F-score map of excellence and diversity of research performance in India

Recently, Prathap[1] identified 70 institutions in India that have published more than 500 papers during 2008–2012. A Framework score (*F*-score) is computed for each institution, quantifying how Indian universities and research-focused institutions have fared in the world of high end research in terms of excellence and diversity of its research base. Seven of these have a pan-India presence: Council of Scientific and Industrial Research, Indian Statistical Institute, Defence Research and Development Organisation, Indian Council of Medical Research, Indian Council of Agricultural Research, Indian Space Research Organisation and Tata Sons Ltd. The remaining sixty-three are dispersed among seventeen states and union territories. Nineteen states and union territories do not have a single institution of this calibre. We see how the dispersion pattern is across India using a cumulative representation of *F*-score against population.

Reference 1 sourced secondary material from a web application[2–5] which visualizes scientific excellence worldwide in 22 major subject areas using Scopus data collected for the SCImago Institutions Ranking[6]. This covers scientific articles published during the publication period 2008–2012. Only those institutions (universities or research-focused) that have published at least 500 articles, reviews and conference papers in each category within the publication period are covered. Also, only subject categories where globally at least 50 institutions are found meeting this criteria are included in the web application. The full counting method was used to attribute papers from the Scopus data base to institutions: if an institution appears in the affiliation field of a paper, it is fully attributed to this institution (with a weight of 1).

India-specific indicators were computed using the web application[2]. For each institution in a specific subject area, the number of papers published, P, and the associated Best Paper Rate (BPR) were available. BPR is the proportion of publications from an institution which belongs to the 10% most cited publications in their respective subject area and publication year, so that the indicator $i = BPR/10$, is a plausible measure of quality. The best paper rate corresponds to the PP (top 10%) used in the Leiden Ranking and the Excellence Rate used in the SCImago Institutions Ranking[6]. BPR is a field-normalized size-independent indicator which serves as a measure of the high quality output of research institutions. We can then compute a single-valued composite outcome indicator for the research performance of each institution in each area by introducing the second-order indicator[7], called the exergy term from the quantity (size) and quality (excellence) indicators, $x = i^2P$.

Within a subject area, we will find several institutions that have P and i varying considerably. Thus, the size-dependent proxy for research performance may vary by orders of magnitude. Similarly, when we take within an institution, a subject-wise cross-section, P, i and X vary considerably[1]. There is therefore a huge variation in performance. This issue of structural diversity was addressed recently[8]. Reference 8 argues that structural diversity – the diversity of disciplines, institutions and support mechanisms is needed as it is a property of a 'strong' research base that not only produces great research today, but also has the capacity to address new challenges flexibly and responsively tomorrow. In a system or set of j categories or sources (that is institutions within a discipline or area, or disciplines or areas within an institution), if x_j is the exergy of each source of a total of S sources, then we can have a measure of consistency or evenness of distribution η defined as[7]

$$X = \Sigma x_j,$$

$$E = \Sigma x_j^2,$$

$$x = X/S,$$

and

$$\eta = X^2/(SE).$$

Reference 1 proposed a measure that combines performance as measured by x_j and X with diversity[8]. The Stirling approach to diversity[9] adopted in ref. 8, combines three basic properties: 'variety', 'balance' and 'disparity'. In our case, S is the measure of variety as it is the number of categories into which system elements (institutions in an area or areas within an institution) are apportioned. All else being equal, the greater the variety, the greater the diversity[8]. In the present case, we interpret balance as a function of the variation of x_j elements across categories. It performs the same role as statistical variance. We find that η as defined above is a natural candidate for measuring this and $\eta = 1$ is the ideal condition when all elements perform at the same level. Again, all else being equal, the more even the balance, the greater the diversity[8].

Reference 1 introduced a Framework score, which combines the number of elements in a system S, the total exergy X within the system (institutions within an area or areas within an institution) and the balance as the product $F = \eta X$. We shall use this Framework score F to see how the Indian science ecosystem is faring from the point of view of its geographical distribution.

Table 1 lists 70 unique entities from India that are good enough to make the cut, i.e. have published more than 500 papers in the respective areas during 2008–2012. Seven have a pan-India presence and we shall discount this in our further analysis. Sixty-three are located state-wise. Some states are well represented, e.g. Tamil Nadu with ten, West Bengal with nine, etc. Eight states have only one each, usually a premier centrally funded institution. That leaves nineteen states and union territories that have no presence as far as such institutions are concerned. This forms a large swathe of India – Bihar, Odisha, Jharkhand, Chattisgarh, Andhra Pradesh and the entire north-east with the exception of Assam.

Table 2 is a re-ordering of the list of 63 institutions on a *F*-score per million of population (*F*/mP) basis. The population figures are taken from the 2011 census. On this basis, we have Chandigarh at the top. The dispersion is unequal – Chandigarh has a per capita *F*-score that is nearly 600 times that of Haryana. Figure 1 is a Lorenz curve representation

Table 1. All-India list of 70 institutions with an *F*-score[1]

Institution	Mapping	*X*	Size	*x*	η	*F*-score
Indian Institute of Technology, Guwahati	Assam	923.3	1	923.3	1.00	923.30
Postgraduate Institute of Medical Education and Research	Chandigarh	629.9	1	629.9	1.00	629.93
Physical Research Laboratory	Gujarat	216.7	1	216.7	1.00	216.71
Chaudhary Charan Singh Haryana Agricultural University	Haryana	26.2	1	26.2	1.00	26.24
Council of Scientific and Industrial Research	India	4477.0	7	1132.9	0.40	3152.73
Indian Statistical Institute	India	978.3				
Defence Research and Development Organisation	India	607.8				
Indian Council of Medical Research	India	976.4				
Indian Council of Agricultural Research	India	383.5				
Indian Space Research Organisation	India	261.4				
Tata Sons Ltd.	India	246.0				
Indian Institute of Science	Karnataka	2424.0	7	683.4	0.36	1729.41
Jawaharlal Nehru Centre for Advanced Scientific Research	Karnataka	1744.9				
National Institute of Technology Karnataka	Karnataka	305.0				
Manipal University	Karnataka	112.5				
Mangalore University	Karnataka	51.7				
National Institute of Mental Health and Neuro Sciences	Karnataka	126.1				
University of Mysore	Karnataka	19.9				
Sree Chitra Tirunal Institute for Medical Sciences and Technology	Kerala	175.6	1	175.6	1.00	175.60
Raja Ramanna Centre for Advanced Technology	Madhya Pradesh	129.4	2	208.9	0.87	364.94
UGC–DAE Consortium for Scientific Research Indore	Madhya Pradesh	288.3				
Indian Institute of Technology, Bombay	Maharashtra	1605.5	8	1485.3	0.60	7175.07
Bhabha Atomic Research Centre	Maharashtra	1116.5				
Tata Institute of Fundamental Research	Maharashtra	3925.2				
Shivaji University	Maharashtra	2875.5				
Institute of Chemical Technology, Mumbai	Maharashtra	898.5				
Tata Memorial Centre	Maharashtra	789.7				
University of Pune	Maharashtra	523.5				
Seth Gordhandas Sunderdas Medical College and King Edward Memorial Hospital	Maharashtra	147.9				
Indian Institute of Technology, Delhi	New Delhi	2134.3	8	805.2	0.53	3413.72
University of Delhi	New Delhi	1472.6				
All India Institute of Medical Sciences	New Delhi	1173.0				
Jamia Hamdard	New Delhi	1276.0				
Inter-University Accelerator Centre	New Delhi	228.3				
Lady Hardinge Medical College	New Delhi	62.1				
Guru Tegh Bahadur Hospital	New Delhi	48.0				
University College of Medical Sciences	New Delhi	47.6				
Jawaharlal Institute of Postgraduate Medical Education and Research	Puducherry	101.4	1	101.4	1.00	101.44
Panjab University	Punjab	5474.6	2	2850.8	0.54	3086.92
Punjab Agricultural University	Punjab	227.1				
University of Rajasthan	Rajasthan	1614.9	1	1614.9	1.00	1614.87
PSG College of Technology	Tamil Nadu	258.5	10	622.2	0.60	3736.86
Indian Institute of Technology, Madras	Tamil Nadu	1840.4				
Anna University	Tamil Nadu	644.8				
National Institute of Technology, Tiruchirappalli	Tamil Nadu	1227.7				
Indira Gandhi Centre for Atomic Research	Tamil Nadu	481.1				
Annamalai University	Tamil Nadu	534.8				
VIT University	Tamil Nadu	378.5				
Christian Medical College, Vellore	Tamil Nadu	614.1				
University of Madras	Tamil Nadu	141.7				
Tamil Nadu Agricultural University	Tamil Nadu	100.1				
University of Hyderabad	Telangana	656.5	2	506.5	0.92	931.32
International Institute of Information Technology, Hyderabad	Telangana	356.5				
Banaras Hindu University	Uttar Pradesh	1129.6	7	651.7	0.67	3078.00
Indian Institute of Technology, Kanpur	Uttar Pradesh	1399.3				
Aligarh Muslim University	Uttar Pradesh	454.2				
Motilal Nehru National Institute of Technology	Uttar Pradesh	744.9				
Sanjay Gandhi Postgraduate Institute of Medical Sciences	Uttar Pradesh	608.7				
King George's Medical University	Uttar Pradesh	198.1				
Govind Ballabh Pant University of Agriculture and Technology	Uttar Pradesh	26.9				

(*Contd*)

Table 1. (*Contd*)

Institution	Mapping	X	Size	x	η	F-score
Indian Institute of Technology, Roorkee	Uttarakhand	1359.9	1	1359.9	1.00	1359.92
Indian Institute of Technology, Kharagpur	West Bengal	2406.0	9	1404.0	0.78	9815.04
Jadavpur University	West Bengal	1585.0				
Indian Association for the Cultivation of Science	West Bengal	2503.5				
Saha Institute of Nuclear Physics	West Bengal	2135.1				
University of Calcutta	West Bengal	504.5				
Variable Energy Cyclotron Centre	West Bengal	1409.9				
National Institute of Technology, Rourkela	West Bengal	614.8				
Bengal Engineering and Science University, Shibpur	West Bengal	757.9				
S.N. Bose National Centre for Basic Sciences	West Bengal	719.2				

Table 2. State-wise list showing cumulative proportion of F-score against cumulative proportion of population

State or UT	Population	F-score	F/mP	CumPop	CumF
Chandigarh	10,54,686	629.93	597.27	1.00	1.00
Delhi	1,67,53,235	3413.72	203.77	1.00	0.98
Uttarakhand	1,01,16,752	1359.92	134.42	0.99	0.89
Punjab	2,77,04,236	3086.92	111.42	0.98	0.86
West Bengal	9,13,47,736	9815.04	107.45	0.95	0.78
Puducherry	12,44,464	101.44	81.52	0.88	0.52
Maharashtra	11,23,72,972	7175.07	63.85	0.88	0.52
Tamil Nadu	7,21,38,958	3736.86	51.80	0.78	0.33
Assam	3,11,69,272	923.30	29.62	0.72	0.24
Karnataka	6,11,30,704	1729.41	28.29	0.70	0.21
Telangana	3,52,86,757	931.32	26.39	0.65	0.17
Rajasthan	6,86,21,012	1614.87	23.53	0.62	0.14
Uttar Pradesh	19,92,81,477	3078.00	15.45	0.56	0.10
Kerala	3,33,87,677	175.60	5.26	0.40	0.02
Madhya Pradesh	7,25,97,565	364.94	5.03	0.37	0.02
Gujarat	6,03,83,628	216.71	3.59	0.31	0.01
Haryana	2,53,53,081	26.24	1.03	0.26	0.00
Lakshadweep	64,429	0	0	0.24	0.00
Daman and Diu	2,42,911	0	0	0.24	0.00
Dadra and Nagar Haveli	3,42,853	0	0	0.24	0.00
Andaman and Nicobar Islands	3,79,944	0	0	0.24	0.00
Sikkim	6,07,688	0	0	0.24	0.00
Mizoram	10,91,014	0	0	0.24	0.00
Arunachal Pradesh	13,82,611	0	0	0.24	0.00
Goa	14,57,723	0	0	0.24	0.00
Nagaland	19,80,602	0	0	0.24	0.00
Manipur	27,21,756	0	0	0.23	0.00
Meghalaya	29,64,007	0	0	0.23	0.00
Tripura	36,71,032	0	0	0.23	0.00
Himachal Pradesh	68,64,602	0	0	0.23	0.00
Jammu and Kashmir	1,25,48,926	0	0	0.22	0.00
Chhattisgarh	2,55,40,196	0	0	0.21	0.00
Jharkhand	3,29,66,238	0	0	0.19	0.00
Odisha	4,19,47,358	0	0	0.16	0.00
Andhra Pradesh	4,93,86,799	0	0	0.13	0.00
Bihar	10,38,04,637	0	0	0.09	0.00
Total	1,20,99,09,538	38379.30	31.72	0	0

of the same data as a state-wise distribution plotting the cumulative proportion of F-scores against the cumulative population.

The Framework score[1] allows us to see how Indian universities and research-focused institutions fare in the world of high end research in terms of excellence and diversity. In the present exercise we have looked at the dispersion of these premier institutions state-wise. Research is concentrated in a few states, and there is little or no presence in the majority of the states. For structural diversity[8] to be effective, i.e. the diversity of disciplines, institutions and support mechanisms needed to produce great research today but also has the capacity to address new

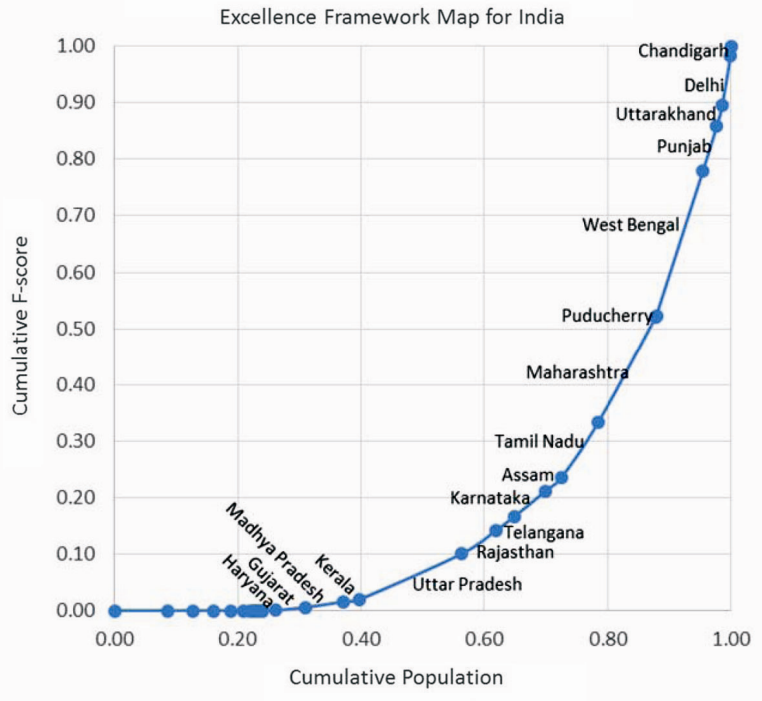

Figure 1. Cumulative Lorenz curve of *F*-score versus population.

challenges flexibly and responsively tomorrow, there should be a more equitable distribution across geographical regions as well. We see that a large swathe of India – Bihar, Odisha, Jharkhand, Chattisgarh, Andhra Pradesh and the entire north-east with the exception of Assam – does not have a single premier institution.

1. Prathap, G., *Curr. Sci.*, 2016, **111**(3), 470–474.
2. http://www.excellencemapping.net/#/view/measure/top10/calculation/a_ohne_kovariable/field/materials-science/significant/false/org/
3. Bornmann, L., Stefaner, M., de Moya Anegón, F. and Mutz, R., *Online Inf. Rev.*, 2014, **38**(1), 43–58.
4. Bornmann, L., Stefaner, M., de Moya Anegón, F. and Mutz, R., *J. Inf.*, 2014, **8**(3), 581-593.
5. Bornmann, L., Stefaner, M., de Moya Anegón, F. and Mutz, R., *COLLNET J. Scientometr. Inf. Manage.*, 2015, **9**(1), 61–68.
6. http://www.scimagoir.com/
7. Prathap, G., *Scientometrics*, 2011, **87**(3), 515–524.
8. Anon., Digital Science and the Science Policy Research Unit, University of Sussex, December 2015.
9. Stirling, A., *J. R. Soc. Interface*, 2007, **4**, 707–719.

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Micro-level Agromet Advisory Services using block level weather forecast – A new concept based approach

Agromet Advisory Service (AAS) deals with extension agrometeorology and is defined as 'all agrometeorological and agro-climatological information that can be directly applied to improve and/or protect the livelihood of farmers'[1]. AAS has been adopted at district level since 2008 by the India Meteorological Department (IMD) and is continued even now. The district level AAS is provided to farmers making use of medium range weather forecast of the National Center for Medium Range Weather Forecasting (NCMRWF) and IMD. However, the validity of blanket advisories disseminated at district level has limitations, particularly in view of the large variability in terms of crops, varieties and spatial weather anomalies at this level.

Keeping in view the recent variability in weather and climate, the Central Research Institute for Dryland Agriculture (CRIDA), Hyderabad pioneered in starting a flagship research programme of the Indian Council of Agricultural Research (ICAR) named 'National Innovations in Climate Resilient Agriculture (NICRA)'. The project aims to enhance resilience of Indian agriculture to climate change and climate vulnerability through strategic research and technology demonstration. Under the aegis of NICRA, the All India Coordinated Research Project on Agrometeorology (AICRPAM) of ICAR took up a pilot project during 2010 to develop and disseminate block level AAS through its 25 cooperating centres spread across the country[2] towards enabling capacity building of farmers for climate resilience. As part of this, AICRPAM initiated block level AAS in Belgavi district of Karnataka through its Vijayapura cooperating centre. However, the forecasts used in this case were also of district level. After three years of experimentation, it was concluded that the district level forecasts were indeed not sufficient to answer the demands of the block level crop and weather variability within the district. To overcome this constraint, special request was made to