Biotechnology Industry Research Assistance Council

A BIRAC-IKP Initiative

MAPPING REGIONAL INNOVATION ECOSYSTEMS

A study of select life sciences clusters in India

REPORT 3

MAPPING REGIONAL INNOVATION ECOSYSTEMS

A study of select life sciences clusters in India

TEAM

Ms. Deepanwita Chattopadhyay

Ms. Kriti Taneja

Mr. Pulkit Kohli

Knowledge Partner: InventIP Legal Services LLP

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COVER PAGE IMAGE: Innovation Input/Output Pillars

सत्यमेव जयते

डॉ. रेणु स्वरूप
DR. RENU SWARUP

सचिव
भारत सरकार
विज्ञान और प्रौद्योगिकी मंत्रालय
जैव प्रौद्योगिकी विभाग
ब्लॉक-2, 7वां तल, सी० जी० ओ० काम्पलेक्स
लोधी रोड, नई दिल्ली-110003

SECRETARY
GOVERNMENT OF INDIA
MINISTRY OF SCIENCE & TECHNOLOGY
DEPARTMENT OF BIOTECHNOLOGY
Block-2, 7th Floor, C.G.O. Complex
Lodhi Road, New Delhi-110003

MESSAGE

BIRAC in partnership with IKP Knowledge Park had set up the BIRAC Regional Innovation Centre (BRIC) at IKP to further advance BIRAC's mandate of building a deeper understanding of the capacity and gaps in innovation to develop targeted programmes for fulfilling its broad vision of stimulating and enhancing biotech innovation and entrepreneurship in the country.

BIRAC's BRIC, through its outreach and entrepreneurship development activities, has been fostering deeper engagement with life science innovators and providing platforms to showcase translational ideas. It has supported innovators to create feasible start up business plans, especially in emerging and promising clusters.

The report provides a framework which captures the innovation maturity of individual clusters and highlights the interlinked factors that are required for growth of clusters. This would help BIRAC to formulate targeted policies to enhance innovation performance of clusters.

The teams at BRIC, IKP Knowledge Park and BIRAC have also been able to create local mentor pools and develop platforms for networking and peer to peer learning in emerging and promising clusters that would stimulate growth of these clusters. The contributions of the experts and BRIC Advisory Committee are greatly appreciated. Their guidance and collaboration would help grow the Indian biotechnology sector.

I congratulate the team members for bringing out such a comprehensive report.

(Dr. Renu Swarup)

Tele : 24362950 / 24362881 Fax : 011-24360747 Email : secy.dbt@nic.in

TABLE OF CONTENTS

FOREWORD

IKP Knowledge Park has been playing a pivotal role in fostering the innovation and entrepreneurship ecosystem in India. It not only supports technology identification and scale up but also has been enabling startups to co-create solutions for tomorrow. IKP's partnership with BIRAC to set up the BIRAC Regional Innovation Centre (BRIC) in 2013 provided an opportunity to study regional life sciences innovation systems in established, emerging and promising clusters and become a strategic partner towards improving the innovation capacity in tier II and tier III cities. Four clusters around Hyderabad, Bengaluru, Chennai and Thiruvananthapuram-Kochi were selected for the first phase of the study. Six more life sciences clusters in western and central India, Ahmedabad, Mumbai, Pune, Bhopal-Indore, Bhubaneswar and Visakhapatnam were added in the 2nd phase of the study. Based on the learnings derived from the above studies and the effectiveness of such work in policy making and programme development, the study was further expanded to 13 new clusters covering North and Eastern India and also two clusters in the West and South. The clusters covered in the Phase III study are Jaipur-Pilani, Mohali-Chandigarh, Shimla-Palampur-Solan-Jammu, Delhi NCR, Karnal-Rohtak, Dehradun-Roorkee, Lucknow-Kanpur, Allahabad-Varanasi, Kolkata-Kalyani-Kharagpur, Guwahati-Shillong-Tezpur, Sikkim, Panaji-Goa and Mangalore-Manipal.

The innovation mapping and analysis framework adopted in this Report is based on Input and Output Innovation indices derived from a set of Input and Output Innovation Pillars and associated innovation indicators pertaining to innovation attributes of life sciences clusters. Apart from mapping the clusters from secondary data and interview of key opinion leaders, a major focus of the current study was on designing specific interactive entrepreneurship development activities for the emerging and promising clusters under study. During this study BRIC reached out to over 2,000 innovators in these clusters, launched two CSR programmes and significantly increased its footprint in Tier 2 and Tier 3 cities.

The report has been structured to provide insightful data on the local network effects and help evaluate the innovation capacity and maturity of various clusters to plan specific programmes /schemes that would enhance their innovation performance. I hope readers will find the report interesting and useful.

We believe in unlocking unrealized strengths to create opportunities for remarkable things to happen.

Deepanwita Chattopadhyay
IKP Knowledge Park

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Our appreciation to the BRIC Advisory Committee chaired by Ms.Anju Bhalla, Joint Secretary DST & MD BIRAC with expert members consisting of Dr. Manish Diwan, Head - Strategy Partnership & Entrepreneurship Development, BIRAC; Dr. Rabindranath Mukhopadhyaya, Retd. Prof. & Principal Investigator Virology, Tata Memorial Centre Mumbai; Prof. Ambuj Sagar, Head - School of Public Policy, IIT Delhi; Dr. Ajith Kamath, Business Advisor - Pandorum Technologies Pvt. Ltd.; Prof. Pramod Tandon, Chief Executive Officer, Biotech Park Lucknow; and Dr. Vinita Jindal, Chief Manager-IP & Technology, BIRAC for overall guidance to BRIC as well as for this report.

The initial findings of the Report were also discussed at several conferences, workshops and annual stakeholder meetings especially at the focused Roundtables held during IKP's International Knowledge Millennium Conferences, IKMC 2018 to IKMC 2020 chaired by several eminent scientists and experts. We appreciate the guidance and contributions made by the experts at the roundtables.

Several experts in the thirteen clusters under study provided helpful comments and insights, made other contributions, and participated in consultative meetings/ interviews. The team would like to thank the 215 experts who provided their perspectives for the study:

A K Chakraborty, IASST
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Aditi kumar, SIIC IIT Kanpur
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Ahmed Kamal, Jamia Hamdard
Ajit Dua, Punjab Biotechnology Incubator
Ajit Patowari, The Assam Tribune
Akhilesh Trivedi, Anand Incubation Centre
Amit Kumar, Workboat Meadia Pvt Ltd
Amit Mehndiratta, IIT Delhi
Amit Singh, IMS BHU
Amit Srivasta, Being Arogyam Herbals Pvt Ltd
Amit Verma, Vibmiks services Pvt Ltd
Amitabha Bandyopadhyay, SIIC IITK
Ameya Abhyankar, Govt. of Goa
Angraj Swami, Ecowrap Pvt Ltd
Anil Koul, CSIR-IMTECH
Anindita Ukil, Calcutta University
Anjana Pandey, MNNIT Allahabad
Ankit Alok Bagaria, Loopworm Pvt Technologies
Ankit Bansal, E&Y Goa

Ankita Gulati, Touch Vision Pvt Ltd
Anupam Mukhrjee, EpioneSwajal Solutions India LLP
Aparna Datta, Dr. B Lal Institute of Biotechnology
Aparna K Sapra, StellarGene Technologies Pvt Ltd
Apoorv Sharma, Atal Incubation Centre GIM
Arjun Adhikari, Paksam Veterinary Hospital
Arun Bandyopadhya, CSIR-IICB
Arun Bhagwath, Yenepoya University
Arun Kumar Grover, Punjab University
Arun Shanbhag, Manipal Academy of Higher Education
Arvind S A, Flexomotiv Technologies Pvt Ltd
Ashish Ganguly, CSIR-IMTECH
Ashutosh Pastor, FITT IIT Delhi
Ashwini Kumar, KMC Manipal
Asim Shiraz, Yenepoya Research Centre
Atishay Jain, MIT Manipal
Atul Sardana, Alfa Corpuscules
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B Kakoti, ASTU Guwahati
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Bijit Sarma, Ruloi Tea Company
Brijesh Srivastava, Tezpur University
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Charmaine Sharma, Observing Eye
Chetan Desai, Qubiseed Technologies LLP
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Darryl Zuzarte, 91 Springboard
Debajit Borah, The Assam Royal Global University
Deepa Bisht, CSIR- CIMAP
Deepindar Dhillon, Dept of IT - Govt of Punjab
Dinesh Dua, Nectar Lifescience Ltd
Divya Dixit, Udhhami Kisan Agri Pvt Ltd
Dr. Amit Rastogi, BHU Hospital
Dr. Siddik Sarkar, CSIR-IICB, Kolkata
Dr. Sujay Shad, Ganga Ram Hospital
G Shriniketan, NIT Kozhikode
Gajanan Nagarsekar, KallowsEngg Pvt Ltd
Gangadhar Mahesh, NIT Kozhikode
Geetika Dayal, TIE Delhi
Gurpreet Kaur, Department of Industries & Commerce Punjab
Hardeep Singh, Department of Industries & Commerce Punjab
Hemant R Kushwaha, Atal Incubation Centre JNU
Hemanta Kumar Borah, IIM Kolkata
Hemen Das, Govt. of Assam
Ishan Verma, JK Startup Association
Jitendra Kumar, CSIR-CIMAP

Jitu Halder, ISF College of Pharmacy
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Kapil Zutshi, WISH Foundation
Kapil Kumar Parashar, Vyom Pvt Ltd
Kiran Vuppula, Cerelia Nutritech Pvt Ltd
Koustab Panda, University of Calcutta
Krishnan Nambiyar, Vanora Robots Pvt Ltd
Kunal Das, Manipal Hospitals
L K Pandey, Indian Industries Association, Delhi State Chapter
Lourdes Soares, Sabrcare Pvt Ltd
M G Barthakur, Guwahati Biotech Park
M Krishna Mohan, BSIR Jaipur
Madhusudhan Murthy, Joish Agri Sciences Pvt Ltd
Mahesh Gupta, CSIR-IHBT
Malthi Lxmikumaran, Laxmikumaran & Sridharan Attorneys
Manan Issar, Piltover Technologies Pvt Ltd
Manesh Thomas, Manipal University
Manish Jhori, Maple Capital Advisors
Manuj Tripathi, CSIR-IMTECH
Manveen Chaddha, IIT Mandi
Manjeet Singh, Central University Jammu
Maria Cordeiro, Goan Pharma Pvt Ltd
Mohd. Amir, Falcon International
Mohd. Nadeen Khan, GCC Biotech Pvt Ltd
Mohd. Samheel, OSIND Meditech Pvt Ltd
Mohit Virmani, Turiya Innovations Pvt Ltd
Mridula Goel, BITS Goa
Mrigank Singh, Indian School of Business
Narsinh Thakur, NIO Goa
Navkiran Kaur, Panjab University
Neeraj Kumar Sethiya, DIT UNIVERSITY
Neerja Bharti, PGI Chandigarh
Neha Samir Bhoir, Satvik Agro Pvt Ltd
Neville Rodrigues, IDAP Mangalore
Nimish Mehra, Fupro Innovations Pvt Ltd
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Nirankar Yadav, Emission Technology Pvt Ltd
P Jeevanandam, IIT Roorkee
Paritosh Trpathi, AIC IIT BHU
Partha Chakraborty, Arogyam Medisoft Solution Pvt Ltd
Partha P Majumder, National Inst. of Biomedical Genomics
Parthasarthi, CSIR-IITR Lucknow Incubation centre
Parul Gupta, DST Jaipur
Pawan Rane, Dexium Technologies Pvt Ltd
Pawan Mehrotra, Aarana Biomedical Products Pvt Ltd

Pintso Gyatso, OurGuest.in
P J Singh, Tynor Orthotics Pvt Ltd
Pooja Mukul, BMVSS Jaipur
Pooja Thakur, Healthivore
Pradeep Srivastava, IIT BHU
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Puneet Gupta, Clensta International Pvt Ltd
Puran Singh, IIT Mandi
Purnananda Gupta Sarma, IISER Mohali
Purnendu Ghosh, BSIR Jaipur
P V M Rao, IIT Delhi
Radhika, Punjab University Chandigarh
Rajan Sharma, NDRI Karnal
Rajat Banerjee, University of Calcutta
Rakesh Sharma, IISER Mohali
Ranjit Baruah, Tender Buds Teas & Crafts Pvt Ltd
Reena Rai, Maato Studio
Renzino Lepcha, Mevedir Sikkim
Ritika Arora, Athene Healthcare
Rohan Tripathi, Inovocare Healthsoft Solutions Pvt Ltd
Ruchi Pathak Kaul, AIIMS Delhi
Rupesh Chaturvedi, JNU
Rupinder Tewari, Punjab University
Ryan Carvalho, EDC Ignite Goa
S C Bardoloi, Innotech Intervention Pvt Ltd
S Roy, NIPER Guwahati
S Raisuddin, Jamia Hamdard
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Sanjoy Ghosh, IIT Roorkee
Santanu, Amity University
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Sarandeep Singh, WEE Delhi

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Satya Dash, Global Innovations in PATH
Saumitra Sahai, Paradigm Innomed
Saurabh Ray, Monosha Biotech Pvt Ltd
Sawarkar Sharma, SMVDU Katra
Sayam Sen Gupta, IISER Kolkata
Shantanu, School of Tropical Medicine Kolkata
Shanti S Sharma, Sikkim University
Shawnn Coutinho, GIM Goa
Shelly Seghal, Central University of Jammu
Shivam Sharma, 6D0F Solutions Pvt Ltd
Shreya, Happy Collar
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Shruti Singh, Eikona X Innovative Solutions Pvt Ltd
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Sidharth, Fermentech Labs Pvt Ltd
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Sitikantha Roy, FlexBot Medical Pvt. Ltd
Somanth Chanda, Brahamaputra TechnoPharmaceuticals Pvt Ltd
Sudesh Kumar, CIAB Mohali
Sudhanshu Gupta, ISF College of Pharmacy
Sudip Mitra, IIT Guwahati
Sukhjinder Singh, CSIR-IHBT
Sukhmeet Singh, A2P Energy Solution Pvt Ltd
Suman Mukhopadhaya, Banglanatak.com
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V M Chariar, Ekam Eco Solution Pvt Ltd
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LIST OF ABBREVIATIONS

AIIMS	All India Institute of Medical Sciences
AU	University of Allahabad
BHU	Banaras Hindu University
BIRAC	Biotechnology Industrial Research Assistance Council
BITS	Birla Institute of Technology & Science
BRIC	BIRAC Regional Innovation Centre
CSIR	Council of Scientific & Industrial Research
DBT	Department of Biotechnology
DIT	Dehradun Institute of Technology
DST	Department of Science and Technology
DU	Delhi University
FTO	Freedom to Operate
GII	Global Innovation Index
GMCH	Government Medical College and Hospital
HP	Himachal Pradesh, India
HR	Human Resource
IACS	Indian Association for the Cultivation of Science
IARI	Indian Agricultural Research Institute
ICAR	Indian Council of Agricultural Research
ICMR	Indian Council of Medical Research
IE	Innovation Ecosystem
IGIB	Institute of Genomics & Integrative Biology
IHBT	Institute of Himalayan Bioresource Technology
IICB	Indian Institute of Chemical Biology
IICT	Indian Institute of Chemical Technology
IIT	Indian Institute of Technology
IIT-BHU	IIT Banaras Hindu University
IIT-D	IIT Delhi
IIT-KGP	IIT Kharagpur
IITR	IIT Roorkee
IKP	IKP Knowledge Park
IMT	Institute of Microbial Technology
INSA	Indian National Science Academy
IP	Intellectual Property
IPC	International Patent Classification
IS	Innovation Support
IVRI	Indian Veterinary Research Institute
JHU	Jamia Hamdard University
JNU	Jawaharlal Nehru University

KOL	Key Opinion Leaders
MDU	Maharishi Dayanand University
MHRD	Ministry of Human Resource Development
MNIT	Malaviya National Institute of Technology Jaipur
MNNIT	Motilal Nehru National Institute of Technology
MU	Manipal University
MVP	Minimum Viable Product
NCBS	National Centre for Biological Sciences
NCR	National Capital Region
NDRI	National Dairy Research Institute
NIPER	National Institute of Pharmaceutical Education and Research
NSIT	Netaji Subhas Institute of Technology
PGIMER	Post Graduate Institute of Medical Education and Research
PP	Patent Performance
PU	Punjab University
RIS	Regional Innovation Systems
RC	Research Capacity
R&D	Research and Development
RAIN	Rajasthan Angel Innovators' Network
RIICO	Rajasthan State Industrial Development and Investment Corporation
RVCF	Rajasthan Venture Capital Fund
SINP	Saha Institute of Nuclear Physics
SMU	Sikkim Manipal University
SMVDU	Shri Mata Vaishno Devi University
TTO	Technology Transfer Office
UCMS	University College of Medical Sciences
UGC	University Grants Commission
UTs	Union Territories
WIPO	World Intellectual Property Organisation

LIST OF FIGURES

LIST OF TABLES

Introduction

Study of clusters and cluster policies have gained momentum to device creative, comprehensive, and proactive approaches in developing innovation-led economies. Cluster theories suggests that stakeholders in a particular cluster gain competitive advantage through local proximity and interdependence and these benefits result in growth in economic activity and output for the cluster.

Successful clusters significantly impact economic development of the region, improve return on investments, mobilize multidisciplinary growth and carve global leadership roles for key technologies. Recognizing this impact, cluster specific interventions become important and both advanced and emerging clusters should invest in promulgating polices to encourage cluster development.

The biotechnology sector is recognised as one of the key drivers for contributing to India's USD 5 trillion economy target by 2024. India is among the top-12 destinations for biotechnology in the world, with approximately 3% share in the global biotechnology industry. In order to achieve the target one of the key challenges in the biotechnology sector is the lack of capacity for bio-manufacturing and the paucity of biotech Incubators necessary to scale up the start-up ecosystem. This can be addressed through development of life science clusters.

In this study we reflect that it takes more than infrastructure and funding to grow and nurture a life science cluster. A successful cluster fosters collaboration needed to develop and market innovations and requires an entire ecosystem in which researchers, entrepreneurs, and investors collaborate to develop and launch new products and companies.

BRIC Phase III Study

In BRIC Phase I and Phase II studies the primary aim was to understand the knowledge generation, innovation capacity, and interaction between various stakeholders in the emerging and fledgling (but promising) innovation ecosystems as compared to the more established ones, identify gaps that hinder commercialisation of innovations, and recommend policy changes and programmes for consideration of BIRAC.

Based on the learnings derived from the above studies and the effectiveness of such work in policy making and programme development, the study was further expanded to 13 new clusters covering North and Eastern India and also two clusters in the West and South that were not covered in the earlier Phases. The clusters covered in the Phase III study are Jaipur-Pilani, Mohali-Chandigarh, Shimla-Palampur-Solan-Jammu, Delhi-NCR, Karnal-Rohtak, Dehradun-Roorkee, Lucknow-Kanpur, Allahabad-Varanasi, Kolkata-Kalyani-Kharagpur, Guwahati-Shillong-Tezpur, Sikkim, Panaji-Goa and Mangalore-Manipal. The study was designed to not only map the life sciences knowledge and innovation capacity of the 13 clusters and provide IP services to the innovators in the clusters, but to also undertake a set of entrepreneurship development activities that were specifically tailored towards emerging and promising clusters of innovation.

Innovation Framework and Analysis

Innovation Mapping, Analysis and Impact in BRIC Phase III were studied using Input and Output Innovation indices. The Innovation Pillars for the Input and Output indices used in this study were selected to suit the innovation attributes of life sciences clusters and the objective of the study, which was to understand the depth and vibrancy of the clusters and grade them as Established, Emerging and Promising clusters.

Analysis of Innovation Input and Output Pillars with the associated Indicators for a cluster provide a good understanding of the Innovation Capacity and Innovation Performance of the cluster. The 1st Innovation Input Pillar, Human Capital & Research Capacity is a crucial input parameter for knowledge and talent generation and technical mentorship within a cluster, and being central to cluster innovation capacity, was studied in considerable detail. The Delhi cluster, which included the National Capital Region (NCR), far outweighed the other clusters in terms of the number of academic and research organisations, number of scientists, publications and citation. Based on the number of scientists and publications, Delhi and Kolkata were categorised as Established Research Capacity (RC) clusters, Chandigarh, Lucknow, and Varanasi as Emerging RC clusters and the rest as Promising RC clusters. Top 100 collaborators of the selected institutes in each cluster over the last 20 years were mapped for both intra-cluster as well as inter-cluster collaborations. Most cluster displayed high intra-cluster collaboration. Goa, Mangalore, Karnal, Roorkee and Sikkim having less institutions had more inter-state collaboration.

The 2nd Innovation Input Pillar is the State Government Support. The local government plays a crucial role in catalysing innovation through policies, regulation and in development of ecosystem through infrastructure like science parks, incubators and accelerators. Innovation Culture is also an important factor that enables innovation activities in a cluster and the report has tried to capture the same through parameters like number of innovation driven companies, availability of talent for industry to hire and the start-up and business culture. The innovation indicators derived from secondary data sources for the four Innovation Input Pillars, State Government Support, Innovation Infrastructure and Support, Investment Climate and Innovation Culture were mapped for the 13 clusters.

All the 13 clusters in this study are covered by their respective Start-up and/or Biotech Policies. Delhi is one of the hotspots for biotechnology innovation in India and has the highest number of biotech incubators (23) and also highest number of biotech startups (1,370) among the 13 clusters. The clusters were grouped on the basis of the analysis of the support that the clusters received from the state governments and other agencies. Delhi, Chandigarh, Jaipur emerged as Established clusters in terms of Innovation Support (IS), Mangalore. Goa, Guwahati and Roorkee were ranked as Emerging IS clusters, and Jammu-HP, Lucknow, Varanasi, Kolkata, Karnal and Sikkim as Promising IS clusters.

The two Innovation Output Pillars are IP Generation, with patents and other IP as the Indicator, and Technology Commercialization, with number of startups and Patents filed by industry as the quantitative indicators and Tech Transfer as a qualitative measure derived from approximately 215 Key Opinion Leaders (KOL) interviews and survey data. The Delhi cluster recorded the highest number of patent applications published (10,664) during the 2000-2020 period. This is more than 11 times that of the patent applications published from the Kolkata cluster (917), the second highest among the 13 clusters in terms of patent filed. Overall, the patent to research publication ratio was found to be highly skewed for all the clusters except Delhi. This points towards the need for IP awareness and workshops in these clusters. The regional TTOs set up by BIRAC may help in bridging this gap. About 28.6% of patents in the Delhi cluster were filed by companies and about 21% each by academia and individuals. Individual filing was found to be high in Kolkata, Jaipur, Jammu-HP, Karnal, Lucknow and Varanasi. Patents filed by academia dominated in Chandigarh, Mangalore and Roorkee clusters. Goa exhibited a high proportion of published patents with industry as assignee and could be attributed to the presence of the pharma industry in Goa. In terms of both Patent Performance (PP) and Innovation Ecosystem (IE) support, only Delhi cluster emerged as Established. While Chandigarh and Kolkata qualified as Emerging PP clusters, Chandigarh, Jaipur and Kolkata qualified as Emerging IE clusters. The rest of the clusters were ranked as Promising in terms of patent performance as well as innovation ecosystem.

Cluster Development Activities

Apart from mapping the clusters based on analysis of a set of Input and Output Innovation Indicators from secondary data and KOL interviews, a major focus of the current study was on designing specific interactive entrepreneurship development activities for the Emerging and Promising clusters under study. These included setting up Innovator Forums and Open Dialogues to facilitate networking among the stakeholders in a cluster, conducting targeted workshops, Idea expositions and instituting exposure stipends.

One of the most successful and engaging aspect of the workshops launched under BRIC was the "Storytelling" sessions showcasing local success stories. This helped IKP identify the local mentors who understood the cluster challenges and help innovators navigate them. These brought in a network pool of 20 plus new mentors across tier 2 and 3 cities.

IKP conducted 11 Idea Expositions, where a total of 236 applications were received,120 innovators were mentored and 24 innovators were selected as winners and awarded the Idea Exposition grants. Chandigarh and Jaipur clusters received the maximum number of proposals with over 40% applications from startups, pointing to the growing innovation culture in the two clusters. Jammu-HP and Sikkim had more than 60% of applications from startups which shows the growing entrepreneurship ecosystem and is attributed to the presence of enabling bodies like the Atal Incubation Centre in Sikkim and Jammu Start-up Association in the Jammu-HP cluster. Clusters like Lucknow and Roorkee showed less than 20% of its applications from startups.

Comparative analysis of clusters

The five Input Innovation Pillars in each cluster assessed through its associated Input Indicators provided a measure of the Innovation Capacity of that cluster. Input Indicators were ranked, colour coded and mapped to arrive at an understanding of the Innovation Capacity of each cluster and where the gaps lay. The map clearly showed that the Innovation Capacity of Delhi was way above that of the rest of the clusters. The Innovation Capacity of Chandigarh, Kolkata, Mangalore and Jaipur are fairly well developed and could be categorised as Emerging clusters. While several input indicators of Lucknow, Varanasi, Roorkee and Guwahati were fairly developed, the rest of the input indicators pulled down the overall score and these clusters were grouped as Promising clusters along with Jammu-HP, Goa, Karnal and Sikkim.

All the seven Innovation Pillars across the 13 clusters were represented as a heat map to indicate how the Output Innovation Sub-Index performed vis à vis the Input Innovation Sub-Index. This provided a sense of the Innovation Performance and efficiency of the clusters. Delhi cluster stood out both in input and output pillars. Chandigarh, Jaipur, Kolkata and Mangalore emerged as the next four top clusters when looked at the input pillars but Mangalore slipped to the Promising cluster category when ranked on the output pillars, especially in the Technology Commercialization pillar. This could be attributed to innovators moving out from Mangalore to Bangalore to form startups. Lucknow, Varanasi, Roorkee, Guwahati, Jammu-HP and Goa featured in the list of Promising clusters. Goa and Jammu-HP clusters fared well in output pillars in comparison. Availability of more innovation funds and IP awareness activities could help the Jammu-HP cluster transition from a Promising to Emerging cluster. The Goa cluster would need thrust in areas like innovation infrastructure and investment climate. Clusters like Sikkim and Karnal need more focussed policy changes and a deeper analysis to help them move up within the Promising clusters group.

Recommendations

Several recommendations made in the earlier phases of the study were adopted by BIRAC through various initiatives in the last few years. A few recommendations have still been retained on the basis of the observations of the existing status of the clusters. In addition, new recommendations have been presented based on the learnings from this study.

1. Design of tailor made programmes for Emerging and Promising clusters

Successful cluster initiatives begin with a combination of data collection and analysis to identify and prioritize cluster opportunities to serve the cluster in the best possible way. During data collection and entrepreneurship development activities for Phase III it was observed that the following programmes are needed the most in emerging and promising clusters in Tier II and III cities.

i. Creation of cluster networking platform

Knowledge transfer, peer to peer learning and information flow across stakeholders are necessary for nurturing and growing an innovation ecosystem. Networking forums are critical for achieving these. To meet this necessity, "Open Dialogues" was launched as a networking platform and meetings in each cluster were conducted with participation from key stakeholders in the local innovation ecosystem. During these events it became evident that stakeholders in emerging and promising clusters do not meet each other often and peer to peer learning was very low. Till a set of local champions were identified in a cluster, there would be a need for an external agency like BRIC to take the initiative to develop such networking platforms.

ii. IP Clinics

Intellectual property (IP) plays an important role in development of a cluster and reflects both on the R&D capacity and entrepreneurship culture of a cluster. During the BRIC activities it was observed that emerging and especially the promising cluster lack in IP awareness activities which is validated though poor numbers of fillings from these clusters. It is highly recommended to not only hold IP awareness workshops but also provide IP services like Patentability searches, FTO and drafting services to these clusters though organized IP Clinics.

iii. Development of local mentor pool

The "storytelling" sessions organised by BRIC were found to be the most successful and engaging workshops that showcased local success stories. This helped BRIC identify the local mentors who understood the cluster challenges and ground level realities and could help innovator navigate them. They were also positively inclined to invest in the local startups and develop the clusters.

iv. Hackathons/ Idea Exposition events based on local flavour

Every cluster has its own local challenges and strengths. Although setting up general hackathons encourage development of entrepreneurship culture, it would be greatly beneficial if specific calls for Hackathons/ Idea Exposition are held with cluster challenges and strengths as thematic areas. This would create interest among local industry as well as the local government to engage in the start-up ecosystem.

2. Creation of alternate structures for financing startups from less developed clusters

Large number of startups from emerging and promising clusters may be able to spin out sustainable and profitable businesses and create jobs, but these ventures may not be investible by Venture Capital funds. There is a need to create blended finance structures such that public money (funding from BIRAC) can be leveraged to raise private capital or bank loans to fund the working capital needs and other project finance needs of the startups.

3. Creation of Virtual Incubation Platform connecting Clusters within a Region

Knowledge sharing and peer-to-peer learning can result in nonlinear growth in the ecosystem if managed and facilitated appropriately. Physical incubators are necessary for access to laboratory equipment. While these facilities also provide a great platform for interaction and learning, emerging and promising clusters often lack a critical mass of innovators and startups for peer-to-peer learning and also mature incubation managers. Both these issues can be addressed through a hybrid model of physical and virtual incubation platforms. The COVID-19 pandemic has clearly helped us realise the power of online platforms, webinars and online coaching and mentoring, and that physical proximity is not essential for quality interaction.

A sustainable model of incubation at scale is possible in emerging and promising clusters by setting up a "Anytime-Anywhere" virtual incubation platform that links several regional incubators in neighbouring clusters. Apart from start-up development activities, these virtual platforms should also emphasize on development of incubation managers and handholding early-stage incubators.

4. Development of Innovation Corridors

Innovation is a big driver of economic development, creating jobs and igniting growth industries. Established innovation clusters are typically concentrated around select cities. While state governments have tried to develop various tier 2, 3, 4 towns by attracting industry and investments and providing infrastructure and tax incentives and developing industrial parks/ zones, these are not enough for developing innovation clusters. Innovation requires the presence of academic excellence and high-quality talent as well as an investment climate and industry. While a single emerging/ promising cluster or town may not be able to provide all these elements, the critical mass or scale could well be achieved by working synergistically across an economic or trade corridor by linking several clusters with complementary strengths.

Based on the learnings from this study, and especially due to the challenges imposed by the COVID pandemic, what clearly emerged was the need for better connectivity and sustained engagement within and among adjacent emerging and promising clusters. It was felt that rather than working with individual clusters, focussed attention should be given to adjoining emerging clusters to facilitate smooth flow of knowledge and innovative businesses among these clusters, thus making them stronger and viable entities. We term these groups of innovation clusters as "Innovation Corridors".

Chapter 1

Introduction

1.1 Background

The Biotechnology Industrial Research Assistance Council (BIRAC) in partnership with IKP Knowledge Park (IKP) set up the BIRAC Regional Innovation Centre (BRIC) in 2013, to further BIRAC's mandate of building a deeper understanding of the capacity and gaps in innovation, commercialisation and technology absorption ecosystems and developing targeted programmes to fulfil its broad vision of stimulating, fostering and enhancing biotech innovation and entrepreneurship in the country.

To understand the evolving nature of regional ecosystems an extensive Regional Innovation Systems (RIS) study was undertaken in phases. The first Phase of the study was conducted between 2014 and 2016 around four established biopharma and medical technology clusters in Southern India, where a set of innovation indicators were studied through analysis of secondary data as well as surveys and interviews of Key Opinion Leaders (KOLs) in these clusters. The clusters studied were Hyderabad, Bangalore, Chennai-Vellore and Tiruvanathapuram-Kochi. As part of its mandate BRIC also provided Intellectual Property (IP) services to the innovators and startups in these clusters. The Phase I Report provided an overview of various landmark studies on the study of regional innovation systems. A detailed note on several models that were used to study innovation were compared and contrasted. The benefits of studying the ecosystem in a dynamic manner while identifying various stakeholders and studying their roles through the helix models were also outlined. The Phase 1 report can be accessed at http://www.ikpknowledgepark.com/images/BRIC REPORT 1.pdf.

The methodology and learnings from the Phase I exercise were extended during 2016-17 as a Phase II study to six other clusters in West and Central India, namely, Ahmedabad, Mumbai, Pune, Bhopal-Indore, Bhubaneswar and Visakhapatnam. Theprimary aim was to understand the knowledge generation and innovation capacity and interaction between various stakeholders in the ecosystems in the emerging and fledgling (but promising) innovation ecosystems as compared to the more established ones, identify gaps that hinder commercialisation of innovations, and recommend policy changes and programmes for consideration of BIRAC. The Phase I cluster data was updated to The Phase 2 report can be accessed at http://www.ikpknowledgepark.com/images/BRIC REPORT 2.pdf.

1.2 Phase III study

Based on the learnings derived from the above studies and the effectiveness of such work in policy making and programme development, the study was further expanded to 13new clusters covering North and Eastern India and also two clusters in the West and South that were not covered in the earlier Phases. The clusters covered in the Phase III study are Jaipur-Pilani, Mohali-Chandigarh, Shimla-Palampur-Solan-Jammu, Delhi-NCR, Karnal-Rohtak, Dehradun-Roorkee, Lucknow-Kanpur,Allahabad-Varanasi, Kolkata-Kalyani-Kharagpur, Guwahati-Shillong-Tezpur, Sikkim, Panaji-Goa and Mangalore-Manipal.

The study was designed to not only map the life sciences knowledge and innovation capacity of the 13 clusters and provide IP services to the innovators in the clusters, but to also undertake a set of entrepreneurship development activities that are specifically tailored towards emerging and promising clusters of innovation. Moreover, while the earlier studies focused on innovation in the biopharma and medical technology sectors, given the industry mix in the selected clusters, agriculture, environment and industrial biotech sectors were included as part of the study. The study was planned from November 2018 to October 2020, but was extended till February 28, 2021 due to disruptions caused by the COVID-19 pandemic.

1.3 Innovation Cluster as the unit of study

A cluster (Porter, 1998) is a geographic concentration of competing and cooperating companies, suppliers, service providers, and associated institutions.

Clusters grow based on their ability to provide a conducive environment to support an innovation and entrepreneurship culture, and may or may not coincide with administrative/state boundaries. While the drivers of agglomeration are not fully understood, the factors that are found to capture the innovation maturity status well include, local government policies and support, human capital and R&D capacity, innovation infrastructure, investment climate, innovation culture, collaboration among various innovation stakeholders and technology transfer and commercialization. These factors are interlinked and success of a cluster lies in its ability to spur continuous innovation; develop entrepreneurship systems that contribute to the growth of regional economies and provide employment. Thus, analysis of innovation clusters as the unit of study is expected to provide BIRAC insightful data on the local network effects and help evaluate the innovation capacity and maturity of various clusters and plan specific programmes /schemes that would enhance their innovation performance.

1.4 Innovation mapping framework

The growth and expansion of each cluster was evaluated using several direct and indirect indicators for research, technology and innovation. The framework adopted in Phases I and II considered four stakeholders - academia, industry, government and enablers. Each of these stakeholders either interact directly or indirectly through other stakeholders. The primary aim was to understand the knowledge generation and innovation capacity and interaction between various stakeholders in the clusters. Intellectual Property generation was taken as an indicator of innovation capacity, and the performance of the clusters were not explicitly measured.

The innovation frame work employed in the earlier studies was refined in the present study to include input and output innovation indicators. This framework was adapted from the Global Innovation Index (GII) framework developed by Cornell University, INSEAD and the World Intellectual Property Organisation (WIPO) (GII Report, 2020) which is widely accepted. The GII 2020 edition provided Global Innovation Index ranking for131 countries globally based on the Innovation Input and Output sub-indices. The Innovation Input Sub-Indexhas five Input Pillars and associated Innovation Indicators that capture the elements that enable innovative activities in a country/ economy, thus measuring the Innovation capacity. The Innovation Output Sub-Index is based on two Output Innovation Pillars and associated Indicators, signifying innovation creation and diffusion that are a result of the innovation activities within an economy. NITI Aayog, Government of India, has also adopted a similar framework for India Innovation Index ranking of the states[3].

The Innovation Pillars for the Innovation Input and Output sub-indices used in this study have been selected to suit the innovation attributes of life sciences clusters and the objective of the study, which is to understand the depth and

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[1] *Porter Michael E. (1998).Cluster and the New Economics of Competition,Harvard Business Review, November - December 1998*

[2] *Dutta S, Lanvin B, Wunsch-Vincent S. Ed. (2020). Appendix 1. The Global Innovation Index (GII) Conceptual Framework. Global Innovation Index 2020: Who will Finance Innovation? (13th ed., p 203). Cornell SC Johnson College of Business, INSEAD, WIPO; retrieved from https://www.globalinnovationindex.org/userfiles/file/reportpdf/GII_2020_Full_body_R_58.pdf*

[3] *http://niti.gov.in/sites/default/files/2021-01/IndiaInnovationReport2020Book.pdf*

vibrancy of the clusters and grade them as Established, Emerging and Promising clusters. The clusters have not been ranked and normalization with respect to population or State GDP or any other parameter was not attempted.

Fig 1.1 depicts the Innovation Mapping Framework with five Innovation Input Sub-Index Pillars with 16 Innovation Indicators forming the Innovation Input Sub-Index and two Innovation Output Sub-Index Pillars with six associated Innovation Indicators forming the Innovation Output Sub-Index. The indicators in peach colour boxes depict those that were collated from available secondary data sources while those in grey boxes are more qualitative, and in the absence of official data, were derived from interviews with KOLs.

Innovation Input Sub-Index					Innovation Output-Sub-Index	
Innovation Input Pillars					Innovation Output Pillars	
Human Capital & Research Capacity	**State Government Support**	**Innovation Infrastructure and Support**	**Investment Climate**	**Innovation Culture**	**IP Generation**	**Technology Commercialization**
Academic, R&D Institution, Business School, Medical College	Start-up Policy and other schemes	Incubators	Funding agencies	Innovation driven companies	Patents and other IP from institutions	No. of Startups
Scientists	Government support	IP firms and IP Support	Availability of Funding	Availability of skilled HR /Talent		Industry patents
Publication, Citation		Mentors, regulatory support		Start-up culture		Technology Transfer & Commercialization
Scientific Collaboration		Collaboration platforms and networks				
R&D Strength						

Figure 1.1: Innovation Framework used in the study

1.5 Study methodology and report structure

Analysis of these Innovation Input and Output Pillars with the associated Indicators for a cluster provide a good understanding of the Innovation Capacity and Innovation Performance of the cluster respectively and where the gaps lie. Based on the strength of the major Input and Output Pillars/ Indicators the clusters were categorised and grouped into Established, Emerging and Promising clusters for those Indicators and then the results were consolidated.

The 1st Innovation Input Pillar, Human Capital & Research Capacity is a crucial input parameter for knowledge and talent generation and technical mentorship within a cluster, and being central to cluster innovation capacity, was studied in considerable detail (refer *Chapter 2.Mapping Human Capital and Research Capacity).* The analysis focussed on four innovation indicators, namely, the number of institutions of higher learning, scientists, publications, citation and scientific collaborations. The clusters were categorised based the strength of their scientific talent and publication, that is Research Capacity (RC) and grouped as Established, Emerging and Promising RC clusters. The 5th Indicator, R&D Strength, was derived from KOL interviews.

The 2nd Innovation Input Pillar is the State Government Support. The local government plays a crucial role in catalysing innovation through policies and regulation. In a growing ecosystem the government also plays a crucial role in funding innovation, support in development of ecosystem through infrastructure like science parks, incubators and accelerators. Innovation Culture is also an important factor that enables innovation activities in a cluster and the report has tried to capture the same through parameters like number of innovation driven companies, availability of talent for industry to hire and the start-up and business culture.

The innovation indicators derived from secondary data sources for the four Innovation Input Pillars, State Government Support, Innovation Infrastructure and Support, Investment Climate and Innovation Culture were mapped for the 13 clusters in *Chapter 3. Mapping Innovation Support Indicators*. The clusters were categorised based the strength of their Innovation Support (IS) and grouped as Established, Emerging and Promising IS clusters.

The two Innovation Output Pillars are IP Generation, with patents and other IP as the Indicator, and Technology Commercialization, with number of startups and Patents filed by industry as the quantitative indicators and Tech Transfer as a qualitative measure derived from KOL interviews. The patent landscape of innovators, startups and companies in the clusters were studied in considerable detail (refer *Chapter 4. Analysis of Patent Data*).The clusters were categorised based the strength of their patents, that is Patent Performance (PP) and grouped as Established, Emerging and Promising PP clusters.

As mentioned earlier, Key Opinion Leaders provided valuable inputs for mapping some of the innovation indicators. KOLs were selected from four major stakeholders in each cluster, namely, academia, industry, government and enablers. These stakeholders are interconnected and are collectively responsible for technological advancement. The interviews focussed on the following Indicators across the five Input Pillars, R&D strength, Government support as an enabler, Innovation support, including IP support, mentorship and regulatory support, collaborative platforms, Innovation Climate depicting the availability of funding, and Innovation Culture, including availability of skilled HR/talent and start-up and business culture. Tech transfer & Commercialization was captured to represent the Output Pillar as a measure of performance.

The above Pillars were collated from the KOL interviews and deployed to create innovation maps to visualise the innovation dynamics and the innovation status of the clusters (refer *Chapter 5. Analysis of KOL Interviews*). From this analysis the clusters were categorised based the strength of their Innovation Ecosystem (IE) and grouped as Established, Emerging and Promising IE clusters.

1.6 Entrepreneurship development activities

It was evident that clusters can be categorised as **Established, Emerging** and **Promising clusters** based on the stage of maturity of the Innovation Indicators mentioned above. The gaps observed in the entrepreneurship ecosystem in Established versus Emerging and Promising clusters were lack of exposure, networking opportunities and peer to peer learning.

Therefore, apart from mapping the clusters based on analysis of secondary data of a set of innovation indicators and KOL interviews, a major focus of Phase III was on designing specific interactive entrepreneurship development programmes for the emerging and promising clusters under study.

Thirteen clusters were selected for Phase III with 12 falling in the category of either emerging or promising clusters. The following activities were launched and executed across these clusters:

- ***Innovator Forums:*** It has been found that life science innovators generally do not participate in start-up forums even if these are present in their cities and several innovators even from established clusters have expressed the need for focussed discussion platforms addressing their industry/sector specific issues. Under BRIC Phase III "Open Dialogues" was launched. Open Dialogues is a platform that is being set up for life sciences startups and Innovators to network with peers and leaders. IKP's role was to identify local champions and trigger formation of these forums. These were expected to be driven and taken forward by the community. Over a period of time these Innovator Forums could turn into Life Science Startup Forums.

- ***Workshops:*** These are an extension of networking meeting with structured talks from experts on various aspects.
- ***Idea Expositions:*** These events are similar to hackathons where innovators propose ideas around particular themes and work over a two-day period to refine their ideas with the advice of mentors. This is to enable a pre-incubation experience and learn the process of need identification and develop business cases. Idea Expositions were organised at individual cluster level or involving innovators from nearby clusters depending on the enthusiasm of innovators and capacity to generate good ideas. The expected outcome was to encourage innovators to think of entrepreneurship path and build a pipeline of incubatees from emerging and promising clusters.
- ***Innovator Exposure Stipends:*** Innovators from emerging and promising clusters often do not have access to good mentors, peers and sophisticated laboratory facilities and lack exposure that innovators and entrepreneurs in larger cities enjoy. Conferences provide only generic view of issues. Winners of the Idea Expositions were given grants to travel and interact with mentors and peers in established clusters to fine-tune their ideas, attend workshops, undertake patentability search or any other activity that would help them further their innovation and business plan. They would typically be linked to an established incubator, mentor or a research organisation of their choice.

A detailed analysis of the above activities has been covered in *Chapter 6. Cluster Development Activities*.

1.7 Conclusion

Analysis of the cluster categories based on Research Capacity, Innovation Support, Patent Performance and Innovation Ecosystem brought out the strengths and weaknesses of the clusters. For an overall comparative analysis of the 13 clusters, the two parameters, Innovation Capacity (Innovation Input Sub-Index) and Innovation Performance(Innovation Output Sub-Index) of all the clusters were examined. The "Institutions" Indicator in "Human Capital and Research Capacity" Pillar was split into 4 types of institutions, the presence of each of which in a cluster is critical for life sciences innovation. Then the 19 Input Indicators were mapped across all the clusters to arrive at an understanding of the Innovation Capacity of each cluster and where the gaps lay. The seven Innovation Pillars (five Input and two Output Pillars) across all the 13 clusters were then represented as a heat map to indicate how the Output Innovation Pillars performed vis à vis the Input Pillars.

The learnings from the above chapters were analysed and summarised as a set of observations and recommendations for BIRAC to consider (refer *Chapter 7. Cluster Performance Analysis and Recommendations*).

Chapter 2

Mapping Human Capital & Research Capacity

2.1 Introduction

Human Capital & Research Capacity, which forms the first Input Innovation Pillar, is the most defining and critical input parameter for assessing the innovation capacity of a cluster. The scientific talent in a cluster and its capacity for knowledge generation was measured through four innovation indicators, namely, the number of institutions of higher learning in a cluster, scientists, publications and citation, and scientific collaborations. This chapter analysed the available data on the four parameters. Analysis of publications from the 13 clusters under study was performed for the period of 20 years (2000-2020) using the Derwent Database.

2.2 Mapping Institutions

Academia plays the central role in conducting fundamental science as well as translational research. In this study, academia is sub-categorized into three categories, academic organisations, research institutes and medical schools/hospitals. An **Academic Organisation** is defined as Nationally or Internationally recognized establishment of professional scholars and students - usually a college, technical institute, university or deemed university engaged in higher education and research. A **Research Institute** is an establishment endowed for doing research. A research institute may specialize in basic research or may be oriented to applied research and **Medical School/Hospital** is defined as a tertiary educational institution or part of such an institution that teaches medicine and awards a professional degree for physicians and surgeons. Figure 2.1 depicts the distribution of life science based academic organisations, research institutions and medical college/hospitals in the 13 clusters.

The Delhi cluster, which included the National Capital Region (NCR), far outweighed the other clusters in terms of the total number of academic organisations, research institutes as well as medical colleges. Besides having a much larger number of institutions of higher learning, the Delhi cluster also hosted several esteemed institutions that were globally acclaimed for their research and quality human resource output. These institutions, such as IIT Delhi, AIIMS, IARI, CSIR-IGIB, and NSIT have established themselves as one of the best in the country. In addition to Delhi, Lucknow was the other cluster with 100+ academic organisations. However, its number of research institutes and medical schools/hospitals was not comparable with Delhi. Jaipur was placed after Lucknow due to its large number of academic organisations. Institutes such as BITS Pilani and MNIT from the Jaipur cluster were among the top technical institutes in India. The Kolkata cluster scored at par with Lucknow with respect to research institutes, and medical schools/hospitals but lagged way behind in terms of academic organisations. This could be explained by the fact that a majority of colleges in Kolkata region were affiliated with various Universities while in Delhi NCR, there is a larger number of autonomous institutions. Nonetheless, institutes such as IIT Kharagpur, University of Calcutta and Jadavpur University were among the oldest academic organisations in the country and recognized globally for high quality knowledge creation. Varanasi has been acknowledged for a long time for its academic excellence but it trailed significantly in research institutions and medical hospitals. However, Banaras Hindu University (BHU), IIT-BHU, and Motilal Nehru National Institute of Technology (MNNIT), Allahabad were the renowned academic organisations in life sciences from this cluster. The Chandigarh cluster, which included Chandigarh and Mohali regions, had established institutions such as Panjab University where skilled personnel was produced in the fields of biotechnology, chemical engineering and food processing to meet the industry demands in the region. However, the number of such institutions is fewer in this cluster. In Guwahati, Goa, and Mangalore clusters, some of the significant academic institutions included IIT Guwahati and NIT Meghalaya, BITS Pilani Goa Campus and NIT Goa, and Manipal University, respectively. In the Roorkee cluster, comprising Roorkee and Dehradun, IIT Roorkee and DIT University were the two prominent academic institutions. Medical schools/hospitals that led the healthcare research have a vital role in the development of an ecosystem for healthcare management, health protection, and preventive medicine. Figure 2.1 summarizes the number of organisations responsible for research activities in a given cluster.

Chandigarh	26	6	6
Delhi	173	35	56
Goa	13	2	4
Guwahati	30	4	3
Jaipur	87	5	16
Jammu-HP	39	4	15
Karnal	40	3	12
Kolkata	47	7	23
Lucknow	114	8	25
Mangalore	19	1	5
Roorkee	35	3	6
Sikkim	12	2	2
Varanasi	55	2	3

Academic Organisations   Research Institutes   Medical Hospital/Schools

Figure 2.1: Distribution of life sciences institutions of higher learning in the 13 clusters.

2.3 Publication Distribution

For the study, top publishing institutes from a cluster were defined as those institutes that fell in the upper quartile of the top 20 institutes from that cluster in terms of the number of publications. Institutes falling below the upper quartile cut-off number of publications by less than 5% were also included in the group of top institutes. The number of publications in a cluster was not uniformly distributed among the institutes which meant that few institutes tend to have a high share of research activities in that cluster. The distribution of the number of publications by research institutes in each of the clusters has been depicted using a box and whisker plot as shown in Figure 2.2. The top institutes with a significantly high number of publications in a given cluster are represented in the graph as coloured dots.

The names of these institutes, having the highest number of publications for their respective clusters, are given in Table 2.1. With this measure, Delhi had seven such top institutes where All India Institute of Medical Sciences (AIIMS) had the maximum number of ~18,000 publications. Similarly, Chandigarh had 5 top institutes where Post Graduate Institute of Medical Education and Research (PGIMER) with ~12,000 publications stood at the first position and far ahead of the rest of the institutes in the region. In Kolkata, the number of publications among top 8 institutes were relatively evenly distributed, even though the total numbers of publications were quite high in its third quartile. Goa, Guwahati and Jammu-HP with 3 top institutes in each cluster and Lucknow with 4 top institutes, followed the same pattern as Kolkata with uniform distribution of publication among the top institutes. Notable outliers in Sikkim and Mangalore clusters were the Sikkim Manipal University (SMU) and Manipal University (MU), respectively. Banaras Hindu University (BHU), Indian Institute of Technology BHU (IIT-BHU), and University of Allahabad (AU) were the top institutes in the Varanasi cluster. In Roorkee cluster, IIT Roorkee (IITR) was the single out performer while other institutes are clubbed together. These top institutes from each of the 13 clusters were selected for further detailed analysis.

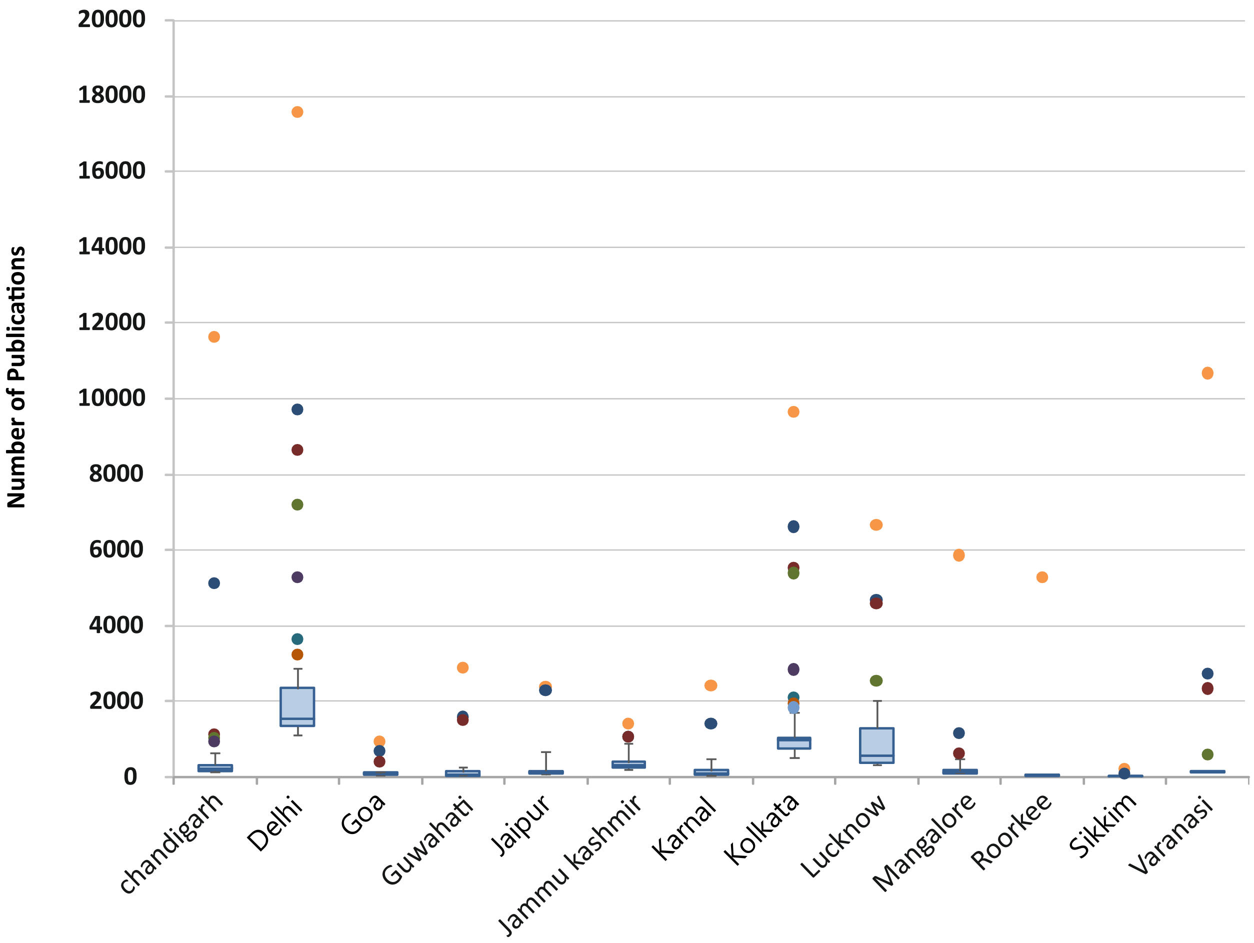


Figure 2.2: A box and whisker plot showing the distribution of publications in the institutes of each of the 13 clusters over the period 2000-2020. The top institutes having significantly high number of publications in a given cluster are represented as coloured dots.

Cluster	Institute	Publications	Cluster	Institute	Publications
Chandigarh	PGIMER	11,641	**Karnal**	NDRI	2,412
	PU	5,125		MDU	1,416
	CSIR-IMT	1,132	**Kolkata**	IIT-KGP	9,641
	NIPER	1,048		JU	6,607
	GMCH	951		IACS	5,528
Delhi	AIIMS	17,574		CU	5,410
	DU	9,691		IICB	2,853
	CSIR	8,635		KU	2,124
	IIT-D	7.207		BI	1,949
	ICAR-IARI	5.291		SINP	1,837
	JNU	3,633	**Lucknow**	IIT-K	6,662
	JHU	3,249		CDRI	4,672
Goa	NIO	929		SGPIMS	4,585
	GU	694		KGMU	2,567
	BITS	406	**Mangalore**	MU	5,854
Guwahati	IIT-G	2,880		MU	1,159
	TU	1,588		NITK	625
	NEHU	1,500	**Roorkee**	IIT-R	5,274
Jaipur	RU	2,387	**Sikkim**	SMU	216
	BITS	2,288		SU	104
Jammu-HP	IIIM	1,400	**Varanasi**	BHU	10,671
	IHBT	1,080		IIT-BHU	2,739
	KU	1,070		AU	2,337
				MNNIT	620

Table 2.1: Top performing institutes from each cluster

2.4 Grouping of Clusters on Research Capacity

The 13 clusters under study were grouped on the basis of their Research Capacity (RC) measured by the Innovation Indicators, number of scientists and publications, of the Input Innovation Pillar 1 using K-means clustering algorithm (Figure 2.3). K-means clustering is a popular technique that is extensively deployed for data cluster analysis. The K-means clustering algorithm splits a given dataset to find groups that have not been explicitly labeled in the data. This can be used to confirm assumptions about what kind of groups exist or to identify unknown groups in complex datasets. The number of publications and the number of scientists were used for grouping these clusters using K-means approach into 3 distinct groups which were further labeled as Established RC cluster, Emerging RC cluster and Promising RC cluster. The analysis presented 3 groups as follows:

Established RC clusters: Delhi and Kolkata

Emerging RC clusters: Chandigarh, Lucknow, and Varanasi

Promising RC clusters: Mangalore, Guwahati, Jaipur, Roorkee, Jammu-HP, Karnal, Goa, and Sikkim

Here, the distance between each cluster belonging to one group represents the difference between their number of publications and scientists. Established RC cluster has two entries, Delhi and Kolkata. Although, Delhi and Kolkatta belong to same RC cluster, the position of Delhi in terms of the number of scientists and publications is higher than Kolkata as reflected by Delhi's placement on the X-Y axis. In the Promising RC cluster, there are eight entries placed nearby that show high similarity among them. However, enteries like Mangalore and Sikkim are distant from one another within the same RC cluster. In the Emerging RC cluster, inter distances among their three enteries are closer and lesser than the Established RC cluster, but greater than the Promising RC cluster.

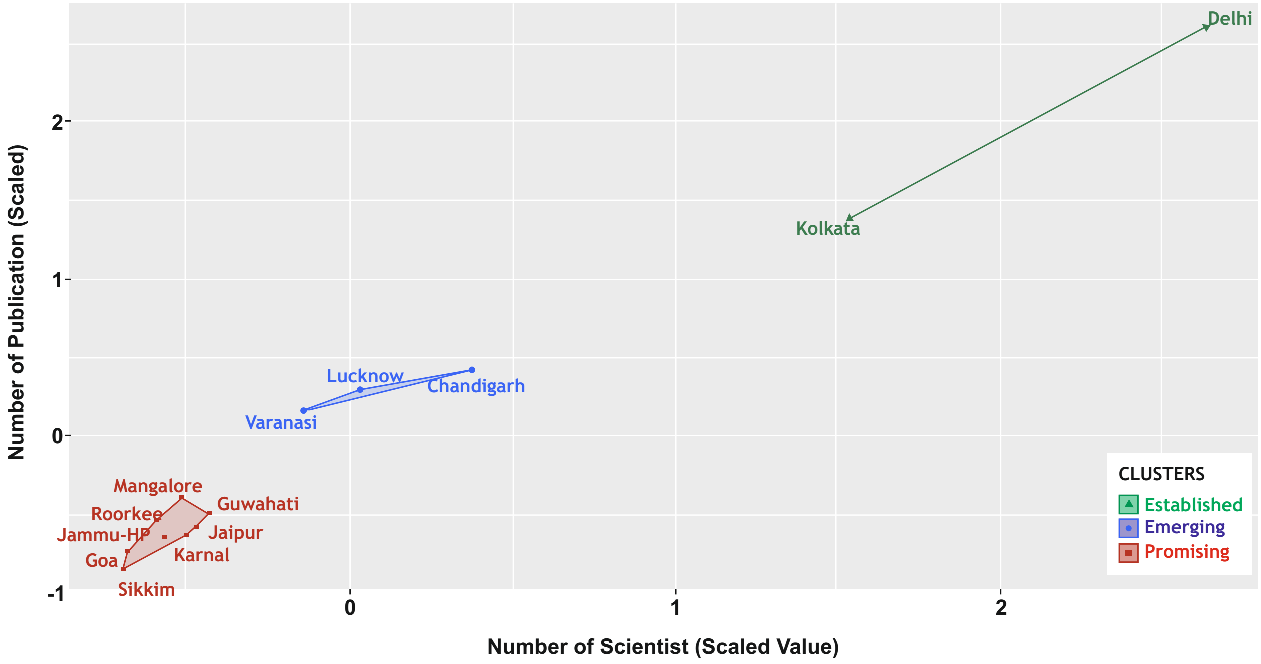


Figure 2.3: Grouping of clusters based on academic input over the 20-year time period of 2000-2020 using K-means clustering algorithm

2.5 Publication Analysis Overview

The publication and citation of 13,510 scientists from 47 institutes across the 13 clusters were selected for analysis. These scientists have produced 216,928 publications which had 2,406,427 citations. Figure 2.4 gives the cumulative output of all 13 clusters considered in the study.

The Delhi cluster produced the most number of publications, 68,160, from 4,706 scientists in the top seven selected institutes in the last 20 years. This was followed by the Kolkata cluster that produced 41,495 publications from 3,178 scientists in its top eight institutes (Figure 2.5). The average citation of publications from Delhi was around 2.4 times higher that of Kolkata. Publications from Varanasi, Lucknow, and Chandigarh clusters between 2000 and 2020 ranged between 19,000 and 25,000. Chandigarh had the highest number of publications as well as scientists among the emerging clusters and the lowest number of citations in the last 20 years. The number of publications per scientist was higher in Varanasi and Lucknow than in Chandigarh for the selected top institutes in these clusters. Guwahati, Jaipur, Jammu-HP, Karnal and Roorkee on an average had around 5,000 publications while Mangalore interestingly produced 10,210 publications despite the relatively lower number of academic and research institutes. It had the highest value of publication to scientist ratio of 31.22. Goa and Roorkee also had a high publication to scientist ratio of 29 and 30 respectively. Other clusters had this ratio between 13-19 showing a decent performance. The Sikkim cluster was fledgling and recorded the lowest number of publications (447) with less citation from 73 scientists, having around six publications per scientist. Citation as an index of the quality of publication has been further analysed in sections 2.7 and 2.8.

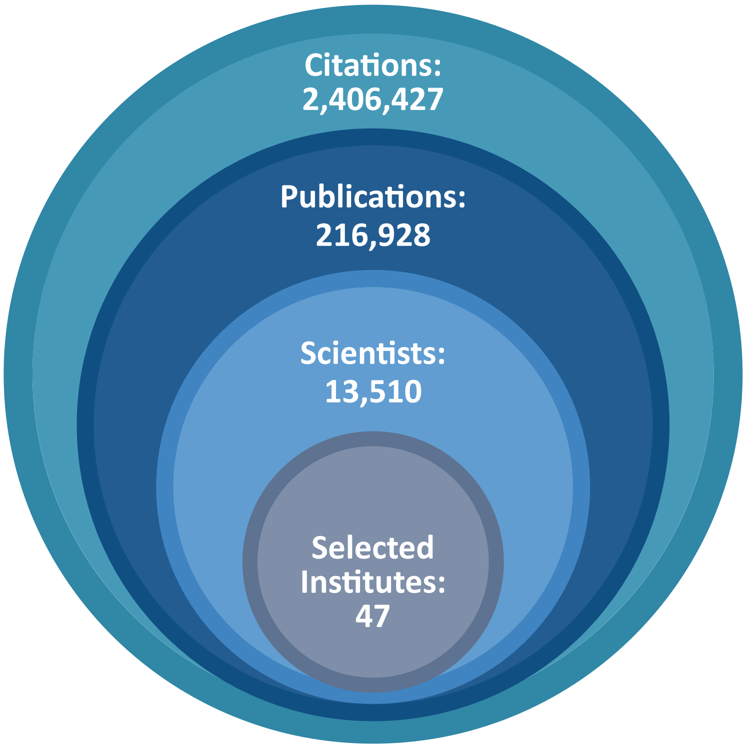


Figure 2.4: Onion chart showing the cumulative number of citations, publications, scientist and institutes for 13 clusters

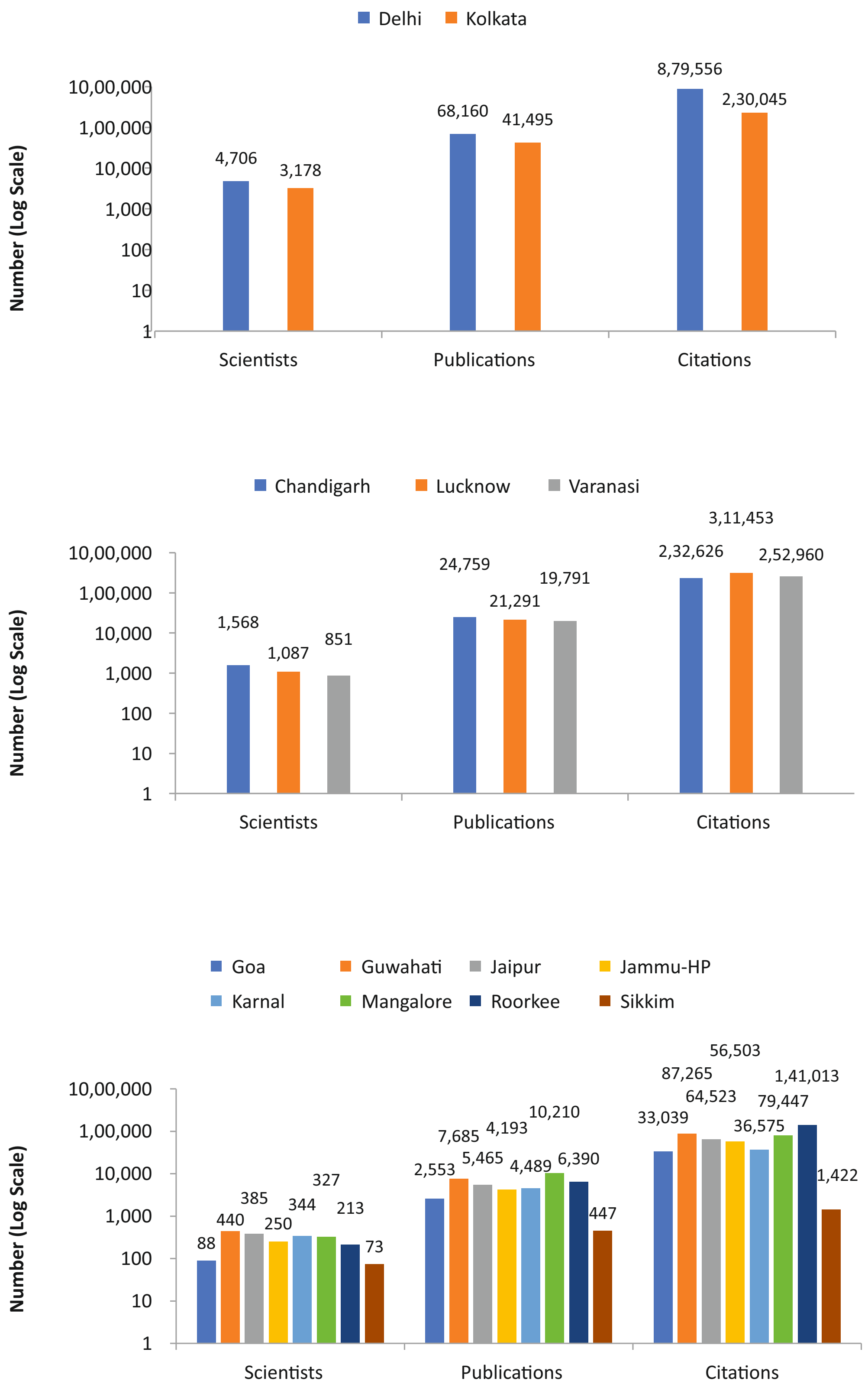


Figure 2.5: Clusterwise number for scientists, publications, and citations from each of the 13 clusters (2000-2020)

2.6 Growth in Number of Publications

Figure 2.6 shows the number of publications from the 13 clusters for each year over the period 2000-20. Over the years, the number of publications grew at a fairly constant rate in each of the clusters barring Delhi, where an exponential growth was observed. In the last three years, the annual number of publications from Delhi cluster has increased whereas the number has declined in other clusters. Among the top institutes, the annual number of publications from AIIMS and CSIR has increased significantly probably indicating a higher allocation of funds for research in these institutes. In Kolkata, the numbers of publications have stagnated over the last 5 years. As a matter of fact, the numbers of publications in Delhi and Kolkata cluster were almost equal in the year 2000, but the growth rate of number of publications in Delhi has been greater than that of Kolkata ever since. The number of publications from Kolkata cluster in 2020 is lower than the number of publications in 2019. This decline, despite Kolkata cluster having the greatest number of top institutes, is due to a drop in the number of publications from IIT Kharagpur by more than 130 publications. The number of publications in the year 2020 also dropped in Bose Institute, Jadavpur University, IACS, CSIR-IICB, and SINP. Could it be an impact of the pandemic and the numbers will pick up again soon?

The growth rate in the number of publications has been fairly similar for Chandigarh and Varanasi clusters over the time period of study. It must be noted that there has been a higher rate of growth in the number of publications for Varanasi cluster over the last decade. The number of publications has remained relatively low in Guwahati, Mangalore and Goa clusters. The numbers in Guwahati, Mangalore and Roorkee clusters have largely been dependent on a single or a select few institutes, thus indicating the need for increasing the research capacity in these clusters.

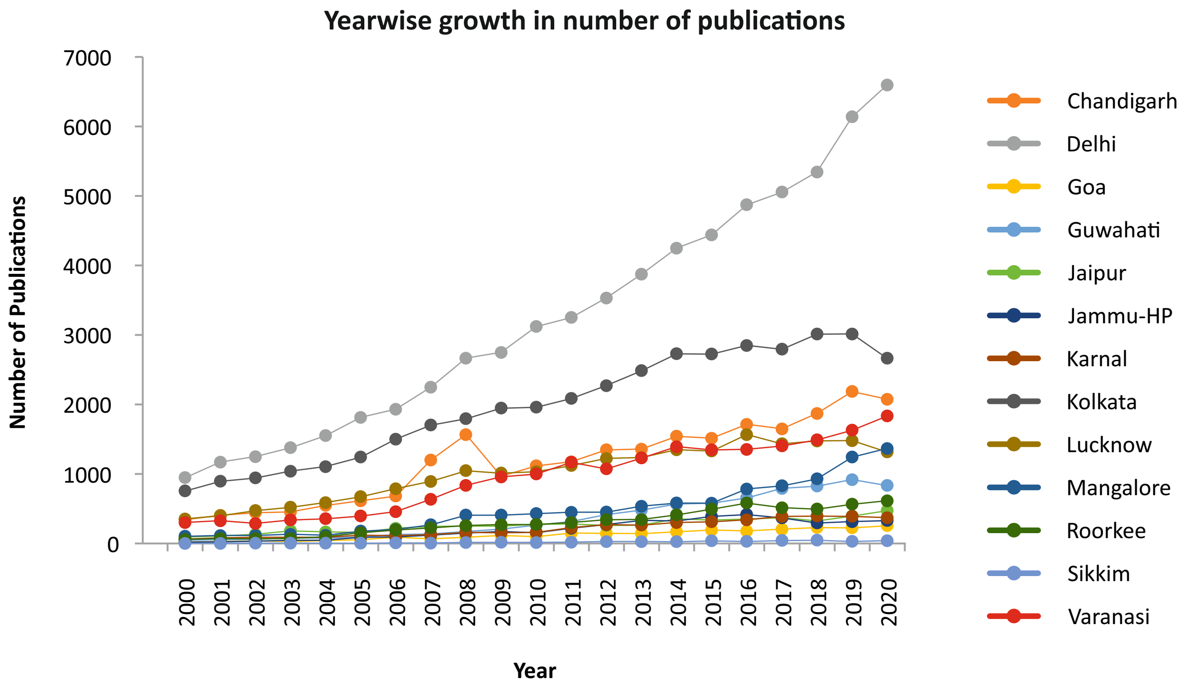


Figure 2.6: Number of publications over the period 2000-20 from 13 clusters

2.7 h-Index: Direct Method for Quality Assessment

The h-index is a metric for evaluating the cumulative impact of scholarly output and performance. It measures the quantity with quality by comparing publications to citations. The h-index corrects for disproportionate weight of highly cited publications or publications that have not yet been cited. According to Hirsch, the h index is defined as: "A scientist/ organisation/ country/ city has index h if h number of papers have at least h citations each."

Among the clusters under study, the Delhi cluster has the maximum h-index of 230 as shown in figure 11 while Kolkata has the next best with a 180 h-index. Both these are categorized in the Established RC cluster group. Chandigarh, Lucknow and Varanasi, members of the Emerging RC cluster have 145, 142, and 141 h-index respectively. Roorkee is a member of the Promising RC cluster group but its h-index of 156 is more than all three members of the Emerging RC cluster. Hence is publication quality is considered Roorkee may also be considered as part of the Emerging RC cluster. Mangalore has the highest number of publications in the Promising RC clusters group but it's h-index 83 is less than Roorkee. Most members of the Promising RC cluster group have h-index between 65-80 except Sikkim. Sikkim has the lowest h-index 28 reflecting the need to improve the quality and quantity of research articles. The citation reported does not have the self-citations so the h-index calculated is the true representative of the quality of the research articles.

The individual h-indices of institutes in each cluster were evaluated. The h-indices for the selected institutes for Delhi cluster are 140 (AIIMS), 114 (CSIR), 130 (DU), 125 (IIT-D), 87 (IARI), 85 (JNU), and 88 (Jamia Hamdard). Among the institutes with h-indices above 100, apart from AIIMS, CSIR, DU, and IIT-D, were PGIMER (105) from Chandigarh cluster, IIT-KGP, IACS (114), and Jadavpur University (104) from Kolkata cluster, IIT-K (118) from Lucknow cluster, IIT-R (156) from Roorkee cluster, and BHU (125) from the Varanasi cluster.

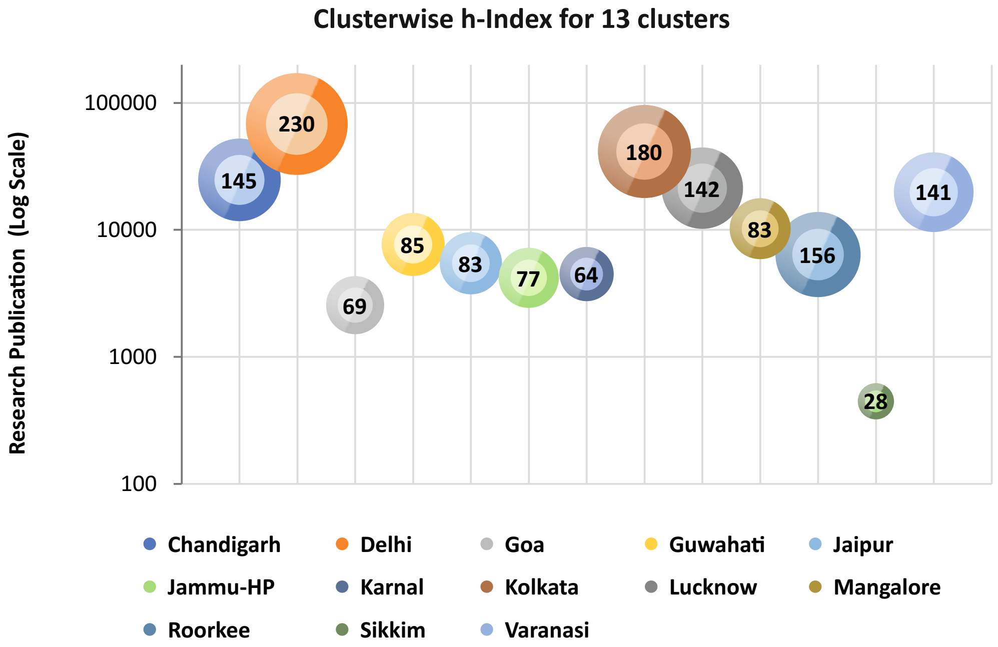


Figure 2.7: h-index score plot for 13 clusters over 2000-2020.

2.8 Average Citation Score

The average citation score is calculated by dividing the total number of citations with number of years the article exists in public domain. Figure 12 shows frequency distribution curves of research articles from the 13 clusters based on average citation score. It is observed that there are certain points on the frequency scale that are having discriminating characteristics. The average citation score with the highest frequency in all the 13 clusters has peak at 10. This showed that most articles are cited between 0-10 times per year. The Established RC clusters Delhi and Kolkata have a high number of publications (25,000 or more) with 0-10 citations per year (Figure 2.8A). However, Delhi has a big leap compared to Kolkata. Delhi also has 8,456 articles that are not cited at all while this number is 2,338 articles for Kolkata.

The number of publications from Emerging RC clusters having 0-10 citations per year is less than that in the Established RC clusters, ranging between 13,000 and 15,000. Here, Lucknow and Chandigarh are overlapping while Varanasi is falling behind these two (Figure 2.8B). The number of publications from Promising RC clusters having 10 citations per year is less than 6,000. Mangalore, Guwahati, and Roorkee are the best performers in this group followed by Jaipur, Jammu-HP, Karnal, Goa and Sikkim (Figure 2.8C). The lowest frequency is that of the Sikkim cluster (213) for the average citation score of 10. It is observed that the average citation for Roorkee for 0-10 range is 4,200 that is lesser than Lucknow, Chandigarh, Varanasi, Mangalore and Guwahati, but its h-index is higher than these clusters. Average citation score might be more influenced by the total number of publication while h-index is the balanced score between the total number of publications and citation.

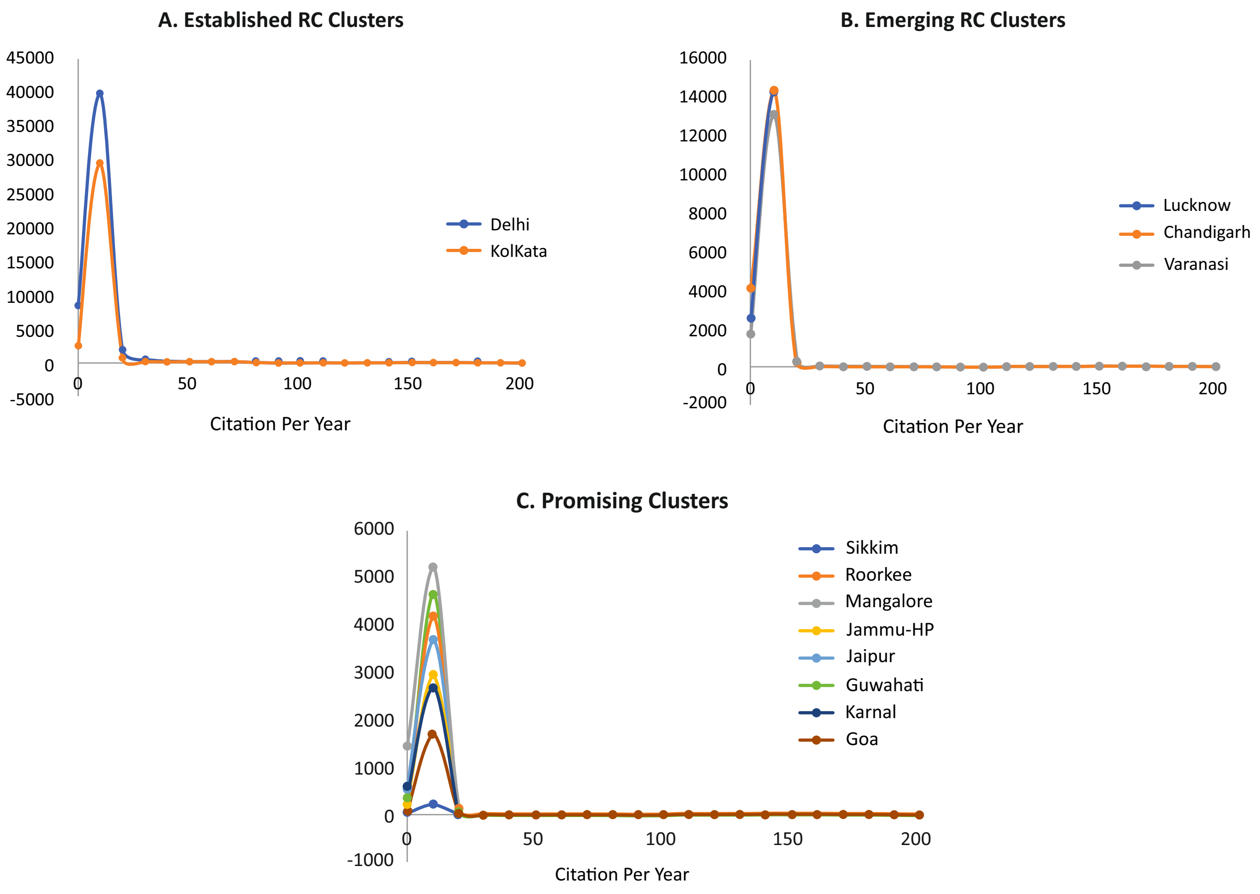
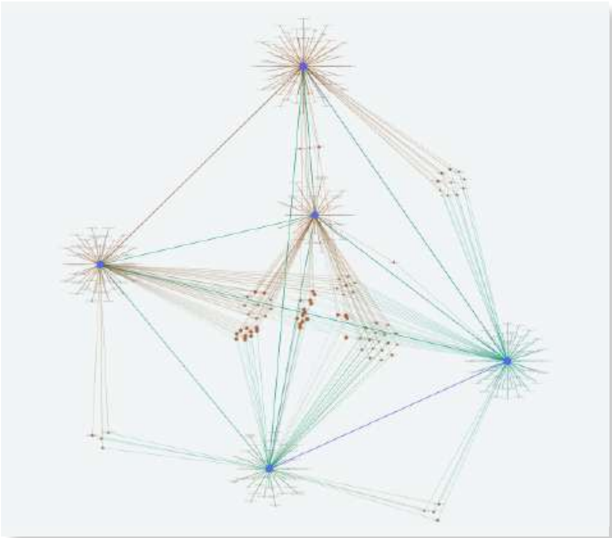


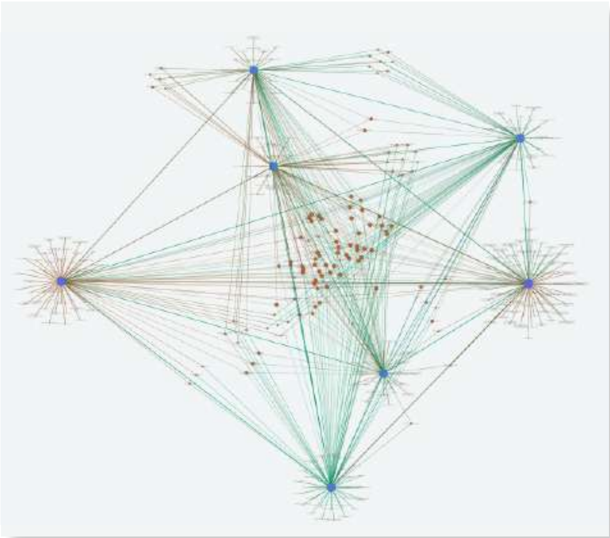
Figure 2.8 A, B, C: Frequency distribution curve of research articles from the 13 clusters based on average citation score.

2.9 Collaboration among Institutes within India

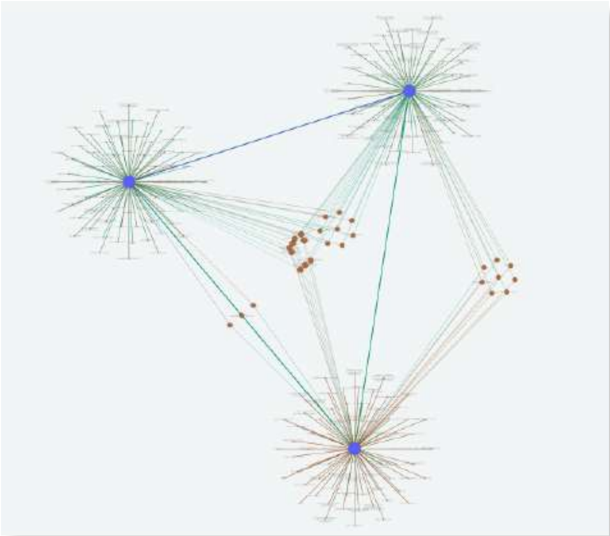
Top 100 collaborators of the selected institutes in each cluster over the last 20 yearswere mapped for both intra-cluster as well as inter-cluster collaborations (Figure 2.8 A-M). The colour of the nodes (institutes) in the graphs indicates the Betweenness centrality, which is a way of detecting the amount of influence a node has over the flow of information in a graph. It is often used to find nodes that serve as a bridge from one part of a graph to another. The blue nodes are the institutes selected for analysis from the clusters, green nodes represent other institutes which influence the cluster, and the brown nodes represent rest of the collaborating institutes. Number of collaborations between the connected institutes were mapped to the colour of the lines, with blue lines representing large number of collaborations, green lines were for moderate number of collaborations and brown lines representing less collaboration.



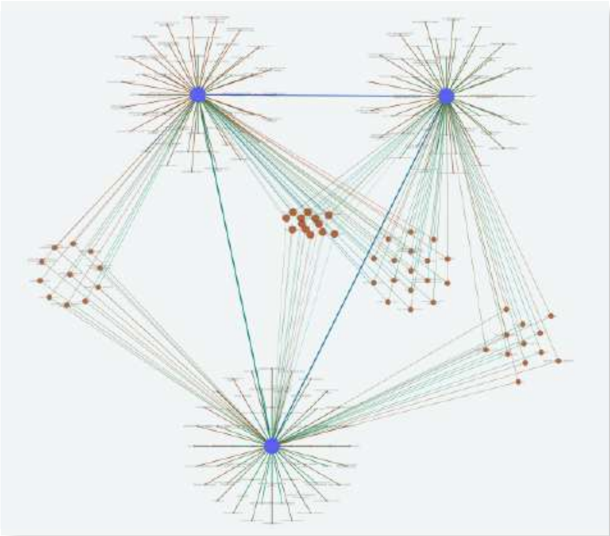
A) Chandigarh Cluster



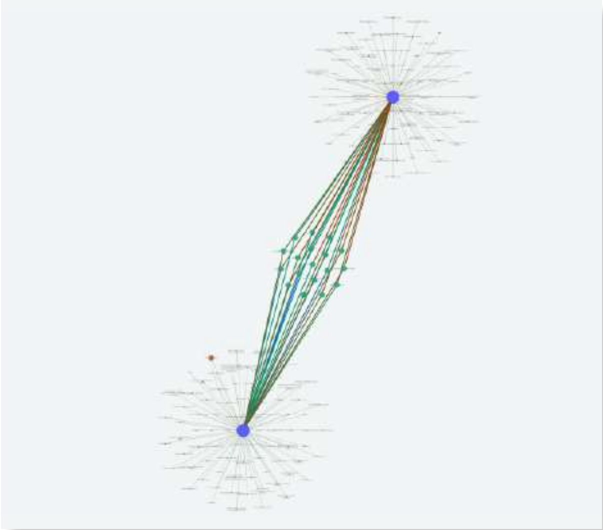
B) Delhi Cluster



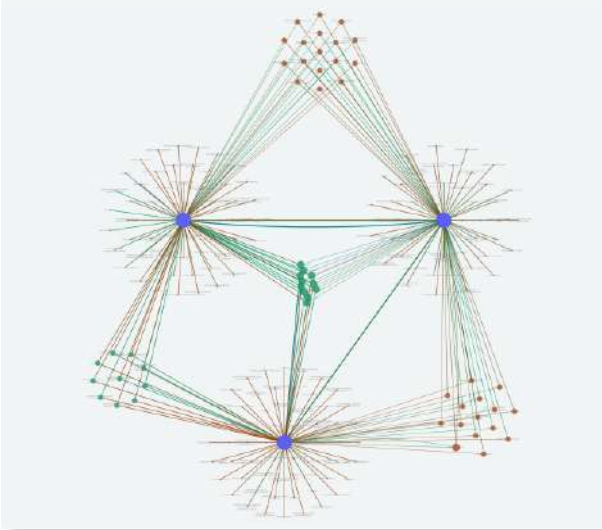
C) Goa Cluster



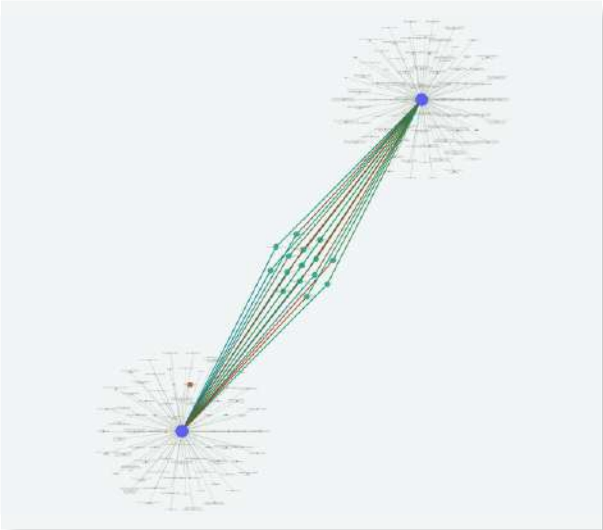
D) Guwahati Cluster



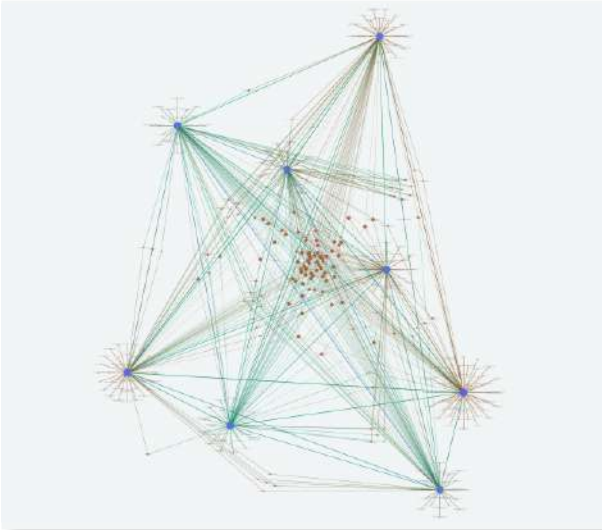
E) Jaipur Cluster



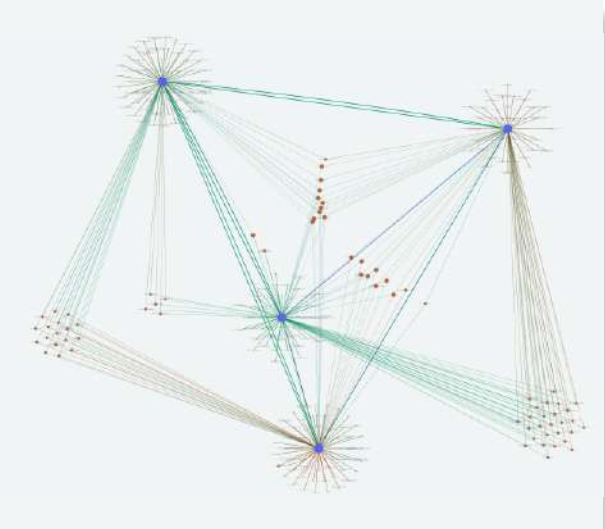
F) Jammu Cluster



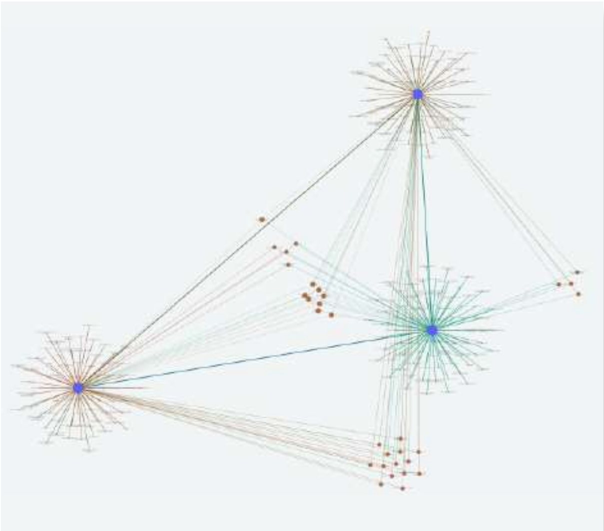
G) Karnal Cluster



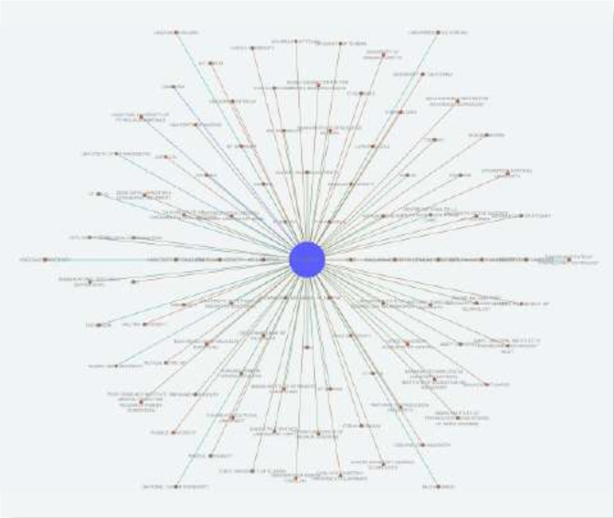
H) Kolkata Cluster



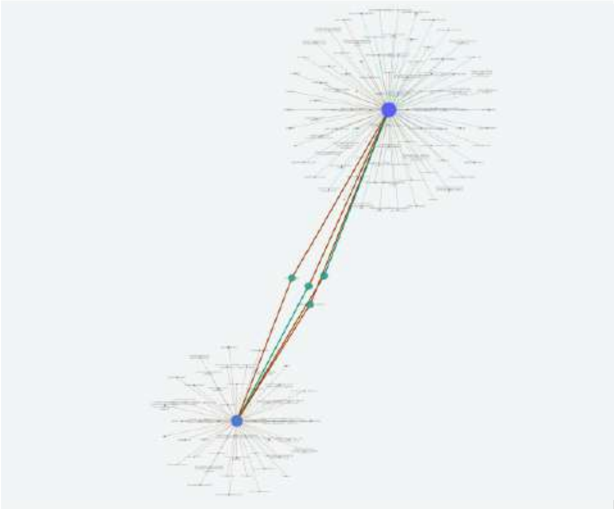
I) Lucknow Cluster



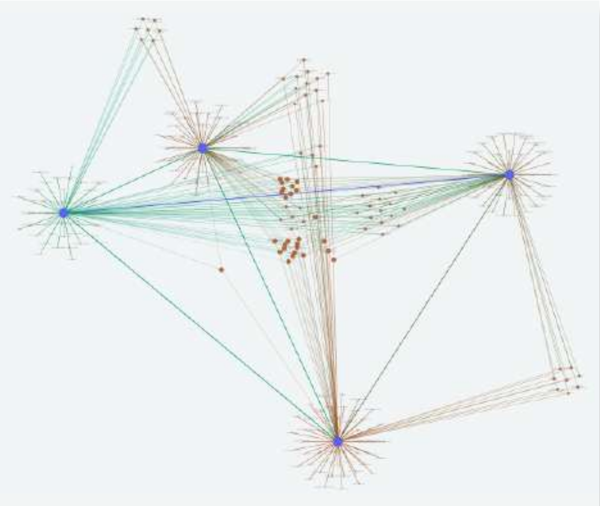
J) Mangalore Cluster



K) Roorkee Cluster



L) Sikkim Cluster



M) Varanasi Cluster

Figure 2.9 A-M: Collaboration maps between the top 100 collaborators of the selected institutes of the cluster over the last 20 years

In Delhi cluster, the greatest number of collaborations was found to be between CSIR and Delhi University. This was followed by collaborations between University College of Medical Sciences (UCMS), Delhi and Delhi University. This implies a high proportion of intra-cluster collaborations in the Delhi cluster. For Chandigarh cluster, collaborations of PGIMER have been the most with Punjab University (PU) followed by collaborations with AIIMS. PGIMER was found to be a highly collaborative institute and had collaborations with a wide range of universities and colleges.

For Kolkata cluster, most collaborations were found to be between Jadavpur University and Calcutta University. This was followed by the collaborations between Jadavpur University and Indian Association for the Cultivation of Science (IACS) Jadavpur, and the collaborations between Jadavpur University and IIT Kharagpur. This indicates that institutes in the Kolkata cluster have mostly collaborated with the institutes of the same cluster. In Guwahati cluster, three of the top five collaborations of the selected institutes were intra-cluster collaborations.

In the Varanasi cluster, the greatest number of collaborations were between BHU and IIT-BHU. Similarly, in Jaipur cluster, University of Rajasthan had a high number of collaborations with Jaipur-based institutes such as, Mohanlal Sukhadia University and Malaviya National Institute of Technology (MNIT) Jaipur. In contrast, Birla Institute of Technology and Science (BITS) Pilani had the maximum number of collaborations with Indian Institute of Chemical Technology (IICT) Hyderabad. In Mangalore cluster, maximum number of collaborations have taken place outside the cluster (such as National Centre for Biological Sciences (NCBS) and Johns Hopkins University) for the selected institutes.

In Lucknow cluster, the maximum number of collaborations were found to be intra-cluster collaborations. Each of the selected institutes in Lucknow cluster was an established institution which may be a cause for higher intra-cluster collaborations in the region. IIT Roorkee, the only selected institute from Roorkee cluster, had maximum collaborations with King Fahd University of Petroleum Minerals, Saudi Arabia, followed by University of Johannesburg, South Africa. The proportion of intra-cluster collaborations was less in the Roorkee cluster. The selected institutes of Jammu cluster were found to have a high proportion of intra-cluster collaborations.

In Goa cluster, the maximum number of collaborations was between Goa University and National Institute of Oceanography, Goa. Yet, a higher percentage of collaborations by the selected institutes were found to be from outside the cluster. In Karnal cluster, National Dairy Research Institute (NDRI) had the maximum collaborations with Indian Veterinary Research Institute (IVRI), Bareilly. Majority of NDRI collaborations were inter-cluster due to lack of other veterinary, animal sciences, or dairy research institutes in the Karnal cluster. Maharishi Dayanand University (MDU), Rohtak had the most number of collaborations with Guru Jambheshwar University of Science Technology, Hisar. Meanwhile Institutes of Sikkim cluster had mostly collaborated with institutes outside the cluster.

2.10 International Collaborations

Figure 2.10 shows the top 5 international collaborators for each cluster over the last 20 years. Scientists from USA stood out as predominant collaborators with scientists from the clusters under study. In Established RC clusters like Delhi and Kolkata, the collaborations were more diverse as compared to other clusters and not dominated by a single country. In most of the Emerging and Promising RC clusters, international collaborations are heavily dominated by USA. For example, in Goa, Jaipur and Lucknow, a high number of international collaborations have been with USA. The government also has several funding schemes for Indo-US collaborative research that makes USA a natural collaborator for India. In all the 13 clusters, most of these collaborations were between Indian origin scientists from abroad. Germany was also among the top 5 international collaborators in every cluster. The scope and significance of the cooperation between German and Indian researchers have increased substantially in the past years. In order to respond to the growing demand for information and assistance in the field of Indo-German scientific collaboration, DFG's India Office was set up in 2006. DFG's main partner agencies in India are the Department of Science and Technology (DST), the Department of Biotechnology (DBT), the Indian National Science Academy (INSA) as well as the research councils under the aegis of the Ministry of Human Resource Development (MHRD). Each cluster also had at least one Asian country among the top 5 international collaborators. Several top institutes such as the IITs also have scholarship programs with foreign institutions which allow Indian students to pursue research abroad. Such programs also add up to international collaborations through published research.

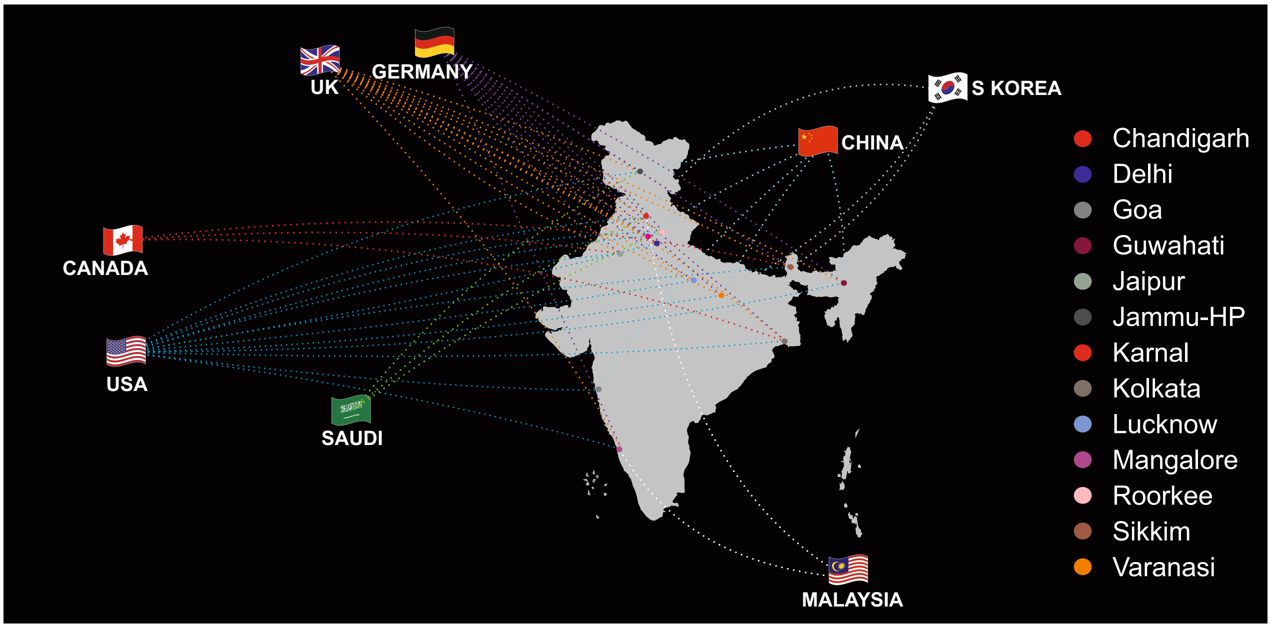


Figure 2.10: Clusterwise top 5 international collaborators

Chapter 3

Mapping Innovation Support Indicators

3.1 Indicators providing innovation support

Apart from Human Capital and Research Capacity, which is a core measure of the innovation capacity of a cluster, it is important to measure the support provided by various stakeholders (e.g., government, incubators, investors, industry, mentors, regulators and IP firms) to the cluster to maintain and grow its capacity to innovate. The Innovation mapping framework adopted in this study considered four Input Innovation Pillars, namely, State Government Support, Innovation Infrastructure and Support, Investment Climate and Innovation Culture, as innovation support pillars. The innovation indicators derived from secondary data sources for these four input pillars have been mapped here. State Government Policies and Schemes available in a cluster was considered as the innovation Indicator for State Government Support for that cluster. Innovation Infrastructure and support provided was measured by the number of Incubators present in each cluster. Investment climate was measured by the availability of start-up capital and grant funding agencies. Innovation culture was measured by the number of innovative companies. Other support indicators, where much data was not available were captured through KOL interviews, survey and meetings.

3.2 Innovation policy of state governments

Twenty-Seven States and Union Territories (UTs) in India have their own notified policy for startups. As of September, 2020, twenty States and two UTs had their own Biotechnology policy. These policy documents supplement the provisions and offerings of the Start-up Policy of the Department for Promotion of Industry and Internal Trade, DPIIT, Govt of India and the Biotechnology Policy of the Department of Biotechnology, Govt. of India. All the 13 clusters in this study are covered by their respective Start-up and/or Biotech Policies.

The Delhi cluster which is the most vibrant innovation cluster in this study was covered under the Incubation Policy of 2016 and the Startup Policy of Delhi, 2019. Delhi does not have a separate Biotechnology Policy. However, with all the central funding agencies and departments in Delhi, this may not have been a requirement.

The Mangalore-Manipal cluster in the State of Karnataka was covered by the Karnataka Biotechnology Policy 2017-2022 and the State Innovation Policy. Karnataka was among the first states to come up with a Biotechnology Policy and has been a leader in promoting life sciences startups through various schemes including setting up incubators and accelerators, promoting student entrepreneurship, launching innovation challenges and hackathons, providing incentives and reimbursements to startups for various expenses like IP filing and instituting a state level seed fund and also a state supported VC fund. While these programmes were not specific to life sciences, the state government provided significant thrust to promote healthcare and life science innovations through these schemes. While the Bangalore cluster received the lion's share of these benefits, the Mangalore-Manipal cluster was also found to be reasonably well attended.

The Jaipur-Pilani cluster in the State of Rajasthan covered by the Innovation Policy as well as the Biotechnology Policy 2015 of the State government of Rajasthan. The state government was found to be very active in promoting innovation and provided good support to the local innovation community. Two notable funds launched by State Government are the Rajasthan Venture Capital Fund (RVCF) and the Bhamashah Techno Fund.

The Karnal-Rohtak cluster in the State of Haryana, Dehradun-Roorkee in Uttarakhand, Lucknow-Kanpur and Allahabad-Varanasi in Uttar Pradesh, Kolkata-Kalyani-Kharagpur in West Bengal and Panaji-Goa in Goa were covered under their respective State Start-up as well as Biotechnology Policies.

The Mohali-Chandigarh cluster was a cross border cluster covering the State of Punjab and the UT of Chandigarh and was governed by the Biotechnology Policy Chandigarh, Innovation Policy, Chandigarh, Punjab Biotechnology Programmes and the and Punjab Industrial and Business Development Policy 2017-22. Similarly, the Shimla-Palampur-Solan-Jammu cluster fell under the administration of the Himachal Pradesh and J&K and covered under the Biotechnology Policy 2014 of HP, Biotechnology Policy 2010 of J&K and the Innovation Policies of the two states. The third cross border cluster in this study was the Guwahati-Shillong-Tezpur cluster falling in the States of Assam and Meghalaya, and came under the Biotechnology Policy 2018-2022 of Assam and its Innovation Policy. The Sikkim cluster comprised the entire State of Sikkim with the Chief Minister's Start-up Scheme and a draft Start-up Policy serving as the guiding documents for supporting innovation.

The Start-up Innovation Policy and the Biotechnology Policy documents of the various states covered similar provisions of setting up incubators and accelerators, promoting student entrepreneurship, launching innovation challenges and hackathons, providing incentives and reimbursements to startups for various expenses like IP filing and instituting a state level seed fund. Although all the clusters have their State Innovation Policy, implementation of the provisions of the policy was found to vary which reflected in some clusters receiving much more support from the government than others. The four clusters that stood out in terms of government support were Delhi, Chandigarh, Jaipur and Mangalore. Mangalore. Goa, Guwahati and Roorkee were found to receive moderate levels of local government support, whereas Jammu-HP, Karnal, Kolkata, Lucknow, Sikkim and Varanasi clusters received inadequate support from the respective state governments.

3.3 Incubators as innovation infrastructure

Technology and innovation advancement is measured both by studying the academia and research infrastructure along with enablers and number of startups present in clusters.

Figure 3.1 illustrates the distribution of Govt funded incubators and startups in the 13 clusters in the domains of healthcare and life sciences, green technology, waste management, and agriculture. Segmentation of these startups is shown as a pie chart for each of the 13 clusters. The startup data shown here is limited to the technology areas of Life sciences, Healthcare, Green Technology, Waste Management and Agriculture.

Delhi is one of the hotspots for biotechnology innovation in India and has the highest number of biotech incubators (23) among the 13 clusters. Also, the state government has launched an incubator policy and funded 11 incubators in the National Capital Territory.

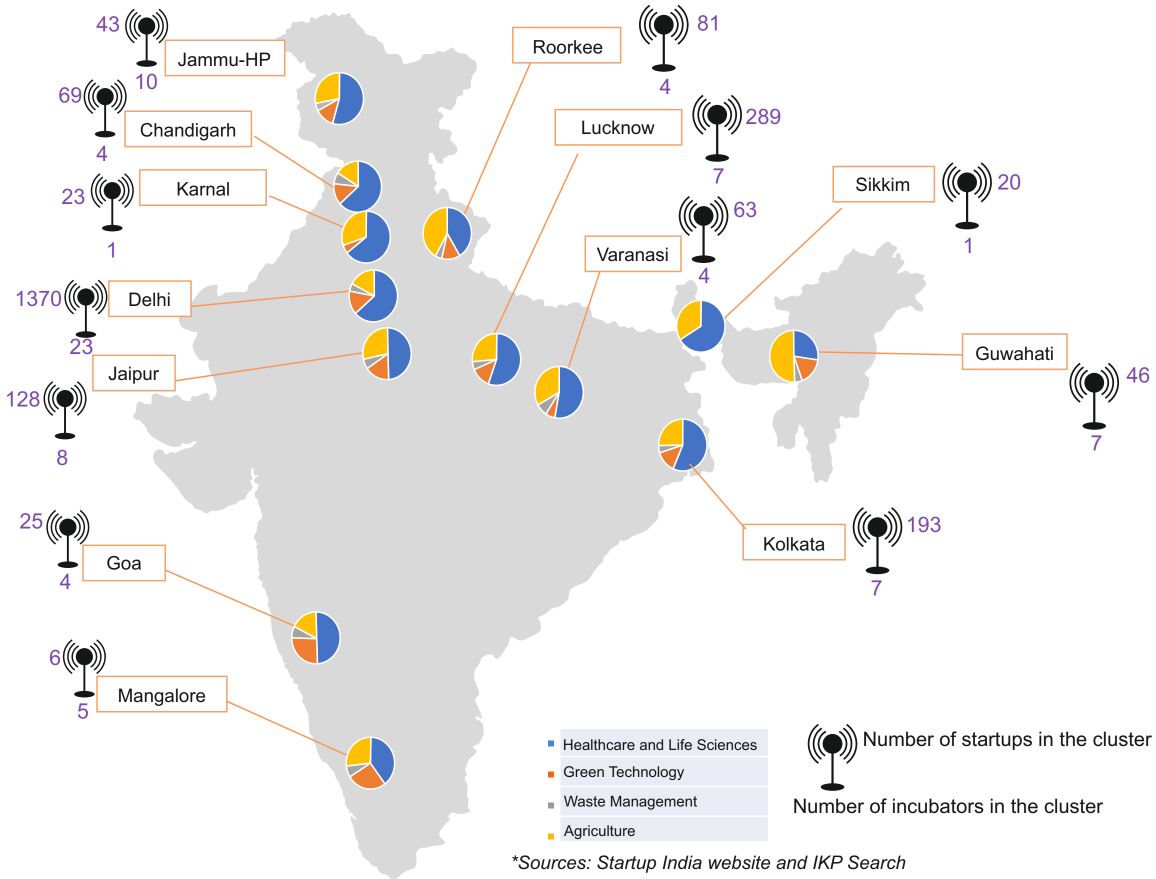


Figure 3.1: A map of India showing the number of startups and the number of incubators in each of the 13 clusters at their geographical locations. Distribution of domains of the startups is given as a pie chart for each of the 13 clusters.

Lucknow, Kolkata, and Guwahati have seven bio-incubators each, but their startups number range from 46 in Guwahati to 289 in Lucknow. The role of incubators is not only to increase the number of startups in the cluster but also for boosting their chances of success by providing financial support and mentorship. In this context, Lucknow (289 startups) and Kolkata (193 startups) need more incubators to improve the survival and growth of their existing startups. These clusters have a high research capacity that further establishes the need for more incubators. Jaipur, with 8 incubators and 128 startups, has set a good example where the government has recently funded four incubators that enhanced its start-up ecosystem. Roorkee also has appreciative numbers of startups (81) with four incubators located at academic institutions such as IIT Roorkee, DIT University, and Graphic Era University Dehradun. Here, Dehradun alone has 70 registered startups. Goa (25) and Mangalore (6) have a fewer number of startups while the number of incubators there, 4 and 5 respectively, are comparable to other clusters. For Goa this indicates the need for boosting the start-up policy implementation to promote innovators. For Mangalore on the other hand, it calls for putting more thrust on promoting bio/healthcare entrepreneurs by implementing the Karnataka start-up and biotech policy. Chandigarh and Varanasi have 60+ startups with 4 incubators that showed a good ratio between enablers and output. Karnal and Sikkim are relatively new in the start-up ecosystem as indicated by their number of incubators but show promising trend in the number of startups.

The Pie charts in figure 3.1 shows that the healthcare and life sciences domains dominated in most clusters followed by agriculture and green technology. Roorkee and Guwahati have agriculture as the largest domain for the startups. These findings reflect on the technological strength of the cluster and could be used to reflect on the policy changes to be made in the cluster. *(Source: DST Centre for Policy Research and IKP search; Start-up India Website)*

3.4 Funding agencies

Life sciences research in India is largely grant funded by the following agencies of the Central Government - the Department of Science & Technology (DST), Department of Biotechnology (DBT), Council of Science and Industrial Research (CSIR), Indian Council of Medical Research (ICMR), Indian Council of Agricultural Research (ICAR) and the University Grants Commission (UGC). BIRAC plays a critical role in funding innovations from idea stage to more mature stage. Various state governments have set up their own seed fund scheme to fund startups and innovators. Private capital as grant, debt and equity are also available in several clusters.

Figure 3.2 shows the percentage of research publications facilitated by the top 5 funding agencies in the last 20 years for each of the Established, Emerging, and Promising clusters. It depicts the role of funding agencies in the 13 clusters, where top 5 funding agencies are selected and shown. DST and CSIR have provided the maximum share of support for research activities in the Delhi cluster in the last 20 years, followed by UGC and DBT. The percentage share of DST-funded research publications is significantly higher in Kolkata cluster (22.82%) than in Delhi cluster (14.97%). This could largely be due to the autonomous DST institution SN Bose NCBS in Kolkata, which is one of the top institutions for this cluster. Kolkata cluster also receives a fair share of funding from CSIR because of the presence of two prominent CSIR institutes in Kolkata and one in Durgapur. Among the Emerging clusters, research in Lucknow is heavily funded by CSIR due to the presence of CSIR-Central Drug Research Institute and three other CSIR laboratories in Lucknow. UGC is the top research facilitator in Varanasi cluster, followed by DST and CSIR. Among the Promising clusters, research in Jammu-HP cluster has been largely supported by CSIR (about 38%) and in Guwahati cluster, it is predominantly funded by DST (about 29%). Mangalore which has the highest number of publications in the Promising cluster group is majorly supported by DBT. Guwahati also has a large percentage of research supported by DST, followed by funding from DBT. Jaipur received minimum support from DBT and thus need more attention. Karnal cluster is dominated by ICAR funding due to NDRI institute. However, the average contribution by ICAR in other clusters is minimal. Overall DST, CSIR and UGC are the biggest contributors followed by DBT.

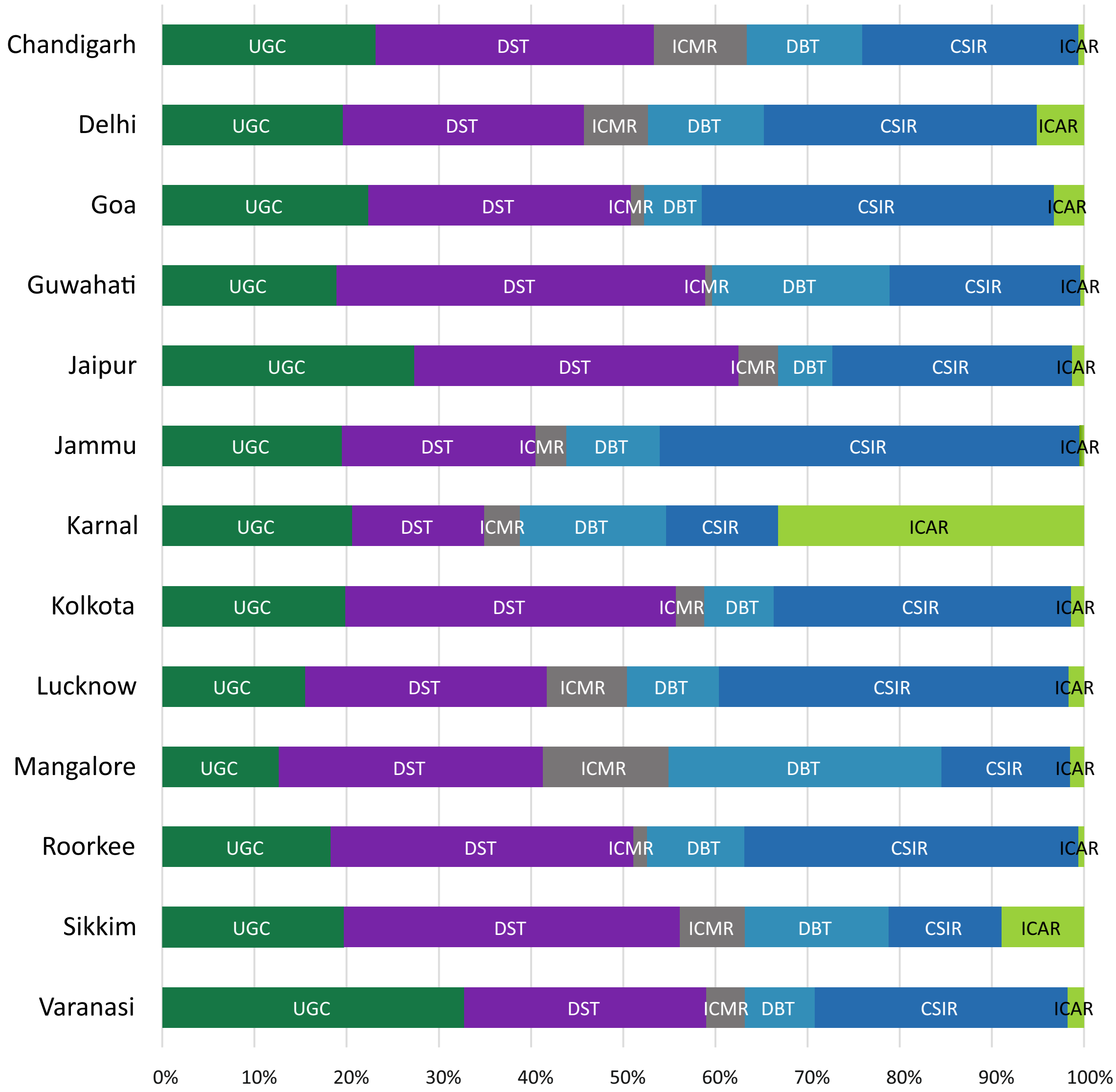


Figure 3.2: Percentage of total research publications facilitated by the top 5 funding agencies in the last 20 years in each of the 13 clusters

BIRAC has been a great support for life sciences innovation in the country since its formation in 2012. BIRAC through its Biotechnology Ignition Grant Scheme (BIG), which is the largest early-stage biotech funding programme in India till date, has received 7367 startups/innovators applications all across India as represented in Figure 3.3. A total of 1659 startups/innovator applications received are from BRIC phase 3 clusters.

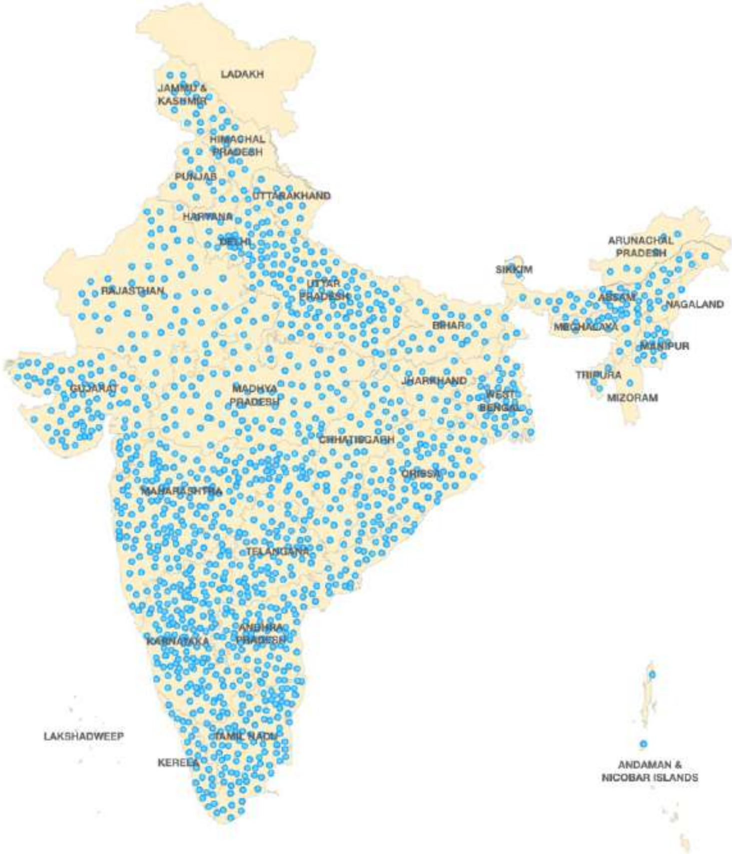


Figure 3.3: Biotechnology Ignition Grant (BIG) Footprint

Several state governments have set up their own seed fund scheme to fund startups and innovators. ELEVATE 100, an annual Idea to POC grant of the Department of Information Technology and Biotechnology, Government of Karnataka provides INR 50 lakhs to 100 selected startups every year across all domains including life sciences. Karnataka also has a Biotech Idea to POC fund. The State-run Venture Capital fund, KITVEN has an INR 50 Cr KITVEN Fund 3 for Biotech startups. Two notable funds launched by State Govt of Rajasthan are the Rajasthan Venture Capital Fund (RVCF) and the Bhamashah Techno Fund. RVCF was established as the state's first venture capital fund under the Rajasthan State Industrial Development and Investment Corporation (RIICO), a Government of Rajasthan undertaking. RIICO is both a fund subscriber and an investor in the fund. Bhamashah Techno Fund is a State launched fund of INR 500 Crore, out of which INR 100 Crore has been specifically earmarked for women entrepreneurs.

In India, there are around 30 Angel Networks, according to Inc42, which have helped startups receive seed fund and then access venture capital. Delhi has two angel networks, the Indian Angel Network and Angel List India. All the three Emerging clusters have their own local angel networks, the Chandigarh Angels Network, Calcutta Angels Network and Rajasthan Angel Innovators' Network (RAIN) in Jaipur and BITS Spark in Pilani.

3.5 Grouping of Clusters on Innovation Support

Innovation Support (IS) being an important measure of the Innovation Capacity of a cluster, the 13 clusters were grouped on the basis of the analysis of the support that the clusters received from the state governments and other agencies.

Based on the information and analysis presented in this chapter, the clusters were categorized into three groups as follows:

Established IS clusters: Delhi, Chandigarh, Jaipur

Emerging IS clusters: Mangalore. Goa, Guwahati and Roorkee

Promising IS clusters: Jammu-HP, Lucknow, Varanasi, Kolkata, Karnal and Sikkim

Chapter 4

Analysis of Patent Data

4.1 Introduction

Intellectual Property, especially patent, is one of the main pillars for measuring the innovation performance of any organisation, region or economy. Patent filing data is an important indicator for estimating innovation and technology outputs and as per the study framework is one of the critical drivers of the Innovation Output Sub-Index. This chapter analyses the patent data from academic and research institutions and industry in the 13 clusters.

4.2 Patent distribution across clusters

The total number of patent applications from the different clusters during the period 2000-2020 is shown in Fig 4.1.

The Delhi cluster recorded the highest number of patent applications published (10,664) during this twenty-year period. This is more than 11 times that of the patent applications published from the Kolkata cluster (917), the second highest among the 13 clusters in terms of patent filed. While the number of research publications between Delhi and Kolkata clusters were comparable as shown in Chapter 2, the difference between the number of patents is significant. Overall, the patent to research publication ratio was found to be highly skewed for all the clusters except Delhi. This points towards the need for IP workshops in these clusters. Creation of IPR cell / Technology Transfer Office (TTO) in academic and R&D institutes is essential to boost and promote the patent filing process. All seven prime institutes of Delhi that were selected in this study have IPR cells/TTOs. IPR cells were found to be present in some institutes in the other clusters, but these were relatively new and would need time to build their patent portfolio. Several institutes, and especially universities still do not have IPR cells and are unable to create awareness about IPR among faculty and students. The two institutions selected for study in the Sikkim cluster do not have IPR cells. BRIC Report 2 had recommended BIRAC to consider setting up regional TTOs to help institutes and incubators in those territories. It is heartening to see that the recommendation has been implemented by BIRAC through the National Biotechnology Mission (NBM) by setting up seven Regional TTOs across India in 2020.

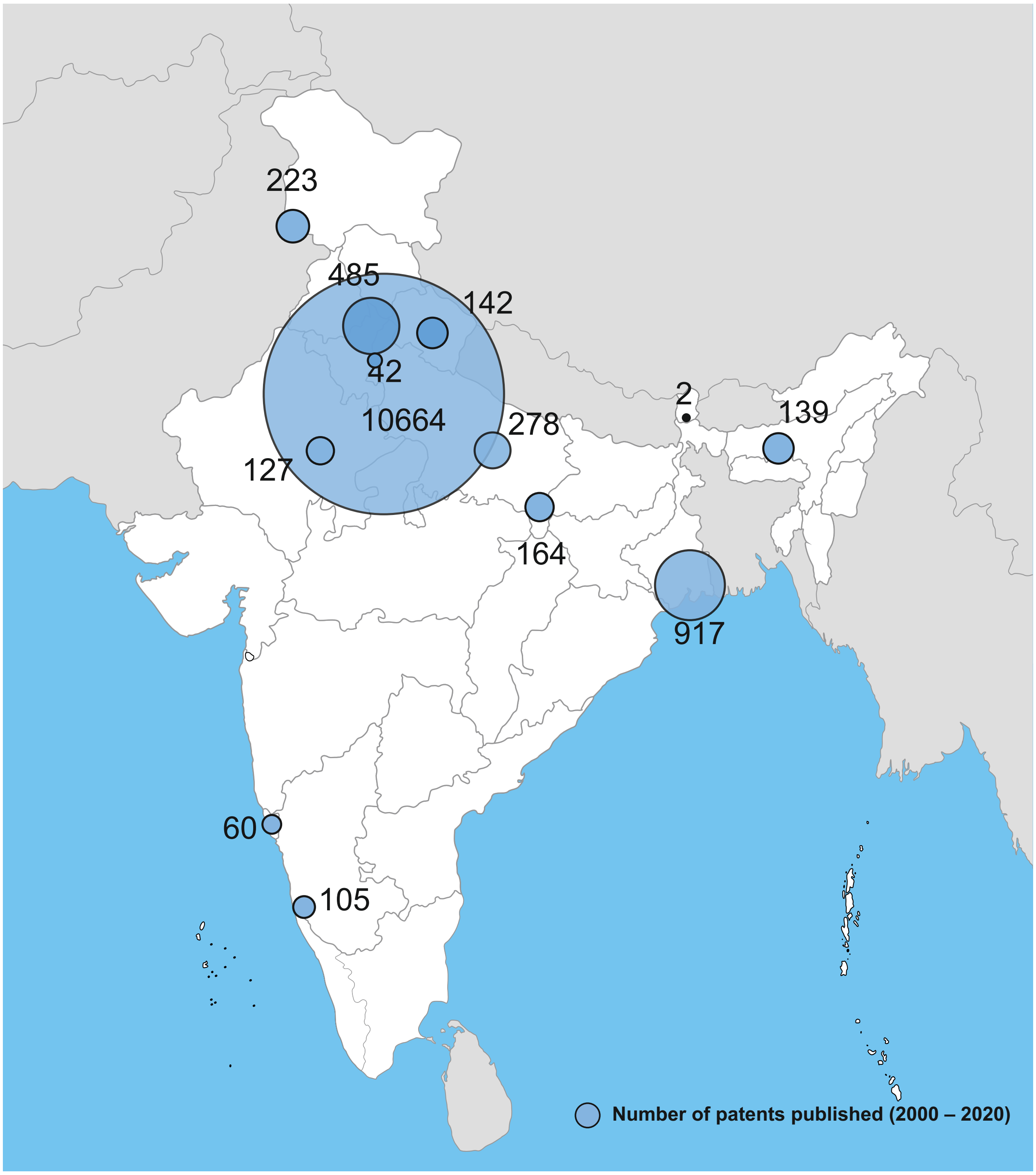


Figure 4.1: Patent distribution across 13 clusters over the period 2000-2020. The size of the bubble is proportional to the number of patents in the cluster. Source: Patseer Database

4.3 Grouping of clusters based on patent published

As was done for research publications and innovation support indicators, clusters were grouped into three categories, Established, Emerging and Promising clusters based on the number of published patents in a cluster during the period 2000 to 2020. Any cluster that published > 2,000 patents in the last 20 years was placed in the Established Patent Performance (PP) cluster category. Clusters that had over 400 but less than 2,000 published patents were grouped in the Emerging PP cluster category and those that published < 400 patents were clubbed in the Promising PP cluster category.

Established PP cluster

Delhi was the only cluster that qualified as an Established cluster in terms of patent filing. The Delhi cluster is a benchmark cluster for this study due to its high number of patents published (10,664 in the time period of 2000-2020), which compared well with other established clusters mapped in the earlier studies e.g., Mumbai, Hyderabad, Bangalore, Chennai and Pune. The Delhi cluster displayed a history of patent filing across the 20 years, with 45.5% patents filed in the last 5 years. It also recorded a high grant percentage of about 28% over the last 20 years (Table 4.1 and Fig 4.2).

Emerging PP clusters

The Emerging category with over 200, but less than 2,000 published patent applications included the Kolkata and Chandigarh clusters (Table 4.1). The Kolkata cluster with 917 published patents over the last 20 years ranked 2nd among the 13 clusters and topped the list of Emerging PP clusters. Around 50% of the patents in the Kolkata cluster were published in the last 5 years signifying a well-entrenched patent system. Only about 15% of the filed patents in the Kolkata cluster were granted over the 20-year period. While the research publications in this cluster compared well with the Delhi cluster, the patent filing as well as the patent grant percentage were much lower which, as discussed above, pointed towards the need for IP services in the research institutions and startups through incubators and TTOs in the region. The total number of patents published by the Chandigarh cluster was 485, with about 95% published in the last 5 years, implying Chandigarh was a relatively new but fast-growing innovation cluster. The grant percentage for the 20-year period for the Chandigarh cluster was 12.47%.

Promising patent clusters

All other clusters with less than 400 published patent applications fell in the Promising PP category. The Lucknow and Jammu-HP clusters, with 278 and 223 published patents respectively over the 20-year period, both had around 74% patents filed in the last 5 years. This signified that both these clusters started performing well and need to be watched as future emerging innovation hotspots. The grant percentage in the Lucknow cluster was impressive at 19.10%, which was close to the Delhi cluster figure and better than the Kolkata cluster performance. The grant conversion ratio for Jammu-HP on the other hand was merely 10.7% (Fig. 4.2). This percentage was expected to improve since a significant number of its patents were published in the last 5 years.

Promising PP clusters with less than 200 patents but over 100 published patents in the last 20 years, included Varanasi, Roorkee, Guwahati, Jaipur and Mangalore. Varanasi cluster topped this list with 164 patents published in this period, followed by Roorkee cluster (142), Guwahati cluster (139), Jaipur cluster (127) and Mangalore cluster (105). The Varanasi cluster, in spite of having well-established research institutions like the Banaras Hindu University (BHU) and IIT-BHU with good research publication, much like the Kolkata cluster, lagged in patent filing compared to the Delhi cluster. This indicates the need for IP awareness. Patents published in the last 5 years in the Varanasi cluster stood at 52% and grant percentage over the 20-year period was 20%. For the Roorkee cluster, the grant percentage for the 20-year period stood at a poor 5.97%. However, more than 76% of the total patents published from this cluster have been published in the last

5 years. For the Guwahati cluster, more than 87% of the total patents published have been published in the last 5 years which indicates that it is a new innovation cluster. The last five years were most productive for Guwahati for publishing the patents but the granting percentage was the lowest in all the 13 clusters (5.30%). Moreover, the grant percentage for the last 5 years had further dropped to 3.48%. For Jaipur and Varanasi clusters, the number of patents published were 127 and 164, respectively. The grant percentage for the 20-year period for both Jaipur and Varanasi clusters was around 20%. In Mangalore cluster, the number of patents published over the last 20 years is 105 and the grant percentage was low (9.38%). The percentage of total patents published in the last 5 years is 85.42%.

Goa, Karnal and Sikkim clusters published less than 100 patents in the last 20 years. A total of 60 patents have been published from the Goa cluster in the last 20 years, out of which, about 34% have been published in the last 5 years. However, it must be noted that this cluster had the highest grant percentage (39.53%) over the last 20 years, which had further improved to 40% in the last 5 years. The number of patents published in the last 20 years from the Karnal cluster was 42. Further, the grant percentage had sharply dropped from 20% for the last 20 years to 5.56% for the last 5 years. About 51% of the total patents published from this cluster have been published in the last 5 years. The Sikkim cluster was a very new cluster characterized by negligible patent filing. A significantly low number of patents filed and published from Sikkim cluster in the last 20 years indicates a need for creating more patent awareness, innovation, and IPR policies in the region.

Group Name	Cluster	Total number of patents published (2000 - 2020)	% of patents published in last 5 years
Established	Delhi	10,664	45.51
Emerging	Kolkata	917	50.06
	Chandigarh	485	**95.15**
Promising	Lucknow	278	73.61
	Jammu-HP	223	74.05
	Varanasi	164	52.21
	Roorkee	142	76.12
	Guwahati	139	**87.12**
	Jaipur	127	66.04
	Mangalore	105	**85.42**
	Goa	60	34.88
	Karnal	42	51.43
	Sikkim	2	50.00

Table 4.1: Classification of clusters into groups based on the number of patents published between 2000 and 2020

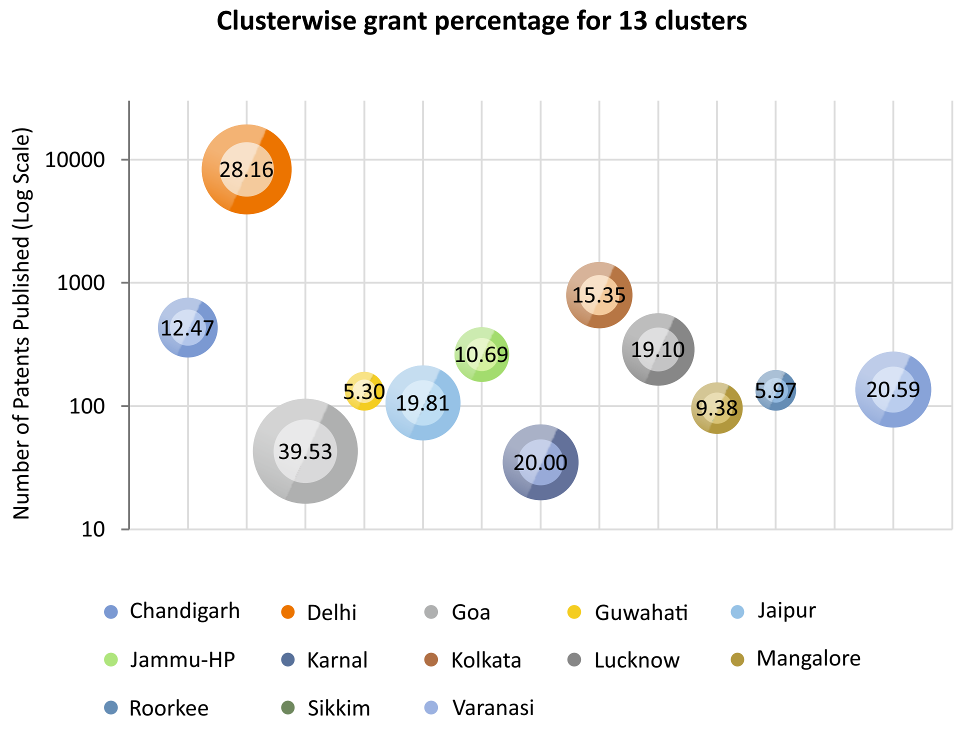


Figure 4.2: Patents published vs granted over the period 2000-2020. The bubble size is proportional to the patent grant % (value denoted inside the bubble).

Most clusters in the Emerging and Promising PP groups were new with respect to patent filing, which was evident by their large percentage of published patents in the last 5 years. Although the grant percentage was small for many of them, it was expected to improve in the coming years. A massive surge in patent publications in Chandigarh, Guwahati, and Mangalore clusters over the last 5 years indicates increasing IP awareness in these regions.

It was noted that over 50% of the total published patent applications in the last 20 years for all 13 clusters combined were in the last five years, It could be said that patenting was taken up seriously only in the last few years. Some of the plausible reasons could be:

- **Lack of awareness:**
  - **Lack of prior art searches:** A filed application may not be granted when a prior art similar to the application was available in public domain. Lack of comprehensive prior art searches before filing may lead to rejection in future.
  - **Access to quality law firms:** Poorly drafted patent applications, particularly the claims, are generally rejected when they lack a concrete strategy. Further, a law firm may mislead the inventors/assignees during the prosecution phase which may further reduce the chances of obtaining a grant.
- **Lack of Funding:**
  - **Abandoning after filing:** A reason for abandoning a patent after filing may be lack of funding or simply lack of TTO office and follow-ups and commercialization.

- **Generally time consuming process:** One of the possible reasons for low conversion is that a request for examination is typically filed after 4 years from the date of filing, unless an early publication is requested. After the request for examination is filed, it takes a few more years for the patent to be granted. It is likely that the patents granted in the 5-year period were filed before 2015.
- **Indiscriminate filing:** Filing patent applications indiscriminately, particularly in larger clusters, may be a reason for high publications and lower grants.

4.4 Analysis of foreign patent filing

The number of foreign filing patents for each cluster was calculated. Figure 4.3 gives a cumulative graph for 20 years of total and foreign filing for all the 13 clusters. The foreign filing number is shown with respect to the total patent filing. Delhi had the maximum number of foreign filings with around 29% patents also filed in one or more foreign territory. Lucknow had 19% of the total patents filed in at least one foreign country. Although Jaipur has around 23% of foreign filing but its total patent published is only 127. Other descent performers in the foreign filing category were Kolkata (15%) and Jammu-HP (17%) with total number of patents at 917 and 223 respectively.

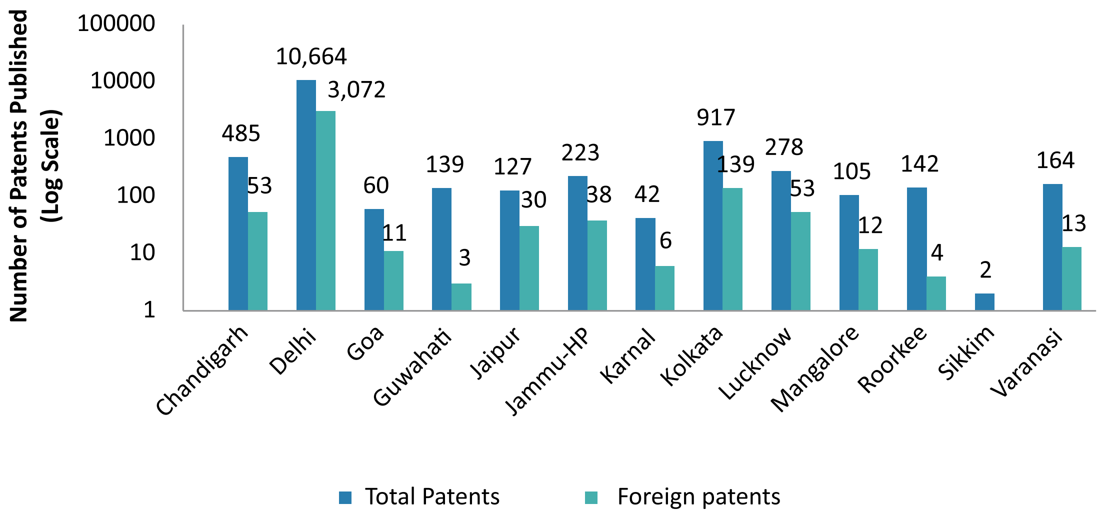


Figure 4.3: Year-wise distribution of patents published and foreign filings between 2000-2020

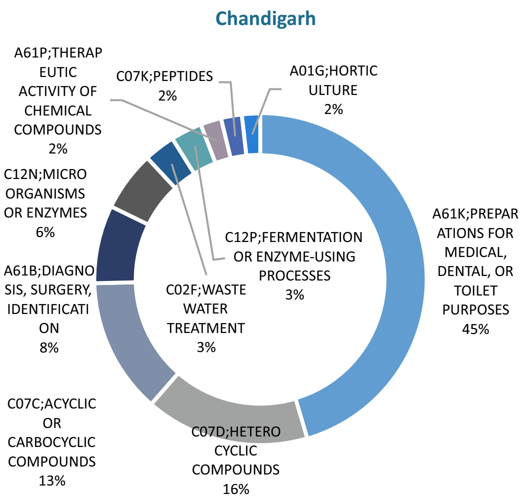
4.5 Patent analysis by domain

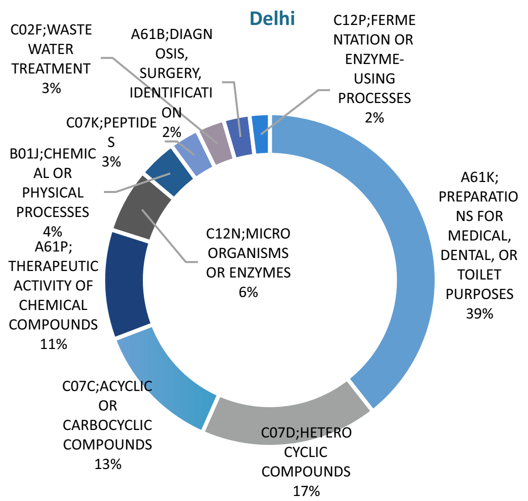
Figure 4.4 shows the top 10 IPC classes (refer Annexure 1 for IPC classification) for 12 clusters (except Sikkim)[4] over the last 20 years. The Established PP cluster, Delhi was found to have more patents in the pharmaceutical (A61K and A61B) and organic chemistry (C07D and C07C) domains. Kolkata, which topped the list of Emerging PP clusters, displayed a similar characteristic as Delhi. The other Emerging clusters showed signs of moving towards the trends shown by Delhi

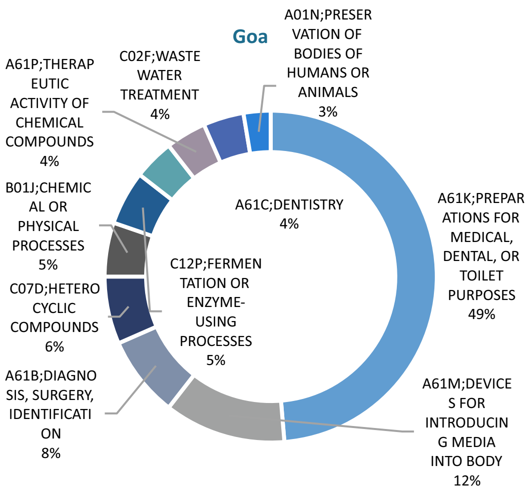
[4] *Since only 2 patents were published from the Sikkim cluster, it was not considered for further analysis.*

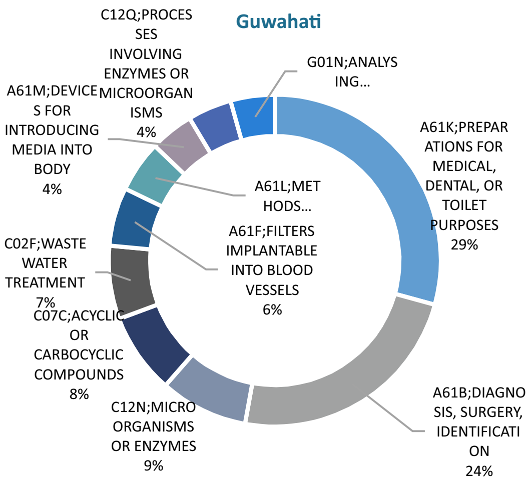
and Kolkata. Almost half of the total patents (45%) published from Chandigarh in the last 20 years were in the domain of pharmaceutical/ therapeutic preparations for medical, dental, or toilet purposes. The next two categories were heterocyclic compounds (16%) and acyclic or carbocyclic compounds (13%), similar to Delhi. The Promising clusters, Goa, Karnal and Mangalore were largely dominated by a single domain, which could be due to a low number of innovators who filed patents from these clusters.

Overall, A61K (preparations for medical, dental, or toilet purposes) dominated in all the clusters and contains 30-40% of published patents in all groups. A61B IPC class that represents the diagnosis and surgery-related invention held the second-most prolific position. There were few clusters where A61M appeared among the top IPC classes that represented the devices for introducing media into the body. A61K, A61B and A61M combinedly showed that 43.6% patents were published in medical and biomedical technology. C07C and C07D (organic chemistry) represented the 2nd position with 28.4% of total patents. Biotechnology constituted 8.4% with two IPC classes, C12N (microorganism/ enzyme) and C12P (fermentation/ enzyme process) in the list of top 10 domains. Delhi had 2,572 patents published in the design therapeutic chemical compound (A61P) domain that raised its contribution to 9.8%. However, other clusters had minimal number of patents in this field. The domain of wastewater treatment (C02F) showed promise with around 3% of total patents across all the cluster. Guwahati and Kolkata had 7% of the patent published in wastewater treatment. Although Delhi contributed the maximum number of the patent (659) in this technology, it constitutes only 2% of its total published patents in 2000-2020.









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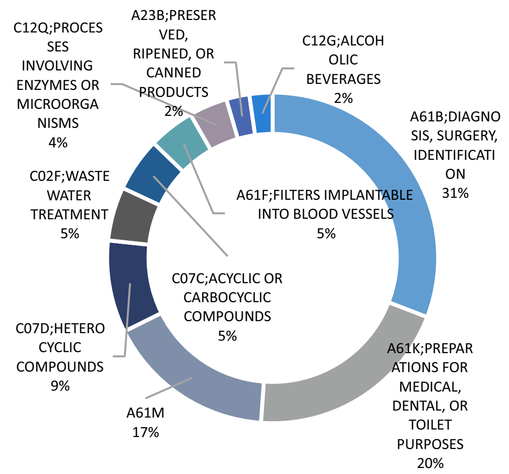
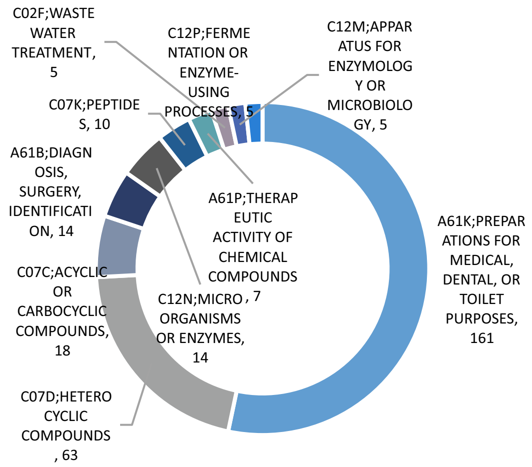
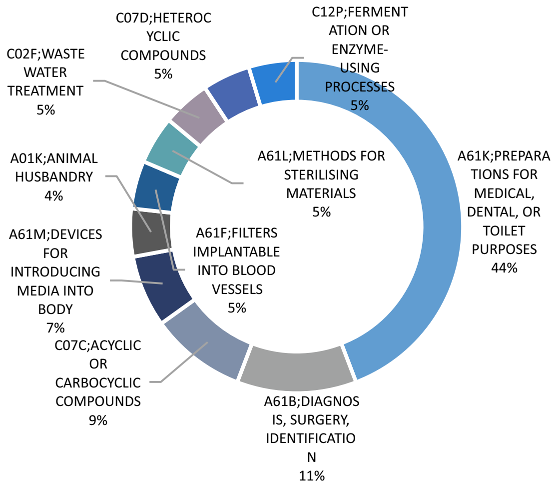


Jammu-HP



Karnal



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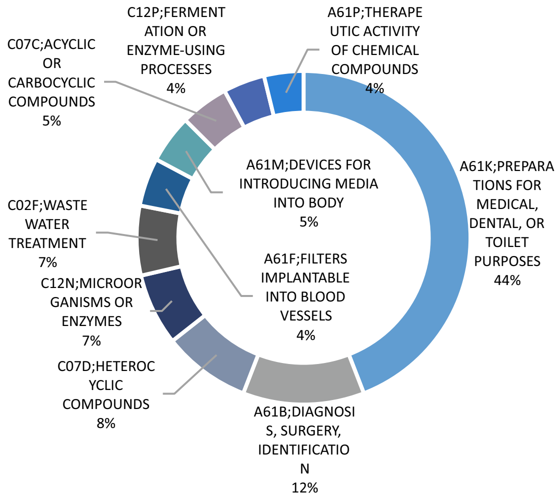

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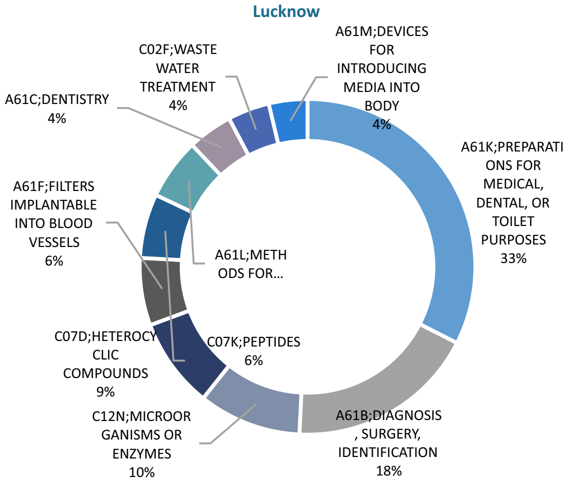
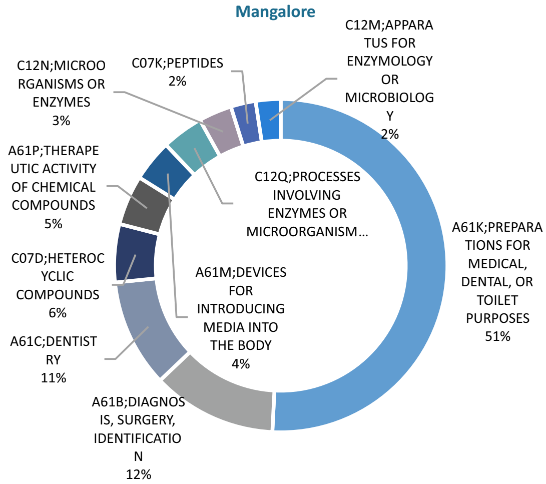


Mangalore



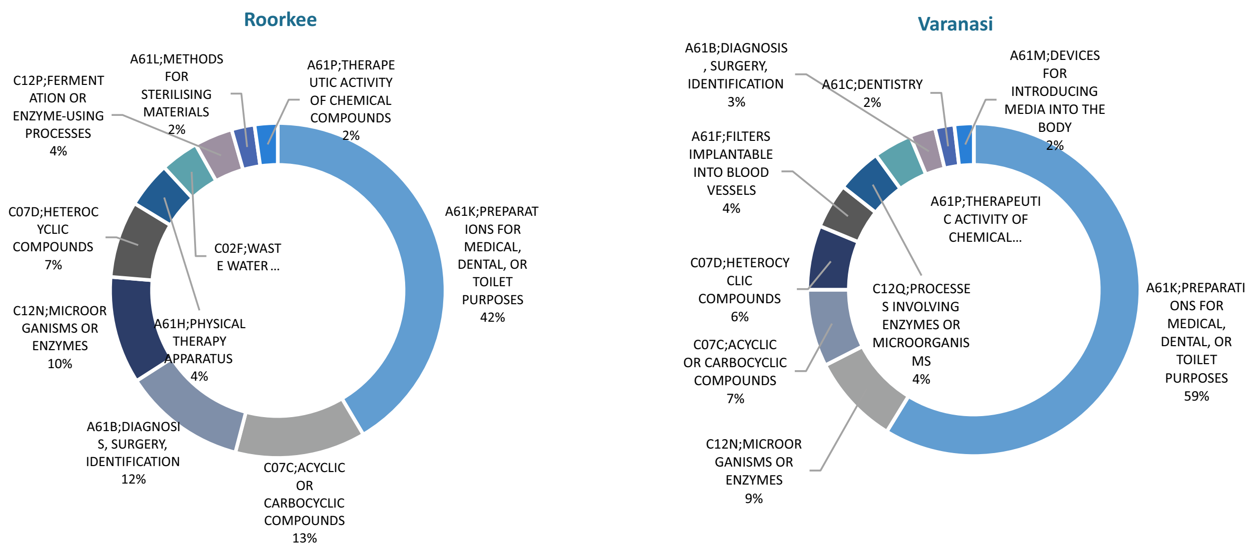


Figure 4.4: Top IPC classes for patents published from 12 clusters between 2000-2020

similar characteristic as Delhi. The other Emerging clusters showed signs of moving towards the trends shown by Delhi and Kolkata. Almost half of the total patents (45%) published from Chandigarh in the last 20 years were in the domain of pharmaceutical/ therapeutic preparations for medical, dental, or toilet purposes. The next two categories were heterocyclic compounds (16%) and acyclic or carbocyclic compounds (13%), similar to Delhi. The Promising clusters, Goa, Karnal and Mangalore were largely dominated by a single domain, which could be due to a low number of innovators who filed patents from these clusters.

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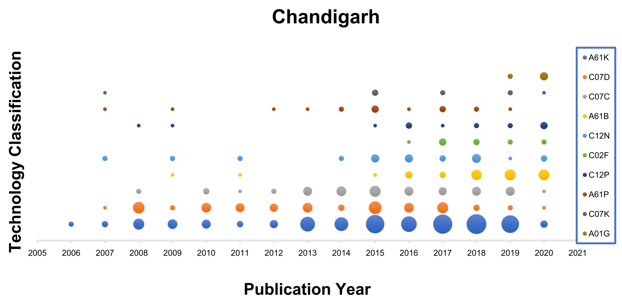
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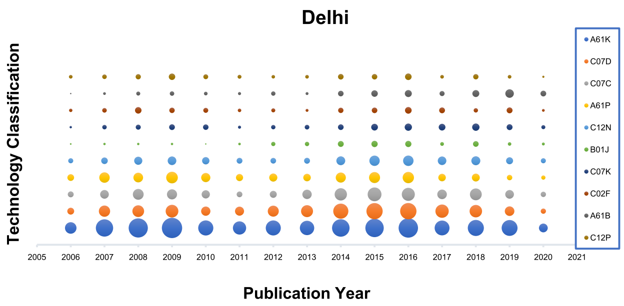
Delhi
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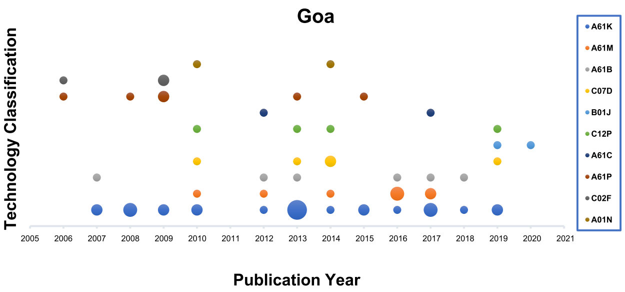
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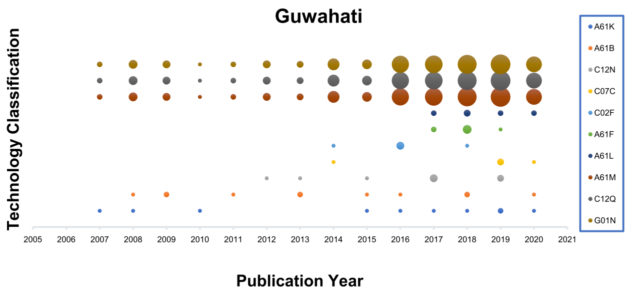
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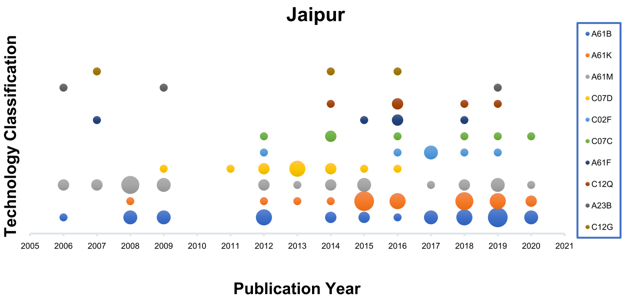
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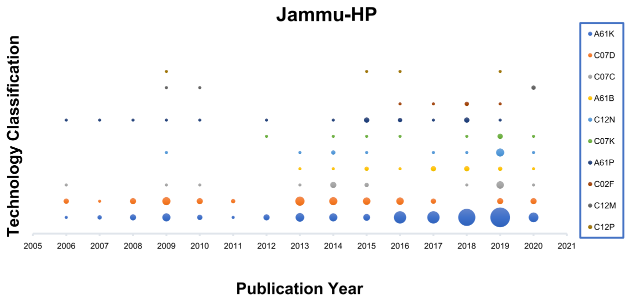
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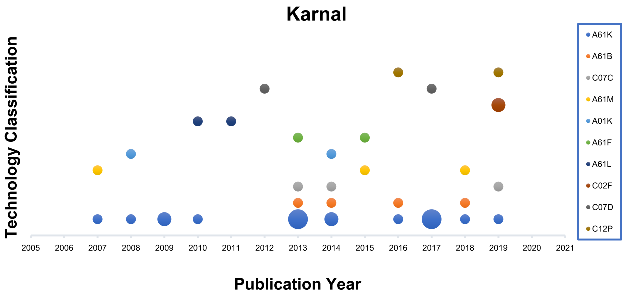
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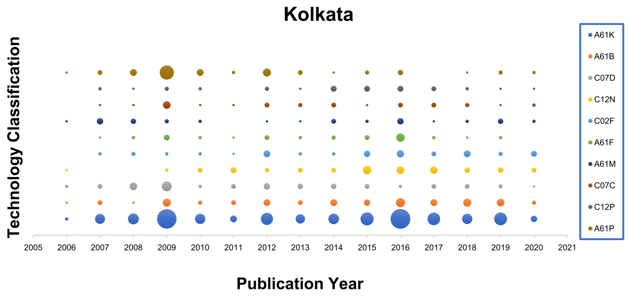
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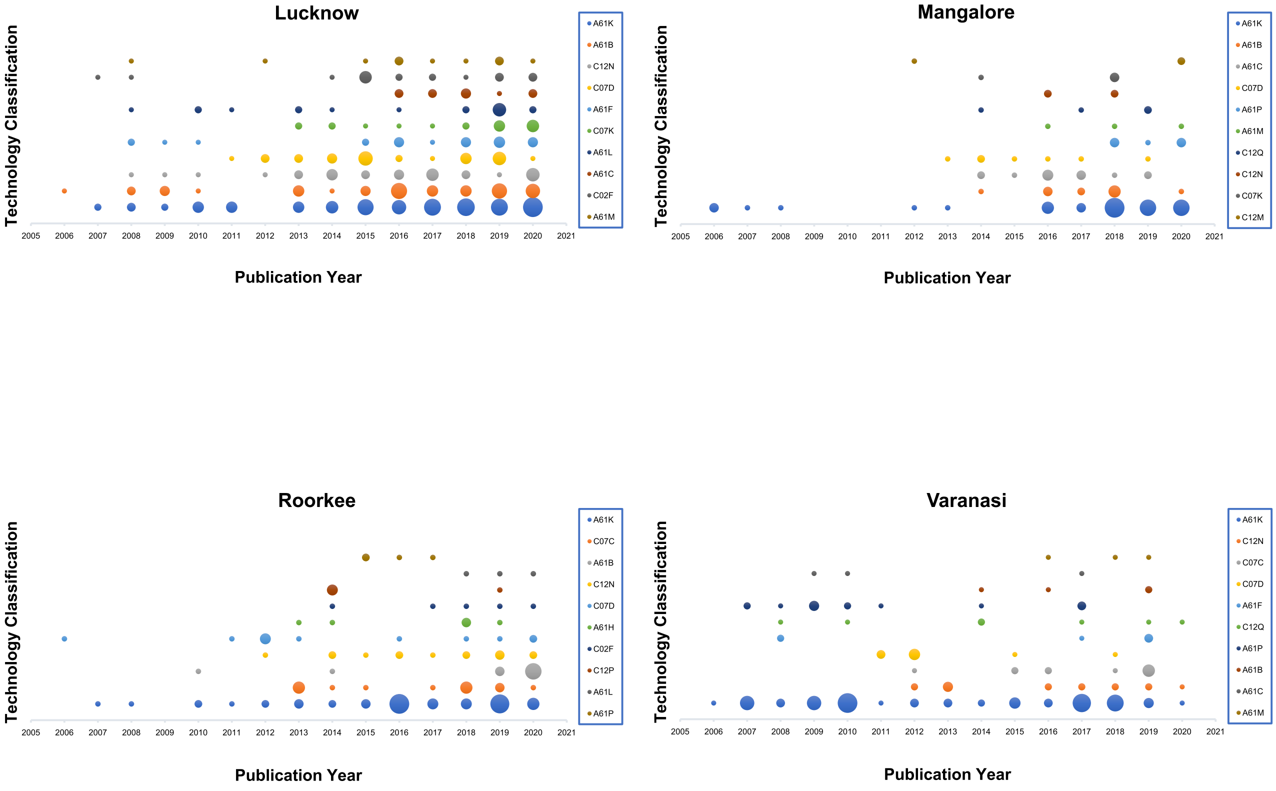

Figure 4.5: Year-wise distribution of top 10 IPC classes of patents from 12 clusters between 2006 and 2020

(*Please note that only 15 years of data was taken for this study as number of patent filings in most clusters up-to 2005 were insignificant)

4.6 Patent analysis by assignee

The Delhi cluster, where a large number of Government funding agencies such as CSIR, ICAR, ICMR etc. are based, had about half (5,159) of their published patents assigned to the funding agencies (Figure 4.6). As per the IPR policy of CSIR, all CSIR-affiliated laboratories across the country have to only file for a patent with CSIR as the assignee. This inflated the number of patents for CSIR as well as that for the Delhi cluster. About 28.6% of patents were filed by companies and about 21% by academia and individuals.

Kolkata exhibited a balanced number of assignees between companies and academia. It may be noted that industry includes both private and public sector corporations. Individual filing was found to be high in Kolkata. It could be due to individual scientists filing on their own without a formal institutional structure and points to the absence of TTOs and incubators in the cluster. 68% of the patents filed from the Chandigarh cluster had an institute, college or an R&D lab as an assignee. Patent filing in Chandigarh was dominated by academia and reflects a need to boost the start-up culture and industry presence. An innovation-friendly start-up policy may lead to a significant difference as well.

Among the Promising PP clusters, Goa exhibited a high proportion of published patents with industry as assignee and could be attributed to the presence of the pharma industry in Goa. For most of the remaining clusters, the patent filing was heavily dominated by academia. In Guwahati, for example, about 87% (122) of the total patents published in the last 20 years were filed by institutes/ laboratories. In Mangalore and Roorkee, the share of patents filed by academia was 80% and 69.71% respectively. Jaipur, Jammu-HP, Karnal, Lucknow and Varanasi had a substantial proportion of individual filing. This points towards a lack of IPR awareness in the clusters across SMEs, startups and scientists in academia. Incubation centres and IPR cells in institutes with trained staff in IP management would go a long way in promoting patent filing among industry, startups as well as faculty and scientists. Apart from funding and mentorship, good IP services is critical in raising the quality of patent portfolio of an institute or start-up. The regional TTOs set up by BIRAC may help in bridging this gap.

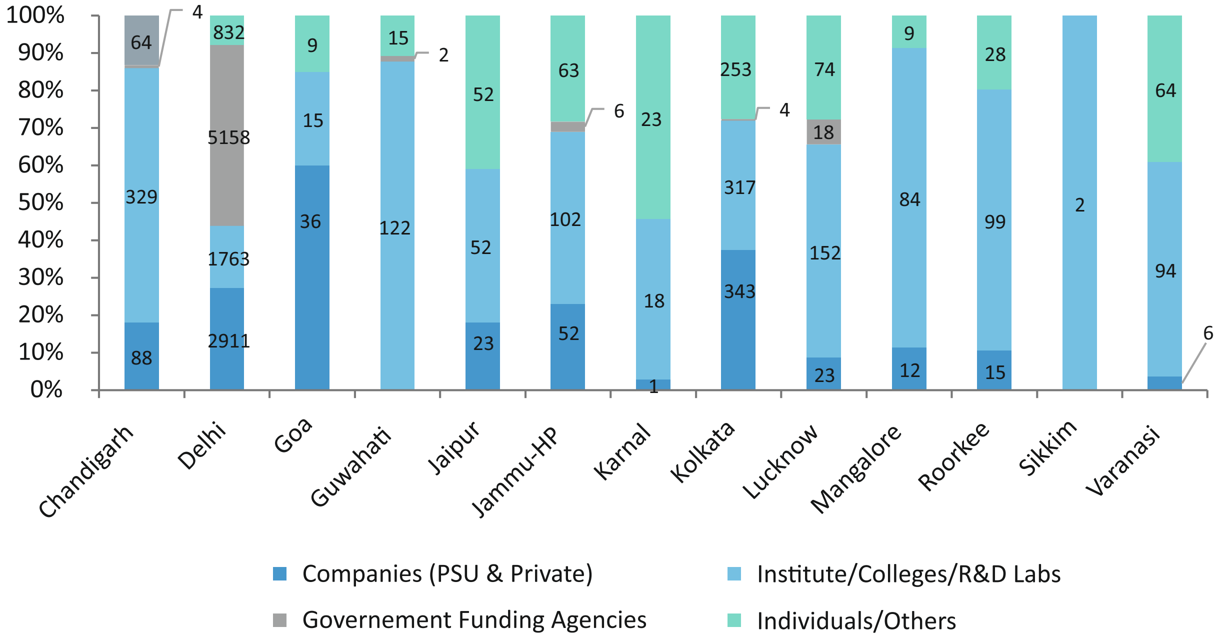

Figure 4.6: Assignee distribution for patents published from 13 clusters between 2000-2020

Chapter 5

Analysis of KOL Interviews

5.1 KOL survey as an analysis tool

To understand an ecosystem, it is imperative to analyse inputs from various stakeholders involved in building the innovation ecosystem. These inputs were collected by one-on-one interviews with Key Opinion Leaders (KOL), surveys and networking meetings. The interviews and surveys were broadly woven around the following topics:

- Current status of innovation ecosystem in their respective clusters in terms of strengths, weaknesses and aspiration of the cluster
- R&D strength of the cluster and availability of skilled human resource
- Policies around startups and innovation
- Availability of innovation infrastructure
- Networking avenues and access to funds
- Mentor network in the cluster
- Issues related to intellectual property rights and technology commercialisation

The above data was collected from approximately 215 KOL interviews and 20 networking meetings. The data served to develop the qualitative innovation indicators of the five Input Innovation pillars and two Output Innovation pillars in the study.

The 1st Innovation Input Pillar, Human Capital & Research Capacity is a crucial input parameter for knowledge and talent generation and technical mentorship within a cluster, and being central to cluster innovation capacity. While secondary data was collated for the four innovation indicators, namely, the number of institutions of higher learning, scientists, publications, citation and scientific collaborations, KOL interview was used to capture the R&D Strength of the clusters.

The 2nd Innovation Input Pillar is the State Government Support. The local government plays a crucial role in catalysing innovation through policies and regulation. In a growing ecosystem the government also plays a crucial role in funding innovation, support in development of ecosystem through infrastructure like science parks, incubators and accelerators. KOL feedback on state government support was collected and analysed as an indicator.

KOL interviews and networking meetings focusing on availability of physical infrastructure for building the innovation ecosystem like Incubators and enabling players like IP firms, mentors and collaboration platforms and networks provided information on the indicators of the 3rd Innovation Pillar, Innovation Infrastructure and Support.

Availability of funding, which is a critical indicator for the 4th Input Innovation Pillar, Investment Climate, was derived from KOL interviews. It plays a crucial role in creating a thriving start-up ecosystem as investors not only provide the required capital for startups but also assist in shaping the business plans for startups. Investors ensure that capital is invested in the correct manner and guide fledgling entrepreneurs in entering the capital market.

The 5th Input Pillar, Innovation Culture, is an important factor that enables innovation activities in a cluster including indicators like number of innovation driven companies, availability of talent for industry to hire and the start-up and business culture. The last two indicators were assessed from interviewing KOLs.

As an Output Indicator for technology transfer and commercialization, along with data on IP generated by industry, views of Key Opinion Leaders on technology commercialization was considered as a measure of the Technology Commercialization Output Innovation Pillar.

5.2 Key findings from KOL interviews and surveys

The challenges / issues expressed by various stakeholders in the 13 clusters were analysed. While many of the challenges were common across clusters, the degree and extent of the problems were found to vary depending on the maturity of a cluster, with specific issues that were more pronounced in the Emerging and Promising clusters. These factors were analysed to understand the challenges faced by the clusters and devise solutions to help them build robust innovation ecosystems.

Intellectual Property Rights

The importance of intellectual property rights is one of the most crucial pillars of innovation. Academia and startups in the Delhi cluster has good knowledge of IP rights and the filing process. But other clusters lacked IP awareness. IP workshops, IP clinics and patent search as a tool for research should be taken up on priority in these clusters. Two clusters that need special attention on IP awareness are Kolkata and Karnal. Both of these clusters have strong research capacity but were found to score low on IP knowledge and filings. Lack of IP awareness is a major hurdle in transforming these clusters from a research cluster to an innovation hub. A peculiar observation made in the Goa cluster was the absence of IP firms in Goa. This could be attributed to a low critical mass of innovation and easy access to IP firms in Mumbai.

Incubators as a key Innovation Infrastructure

Creation of biotech incubators is critical to the growth of this sector as biotech startups face challenges of long gestation period for product development, high capital requirements including access to expensive instrumentation and business advisory. A lot of effort from the central as well as state governments is seen towards setting up Incubators in Tier 1 and 2 cities, which has led to improvement in the required innovation infrastructure. A few gaps that were identified through the surveys, KOL interviews and networking meetings were the need to build more life sciences incubators, for example, in clusters like Kolkata, Karnal, Goa and Sikkim, the need for interconnectivity and networking between the incubators for clusters like Lucknow and Jammu-HP, and of course the need for well-trained incubator managers.

Funding

Lack of innovation funding was one of the main factors that determined the innovation maturity of a cluster. In addition to lack of funding from large/ institutional investors, several clusters in the study were found to also suffer from the lack of angel and seed level funding.

While it is established that lack of funding in development phase for startups and a limited number of players in angel and early-stage VC rounds hamper the growth of startups, it was observed that even availability of small idea exposition funds could be helpful in building a pipeline of innovations in promising and emerging clusters. The boost in the smaller funding would typically enable innovators to explore the ideas in greater depth and would encourage more students to explore entrepreneurship as an alternative career. Other alternative ways to enable access to funds should also be explored like early integration of academia and industry collaboration enabled through open challenges and hackathons especially in clusters where there is strong industry presence, for example, in Chandigarh and Goa. Organizing local technology exposition and investor meets were also recommended as they help attract investors to a particular cluster.

Networking forums

Knowledge transfer, peer-to-peer learning and information flow across stakeholders are necessary for nurturing and growing an innovation ecosystem. Networking forums in a cluster are crucial for facilitating these activities. To meet the need for development of networking forums "Open Dialogues" was launched as a networking platform in each cluster and meetings were conducted with participation from key stakeholder in the local innovation ecosystem. During organizing these events it became evident that stakeholders, especially in the emerging and promising clusters, do not meet each other often and peer-to-peer learning was very low. Jaipur and Kolkata fared poorly in this aspect since stakeholders did not meet each other periodically, thus hampering knowledge transfer. Institutes like Banasthali Vidyapith in the Jaipur cluster which made notable efforts to create a networking forum was doing so as a focussed effort for its AIC incubator. The same was observed in Kolkata. The same phenomenon of a single institute centric networking forum was observed in some other clusters like Roorkee (IIT R) and Jammu-HP (IIT Mandi). Upon further analysis on the possible causes of the absence of networking forums, poor state government support and understanding of the benefits of cluster-level development, lack of structured funds for such events and lack of trained incubator managers were found to be the major deterrents. Clusters making noticeable progress towards launching networking forums were Guwahati and Mangalore.

Mentoring

During interviews with startups and innovators, lack of available mentors especially in the emerging and promising clusters came out as a strong point. Mentors play a crucial role in the start-up ecosystem, both technical and business mentoring are required to build a successful start-up. Proposals from clusters with poor understanding of Need Identification at early stage of an idea, can directly be attributed to lack of mentorship at early stage. Also, for a cluster to grow and thrive it is important to build a local mentor pool with mentors both from academia and industry. For example, some of the neighbouring clusters of Delhi like Jaipur, Roorkee and Chandigarh were heavily dependent on business mentors from Delhi which led to poor access to mentors and lack of empathy towards local challenges faced by the startups. The lack of available mentors could also be attributed to lack of networking forums in the clusters. Some of the clusters that were positively working towards developing its mentoring network were Sikkim and Guwahati wherein it was observed that at least couple of local industry mentors were engaged for business mentoring of startups.

5.3 Grouping of clusters based on KOL interviews and survey data

Radar chart was used to depict the performance of clusters across all five Input Innovation pillars and the two Output Innovation pillars, including adoption of policies, presence of enablers, intensity of innovation culture and commercial output. The scores in each of the pillars were used to categorise the clusters as Established, Emerging and Promising clusters from the point of Innovation Ecosystem (IE) support. The spread of the graph shows a cluster's ability to innovate and support a sustainable entrepreneurial ecosystem.

Delhi is the only Established IE Cluster among the 13 BRIC clusters studied in Phase III. As evident in Figure 5.1 the Established IE Cluster has a well spread area in the chart below depicting its high scores across pillars like Human Capacity & Research Capacity, State Govt Support and Investment climate, aided with presence of anchor industries and a thriving start-up culture. It was apparent from the KOL interviews and discussions that the Delhi cluster needed a push for start-up and industry collaboration and commercialization, especially for integration of the start-up ecosystem with the MSME network.

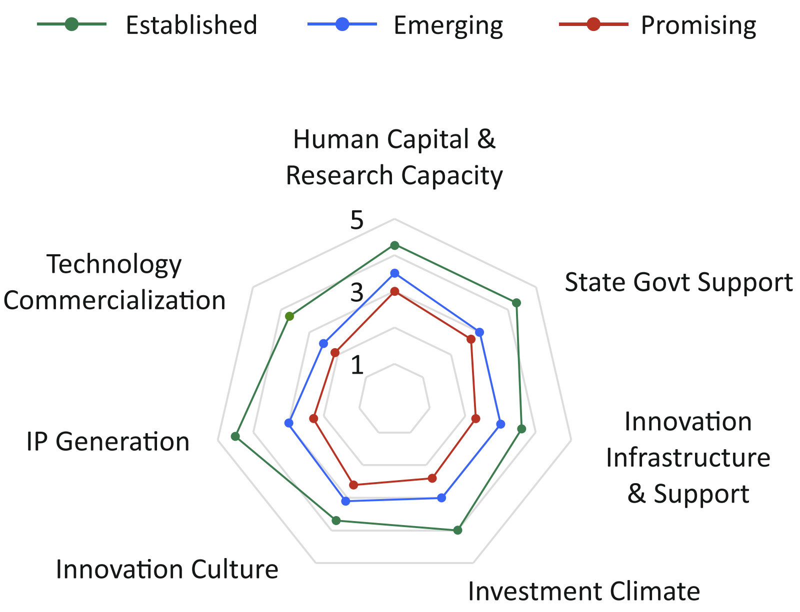

Figure 5.1: Cluster groups based on Innovation Ecosystem support indicators

Figure 5.1 above shows three lines depicting the Established, Emerging and Promising Innovation Ecosystem clusters.

Established IE Cluster: Delhi

Emerging IE Cluster: Chandigarh, Jaipur, Kolkata

Promising IE Cluster: Goa, Guwahati, Jammu-HP, Karnal, Lucknow, Roorkee, Sikkim, Mangalore and Varanasi

Figure 5.2, 5.3 and 5.4 give detailed scores of each subgroup of clusters. These figures also clearly bring out the areas of need for the emerging and promising clusters to move towards becoming established clusters.

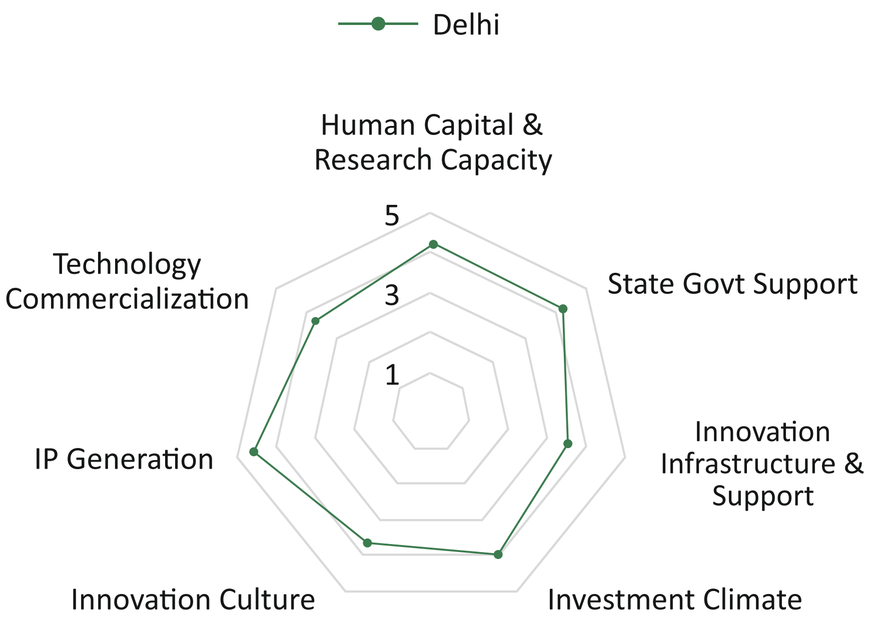

Figure 5.2: Established IE Cluster Chart - Delhi

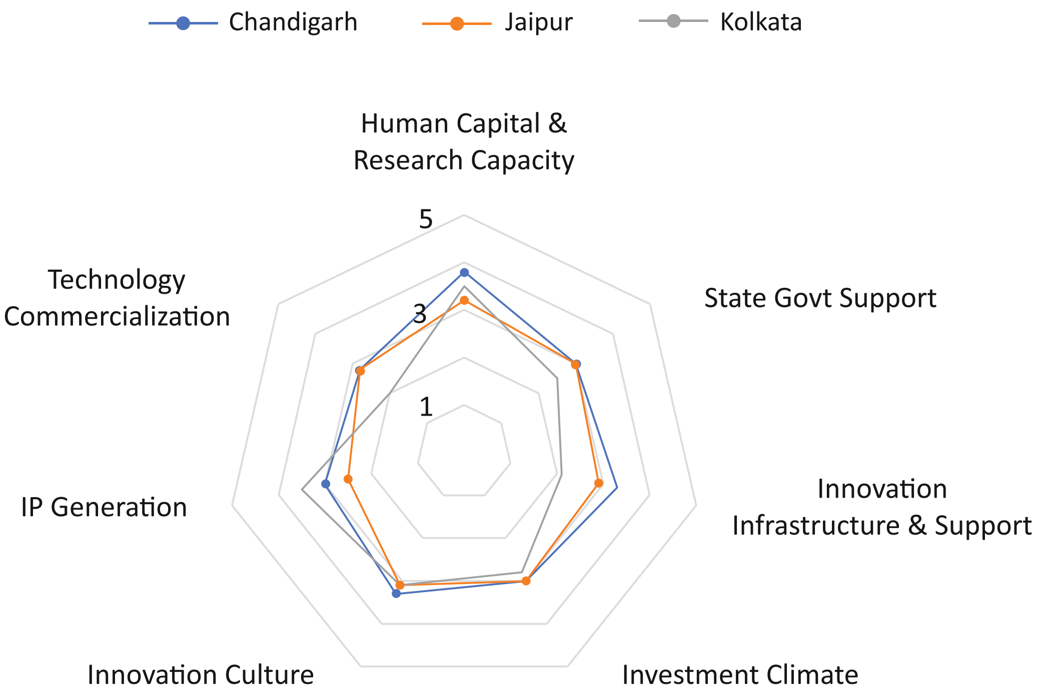

Figure 5.3: Emerging IE Clusters – Chandigarh, Jaipur and Kolkata

The biggest dip in moving from the category of Established to that of Emerging IE clusters are in the pillars of State Govt Support and Investment Climate, which directly impact the output pillars of IP generation and also technology commercialization. Within the three Emerging IE clusters, while Chandigarh and Jaipur clusters present a more even development of the various aspects on innovation capacity as well as innovation performance, the Kolkata cluster needs concerted focus on State Government Support and Innovation Infrastructure. This has resulted in poor technology commercialization in spite of reasonably strong Research Capacity and IP Generation.

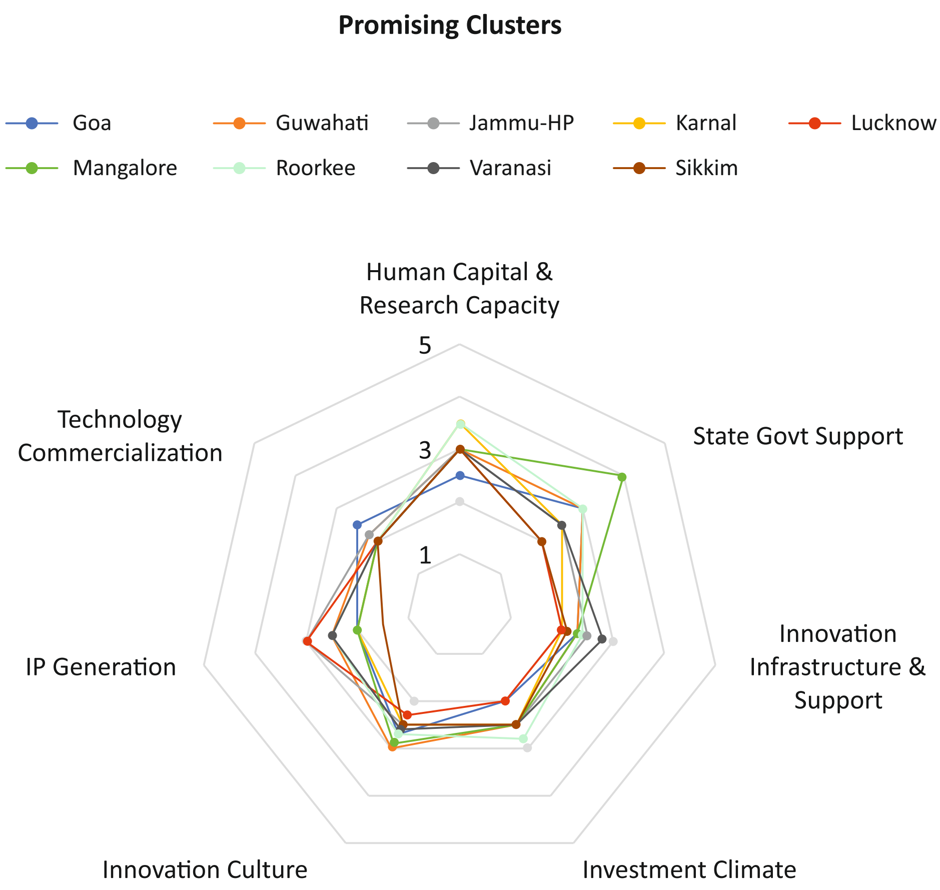

Figure 5.4: Promising IE Clusters – Goa, Guwahati, Jammu-HP, Karnal, Lucknow, Mangalore, Roorkee, Varanasi and Sikkim

Between Promising IE clusters and Emerging IE clusters, the dip is seen in Innovation Infrastructure & Support, Investment climate and Innovation Culture which reflects on the need for more awareness activities, schemes to improve innovation and start-up funding and formation of networking and collaborative platforms to enhance peer-to-peer learning. The Output Pillars of IP generation and Technology Commercialization also show a drastic fall due to lack of funds and available innovation infrastructure and support.

Chapter 6

Cluster Development Activities

6.1 Introduction

Apart from mapping the clusters based on analysis of a set of Input and Output Innovation Indicators from secondary data and KOL interviews, a major focus of the current study was on designing specific interactive entrepreneurship development activities for the Emerging and Promising clusters under study. These included setting up Innovator Forums to facilitate networking among the stakeholders in a cluster, conducting workshops and Idea expositions, and instituting exposure stipends with a total reach out to approximately 2100 innovators under BRIC Phase 3.

6.2 Innovator Forums

The need for establishing a networking platform especially in Emerging and Promising clusters was identified in the earlier studies and reiterated in the KOL interviews and surveys conducted. It was observed that currently workshops and seminars were the only means of networking available. Although these activities provided opportunities for collaboration, it did not fulfil the need for focussed discussion amongst stakeholders to address the issues of a cluster. To bridge the gap a networking platform, “Open Dialogue”, was launched in each cluster to encourage stakeholders from across the local ecosystem to network, discuss and support development of the cluster. The “Open Dialogue” meetings were a great hit and led to intra-cluster networking. Two success stories of Open Dialogues were one in the Delhi cluster where a start-up, Crimson Health, met an MSME, Alfa Corpuscles, and the meeting ended up with an MoU between them for design improvement and product development of the start-up product. In the HP cluster the Open Dialogue led to the formation of a Start-up Fund by The Unnati Cooperative Societies to promote and mentor local the start-up ecosystem.

Open Dialogue meetings also helped IKP understand the clusters better so as to conduct more meaningful activities for development of the clusters and expand its footprint within the local ecosystem. In total 15 Open Dialogue meetings were conducted that enabled reaching out to 200 innovators and 150 enablers. Due to travel restrictions and lockdown imposed by the COVID -19 pandemic, Open Dialogue meetings at Lucknow, Karnal, HP-Jammu, and Sikkim clusters were held virtually.

6.3 Workshops

KOL interviews, surveys and Open Dialogues helped IKP identify the areas where workshops or structured talks were required. Keeping the cluster specific needs in mind, workshops and talks were curated to gain maximum engagement within the ecosystem. A total of 18 workshops were conducted across 13 clusters. For example, in Emerging clusters like Chandigarh and Kolkata, there was a need to conduct workshops in areas like "Need Identification" and “Role of IP in academic research”, as these clusters exhibited high potential in academic research but lacked the understanding of translational R&D. On the other hand, in Promising clusters like Jammu-HP, Karnal and Lucknow there was still a need to conduct workshops on "Basics of IP". In Delhi no workshop was scheduled earlier but due to the pandemic there was a felt need for a workshop to guide incubator managers, and provide support to startups, and hence a virtual workshop on " Navigating the Uncertain times" was organized in partnership with NITI Aayog.

One of the most successful and engaging aspect of the workshops launched under BRIC were the "Storytelling" sessions showcasing local success stories. This helped IKP identify the local mentors who understood the cluster challenges and help innovators navigate them. These brought in a network pool of 20 plus new mentors across tier 2 and 3 cities.

6.4 Idea Exposition

An Idea Exposition is similar to a hackathon where a Call for Proposal for innovative ideas around a theme is announced and from the applicants, shortlisted innovators work over a two-day period to refine their ideas with the advice of mentors. This is to enable a pre-incubation experience and learn the process of “need identification” and develop business cases. Idea Expositions were organised at individual cluster level or involving innovators from nearby clusters depending on the enthusiasm of innovators and capacity to generate good ideas. Idea Exposition served as a great tool to both determine the existing innovation culture and nurture new ideas at the cluster level. The theme of the Idea Exposition in a cluster was determined through Open Dialogues, workshops and secondary data analysis. The proposals received via the applications helped understand the strengths and weak points of the cluster, for example, the Emerging clusters like Chandigarh, Jaipur and Kolkata saw a high number of applications but the quality of proposal from them varied as proposals from Kolkata were technically good but lagged in the business plan whereas the proposals from Jaipur lacked understanding of IP involved.

Figure 6.1 below shows the number of proposals received across various Idea Exposition events conducted in the clusters. Chandigarh and Jaipur clusters received the maximum number of proposals, pointing to the growing innovation culture in the two clusters; also approximately 40% of applications from these clusters were by startups. Two notable clusters, Jammu-HP and Sikkim showed more than 60% of its applications from startups which shows the growing entrepreneurship ecosystem and is attributed to the presence of enabling bodies like the Atal Incubation Centre in Sikkim and Jammu Start-up Association in the Jammu-HP cluster. Clusters like Lucknow and Roorkee showed less than 20% of its applications from startups and this reflected on the quality of the proposals that were more academic and lacked in business plans, which in turn led to no Idea Exposition winners from the Lucknow cluster.

IKP conducted 11 Idea Expositions, where a total of 236 applications were received,120 innovators were mentored and 24 innovators were selected as winners and awarded the Idea Exposition grants.

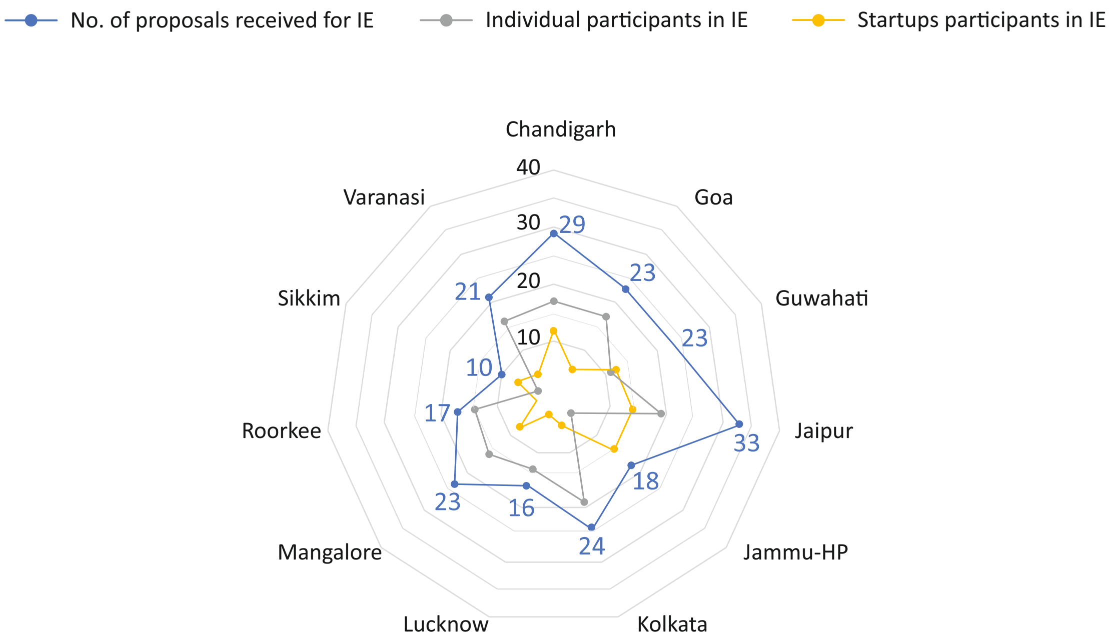

Figure 6.1: Idea Exposition proposals received across clusters

6.5 Innovator Exposition stipends

Innovators from Emerging and Promising clusters often do not have access to good mentors or peers and lack exposure of activities in larger cities. Conferences provide only generic view of issues. The Idea Exposition Grant was structured around four major components: Immersion with similar domain startups for peer-to-peer learning, Potential customer feedback, IP advisory and networking through workshops and seminars. Select innovators from the Idea Exposition events were given travel grants to interact with mentors and peers in established clusters to fine tune their ideas. However, this could not be taken up by most startups due to the travel restrictions for the pandemic. It was observed that 80% of the winners opted for an IP search report with detailed technology landscape and four went ahead with patent drafting services. All the participants had positive review about the start-up immersion program and 13 out of 24 winners were able to take their MVP (Minimum Viable Product) level prototype for customer feedback.

Figure 2 shows the distribution of Idea Exposition winners across different domains. From a total of 24 winners, around 42% were from healthcare and pharma domains, with nine winners from the healthcare domain, followed by seven from Green Technology. Out of the 24 winners, 8 were individuals and 16 were startups showing the positive overall trend of a growing entrepreneurial ecosystem. A survey conducted on the winners of the Idea Exposition showed that they created a total of 66 jobs and raised around INR 2.5 Crore. Two startups, Green Trek Research & Development Pvt Ltd from Jammu and Paradigm Innomed LLP from Varanasi were listed on the AGNIi portal of Start-up India. Eikona X Innovative Solutions Pvt Ltd from Mangalore-Manipal cluster, was a recipient of the BIRAC BIG grant. Agriculture based start-up EF Polymers Pvt Ltd from the Jaipur cluster represented India at Grand global Finals of Climate Launchpad held at Amsterdam and Fermentech Labs Pvt. Ltd from Roorkee Cluster was selected for product showcase in BIO Asia 2020.

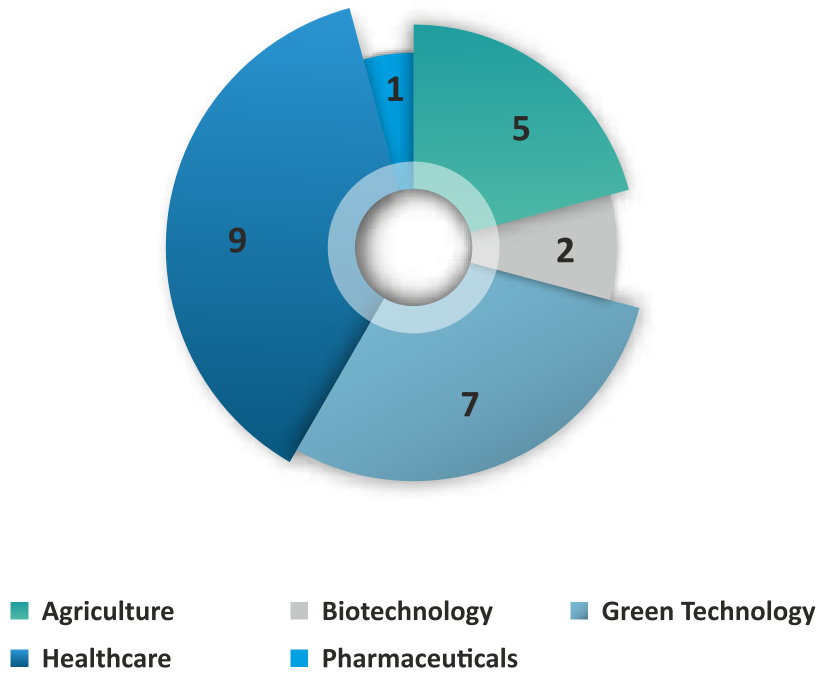

Figure 6.2: Distribution of Idea Exposition winners across different domains

6.6 IP Clinics

As mentioned earlier, from the KOL interviews, surveys and workshops it was evident that most of the Emerging and Promising clusters lacked exposure to Intellectual Property (IP) Rights, patenting and technology transfer. Hence apart from the IP workshops BRIC initiated IP clinics at clusters to conduct prior art searches, detailed competitive analysis reports and patent drafting services. A total of 80 patentability searches were conducted out of which 26 were requested by individuals and 53 were from startups. 61.3% patentability searches were in the domain of healthcare and pharma. Figure 6.3 below shows the spread of IP searches across technologies.

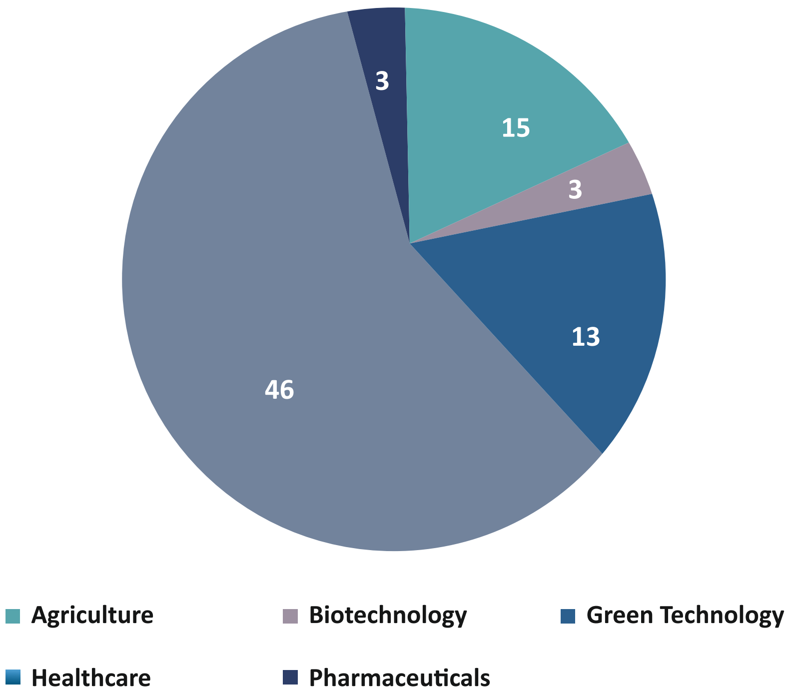

Figure 6.3: Distribution of patentability search

Chapter 7

Cluster Performance Analysis and Recommendations

7.1 Comparative analysis of clusters

The 13 clusters were analysed across four broad innovation parameters, Research Capacity, Innovation Support, Patent Performance and Innovation Ecosystem Support and classified as Established, Emerging and Promising clusters for these parameters in Chapters 2, 3, 4 and 5. The results were collated in Table 7.1, where an Established cluster is represented by 1, Emerging cluster by 2 and Promising cluster by 3. As mentioned earlier the purpose was not to rank the clusters but to categorize and group them into three buckets, Established, Emerging and Promising clusters so that suitable policy measures and activities can be initiated to improve and enhance the performance of the clusters.

Cluster	Research Capacity (RC)	Innovation Support (IS)	Patent Performance (PP)	Innovation Ecosystem (ES)
Delhi	1	1	1	1
Chandigarh	2	1	2	2
Kolkata	1	3	2	2
Jaipur	3	1	3	2
Lucknow	2	3	3	3
Varanasi	2	3	3	3
Roorkee	3	2	3	3
Guwahati	3	2	3	3
Mangalore	3	2	3	3
Goa	3	2	3	3
Jammu-HP	3	3	3	3
Karnal	3	3	3	3
Sikkim	3	3	3	3

Table 7.1: Grouping of Clusters based on RC, IS, PP and ES

Innovation Input Sub-Index: Innovation Capacity

The status of the Input Innovation Pillars in each cluster assessed through its associated Input Indicators provided a measure of the Innovation Capacity of that cluster. The "Institutions" Indicator in "Human Capital and Research Capacity" Pillar was split into 4 types of institutions, presence of each of which in a cluster is critical for life sciences innovation. Then the 19 Input Indicators for each cluster were assigned a colour score, with the colour green signifying "Good", orange standing for "Fair", yellow representing "Under developed" and red assigned for those indicators that were "Poor". These indicators were mapped to arrive at an informed understanding of the Innovation Capacity of each cluster and where the gaps lay. Figure 7.1 provides a colour map of 19 Input Innovation Indicators representing five Input Innovation Pillars across 13 clusters.

Input Pillars	Clusters	Chandigarh	Delhi	Goa	Guwahati	Jaipur	Jammu-HP	Karnal	Kolkata	Lucknow	Mangalore	Roorkee	Sikkim	Varanasi
Human Capital & Research Capacity	Academic Institutes	Orange	Green	Orange	Orange	Green	Orange	Orange	Green	Green	Orange	Orange	Yellow	Green
	Research institutes	Green	Green	Yellow	Yellow	Orange	Yellow	Yellow	Orange	Green	Yellow	Yellow	Yellow	Orange
	Business schools	Green	Green	Yellow	Orange	Orange	Yellow	Yellow	Green	Green	Orange	Yellow	Yellow	Yellow
	Clinical Community	Orange	Green	Yellow	Red	Orange	Orange	Green	Green	Green	Yellow	Yellow	Yellow	Orange
	Scientist	Orange	Green	Red	Yellow	Yellow	Yellow	Yellow	Green	Orange	Yellow	Yellow	Red	Orange
	Publications, Citations	Orange	Green	Red	Yellow	Yellow	Yellow	Yellow	Green	Orange	Yellow	Yellow	Red	Orange
	Scientific Collaboration	Orange	Green	Red	Yellow	Yellow	Yellow	Yellow	Green	Orange	Yellow	Yellow	Red	Orange
	R&D Strength	Orange	Green	Red	Yellow	Yellow	Yellow	Yellow	Green	Orange	Yellow	Yellow	Red	Orange
State Govt Support	Government support	Green	Green	Orange	Orange	Orange	Yellow	Yellow	Yellow	Red	Green	Orange	Yellow	Yellow
	Startup State policy and Other Schemes	Green	Green	Orange	Orange	Orange	Yellow	Yellow	Yellow	Yellow	Green	Orange	Yellow	Yellow
Innovation Infrastructure and Support	Incubatore	Green	Green	Orange	Orange	Orange	Yellow	Red	Red	Yellow	Orange	Orange	Red	Orange
	IP Firms and IP Support	Orange	Orange	Red	Red	Orange	Red	Red	Yellow	Yellow	Orange	Yellow	Red	Yellow
	Mentors, Regulatory Support	Orange	Green	Yellow	Red	Yellow	Orange	Yellow	Orange	Orange	Orange	Yellow	Yellow	Orange
	Collaboration platforms and	Orange	Orange	Red	Yellow	Yellow	Red	Red	Yellow	Yellow	Orange	Yellow	Yellow	Yellow
Investment Climate	Private investors - Angel/VC/PE	Green	Green	Yellow	Yellow	Orange	Yellow	Yellow	Red	Red	Orange	Yellow	Yellow	Yellow
	Availability of Funding	Orange	Green	Yellow	Orange	Orange	Red	Yellow	Yellow	Yellow	Orange	Yellow	Yellow	Yellow
Innovation Culture	Innovation Driven Companies	Orange	Green	Orange	Red	Orange	Orange	Red	Green	Yellow	Yellow	Yellow	Red	Red
	Availability of Skilled HR / Talent	Green	Green	Yellow	Yellow	Orange	Yellow	Yellow	Orange	Orange	Orange	Yellow	Yellow	Yellow
	Start-Up Culture	Orange	Green	Orange	Orange	Orange	Orange	Red	Yellow	Red	Orange	Orange	Yellow	Yellow

Figure 7.1: Innovation Capacity Map of 13 clusters

The map clearly shows that Innovation Capacity of Delhi was way above the rest of the clusters and Delhi deserves to be categorised as an Established cluster. The Innovation Capacity of Chandigarh, Kolkata, Mangalore and Jaipur are fairly well developed and could be categorised as Emerging clusters. It needs to be mentioned that the innovation capacity of Chandigarh was found to be more robust than the other three members of the Emerging Cluster category. While several input indicators of Lucknow, Varanasi, Roorkee and Guwahati were fairly developed, the rest of the input indicators pulled down the overall score and these clusters were grouped as Promising clusters. The input indicators of the other four clusters, Jammu-HP, Goa, Karnal and Sikkim were largely under developed or poor.

Innovation Performance and Overall Heat Map

All the seven Innovation Pillars across the 13 clusters were represented as a heat map to indicate how the Output Innovation Sub-Index performed vis a vis the Input Innovation Sub-Index. This provided a sense of the Innovation Performance and efficiency of the clusters.

Figure 7.2 shows a heatmap of clusters in respect to the seven pillars (5 input and 2 output pillars). The heatmap shows the magnitude of each indicator as colour in two dimensions - colour light pink represents lower numbers while the colour red represents higher numbers. The intensity of colour provides visual cue with respect to 'how the parameter is performing'.

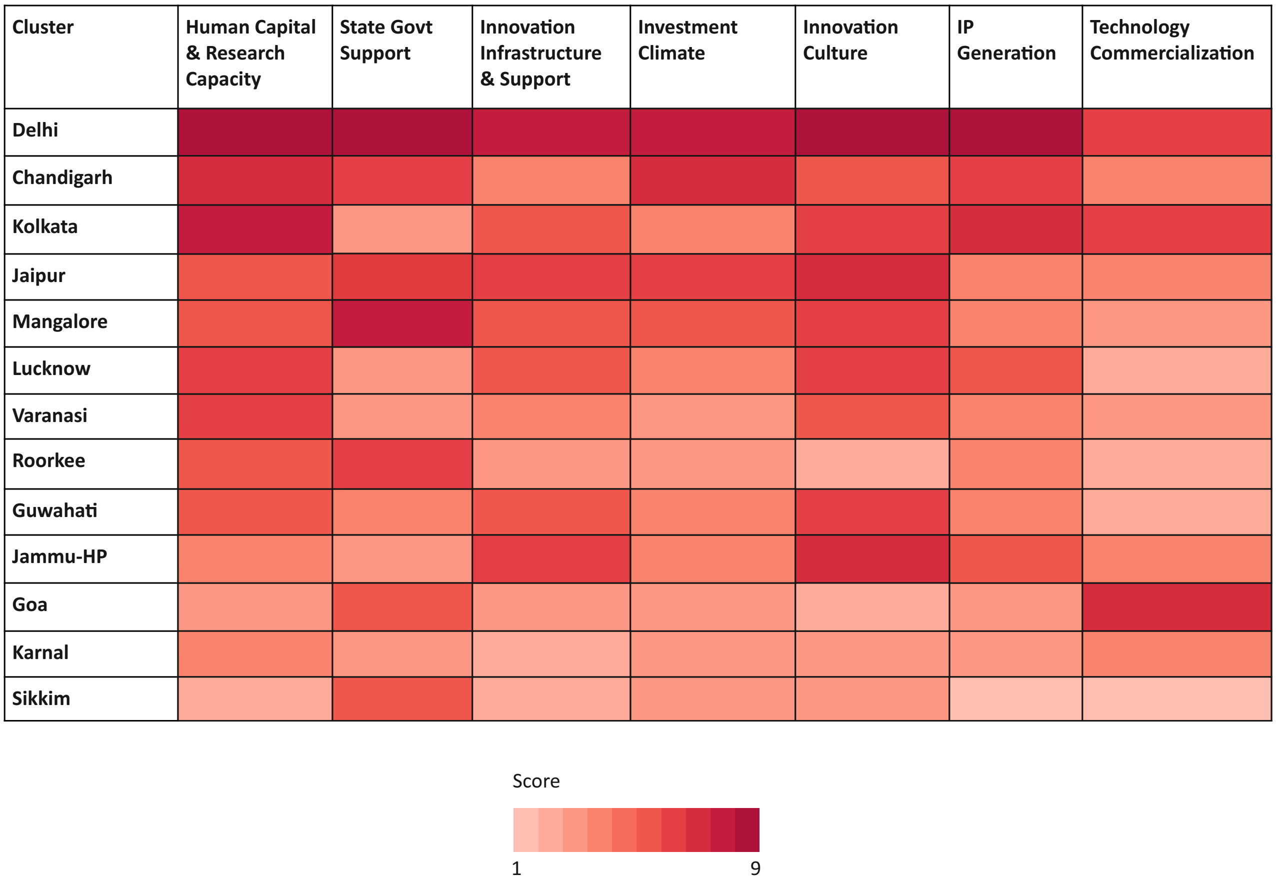

Figure 7.2: A heatmap of all the parameters combined for each of the 13 clusters.

Grouping of the clusters into Established, Emerging, and Promising clusters was achieved based on each of the parameters from the heatmap. Delhi cluster stood out both in input and output pillars. Chandigarh, Jaipur, Kolkata and Mangalore emerged as the next four top clusters when looked at the input pillars but Mangalore slipped to the Promising cluster category when ranked on the output pillars, especially in the Technology Commercialization pillar. This could be attributed to innovators moving out from Mangalore to Bangalore to form start-ups and hence efforts should be made on talent retention by implementing adequate policy changes and incentives.

From the overall performance perspective, Lucknow, Varanasi, Roorkee, Guwahati, Jammu-HP and Goa featured in the top of the list of Promising clutters. Goa and Jammu-HP clusters fared well in output pillars in comparison. For Jammu-HP cluster, this could be attributed to the presence of top academic institutions like IIT Mandi, CSIR-IHBT and SMVDU, and also the active presence of the Jammu Start-up Association which resulted in generation of patents. The presence of large Pharma companies in the Goa cluster has resulted in patent filing by industry. Availability of more innovation funds and IP awareness activities could help the Jammu-HP cluster transition from a Promising to Emerging cluster. The Goa cluster would need thrust in areas like innovation infrastructure and investment climate. Clusters like Sikkim and Karnal need more focussed policy changes and a deeper analysis to help them move up within the Promising clusters group.

7.2 Learnings and recommendations

The biotechnology sector is recognised as one of the key drivers for contributing to India's USD 5 trillion economy target by 2024. India is among the top-12 destinations for biotechnology in the world, with approximately 3% share in the global biotechnology industry. In order to achieve the target one of the key challenges in the biotechnology sectors that need to be addressed is the lack of capacity for bio-manufacturing and the paucity of biotech Incubators necessary to scale up the start-up ecosystem.

The analysis of the available secondary data on publications and patents from the clusters and the strengths as well as challenges expressed by various stakeholders in the 13 clusters provided useful insights on the capacity and performance of the clusters. While many of the challenges were common across clusters, the degree and extent of the problems were found to vary depending on the maturity of a cluster, with specific issues that were more pronounced in the Emerging and Promising clusters. Some of the areas of strength, especially in some of the Emerging and Promising clusters were availability of trained HR, untapped local mentor pool, active government policies and willingness to learn, adapt and prosper. These factors were considered while framing the recommendations that could help the clusters evolve to the next level of growth.

The three biggest hurdles faced by all stakeholders in Emerging and Promising clusters were lack of access to funds, few or no networking forums and poor innovation infrastructure which led to movement of start-ups from these clusters to more established clusters, which in turn spiralled into another challenge, that of retention of talented human resource within the cluster. This was most evident in clusters like Mangalore and Kolkata. It was observed that a series of parallel actions would be required to target the problem like funding of incubators, providing IP services, establishing networking forums and local story telling sessions and other interactive events.

One of the problems that was particularly highlighted in the Promising clusters was the lack of networking forums which led to working in silos and lack of peer-to-peer learning which plays a crucial role in the development of a cluster.

The issue of lack of IP awareness was also directly correlated to slowing down translational research and this needs to be rectified to translate the clusters into vibrant innovation ecosystems. Goa was the only cluster wherein there was a complete lack of availability of IP firms within the ecosystem. Also, clusters like Guwahati and Jammu- HP need a lot of thrust towards IP awareness. Capacity building for incubation managers, especially for the Emerging and Promising clusters, was the other important aspect. To overcome these challenges, Emerging and Promising clusters need tailor made programmes.

Recommendations

Several recommendations made in the earlier phases of the study were adopted by BIRAC through various initiatives in the last few years. A few recommendations have still been retained on the basis of the observations of the existing status of the clusters. In addition, new recommendations have been presented based on the learnings from this study.

1. Design of tailor made programmes for Emerging and Promising clusters

Successful cluster initiatives begin with a combination of data collection and analysis to identify and prioritize cluster opportunities to serve the cluster in the best possible way. During data collection and entrepreneurship development activities for Phase III it was observed that the following programmes are needed the most in emerging and promising clusters in Tier II and III cities.

i. Creation of cluster networking platform

Knowledge transfer, peer to peer learning and information flow across stakeholders are necessary for nurturing and growing an innovation ecosystem. Networking forums are critical for achieving these. To meet this necessity, "Open Dialogues" was launched as a networking platform and meetings in each cluster were conducted with participation from key stakeholders in the local innovation ecosystem. During these events it became evident that stakeholders in emerging and promising clusters do not meet each other often and peer to peer learning was very low. Till a set of local champions were identified in a cluster, there would be a need for an external agency like BRIC to take the initiative to develop such networking platforms.

ii. IP Clinics

Intellectual property (IP) plays an important role in development of a cluster and reflects both on the R&D capacity and entrepreneurship culture of a cluster. During the BRIC activities it was observed that emerging and especially the promising cluster lack in IP awareness activities and which is validated though poor numbers of fillings through these clusters. It is highly recommended to not only hold IP awareness workshops but also provide IP services like Patentability searches, FTO and drafting services to these clusters though organized IP Clinics.

iii. Development of local mentor pool

The "storytelling" sessions organised by BRIC were found to be the most successful and engaging workshops that showcased local success stories. This helped BRIC identify the local mentors who understood the cluster challenges and ground level realities and could help innovator navigate them. They were also positively inclined to invest in the local start-ups and develop the clusters.

iv. Hackathons/ Idea Exposition events based on local flavour

Every cluster has its own local challenges and strengths. Although setting up general hackathons encourage development of entrepreneurship culture, it would be greatly beneficial if specific calls for Hackathons/ Idea Exposition are held with cluster challenges and strengths as thematic areas. This would create interest among local industry as well as the local government to engage in the start-up ecosystem.

2. Creation of alternate structures for financing start-ups from less developed clusters

Large number of start-ups from emerging and promising clusters may be able to spin out sustainable and profitable businesses and create jobs, but these ventures may not be investible by Venture Capital funds. There is a need to create blended finance structures such that public money (funding from BIRAC) can be leveraged to raise private capital or bank loans to fund the working capital needs and other project finance needs of the start-ups.

3. Creation of Virtual Incubation Platform connecting Clusters within a Region

Knowledge sharing and peer-to-peer learning can result in nonlinear growth in the ecosystem if managed and facilitated appropriately. Physical incubators are necessary for access to laboratory equipment. While these facilities also provide a great platform for interaction and learning, emerging and promising clusters often lack a critical mass of innovators and start-ups for peer-to-peer learning and also mature incubation managers. Both these issues can be addressed through a hybrid model of physical and virtual incubation platforms. The COVID-19 pandemic has clearly helped us realise the power of online platforms, webinars and online coaching and mentoring, and that physical proximity is not essential for quality interaction.

A sustainable model of incubation at scale is possible in emerging and promising clusters by setting up a "Anytime-Anywhere" virtual incubation platform that links several regional incubators in neighbouring clusters. Apart from start-up development activities, these virtual platforms should also emphasize on development of incubation managers and handholding early-stage incubators.

4. Development of Innovation Corridors

Innovation is a big driver of economic development, creating jobs and igniting growth industries. Established innovation clusters are typically concentrated around select cities. While state governments have tried to develop various tier 2, 3, 4 towns by attracting industry and investments and providing infrastructure and tax incentives and developing industrial parks/ zones, these are not enough for developing innovation clusters. Innovation requires the presence of academic excellence and high-quality talent as well as an investment climate and industry. While a single emerging/ promising cluster or town may not be able to provide all these elements, the critical mass or scale could well be achieved by working synergistically across an economic or trade corridor by linking several clusters with complementary strengths.

Based on the learnings from this study, and especially due to the challenges imposed by the COVID pandemic, what clearly emerged was the need for better connectivity and sustained engagement within and among adjacent emerging and promising clusters. It was felt that rather than working with individual clusters, focussed attention should be given to adjoining emerging clusters to facilitate smooth flow of knowledge and innovative businesses among these clusters, thus making them stronger and viable entities. We term these groups of innovation clusters as "Innovation Corridors".

Annexure 1

IPC Classification used

1. **Agriculture:** Patents under the following IPC classes fall under agriculture domain.

A01B: Soil Working in agriculture or forestry; parts, details, or accessories of agricultural machines or implements, in general

A01C: Planting; Sowing; Fertilising

A01D: Harvesting; Mowing

A01G: Horticulture; cultivation of vegetables, flowers, rice, fruit, vines, hops or seaweed; forestry; watering

A01H: New plants or non-transgenic processes for obtaining them; plant reproduction by tissue culture techniques

A01J: Manufacture of dairy products

A01K: Animal husbandry; care of birds, fishes, insects; fishing; rearing or breeding animals, not otherwise provided for; new breeds of animals

A23K: Fodder

2. **Biotechnology:** Patents under the following IPC classes fall under biotechnology domain.

A23B: Preserving, e.g. by canning, meat, fish, eggs, fruit, vegetables, edible seeds; chemical ripening of fruit or vegetables; the preserved, ripened, or canned products

A23C: Dairy products, e.g. milk, butter, cheese; milk or cheese substitutes; making thereof

A23D: Edible Oils or fats, e.g. margarines, shortenings, cooking oils

C07: Organic Chemistry

C12: Biochemistry; Beer; Spirits; Wine; Vinegar; Microbiology; Enzymology; Mutation Or Genetic Engineering

C02: Treatment of Water, Waste Water, Sewage, Or Sludge

3. **Medical Devices:** Patents under the following ipc classes fall under the medical devices domain.

A61B: Diagnosis; Surgery; Identification

A61C: Dentistry; Apparatus or Methods for Oral or Dental Hygiene

A61D: Veterinary Instruments, Implements, Tools, Or Methods

A61F: Filters implantable into blood vessels; prostheses; devices providing patency to, or preventing collapsing of, tubular structures of the body, e.g. stents; orthopaedic, nursing or contraceptive devices; fomentation; treatment or protection of eyes or ears; bandages, dressings or absorbent pads; first-aid kits

A61G: transport, personal conveyances, or accommodation specially adapted for patients or disabled persons (appliances for aiding patients or disabled persons to walk); operating tables or chairs; chairs for dentistry; funeral devices

A61H: Physical therapy apparatus, e.g. devices for locating or stimulating reflex points in the body; artificial respiration; massage; bathing devices for special therapeutic or hygienic purposes or specific parts of the body

A61J: Containers specially adapted for medical or pharmaceutical purposes; devices or methods specially adapted for bringing pharmaceutical products into particular physical or administering forms; devices for administering food or medicines orally; baby comforters; devices for receiving spittle

A61M: Devices for introducing media into, or onto, the body; devices for transducing body media or for taking media from the body; devices for producing or ending sleep or stupor

A61N: Electrotherapy; Magnetotherapy; Radiation Therapy; Ultrasound Therapy

4. Pharmaceuticals: Patents under the following IPC classes fall under pharmaceuticals domain.

A61K: Preparations for medical, dental, or toilet purposes

A61L: Methods or apparatus for sterilising materials or objects in general; disinfection, sterilisation, or deodorisation of air; chemical aspects of bandages, dressings, absorbent pads, or surgical articles; materials for bandages, dressings, absorbent pads, or surgical articles

A61P: Specific therapeutic activity of chemical compounds or medicinal preparations

A61Q: Specific use of cosmetics or similar toilet preparations

"Biotechnology Industry Research Assistance Council (BIRAC) is a not-for-profit Section 8, Schedule B, Public Sector Enterprise, set up by Department of Biotechnology (DBT), Government of India as an Interface Agency to strengthen and empower the emerging Biotech enterprise to undertake strategic research and innovation, addressing nationally relevant product development needs.

BIRAC is an industry-academia interface and implements its mandate through a wide range of impact initiatives, be it providing access to risk capital through targeted funding, technology transfer, IP management and handholding schemes that help bring innovation excellence to the biotech firms and make them globally competitive.

In its nine years of existence, BIRAC has nurtured biotech startup ecosystem through several specialised schemes, networks and platforms. It also helps to bridge the existing gaps in the industry-academia Innovation research and facilitates novel, high quality affordable products development to address the unmet needs. BIRAC partners with ecosystem stakeholders including national and global partners to collaborate, create opportunities for India's biotech ecosystem growth. So far, BIRAC has supported around 5000+ startups, established a network of 60 BioNEST incubators, 14 Sparsh Centres, 10 E-YUVA centres, 7 Technology Transfer offices, funded 1500+ entrepreneurs, startups for ideation to development of product and technologies. This has led to about 500+ patents filed and 350+ commercialised products by biotech startups."

IKP Knowledge Park (IKP) is a 200-acre premier Science Park and Incubator headquartered in Hyderabad, India with two incubators in Bengaluru and facilities in four tier II cities. IKP promotes the advancement of technology-based innovators, entrepreneurs and small and large companies through customised space, shared equipment, incubation, mentorship, and funding. In the last 21 years of operations, IKP has touched over 10,000 innovators across 53 cities in India, supported over 800 companies & innovations and funded 380+ innovations.

Inspired by TechShop and MIT FabLab, IKP set up IKP-EDEN™ in Bengaluru in 2015 to help the prototyping and product development ecosystem. IKP-EDEN™ is a membership-based Do-It-Yourself fabrication studio and a startup accelerator. Building on the vast experience gained from helping Medtech startups and managing scientific research facilities, IKP is working towards furthering engineering and technology product startups.

IKP launched its Grants Management Programme in 2011 and conducts Grand Challenges and other innovation scouting programmes in partnership with the Bill & Melinda Gates Foundation, USAID, DFID, BIRAC, DBT, NSTEDB, DST and the Government of Karnataka. BIRAC, in partnership with IKP, set up the BIRAC Regional Innovation Centre (BRIC) in 2013 to further BIRAC's mandate of building a deeper understanding of the capacity and gaps in innovation, commercialisation and technology absorption ecosystems, and developing targeted programmes. IKP has partnered with BIRAC on several programmes including the Biotechnology Ignition Grant (BIG), Biotechnology Incubation Support Scheme, Grand Challenges in TB Control, Grand Challenges Explorations in global health, Sparsh, BRIC, BioNEST, IKP PRIME – Regional Tech Transfer Office and BIRAC SEED & LEAP Funds. In 2021 IKP received the Best Biotech Incubator Award from BIRAC.

IKP2.0 was launched in 2019 with the mission to advance deep-teching and co-creating solutions for tomorrow in health and plant systems. In March end 2020 IKP was among the first responders to launch the IKP COVID Fund (ICO Fund) supporting technology solutions to handle the pandemic. In 2021 IKP launched four new initiatives, DEEP Digital Health Accelerator, ATHENA Online Startup Platform, IKP Growth Labs in partnership with manufacturing partners and the Accredited Analytical Labs, A-Labs.

IP Generation
Technology Commercialization
Innovation Infrastructure
Human Capital
Research Capacity
Investment Climate
Government Support
Innovation Culture