapatnam	412	20	17	4	3	13	7	0	112	90
Nagpur	508	79	21	11	12	3	10	0	163	139
Roorkee	559	33	29	4	4	15	5	0	337	79
Annamalainagar	324	27	15	3	5	2	2	0	98	119
Other cities	24878	6358	2410	553	990	1085	289	57	10068	8608

Chapter 8

Cost range-wise Analysis of Extramural R&D Projects and their Outcome

The amount sanctioned to a R&D project by a funding agency is an indicator of the potential outcome from that project. In this chapter, the amount sanctioned to different cost-ranges of R&D projects is tabulated and outcome is analysed for the period 2010-11 to 2014-15.

Cost range-wise distribution of extramural R&D projects

Support to different projects was found to vary widely-from a few lakh to more than a crore of rupees. Therefore, the grants given to all the 27900 projects were grouped into fives cost range-wise-categories as shown in the Table 8.1.

(i) Low cost (below Rs. 10 lakh)
(ii) Middle cost (from Rs. 10 lakh to below Rs. 25 lakh)
(iii) High cost (from Rs. 25 lakh to below Rs. 50 lakh)
(iv) Very high cost (from Rs. 50 lakh to below Rs. 1 crore)
(v) Ultra High cost (Rs. 1 Crore & above).

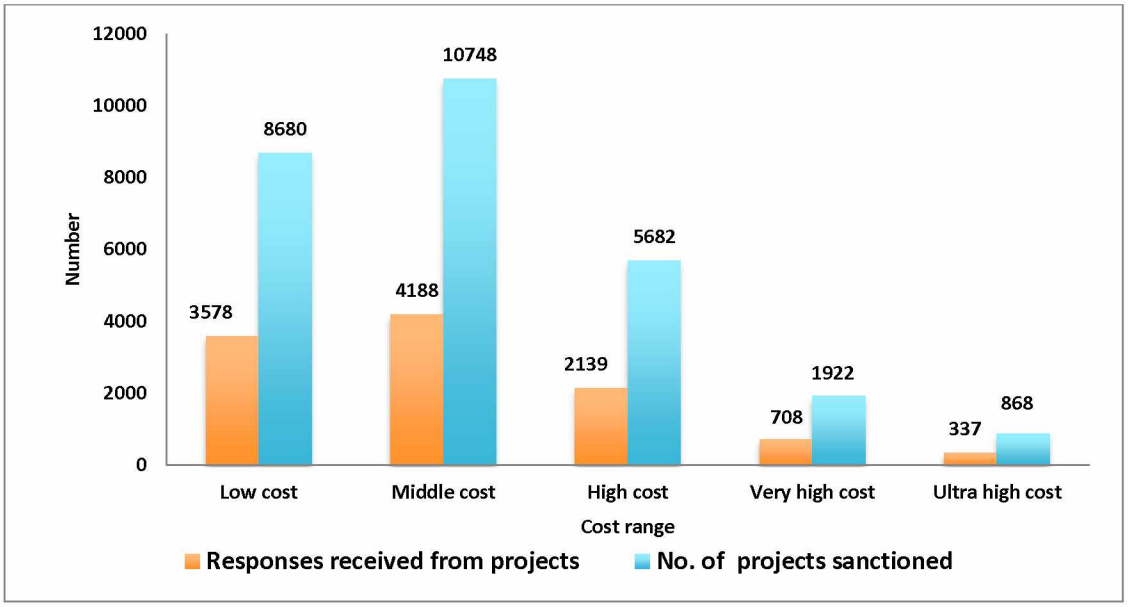
Cost range-wise analysis of extramural R&D projects

The total number of projects sanctioned and the responses received varied in accordance with the costs of projects. The total number of projects with low cost has highest responses (around 41%) while high-cost projects response was only 37%. The very high cost and ultra high projects responses were 36% and 38% respectively. The maximum number of projects approved (10748) were in the middle cost range while minimum (868) projects approved were in ultra high-cost range category.

Table 8.1: Project cost range-wise break-up of extramural R&D projects

Project cost range	No. of projects sanctioned	Responses received from projects	Percentage of response received
Low cost	8680	3578	41.22
Middle cost	10748	4188	38.96
High cost	5682	2139	37.64
Very high cost	1922	708	36.83
Ultra high cost	868	337	38.82
Total	**27900**	**10950**	**39.25**

Figure 8.1: Project cost range-wise response received under EMR projects



Cost range-wise outcome of R&D projects

Research paper published

It is evident from the data that research papers published/presented in Indian journals/conferences broadly decreased with the increase in the cost of the project, as number of projects also decreased accordingly. Similar is the case with foreign journals & conferences with only exception of middle cost-range where number of research papers increased to 14704 from 9838 of low cost.

The highest numbers of papers were published/presented in both Indian (7786) & foreign (14704) journals/conferences by PIs from middle cost projects. The lowest numbers of research papers were published/presented by PIs of ultra high cost with 778 research papers in Indian and 1162 papers in foreign journals/conferences.

Table 8.2: Project cost range-wise number of research papers published/presented under EMR projects

Project cost range	Indian			Foreign			Total
	Journal	Conference	Sub total	Journal	Conference	Sub total	
Low cost	2319	3609	5928	6842	2992	9834	15762
Middle cost	2926	4860	7786	10396	4308	14704	22490
High cost	1436	2618	4054	5283	2400	7683	11737
Very high cost	505	861	1366	1779	860	2639	4005
Ultra high cost	400	378	778	743	419	1162	1940
Total	**7586**	**12326**	**19912**	**25043**	**10979**	**36022**	**55934**

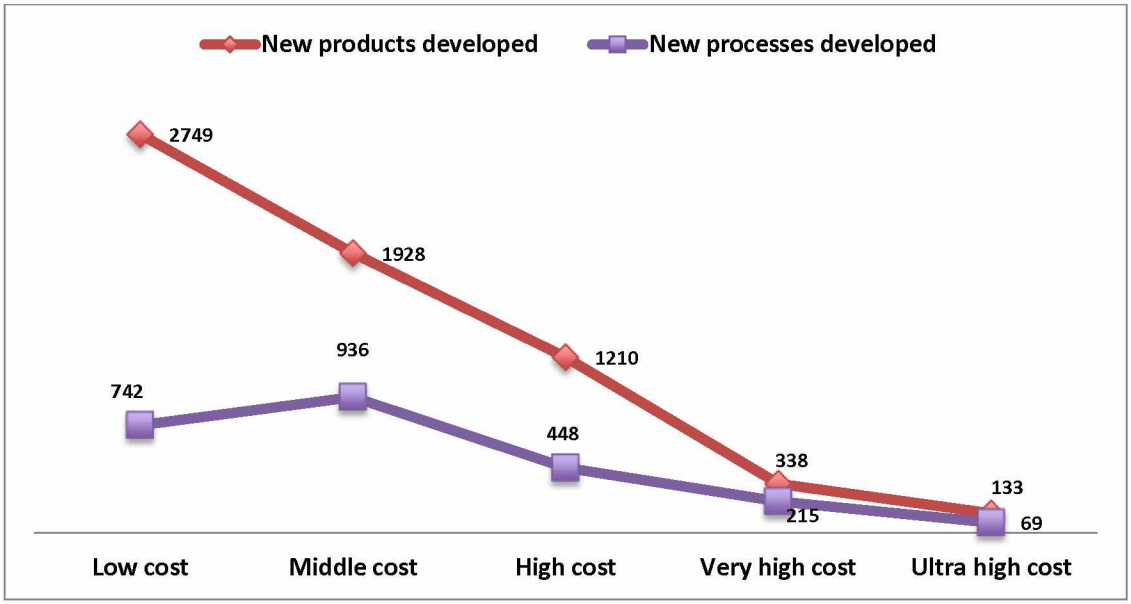
New processes & products developed

The low-cost projects developed highest number of new products (2749) and new varieties (200) while middle cost projects developed higest number of new processes (936), new instruments (227), new prototypes (412) and new principles/theories (479). The projects with high cost and very high-cost range projects developed 1210 & 338 new products and 448 & 215 new processes respectively. The project with ultra high-cost range developed 133 new products and 69 new processes.

Table 8.3: Project cost range-wise new products, processes, instruments and prototypes developed under extramural R&D projects

Project cost range	New products developed	New processes developed	New instruments developed	New prototypes developed	New principles / theories developed	New variety developed
Low cost	2749	742	139	266	319	200
Middle cost	1928	936	227	412	479	177
High cost	1210	448	115	170	202	80
Very high cost	338	215	54	102	63	51
Ultra high cost	133	69	18	40	22	35
Total	**6358**	**2410**	**553**	**990**	**1085**	**543**

Figure 8.2: Project cost range-wise new products & processes developed



New instruments & prototypes developed

Intellectual Property Rights (IPRs) obtained

Out of the total 789 patents filed and 222 patents sealed in India & foreign countries, the middle cost projects filed the maximum 380 patents sealed the highest 93 patents.

Table 8.5: Number of patents filed & sealed under different cost range under extramural R&D projects

Project cost range	Patent filed		Patent sealed		Copyright
	India	Foreign	India	Foreign	
Low cost	107	22	17	6	78
Middle cost	297	83	44	49	147
High cost	139	19	16	19	56
Very high cost	56	14	0	2	12
Ultra high cost	47	5	2	9	9
Total	**646**	**143**	**79**	**85**	**302**

The low-cost projects filed 129 patents but could seal only 23 patents while the high-cost projects filed 158 patents and very high-cost projects filed 70 patents.

Manpower generated/employed

a) manpower generated

It is evident from the data that middle cost projects produced the highest number of PhD, DSc, MPhil and MTech, while high-cost projects produced the highest number of MD (11). The very high & ultra high-cost projects were at the bottom of each category of specialised manpower produced.

Table 8.6: Project cost range-wise manpower generated under extramural R&D projects

Project cost range	PhD	DSc	MPhil	MTech	MD	Others
Low cost	1759	2	285	740	7	3727
Middle cost	2619	3	333	1202	10	3367
High cost	1406	3	180	568	11	1917
Very high cost	504	0	34	176	4	474
Ultra high cost	234	0	37	140	1	180
Total	**6522**	**8**	**869**	**2826**	**33**	**9665**

The highest number of PhDs was produced by projects in middle cost range (2619) followed by low-cost range (1759) while minimum PhD produced by projects in ultra high-cost range (234). The high cost and very high cost produced 1406 and 504 PhD respectively.

b) Manpower employed

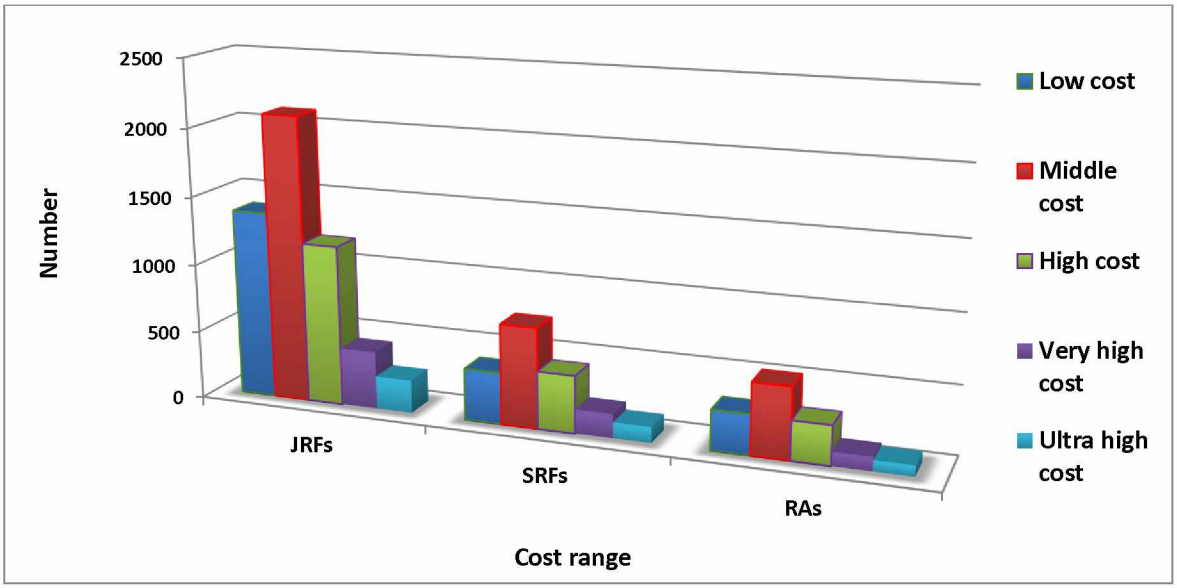
It is evident from the data that the highest number of JRF (2099), SRF (733), engineers & doctors (1600), RA (551), other professionals (3996) and technicians (653) were employed in middle cost range projects.

Table 8.7: Project cost range-wise Manpower employed under extramural R&D projects

Project cost range	JRF	SRF	RA	Engineer & doctor	Other professionals	Technicians	Others	Total
Low cost	1376	378	295	173	1312	508	1008	5050
Middle cost	2099	733	521	1600	3996	653	916	10518
High cost	1176	420	287	170	591	305	852	3801
Very high cost	423	177	101	75	270	127	128	1301
Ultra high cost	242	118	79	107	255	133	182	1116
Total	**5316**	**1826**	**1283**	**2125**	**6424**	**1726**	**3086**	**21786**

In rest of the cost ranges high, very high and ultra high, number of manpower employed gradually decreased with the increase in the cost of the project, as number of projects sanctioned also decreased.

Figure 8.3: Project cost range-wise manpower employed under EMR projects



Observations & Conclusions:

A look at the cost range-wise analysis indicates that the highest number of JRFs (2099) SRFs (733) and RAs (521) were employed in middle cost range projects. Employment of scientific personnel was found to be inversely proportional to the cost range of projects. In other words, as the cost-range of EMR projects increased, number of personnel employed in projects decreased.

When very high and ultra high costing projects were further analysed, it was found that infrastructure support (scientific equipments) was major component in these projects which lead to increase in their cost-range not the manpower.

Cost-wise outcome of EMR projects sanctioned during 2010-2015

Outcome parameter	Low cost	Middle cost	High cost	Very high cost	Ultra high cost
Research papers published/ presented	15762	22490	11737	4005	1940
New products developed	2749	1928	1210	338	133
New processes developed	742	936	448	215	69
New instruments developed	139	227	115	54	18
New prototypes developed	266	412	170	102	40
New principle/ theory developed	319	479	202	63	22
New varieties developed	200	177	80	51	35
Patent filed	129	380	158	70	52
Patent sealed	17	93	35	2	9
Copy rights obtained	78	147	56	12	9
Manpower generated	3727	3367	1917	474	180
Manpower employed	5050	10518	3801	1301	1116

Chapter 9

PIs' Age-wise Analysis of Extramural R&D Projects and their Outcome

The age of a Principal Investigator plays an important role in producing results from the sponsored projects because age brings along experience, decision-making power and management capability. In this chapter, sanctioning of R&D projects as per the age of PIs is reported and consequent outcome from these projects is analysed in terms of publication of research papers, development of new products, processes, instruments, theories and varieties and obtaining of IPRs. The generation of specialized manpower is also discussed in terms of PI's age.

PI's age-wise extramural R&D projects

Considering a wide gap in the age of PIs, it was divided into seven broad categories, as given in Table 9.1.

There were a total 10950 principal investigators responded out of the 27900 projects. The highest numbers of responses (2353) were received from the PIs having age above 55 years. This was followed by the age group 41-45 years with 2331 responses received. The PIs in the age group 46-50 years gave 1849 responses. The minimum numbers of responses (30) were received in age group of below 31 years.

Table 9.1: PIs age group-wise responses received from EMR projects

PIs age group (years)	Responses received
< 31	30
31-35	439
36-40	1864
41-45	2331
46-50	1849
51-55	1770
> 55	2353
Age not specified	314
Total	**10950**

PIs age-group-wise outcome

Research papers published

The maximum number of research papers (12651) which includes 4565 papers in Indian journals & conferences and 8086 papers in foreign journals & conferences were published/presented by the PIs from the age group of 41-50 years and the minimum number of research papers (120) was published by PIs in the age group of below 31 years.

Table 9.2: PIs age group-wise number of research papers published/presented from EMR projects

PIs age group (years)	Indian			Foreign			Total
	Journals	Conferences	Sub total	Journals	Conferences	Sub total	
< 31	23	17	40	64	16	80	120
31-35	272	407	679	1033	453	1486	2165
36-40	1354	2171	3525	4258	1812	6070	9595
41-45	1664	2901	4565	5590	2496	8086	12651
46-50	1282	2065	3347	4015	1828	5843	9190
51-55	1126	1819	2945	4032	1817	5849	8794
> 55	1696	2637	4333	5337	2217	7554	11887
Age not specified	169	309	478	714	340	1054	1532
Total	**7586**	**12326**	**19912**	**25043**	**10979**	**36022**	**55934**

New products, processes, instruments & prototypes developed

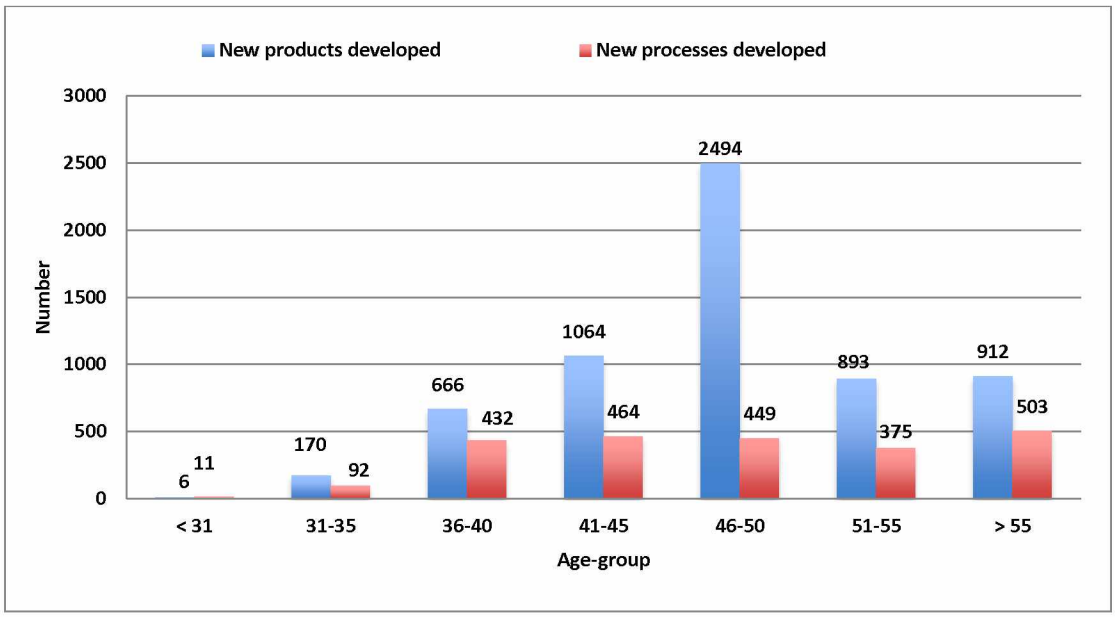
The highest numbers of new products (2494) were developed by the PIs from age group of 46 -50 years while new processes (503) were developed by PIs above age group of more than 55 years. The new prototypes (245) and new instruments (130) were developed by investigators in age group of 41-45 years. Investigators below the age of 31 years developed only 6 new product and 11 new processes. The PIs between 51 and 55 years of age have developed 893 new products, 375 new processes and 96 new instruments.

Table 9.3: PIs age group-wise new products, processes, instruments & prototypes developed under EMR projects

PIs age group (years)	New products developed	New processes developed	New instruments developed	New prototypes developed
< 31	6	11	0	2
31-35	170	92	22	31
36-40	666	432	94	153
41-45	1064	464	130	245
46-50	2494	449	111	154
51-55	893	375	96	127
> 55	912	503	82	205

Age not specified	153	84	18	73
Total	**6358**	**2410**	**553**	**990**

Figure 9.1: PIs age group-wise new prototypes, processes, instruments developed under EMR projects



New principles/theories developed

The maximum number of new principles/theories (242) was developed by the PIs in the age group of 41-45 years. It was followed by investigators in the age group of above 55 years and 36-40 years who have developed 237 and 216 new principles/theories respectively.

Table 9.4: PIs age group-wise new Principles/theories & varieties developed under EMR projects

PIs age group (years)	New principles/ Theories developed	New varieties developed
< 31	3	0
31-35	38	8
36-40	216	73
41-45	242	104
46-50	177	97
51-55	144	30
> 55	237	222
Age not specified	28	9
Total	**1085**	**543**

Patents and Intellectual Property Rights (IPRs) obtained

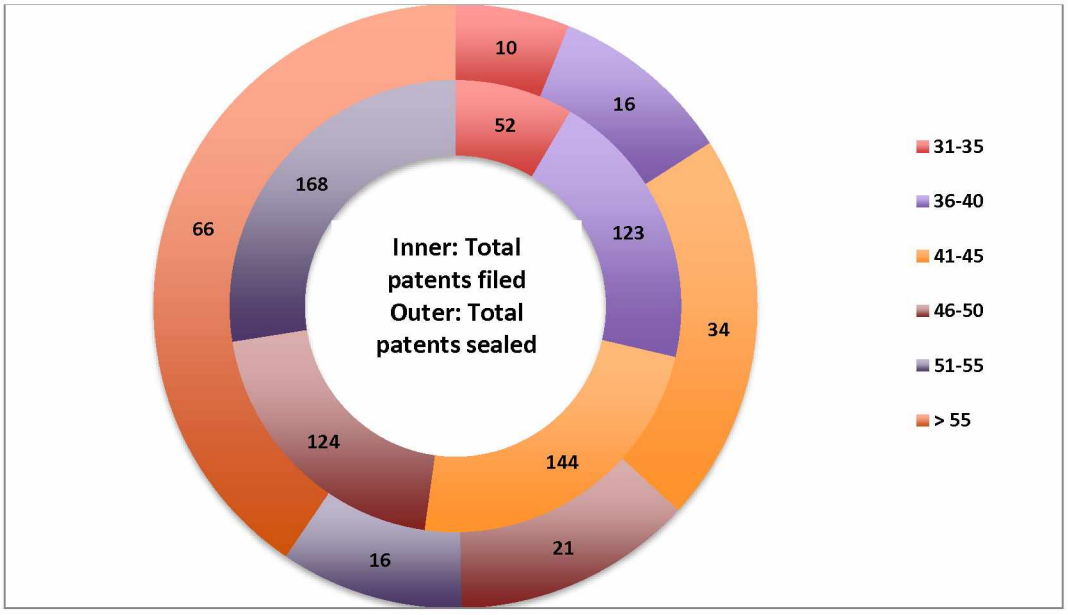
Principal investigators in the age group of 51-55 years have filed 168 patents while PIs in the age group of above 55 years sealed 66 patents, which are the highest number in all age groups. The PIs in the age group of 41-45 years have filed 144 patents and sealed 34 patents while 21 patents were sealed and 124 filed by PIs in the age group of 46-50 years.

Only 4 patents were filed and no patent was sealed by the PIs in the age group of below 31 years, although 52 and 123 patents were filed by the PIs of age group 31-35 years and 36-40 years respectively.

Table 9.5: PIs age group-wise Intellectual Property Rights (IPRs) obtained under EMR projects

PIs age group (years)	Patent filed		Patent sealed		Copyright
	India	Foreign	India	Foreign	
< 31	4	0	0	0	2
31-35	38	14	5	5	11
36-40	111	12	3	13	57
41-45	118	26	19	15	68
46-50	107	17	14	7	43
51-55	121	47	13	3	50
> 55	135	23	24	42	64
Age not specified	12	4	1	0	7
Total	**646**	**143**	**79**	**85**	**302**

Figure 9.2: PIs age group-wise patents filed & sealed under EMR projects



Manpower generated/employed

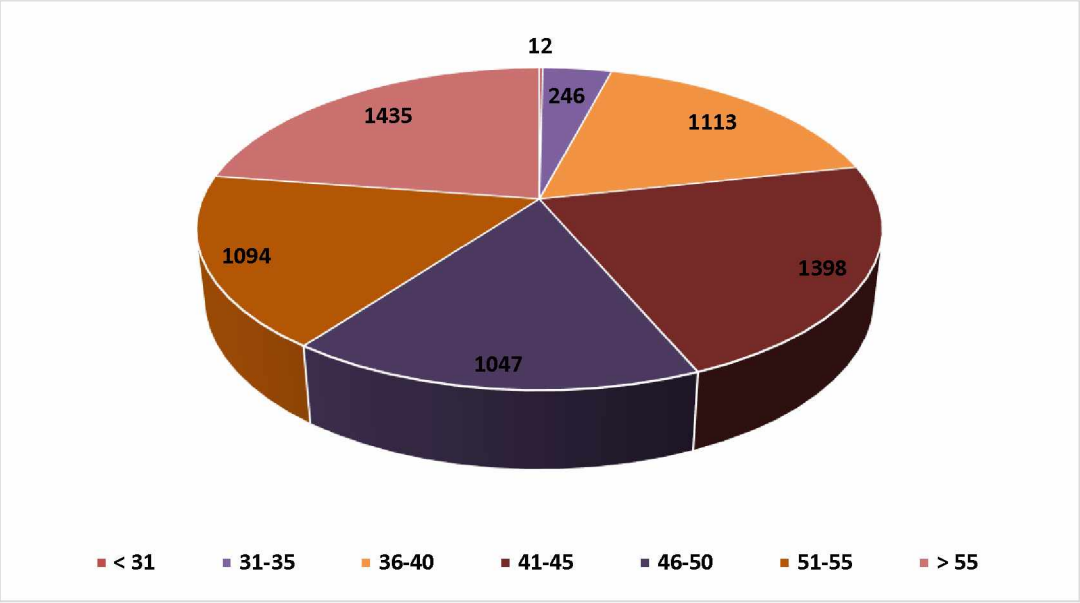
a) Manpower generated

Out of the total 6522 PhDs produced during the year 2010-11 to 2014-15 maximum 1435 were produced by the PIs of age group of more than 55 years, but in the case of MTechs, PIs of age group 41-45 years produced the maximum number 613.

Figure 9.6: PIs age group-wise manpower generated under extramural R&D projects

PIs age group (years)	PhD	DSc	MPhil	MTech	MD	Others
< 31	12	0	1	2	0	9
31-35	246	0	17	117	4	505
36-40	1113	1	163	550	5	1870
41-45	1398	1	187	613	7	1420
46-50	1047	5	120	483	5	1612
51-55	1094	1	158	489	4	1740
> 55	1435	0	212	490	8	1690
Age not specified	177	0	11	82	0	819
Total	**6522**	**8**	**869**	**2826**	**33**	**9665**

Figure 9.3: PIs age group-wise PhDs produced under EMR projects



b) Manpower employed

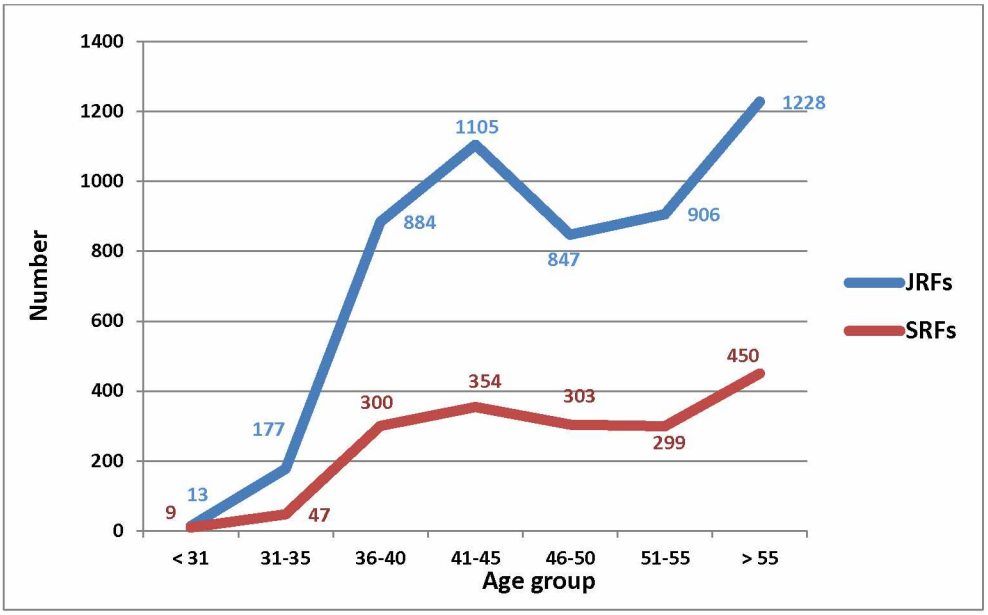
PIs age group 55 years and above outperformed in all the categories of manpower employment except engineers & doctors and other professionals where age group 51-55 years is at the top. This

was followed by age group 41-45 years and 51-55 years. Insignificant manpower was employed by the PIs in age group below 31 years.

Table 9.7: PIs age group-wise manpower employed under extramural R&D projects

PIs age group (years)	Professional staff					Support staff	
	JRF	SRF	RA	Engineer & doctor	Other professionals	Technicians	Others
< 31	13	9	1	4	27	16	3
31-35	177	47	42	47	118	56	252
36-40	884	300	242	154	623	345	362
41-45	1105	354	257	201	1250	313	526
46-50	847	303	195	85	583	246	271
51-55	906	299	191	1418	2711	298	505
> 55	1228	450	322	199	1002	408	1121
Age not specified	156	64	33	17	110	44	46
Total	**5316**	**1826**	**1283**	**2125**	**6424**	**1726**	**3086**

Figure 9.4: PIs age group-wise manpower employed under EMR projects



Observations & Conclusions:

The PIs age-wise analysis of sponsored R&D projects have revealed an interesting finding that PIs above 55 years of age have outperformed on most of the outcome parameters. This category of PIs gave maximum response to questionnaires, generated maximum number of JRF (1228), SRF (450) & RA (322) and produced highest number of Ph.Ds (1435), M.Phils (212), new varieties (222). This age group has also filed maximum 158 and sealed 66 patents.

PIs Age group-wise outcome of EMR projects sanctioned during 2010-2015

Outcome parameter	< 31	31-35	36-40	41-45	46-50	51-55	> 55	Age not specified
Research Papers published/ presented	120	2165	9595	12651	9190	8794	11887	1532
New products developed	6	170	666	1064	2494	893	912	153
New processes developed	11	92	432	464	449	375	503	84
New instruments developed	0	22	94	130	111	96	82	18
New prototypes developed	2	31	153	245	154	127	205	73
New principle/ theory developed	3	38	216	242	177	144	237	28
New varieties developed	0	8	73	104	97	30	222	9
Patent filed	4	52	123	144	124	168	158	16
Patent sealed	0	10	16	34	21	16	66	1
Copy rights obtained	2	11	57	68	43	50	64	7
Manpower generated	24	889	3702	3626	3272	3486	3835	1089
Manpower employed	73	739	2910	4006	2530	6328	4730	470

Chapter 10

PIs Gender-wise Analysis of Extramural R&D Projects and their Outcome

Due to various initiatives taken by the government in S&T sector, women participation in extramural R&D projects has increased significantly in the last decade. This increasing participation of women in different fields during the past one decade or so made us to find their status in the area of scientific research and development also. In this chapter, sanctioning of projects to women PIs is reported. The outcome of women-headed R&D projects is also reported. It is evident from the analysis that the total number of projects undertaken by the women is less as compared to men.

PIs gender-wise analysis of extramural R&D projects

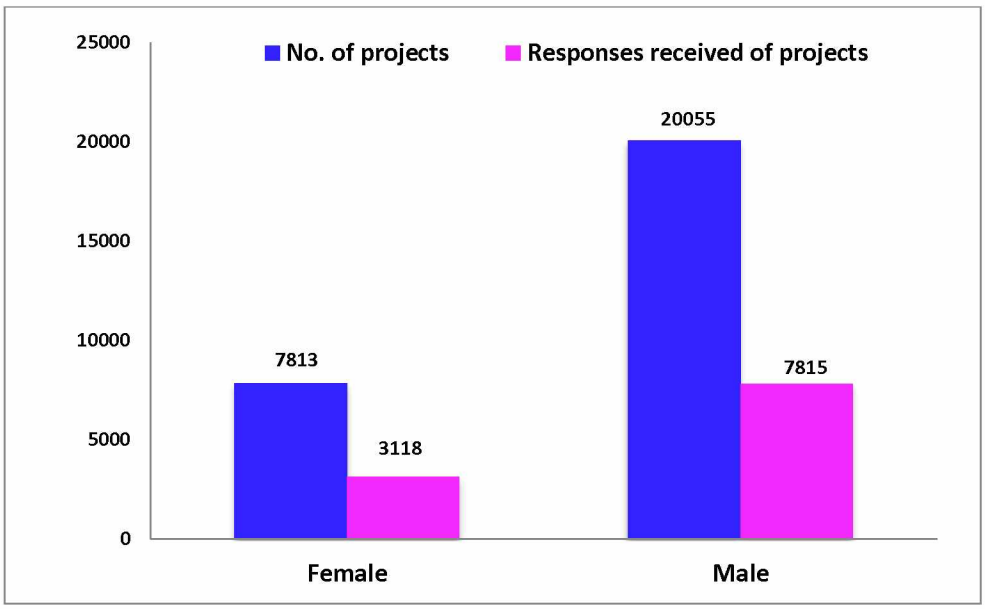
It is evident from the table 10.1 that the total number of projects undertaken by female PIs was 7813 (28.0% of total approved projects) and responses received was 3118 which constitute 28.47% of the total response received, while the total number of responses from male PIs were very high 7815 (71.36%), as total number of projects approved were also high (20055).

Table 10.1: PIs gender-wise extramural R&D projects and responses received

Gender of P.I.	No. of projects	Responses received of projects	Percentage
Female	7813	3118	39.90
Male	20055	7815	38.96
Total	**27868**	**10933**	
Gender information not available	32	17	53.12
Grand total	**27900**	**10950**	**39.25**

The female PIs responded better with a response rate of 39.90% in comparison to 38.96% of male PIs.

Figure 10.1: PIs gender-wise break-up of responses received under EMR projects



The analysis of projects undertaken by female Principal Investigators was carried out under following parameters-

Type of institute

The sanctioning of R&D projects to female PIs as per the type of their affiliated institute is depicted in Table 10.2. It shows that women prefer to work in the colleges & universities as the maximum number of responses (2138) were received from these institutions. It can be attributed to the flexible working conditions in colleges & universities. It was followed by institutes of national importance (305) and national research laboratories (201).

Table 10.2: Type of institute-wise extramural R&D projects to female PIs

Type of institutes	No. of responded Projects
Colleges & universities	2138
Institute of national importance	305
National research laboratories	201
Deemed universities	143
Others	393
Total	**3180**

Subject areas of female PIs

The subject area-wise sanction of R&D projects to female PIs is shown in table 10.3. It shows that the most preferred subject area of female investigators was biological sciences (1260 projects), followed by medical sciences (508 projects) and chemical sciences (388 projects). Agriculture sciences was least preferred by women for R&D as only 65 projects had female PIs.

Table 10.3: Subject area-wise extramural R&D projects to female PIs

Subject Area	No. of responded Projects
Agricultural sciences	65
Biological sciences	1260
Chemical sciences	388
Earth sciences	138
Engineering & technology	377
Mathematics	174
Medical sciences	508
Physical sciences	270
Total	**3180**

Age-group-wise analysis of female PIs

The age group-wise allocation of R&D projects to female PIs is shown in Table 10.4. It is interesting to note from this table that involvement of women in the R&D programmes increased with the advancing of their age. This peaked (687) in the age group of 41 - 45 years, followed in the decreasing order on both side with 561 in age-group of 36-40 years and 515 in age-group of 46-50 years, but again increased to 672 in age-group of above 55 years. Only 9 females in the age-group of up to 30 years seemed to be the PIs of extramural R&D projects.

Table 10.4: Age group-wise extramural R&D projects to female PIs

Female PIs age-group (years)	No. of responded Projects
Up to 30	9
31-35	153
36-40	561
41-45	687
46-50	515
51-55	506
> 55	672
Total	**3180**

EMR support received by female PIs

The project cost range-wise allocation of projects, as envisaged in chapter 8, to female PIs is shown in Table 10.5. In contrast to age-wise responses, women participation in scientific R&D steadily decreased with increase in the cost of projects. The maximum number of responses from female PIs were from middle cost projects (1219), closely followed by low cost-range (1180) and high cost-range (589) projects. Very high cost and ultra high-cost ranges had only 140 and 52 responses, respectively.

Table 10.5: Project cost range-wise extramural R&D projects to female PIs

Project cost range	No. of responded Projects
Low	1180
Middle	1219
High	589
Very High	140
Ultra High	52
Total	**3180**

Outcome of extramural R&D projects by female PIs

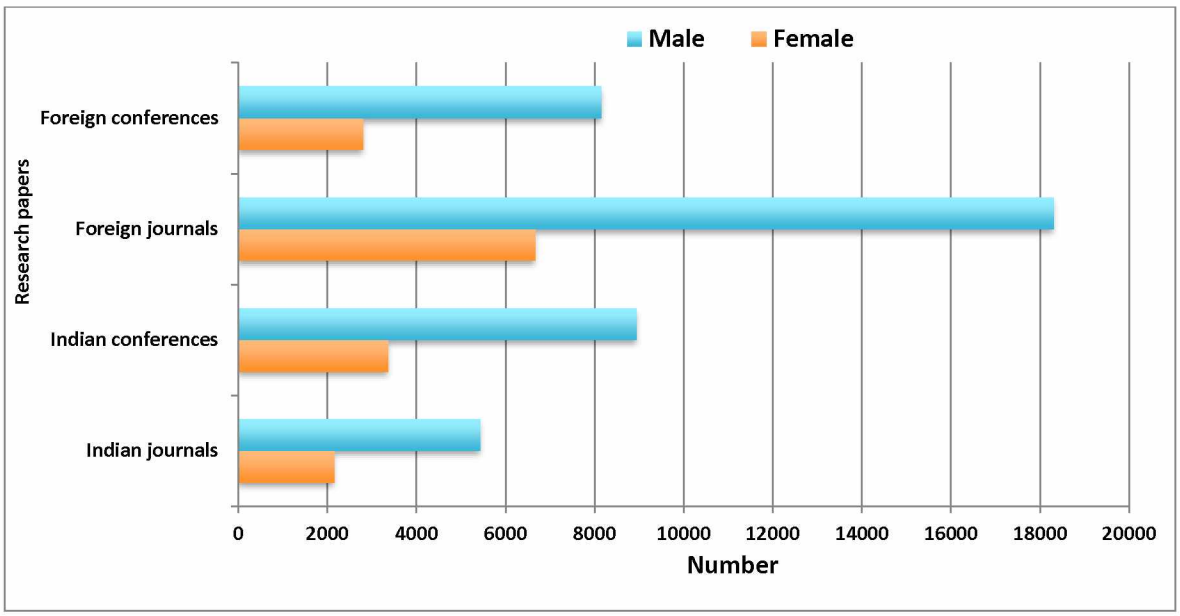
Research papers published

The total number of papers published in Indian journals & conferences by female PIs was 5511 comprising of 2151 in Indian journals and 3360 in Indian conferences while 14377 papers were published by male PIs comprising of 5429 in Indian journals and 8948 in conferences.

Table 10.6: Gender-wise research papers published & presented under EMR projects

Gender of P.I.	Indian			Foreign			Total
	Journals	Conferences	Sub total	Journals	Conferences	Sub total	
Female	2151	3360	5511	6667	2799	9466	14977
Male	5429	8948	14377	18312	8157	26469	40846
Gender information not available	6	18	24	64	23	87	111
Total	**7586**	**12326**	**19912**	**25043**	**10979**	**36022**	**55934**

Figure 10.2: Gender-wise No. of research papers published & presented under EMR projects



New products, processes & instruments developed

The number of new products, new processes and new instruments were developed by male PIs ranges very large than those developed by female PIs. The male PIs developed maximum number (3501) of new products, processes (1771) and instruments (432) while female PIs developed 2855 new products, 637 new processes and 120 new instruments.

Table 10.7: Gender-wise development of new products, processes, instruments, prototypes, principles/theories & varieties under extramural R&D projects

Gender of P.I.	New products developed	New processes developed	New instruments developed	New prototypes developed	New principles/ theories developed	New varieties developed
Female	2855	637	120	307	300	168
Male	3501	1771	432	680	783	375
Gender information not available	2	2	1	3	2	0
Total	**6358**	**2410**	**553**	**990**	**1085**	**543**

Patents and Intellectual Property Rights (IPRs) obtained

As trend prevails in other parameters male PIs dominated in obtaining IPRs also. Out of total 952 patents filed and sealed (both India & foreign countries) male PIs had 717 in comparision to 235 patents by female PIs.

Similarly in obtaining copyrights, male PIs had 238 and female PIs 64. Out of total 30 other IPR's registered male PIs had 23 and female PIs only 7.

Table 10.8: Intellectual Property Rights (IPRs) obtained by male & female PIs under EMR projects

Gender of P.I.	Patent filed		Patent sealed		Copyrights	Other IPR's registered
	India	Foreign	India	Foreign		
Female	172	26	23	14	64	7
Male	473	117	56	71	238	23
Gender information not available	1	0	0	0	0	0
Total	**646**	**143**	**79**	**85**	**302**	**30**

Manpower generated/employed

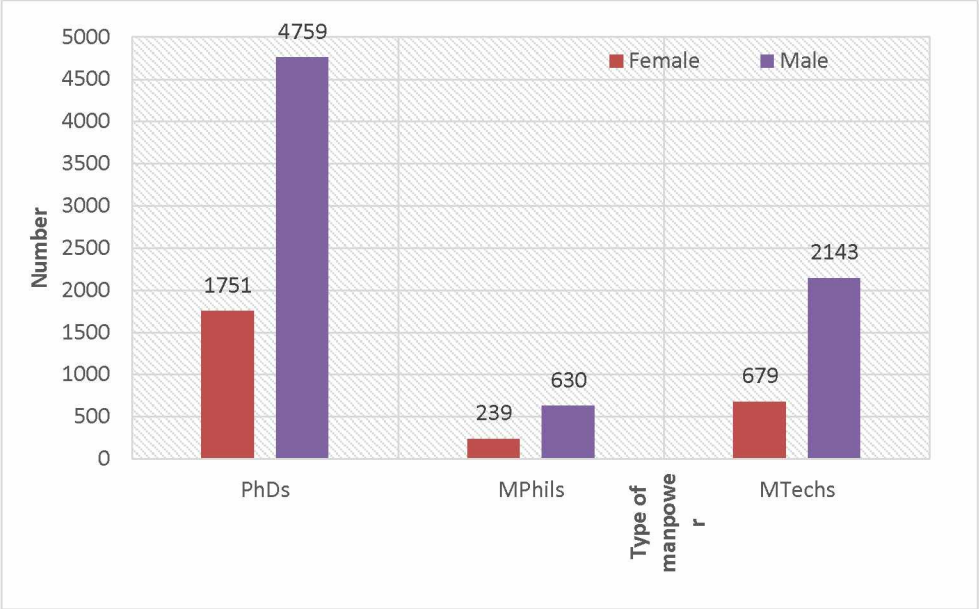
a) Manpower generated

Out of the total 6522 PhDs produced during the study period, 4759 were produced by the male PIs. Similar is the case with MPhils, it was 630 out of total 869 MPhil. In case of MTech again male PIs (2143) produced higher numbers.

Table 10.9: Manpower produced with male & female PIs under EMR projects

Gender of P.I.	PhD	DSc	MPhil	MTech	MD	Others
Female	1751	2	239	679	9	2625
Male	4759	6	630	2143	24	7019
Gender information not available	12	0	0	4	0	21
Total	**6522**	**8**	**869**	**2826**	**33**	**9665**

Figure 10.3: Manpower produced from extramural R&D projects with male & female PIs



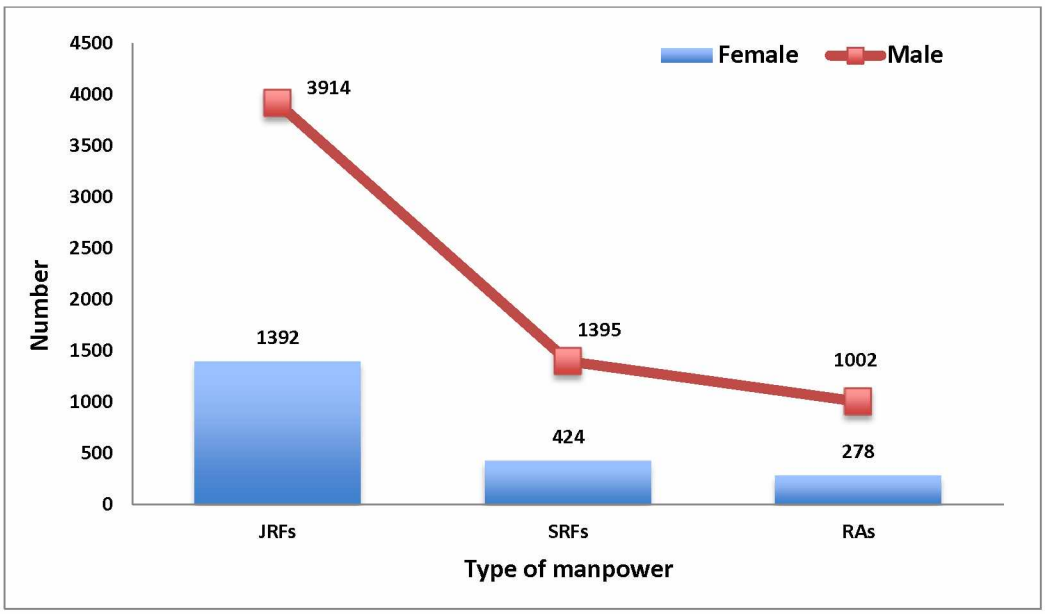
b) Manpower employed

The higher number of JRFs (3914), SRFs (1395), RAs (1002), engineers & doctors (1883) and technicians (1274) were employed by male PIs, while female PIs employed only 1392 JRFs, 424 SRFs, 278 RAs, 241 engineers & doctors and 1353 other professionals.

Table 10.10: Manpower employed in extramural R&D projects by male & female PIs during 2005-2010

Gender of P.I.	Professional staff					Support staff	
	JRF	SRF	RA	Engineer & doctor	Other professionals	Technicians	Others
Female	1392	424	278	241	1353	448	578
Male	3914	1395	1002	1883	5068	1274	2507
Gender information not available	10	7	3	1	3	4	1
Total	**5316**	**1826**	**1283**	**2125**	**6424**	**1726**	**3086**

Figure 10.4: Manpower deployed in extramural R&D projects with male & female PIs during 2005-2010



Observations & Conclusions:

The gender-wise analysis of R&D projects and their performance is a novel aspect of the report. It is evident from the analysis that the total number of projects undertaken by the female PIs is very less (28.0%) in comparison to the male; hence they lagged behind in all categories.

In terms of outcome, the female PIs published 8818 papers in journals (6667 in foreign journals and 2151 in Indian journals). They also participated in Indian and foreign conferences and presented 6159 papers. The performance of female PIs in terms of development of new products, processes, prototypes, varieties, etc. per project has been found quite good and comparable with male PIs.

In terms of number of specialized manpower generated per project, the number is not only comparable in each category of degree/diploma with men PIs but is higher also in some cases like DSc and MD. Thus, projects with female as PIs are in no way behind the male as PIs in terms of performance.

Gender-wise outcome of EMR projects sanctioned during 2010-2015

Outcome parameter	Female	Male	Gender information not available
Research Papers published/ presented	14977	40846	111
New products developed	2855	3501	2
New processes developed	637	1771	2
New instruments developed	120	432	1
New prototypes developed	307	680	3
New principle/ theory developed	300	783	2
New varieties developed	168	590	0
Patent filed	198	557	1
Patent sealed	37	127	0
Copy rights obtained	64	238	0
Manpower generated	5305	14581	37
Manpower employed	4714	17043	29

Chapter 11

Suggestions / Comments of Principal Investigators

In the questionnaire, all Principal Investigators were asked to give details of problems faced by them and suggestions/comments were also invited. Most of the problems faced were project specific, hence are out of the purview of this chapter. But a number of problems and suggestions/comments were generic in nature and given by large number of PIs. Important ones are summarized below-

- **Lack of desired manpower with appropriate qualifications**: It was very difficult to get a NET qualified candidate for appointment as JRF or RA. In case found, then it became impossible to retain them for the full term of the project, which hindered the progress of projects.

- **Logistics problems with reference to supply of important equipment**: It was time consuming exercise and due to exchange rate fluctuation, cost of the equipment keeps increasing and create major problem in procurement.

- **Higher attrition rate**: It hindered the progress of the project. The salary of the project staff should be comparable to the prevailing market condition.

- **Lack of motivated students/staff**: Due to this the progress of project slows down.

- **Delay in release of funds**: This tendency from the funding agency cause delay in progress of the project and prohibits full utilization of approved grants.

- **Inordinate delay in receiving replies**: The late replies to communications sent to funding agency for clarification/guidance stops the project work in many cases.

- **Delay in release of project staff arrears:** The arrears of the project staff were released 2-3 years after the completion of the projects in many cases.

- **No provision of maintenance cost of equipments:** Maintenance cost is not provided in the projects makes the functioning of sophisticated equipments very difficult during and after completion of the project.

- **Poor infrastructure**: Like interrupted electricity and water supply is major cause for failure of experiments a number of times.

- **Vehicle cost is not sanctioned**: This was not provided in most of projects but it should be considered on case-to-case basis, as some time samples have to be collected from remote/far places and quality get deteriorated.

- **Administrative hindrances**: The delay in appointment of staff or getting the money released from the implementing institute for project activities affects timely implementation of project.

- **Funds approved were insufficient**: As large portion of the proposed budget was scale down by funding agencies, killing the purpose of the project. Number of essentially planned work could not be carried out since full amount of proposed budget was not sanctioned.

- **No incentive to PIs:** There should also be incentive to the PIs so that they feel encouraged to guide research and submit projects.

Chapter 12

Conclusions & Recommendations

Following are the main Conclusions based on the study.

During the period 2010-2015, total amount of Rs. 10,504.27 crore was approved for funding of 27900 projects sanctioned by 21 central government departments and agencies. During this period, major sponsors of R&D projects were DST (9808), UGC (8175), DBT (2921), ICMR (1913) and CSIR (1778), accounting for more than 88% of the total number of projects sanctioned. In terms of funding support, DST was at top (Rs. 3591.53 crore), followed by DBT (Rs. 2671.79 crore), MOCIT (Rs. 1188.55 crore) and ICMR (Rs. 658.92 crore). These four scientific agencies accounted for 77% of the total extramural R&D funding.

Subject area-wise analysis of data reveals that biological sciences received the maximum support by way of number of projects (29.95%), followed by engineering and technology (18.88%), chemical sciences (14.55%) and medical sciences (14.46%). These subject areas together accounted for 78% of total number of projects sanctioned.

Year-wise analysis of projects supported has interesting to note that number of project and amount sanctioned are both declining from 2010-11 to 2012-13 with slight increase in after that. A total of 5855 projects were supported in 2010-11 which were highest in all the five-year period.

About 71.66% of the projects were sanctioned to the institutions located in eight states viz. Andhra Pradesh, Delhi, Karnataka, Maharashtra, Tamil Nadu, Uttar Pradesh and West Bengal. These states also received 73% of total funding during the reporting period.

During the reporting period, 630 cities/towns were covered under EMR projects. Among these locations, institutions based in six metro cities received 29% of total projects. 107 cities had 50 or more projects.

The maximum number of projects approved (10748) were in the middle cost range while minimum (868) projects approved were in ultra-high-cost range category. As the cost-range increased, the number of R&D projects decreased.

Gender-wise analysis of PIs who undertook these R&D projects indicated that the number of R&D projects with women PIs was small as compared to projects carried out by male PIs. 7813 projects had women PIs while 20046 projects had male PIs.

The highest number of research papers were published from the projects funded by DST. Among different funding agencies, the share of DST is highest (around 37%) in the total publications/presentations of research papers, followed by UGC (27%), DBT (10%), ICMR (7%) and CSIR (6% papers) funded projects.

The PIs of the sponsored projects published more papers in foreign journals (25043) than in Indian journals (7596) - almost 3.1 times. This shows that the PIs sent a greater number of quality research papers for publication in foreign journals which were accepted and published by them.

DST leads in almost all fields like new products, new processes, new prototypes developed, intellectual property rights (IPR's) registered, patents filed, patents sealed, new theories and new instruments developed.

A total of 789 patents were filed and 164 patents were obtained. In filing and sealing of patents, the DST-funded projects were on the top with 334 patents filing and 77 patents sealed during the period 2011-2015. It was followed by UGC with filing of 168 patents and CSIR-funded projects with 37 patents granted. The DST-funded projects obtained highest number (100) of copyrights.

The specialised manpower generated from all the analysed R&D projects included 6522 PhD, 8 DSc, 869 MPhil, 33 MD and 2826 MTech. The share of DST-funded projects was maximum in almost all categories of manpower generation with 2361 PhD, 1225 MTech and 314 MPhil while ICMR funded projects was at top with 12 MD produced. The second highest number of PhDs were produced by projects funded by UGC (1679) followed by DBT (738) and ICMR (458).

A total of 21786 personnel were employed in different categories by all the projects analysed. The scientific staff (16974) included JRFs (5316), followed by SRFs (1826), RAs (1283), Engineers/Doctors (2125) and other scientific staff (6424). Agency-wise analysis shows that DST-funded projects employed highest number of scientific personnel (8808), followed by UGC (3004), DBT (1362), ICMR (886) and CSIR (794) funded projects.

Among the subject areas, the highest numbers of Patents filed and sealed were in the area of engineering & technology followed by biological sciences and chemical sciences. As far as research papers are concerned, maximum number of papers were published in the area of biological sciences (17009) followed by engineering & technology (10580), chemical sciences (8401) and physical sciences (7195).

The analysis of Institute-wise outcome revealed that the outreach of the R&D support was confined mainly to the academic sector. As colleges & universities were awarded maximum number of projects by the funding agencies, the outcome has also reflected similar patterns in publication/presentation of research papers, development of new products, processes, instruments, prototypes, principles/theories, varieties, filing & sealing of patents, producing PhDs, employing JRF, SRF & RA etc.

The PIs age-wise analysis of sponsored R&D projects gives an interesting finding that PIs above 55 years of age have outperformed on most of the outcome parameters. This category of PIs gave maximum response to questionnaires (21%), published second highest research papers (11887) and developed highest number of new processes (503), new and new varieties (222).

A look at the cost range-wise analysis indicates that the highest number of JRF (2099) SRF (733), RA (521) and number of engineers & doctors (1600) were employed in middle cost range projects. Employment of scientific personnel was found to be inversely proportional to the cost range of projects. In other words, as the cost-range of EMR projects increased, number of personnel employed in projects decreased. In the high-cost range, very high-cost range and ultra-high-cost range, the number of persons employed gradually decreased with the increase in the cost range of the projects.

Out of total 789 patents filed and 164 patents obtained at national and foreign levels, the very high-cost range projects (50 lakh to less than 1 crore) obtained 2 patents out of 70 patents filed. The middle cost range projects (10 lakh to 25 lakh) could obtain 93 patents while filed 380 patents.

The gender-wise analysis of R&D projects and their performance is a novel aspect of the report. It is seen that the share of women as PIs in extramural R&D projects was small, only 22.64%. In terms of outcome, the women PIs published 8818 papers in journals (6667 in foreign and 2151 in Indian). They also participated in Indian and foreign conferences and presented 6159 papers. The performance of female PIs in terms of development of new

products, processes, prototypes, varieties, etc. per project has been found quite good and comparable with male PIs. In terms of number of manpower generated per project, the number is comparable in each category of degree/diploma with male PIs. Thus, projects with women as PIs are in no way behind the men as PIs in terms of performance.

Number of problems were faced by the PIs in carrying out EMR projects and some common one was: delay in approving the project, curtailment of budget for equipment, delay in the releasing of next instalment of grant, lack of infrastructure facilities, resignation of project staff at crucial time, lack of motivation among students for research etc. These should be looked into by the funding agencies.

Based on the study, few recommendations are made. Prominent among them are need for central repository of Project Completion Reports (PCRs) in every funding department/agency, need for uniformity in project completion report (PCR) of all funding agencies, more use of IT in data collection, women participation in extramural R&D needs to be encouraged by funding agencies and increasing awareness of R&D schemes in all states to maintain regional balance.

ANALYSIS OF OUTCOME OF EXTRAMURAL R&D PROJECTS FUNDED DURING 2011 - 2015

A Department of Science & Technology, GOI Sponsored Project
Under taken by
Society for Environment & Development

QUESTIONNAIRE

Record No. _____

SECTION – A

PRINCIPAL INVESTIGATOR'S (P.I.) PROFILE

1. Name of the Principal Investigator:

_____

2. Age (years) [ ] **Sex** [M] [F] [T]

3. Highest Qualification: _____ **Subject Specialisation:** _____

4. Present Address of P.I.

_____

_____

_____

_____

5. Tel. No. : _____ **Mobile No. :**_____

6. E. mail: _____**Alternate Email:**_____

SECTION – B

PROJECT PROFILE

1. Title of the project:

_____

_____

_____

_____

2. Funding Agency:

_____

3. Department & Institute, where project was implemented:

_____

_____

_____

4. Name(s), Designation and Gender of Co-investigator(s):

i) Name _____ Designation _____ Sex M F

ii) Name_____Designation _____ Sex M F

5. Subject area of the project:

_____

Mention 3-4 key-words: _____

6. Project Type *(*Definition on last page*) Please tick the appropriate box:*

i) Basic Research ☐ (ii) Applied Research ☐

iii) Experimental Development ☐ iv) Other *(Please specify)*

……

7. Nature of Project *(Please tick)*: Individual ☐ Collaborative ☐

If collaborative, please specify: Intra-institution ☐ Inter-institution ☐ Industry- Institution ☐

International collaboration ☐ Others ☐

8. Year of start of project: _____ **Year of Completion of project:**

_____

SECTION – C

FUNDING PROFILE

1. **Total sanctioned cost** *(Rs in Lakhs)*:

   _____

2. **Project Expenditure** *(Rs in Lakhs)*:

   _____

3. **Expenditure on Equipments in this project***(Rs in Lakhs)*:

   _____

4. **Total Manpower employed for this project:**

a) Professional	**Total**	**M**	**F**
i) JRF	☐	☐	☐
ii) SRF	☐	☐	☐
iii) RA	☐	☐	☐
iv) Engineer/Doctor	☐	☐	☐
v) Others (Please specify) _____	☐	☐	☐
b) Support Staff			
i) Technicians	☐	☐	☐
ii) Others	☐	☐	☐

5. **Whether final Statement of Expenditure (SE) / Utilisation Certificate (UC) submitted to the funding agency?**

Yes ☐ **No** ☐

SECTION – D

OUTPUT OF THE PROJECT

(Please Tick relevant point & give details for the same. Attach extra sheets if needed):

1. **No. of Research Paper(s) published out of the project:**

	National (Definition on last page)	International (Definition on last page)
a) Published in Journals	☐	☐
b) Presented in conference(s)	☐	☐

List all authors by last name and initials, separated by commas if there are more than two authors. Put an "and" before the last author in the list, then give the year, the title of the article or chapter (no quotes, italics or underlines), then the title of the journal or magazine (in italics if possible), the volume number of the journal, and page numbers.

i. _____
ii. _____
iii. _____
iv. _____

c) Whether Papers found place on cover page of the Journal? **Yes** ☐ **No** ☐

(If yes, give numbers in National ☐ International ☐ (Also provide name, volume, page no. etc.)

_____

_____

_____

_____

2. **Any Monograph /Book/Technical report produced out of the project** *(Please give numbers):*

Monograph ☐ **Book** ☐ **Book Chapter** ☐ **Technical report** ☐

Item	*Number*	*Details*
3. **New Product(s) developed:**	☐	_____
4. **New Process(es) developed:**	☐	
5. **New Instrument(s) developed:**	☐	_____
6. **Prototype(s) developed:**	☐	_____
7. **Patents**		
a. **Filed: National**	☐	

International ☐

b. Granted: National ☐

International ☐

8. Copyright(s) ☐

9. New Principle/Theory developed: ☐

10. New Variety (crop) developed: ☐

11. New Lead/ Potential Molecule developed ☐

12. Others (Please specify) ☐

13. Utilisation of R&D results/technologies by the implementing Institute/sponsoring agency/other users *(Please tick the appropriate box)*:

Implementing Institute ☐ **Sponsoring Agency** ☐ **Industry** ☐ **Society** ☐ **Others** ☐

*Please provide details like name of Industry, agency etc.*_____

14. No. of Manpower produced out of this project:

☐ Ph. D.'s ☐ M. Phil's ☐ M. Tech. ☐ M. D. ☐ Others (pl. specify)

15. Please give your feedback on implementation of the project:

Definitions of types of project

Projects can be classified into four categories using the following standard definitions:

1. **Basic Research:** Basic research may be defined as any experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundations of phenomena and observable facts, without any particular or specific application or use in view.

2. **Applied Research:** Applied research may be defined as any original investigation undertaken to acquire new knowledge and is directed primarily towards a specific practical aim or objective.

3. **Experimental Development:** Experimental development may be defined as any systematic work, drawing on existing knowledge gained from research and/or practical experience that is directed to produce new material, products and devices, to install new processes, systems and services, and to improve substantially those already produced or installed.

4. **Other Activities:** Other activities would include S&T services provided by libraries, information and documentation centres, data banks and information processing institutions.

Definitions of National and International journal

1. **National:**
   - If journal published in any one of the Indian languages. Many journals are published in Bi-lingual/Tri-lingual/Multi-lingual and even in English language in India…. as English is generally accepted as the lingua franca for scholarly communication.
   - If journal has Editorial board only from India or majority in editorial board are Indians.
   - Majority of published papers in the journal are from within the country with a smattering of papers from abroad either as single authorship or collaborations with Indians is still termed 'national'.
   - Majority subscriptions should originate from within the country subscribers (individuals or institutions).
   - Majority of Reviewers (experts of given discipline) are from India only with an occasional reviewer from 'abroad'.

2. **International:**
   - If journal has Editorial board that is truly international in its composition. Majority of editors should be from countries other than India.
   - Majority of published papers in the journal should be 'international' submissions.
   - Majority subscriptions should originate from 'global' subscribers (individuals or institutions).
   - Reviewers (experts of given discipline) from countries all over the world.
   - Published from any other country other than India.

Note:

i. This questionnaire can also be downloaded from our web-site www.sed.org.in and sent as attachment to E-mail: sed.nstmis@gmail.com

ii. Kindly provide information for the above asked questions pertaining to the project.

iii. Fill only those points relevant to your project.

Kindly return completed questionnaire to the following address:

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