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Science, Technology, Innovation in India and Access, Inclusion and Equity: Discourses, Measurement and Emerging Challenges

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Abstract: The role of Science, Technology and Innovation (STI) in economic growth is well accepted. Tracing the debate on the role of science in Indian society in the pre-1947 India, the discourses and narratives on science, technology and society in India are mapped and their impact on policies is discussed. However, in the backdrop of growing inequalities and access to technology the debate on technology and development has assumed greater policy relevance. In this paper, we have used qualitative analysis and quantitative methods to discuss the issues in understanding and evaluating S&T policy in India and measuring access, equity and inclusion (AEI) through indicators. Although AEI as principles can be used for policy analysis and studying the impacts of S&T policies, the need for robust indicators is obvious. But the current indicators of impacts of S&T, or innovation indicators do not capture AEI nor consider them as important values to be measured. In development economics attempts are being made to measure inclusion and exclusion and to study marginalisation or marginality. We have constructed three indices using Principal Component Analysis (PCA) where weights in each index are the variances of successive principal components. The paper suggests that research on AEI should become part of S&T policy process. It is suggested that in major technology initiatives and policy proposals 3 to 5 per cent of the proposed budgets could be allotted to such research. Another suggestion is to develop new methodologies and models, in the context of emerging technologies and S&T related indicators should be linked to socio-economic indicators.

Keywords: Access, Equity, Inclusion, S&T indicators, S&T policy, innovation policy

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1. Introduction

While the role of Science and Technology and Innovation (STI) in national growth is well known and widely accepted by many governments and the UN agencies, what constitutes ethics in Science and Technology (S&T) and Innovation policy is a matter of debate. Instead of taking a traditional approach we have approached the question of ethics through Access, Inclusion and Equity (AIE). This assumes great importance for a country like India, where 'access' itself is a larger issue which arouses intense and passionate debates, for instance, on questions related to intellectual property rights (IPRs). The wider inequality within the country and across various regions raises the debate on inclusion and equity. The idea of ethics in this respect is also significant since technology and gender divide are pre-dominantly evident across the board. In the context of this discussion paper, the endeavour is to contribute to measuring AIE as an outcome of policies including S&T policies and as a norm in STI policy frameworks. Measuring AIE through indicators is a challenging task given the methodological issues, data availability and other issues in developing indicators.

In giving importance to AIE we are not taking the position that values like autonomy are irrelevant. Rather in our view AIE is more relevant in the Indian context than abstract values like autonomy, freedom and human dignity. In this regard, it is worth pointing out that inclusive growth and social inclusion are now part of the development economics literature and economists are developing indicators to measure them.[1] The 12th five year plan focuses on inclusive growth and states that "our focus should not be just on GDP growth itself, but on achieving a growth process that is as inclusive as possible" and rightly accepts that "strong inclusive growth is the only scenario that will meet the aspiration of the people". This reflection indicates that the planners are aware of the need to move beyond GDP growth and promote inclusive growth. Just as it has been pointed out that economic growth per se does not result in inclusive growth or in more social inclusion, we want to point out that S&T policies can impact inclusion.

Access and Equity are linked with inclusion. Access to benefits of advances in S&T and deriving the benefits of technological advances is important. Hence, we argue that access is an important value. Equity is a contested term but iniquitous distribution of benefits of advances of S&T and/or bearing the disadvantages from developments in S&T without deriving any benefits indicates that S&T policies can exacerbate persisting inequalities in the society and thereby contribute to widening disparities or worsening of the condition. Hence we take the position that AIE could be considered as ethical principles that would help in assessing impacts of S&T policies and their outcomes. This also means S&T policies should ensure that policy design or institutional frameworks do not reduce access, result in more exclusion and more iniquitous distribution of benefits. In the recent years scholars have used ideas of Amatrya Sen and John Rawls to address distributive justice implications of innovations in life sciences and for developing normative theory of information society.[2] AIE is closely related to distributive justice.

In India, there are several initiatives undertaken by various agencies, institutions, civil society organisations and individuals, working in the area of science and technology for improving access and inclusion. The various Five Year Plan documents and policy statements have repeatedly emphasised on ensuring that benefits of S&T reach the masses, i.e. access, equity and inclusion.

The legitimacy of science and its role in national development was hotly debated from the 1930s to the 1950s and science became part of the developmental imagination and science was promoted as an agent of progress.[3] However, over the years, the debates resulted in four different discourses. They reflected not just different ideas on STI but as well brought forward different perspectives on national development. We can classify the discourses on S&T and development in Post-1947 India into the four broad categories: Nehruvian Discourse; Gandhian Discourse and Kumarappa's discourse on S&T for development; Peoples' Science Movements and their discourse on S&T and development and Other Voices and Discourses on S&T.

Although none of them took irrational or anti-S&T position the role envisaged for S&T in these discourses and framing of the problems and solutions resulted in very different perspectives and proposals that were at odds with each other. The assumptions in the discourses and the ideals/ objectives they put forth have to be taken into account to understand the divergence.[4]

2. Access, Inclusion and Equity: Conceptual and Research Framework

Ethics in S&T policy or in science is often linked with values like autonomy, justice and human dignity and the objectives of ethical analysis is to evaluate the policies and practice of S&T in terms of realising them.[5] Instead of this, we propose a new approach which in our view makes more sense in developing countries, like India where distributional effects are more important to evaluate the impacts of STI policies than traditional S&T indicators or innovation indicators.

In literature, access is often studied in terms of access of certain groups/classes to technologies and/or access to services and goods like drugs and how race, gender affect access to technologies particularly the digital technologies and related services, and/or participation in science.[6] While inclusion has been discussed in the context of exclusion and on the inclusiveness of technology or policy it has been linked with social inclusion/exclusion.[7] Equity has been studied with reference to specific technologies like nanotechnologies or equitable distribution of outcomes.[8] Another strand of inquiry has been on the social inequalities and S&T policies.[9] A key question is how to ensure that S&T policy addresses these issues and contributes to equitable and sustainable development. Unequal access to S&T or its benefits are not equal resulting in inequitious outcomes for vulnerable groups.[10] Distributional inequities can occur on account of inequalities in the distribution.[11] According to UNCTAD,"In a highly unequal society, STI is often an elite activity, serving a few people and industries. In inclusive development, STI is no longer restricted to laboratories and frontier technologies, but contributes to solving day to day challenges."[12]

According to Bozeman, Slade and Hirsch (2010) political equity, equity of opportunity and basic needs fulfillment have linkages to S&T and in determining as to who benefits from the outcomes of advances in S&T.[13] In reality the linkages between political equity and equity of opportunities are mediated by different factors while fulfilling basic needs itself is a major challenge in many countries. Political equity in democratic country need not necessarily result in equity of opportunity for all on account of various factors. But political equity provides opportunities to mobilize for demanding equity of opportunity. This can result in lesser inequality or at least measures for safeguarding equity and social justice. Analysing the Indian experience in innovation and its linkage with (in)equality Jospeh, Singh and Abraham (2014) state, "While interpersonal inequality over the years has not aggravated, it has not mitigated to a satisfactory level; inequality across different regions and that between different social groups has increased. Nonetheless India appeared to be more equal today than its counterparts in BRICS countries, providing credence to the constitutional assurance for equity and social justice."

In this paper we have used qualitative analysis and quantitative methods to discuss the issues in understanding and evaluating S&T policy in India and measuring AIE through indicators. Although AIE as principles can be used for policy analysis and studying the impacts of S&T policies, the need for robust indicators is obvious. But the current indicators of impacts of S&T, or innovation indicators do not capture AIE nor consider them as important values to be measured.[14] In development economics attempts are being made to measure inclusion and exclusion and to study marginalisation or marginality.[15] Hence in the absence of suitable indicators an attempt has been made to develop indices to link AIE with economic growth and socio-economic data. For this purpose, we have devised a methodology and accessed available data sets to construct three indices. The results are preliminary and cannot be construed as judgments on performance of the states in India.

At the quantitative level we have constructed three indices using Principal Component Analysis (PCA) where weights in each index are the variances of successive principal components. PCA is a multivariate statistical approach that uses orthogonal transformation to convert a set of correlated variables into a set of uncorrelated variables called principal components. Nagar and Basu (2002) used this technique to construct infrastructure index for 17 major states in India during the period 1990-91 to 1996-97. As there are no similar studies elsewhere we could not compare out methodology or adopt available ones. In case of data sets we have used the available ones. While the methodology and the indices will certainly need further work and revision, it is our submission that these results should be considered as preliminary results and not taken as evaluations or judgments on the performance of states or of the national S&T policy.

Before calculating the index, we normalised all the indicators to make them scale free. In order to do so, we calculate mean and standard deviation of each indicator (included for the construction of an index) across the states for a given year and then normalize the indicators using following formula:

$$\frac{X_{is} - \bar{X}}{\sigma_i} \qquad \text{...(1)}$$

In the above equation, X_{is} is value of an indicator i for state s, $\bar{X}$ is mean of indicator i, and σ_{is} is standard deviation of indicator i.

After transforming all the indicators we have computed the correlation matrix (R) between all the indicators for a given index to move towards the next step of calculating characteristic roots and vectors. The characteristic roots of the correlation matrix for any given year are calculated by solving the determinant $|R - \lambda I| = 0$ for λ, where R is an n×n matrix. This provides a n^{th} degree polynomial equation in λ and thus n roots. These roots are eigenvalues of correlation matrix R. These eigenvalues are arranged in descending order of magnitude. Corresponding to each value of λ, the matrix equation $(R - \lambda I)\alpha = 0$ is solved for the n×1 characteristic vector □, subject to the condition $\alpha \alpha = 1$. Following this, we calculate principal components as linear functions of standardised variables, where the coefficients of the variables are elements of successive characteristic vectors. The first component is calculated as follows:

$$P_1 = \alpha_{11} X_1 + \alpha_{12} X_2 + \cdots + \alpha_{1n} X_n \qquad \text{..........(2)}$$

In the above equation, $X_1, X_2, \dots\dots, X_n$ are n indicators in a given index. Similarly, we have calculated all the principal components equivalent to number of indicators included in the given index. Based on principal components the index is calculated as follows:

$$Index = \frac{\lambda_1 P_1 + \cdots + \lambda_n P_{n1}}{\lambda_1 + \cdots + \lambda_n} \qquad \text{................................(3)}$$

In equation (3) $\lambda_1 = varP_1, \dots, \lambda_n = P_n$

With this technique we take into account total variation in indicators. First component explains largest variation so highest weight has been assigned to this component and second component has been assigned the second highest weight. Please refer to Annexes for details on data sources, Indices and Indicators used in various studies.

3. Discourses and Narratives in Indian S&T Policy: An Overview

The Indian response to modern science included debates on using science for national development and social transformation. Science was projected as a harbinger of progress and an effective tool for modernising the traditional society in India. Within Indian National Congress and elsewhere there were many views on science and its role in social development. But a strong and influential section felt that science was essential for India and as a nation and as a society India would benefit immensely from it. By the 1930s, a few like Meghanand Saha wrote about the important role that science could play in Independent India. Saha was a member of National Planning Committee chaired by Nehru and argued for a positive role for science and scientists in free India backed with support from state, for using science for national development and highlighted the role of science in Indian economic development and planning.

In 1940, a National Planning Committee was constituted which had a sub-committee on science. Sir M. Visvesvaraya as President of Court of the Indian Institute of Science proposed a roadmap for developing national infrastructure and policy approach.[16] Political documents were evolved arguing S&T as an agent of social, economic and political transformation and its role in promotion of peace. In these documents, Mahatma Gandhi's influence was of great significance as he tried to infuse the struggle for independence with a new or a modern interest in traditional techniques.[17] Thus, by 1947 there was almost a consensus among an influential section of scientists, industrialists and politicians, that S&T would play an important role in national development. This consensus was followed up with action plans after India got independence.

3.1 Nehruvian Discourse

Pandit Jawaharlal Nehru, the first Prime Minister of India, played a key role in the evolution of a political consensus on the role of science, as he recognised that political freedom would be incomplete without economic independence and that economic independence would be out of the grasp without scientific self-reliance. Thus, when India attained Independence Nehru had the support from Homi Bhabha, Saha and S.S. Bhatnagar in drawing plans for shaping Indian S&T system for national development. The five year plans resulted in expanding the laboratories under CSIR, setting up of National Laboratories, establishing specialised research centers, substantial investments in space and atomic energy and all this resulted in development of a massive S&T system in India. The political elite continued to support this and a major component of S&T expenditure was spent on them while science in universities was not supported so extensively.

Later the Green Revolution was embarked upon in late 1960s and this also resulted in expanding and strengthening research in agriculture under ICAR institutes. The Mahalanobis rate of growth required investment of seven per cent and above in the Second Five Year plan and this needed more capital intensive planning and investment across sectors. On account of the green revolution which envisaged a capital and input intensive approach in agricultural growth, agriculture itself was not a low capital activity as it was before and this necessitated larger investment in production of fertilisers, etc., besides investments in large/ integrated irrigation projects and delivery systems. All this called for larger investments and in many cases they were technology intensive as well.

Hence India had to import technology, plan for technology absorption and also develop indigenous capacity in different sectors to produce goods which were technology intensive. As a result the contribution of S&T to national economic development was beyond any doubt and import substitution plans called for development of technological capacity in key sectors. In the 1970s S&T received considerable support from the then Prime Minister Indira Gandhi who gave importance to technological self-reliance. In 1972, the Department of S&T was formed and support to the Department of Atomic Energy and Space Programmes was expanded. The question of self-reliance in technology was linked to foreign policy as India was denied access to nuclear technology on account of the testing of a nuclear device in 1974. This resulted in more support for initiatives in development of indigenous technology and import substitution. By the early 1980s the S&T system in India had expanded considerably with strong state support; and the state set the priorities and direction for S&T in India through plans, policy documents and other measures.

Two major concerns, namely,Science for National Development and Security and Self-reliance, have been at the core of India's efforts in S&T. India's S&T policy should be seen in the context of its five year plans and other policy measures. Thus while S&T as such had been dealt with DST and DSIR over the years the ministries and departments supporting S&T in different fields have expanded. A major criticism is that India spends more on Space and Nuclear science and technology through the Department of Space and Department of Atomic Energy and a major chunk of S&T spending is done through them. India considers both space and nuclear as subjects of strategic importance but the allocation of funds and supporting research in them is not limited to that alone. For example, over the years India has built up expertise in launching rockets, satellites and this expertise has helped India to use them for developmental purposes and in meeting natural calamities. Similarly, the Indian experience with atom for peace may be mixed but India's indigenous capacity has been built up over the decades with substantial component directed towards building reactors that could be used for power generation.

In case of Biotechnology, the move to establish first a Board within DST and then later a Department was made with the idea that India should build capacity in an emerging field and use it for national development. This paid rich dividends and the continued support has helped India to launch cheaper vaccines and other products. AIE was not the intended objective of the policy but the outcome of the policy facilitated that. The Nehruvian vision that envisaged greater role for the state in S&T resulted in these developments.

In contrast private sector contribution to S&T in India was minimal and was confined to applied research. While universities and other research centers contributed to S&T, the state gave more importance to special institutions set up under DAE, ISRO, DST, DSIR/CSIR, ICMR and other agencies like ICAR while institutions like IISc, IITs were strongly supported by the state. Even now it is the Nehruvian vision that is the predominant vision in guiding S&T at the level of S&T system in India.

The major contribution of Nehurvian discourse was its stress on S&T for economic development and self-reliance and this was affected by the state becoming the most important player in S&T in India. This also resulted in centralisation of funding and determination of thrust areas in S&T. An unintended consequence was the weakening of the S&T capacity in universities despite the expansion of higher education sector. Although India has a federal system, the states have played a marginal role in S&T policy making and their support to S&T has been limited. Despite liberalisation and globalisation, Nehruvian discourse still has significant impact in S&T policy and as over the years the role of state in S&T has not declined and it will continue to be the dominant discourse in S&T policy.

3.2 Gandhian Discourse

It can be argued that while Gandhi was critical of the use of technology for exploitation he was not against modern science per se. Gandhians had a different vision of national development and while they were not anti-Science per se, their thrust was different. But such voices were marginalised or avenues like Khadi and Village Industries were made available to them. The Gandhian discourse and practice was based on the principle of production by masses for masses through small scale and tiny industries and increasing self-sufficiency of the villages in essential commodities. After examining the works of Gandhi and his associates on science and technology Ninan argued that they engaged with science and technology with an understanding of values and institutional structures.[18] But Gandhian approach was not developed further as a vibrant radical critique and it marginalisation ensured that it had little impact on S&T policy or on agricultural policy. While state and central governments supported initiatives of Gandhians, through bodies like Khadi and Village Industries Commission (KVIC) many Gandhians had fundamental problems with massive industrialisation, and centralised mode of Governance.

J.C Kumarappa was a key Gandhian voice in Post-1947 India on S&T and national development. He was a critic of the Nehruvian approach to S&T and argued that neither capitalism nor socialism was suitable for India. He argued for an Economy of Permanence and favoured nuanced approaches to solving problems instead of opting for solutions like applying chemical fertilisers in all types of soils and for all types of crops. His vision of agriculture provided scope for the state to intervene in agriculture and support it. His idea of village industries was linked to his idea of economy of permanence. While Kumarappa had critical views on centralisation, he argued that states could centralise some sectors of economy like railways and retain control and support to village industries did not mean negating such control.

Dharampal, a Gandhian, wrote an important book on Indian S&T in 18th Century India and argued that Indian indigenous tradition could not be dismissed as irrelevant or archaic. His earlier work on Panchayat Raj and non-violent protests in pre-British and British India and later work on Local Governance in post-1947 India were pioneering and attracted the attention of many who were questioning the development model. Scientists, academics and activists came together and formed Patriotic and People Oriented S&T (PPST) group. PPST drew the attention to the relevance of the traditional technologies and traditional science and argued that they deserved a relook and revitalisation as western S&T alone will not work in India. Although PPST as a group is not now as active as it was, persons associated with PPST then are active today in many fields including traditional agriculture and traditional medicine.

3.3 Peoples' Science Movements

In Kerala, the Keral Sastra Shatiya Parishad (KSSP) which was started as a science popularisation movement campaigned against the Silent Valley Project that was to destroy evergreen rainforests in Silent Valley in the Western Ghats. They involved grassroots activists and mobilised people's support against the project. As a result the Central Government cancelled the permission given after a committee suggested that it should be scrapped as it would destroy the forests in Silent Valley. Many such organisations working on science popularisation and science communications with leftist leanings came together and formed all India People's Science Movements (PSMs) Network. Some of them associated with this Network developed critiques of S&T policy and Network had Science for Social Revolution as the slogan. They did not question modern S&T per se but criticised S&T policy and development model that failed to apply S&T for meeting people's development needs and argued that modern S&T per se is neutral and could be harnessed effectively for development only if the policy was right and institutions for that were developed. In that sense their critique was different from the post-modernists critique of S&T and that of those who argued from a social constructionist perspective of S&T. They argued that unless the public sector S&T is strengthened and directed towards making the best use of S&T for national development the society will not benefit the most from S&T.

They were involved in debates on changes in patent laws and India's response in the Uruguay Round of Negotiations. Although they did not reject the Green Revolution totally they argued for rational use of chemicals in agriculture while some of them started working on agro-ecological approaches in agriculture. They had no romantic illusion about traditional sciences and traditional technologies although they argued that these could be used in some contexts. Later in the 1990s, this Network worked on mass literacy campaign in many states and also started working on documenting people's knowledge and practices. People's Science movements also experimented with alternatives in technologies through initiatives like Center for Technology Development and KSSP sponsored a centre for development of technology and assessment. In Kerala, KSSP advocated setting up mini-hydel plants instead of opting for massive hydel projects and advocated the cause of renewable energy. Although PSMs have not been able to build a strong national network that has active support from grass root initiatives and other mass movements, they continue to be strong dissenters to the official wisdom on S&T and are active in issues relating to agriculture, health and environment.

3.4 Other Voices and Discourses on S&T

Even during the Nehruvian era there were critiques from scientists like Saha who were critical of centralised science planning and emphasis on nuclear energy. Similarly D.D.Kosambi, mathematician and historian questioned the emphasis on nuclear energy and favoured more research on solar energy as that would be more relevant for India. Ideas of Ivan Illich, E.F. Schumacher and Paulo Freier gained popularity in the late 1970s and 1980s. The Intermediate Technology Group inspired by Schumacher developed many appropriate technologies and solutions particularly for rural areas.[19] Schumacher wrote about Intermediate Technology and his thinking was influenced by Gandhi's writings on technology and development. Similarly, some of the ideas of Ivan Illich resonated well with the Gandhi's ideas. Initiatives like Barefoot College, Center for Science in Villages and centers on appropriate technology/ rural technology experimented with many of the ideas found in their writings by appropriating them for the Indian context.

A.K.N. Reddy and C.V. Seshadri worked on technologies that were appropriate and wrote on alternative visions on technology and society. While PPST talked of revitalising traditional sciences and technologies, these initiatives did not think in terms of tradition vs. modern but focused on appropriateness of technologies and institutions. There was much overlap between the ideas of PPST and many of those who worked in these initiatives saw that applying modern S&T through centralised S&T policy and mega projects as a solution to India's problems themselves created problems that needed attention and alternatives. At the grassroots level there were movements against large dams like Narmada Bacho Andolan (NBA), groups working on displacement and livelihood issues, groups working on farmers' issues and environmental groups working on pollution and forestry issues.

Critiques by Anil Agarwal, Vandana Shiva and Jayant Bandhopadhyay, Madhav Gadgil and Ramachandra Guha on environment, irrigation and forestry issues contributed to this debate. Across India environmental groups started using Public-Interest Litigation (PIL) as a tool to question mega projects and to address issues like pollution and rights of those affected by the mega projects. The Chipko movement was widely noticed and inspired many such movements in forestry sector. A generation of environmental historians starting with Ramachandra Guha wrote extensively on forestry issues and made a strong case for rethinking state's control over forests while participatory conservation was endorsed by the International Union for Conservation of Nature (IUCN). Their work gave legitimacy to Joint Forest Management (JFM) and community conservation efforts were supported by the state. This in turn had an impact on donors like Swedish International Development Agency (SIDA) who were funding forestry projects.

Academics like Ashis Nandy, Shiv Visvanathan wrote critiques of modern S&T and S&T policy and linked modern S&T with hegemony and violence.[20] Although this line of thinking is not pursued by many academics today, their works has had an impact on the discourse on S&T and development and this was echoed by many civil society groups and NGOs who sought to promote alternative agriculture, traditional medicine and traditional models of water resource sharing and conservation.

While Gandhi's influence on many critics is obvious we have to differentiate them from the traditional Gandhians whose world view was inspired by Gandhi and they confined themselves to creating alternative spaces and institutions instead of developing critiques of modern S&T, nor were they deeply involved in issues like patent laws and development policy, agricultural biotechnology. Moreover Gandhians neither developed a political economic perspective on modern S&T and development, nor engaged in debates on techno-science and issues raised by technologies like nanotechnology.[21] In the recent years some academics and civil society organisations have come up with a call for Knowledge Swaraj.[22]

Thus, these different streams of discourse provided an alternative narrative to the application of S&T for development. While they did not bring in major changes in S&T policy they had their impacts in policies relating to land displacement, large dams and mega projects and forestry. They played an important role in legitimising the subaltern voices and their claims over natural resources. Today much of such critiques have become part of common wisdom in policy making, at least in theory. Policies relating to forest rights, displacement, Environmental Impact Assessment, etc., have absorbed some of the points raised by these discourses. Grassroots movements are still active around many issues.

3.5 The Major Discourses and AIE

In the Nehruvian discourse AIE was not an explicitly stated goal or objective although the presumption was that S&T can result in social transformation that would bring in more inclusion, improve access and result in better and equitable distribution. The top down approach presumed that the policies of the state would ensure that S&T policies do not exacerbate social inequalities and/or result in new inequalities. The value and scale neutrality of S&T was another unquestioned assumption that resulted in more attention being paid to application of S&T than to measuring the AIE aspect of the outcomes. For Gandhians AIE was not an external norm as Gandhi was always concerned about the last man (antyodhya) in his thinking and reaching the last and the least thought of person whether that was a family or an individual person or dalit was his concern. The famous talisman attributed to him is an example of his concern.

As Gandhian approach envisaged simple living, sharing of resources, need over greed and gave importance to self-control over control by others and other moral aspects in production, distribution and consumption, there was no distinct AIE discourse. From an AIE perspective Kumarappa was certainly an important thinker and AIE implications of his idea of Economy of Permanence and his warnings on capital intensive growth and economic concentration of power and wealth need to be studied. PSM did not bring in AIE as a norm or as a value perhaps because PSM discourse was more on science for the masses and science for social revolution and meeting these objectives was likely to result in an egalitarian distribution of outcomes and control over resources by the state for larger public welfare. From a PSM perspective meeting socialist objectives would result in better AIE than through any other means. For example, a PSM approach to access to health would mean universal health care access supplemented with generics, state subsidy in medical care and state's health policy that is geared towards maximising public welfare instead of applying S&T for private gain. In case of other voices and discourses AIE was not explicitly mentioned although scholars like Guha and Gadgil have noted the negative impacts of Nehruvian discourse and large scale development projects on livelihoods. Both AKN Reddy and Seshadri had done pioneering work in enhancing access to technologies and using technologies for equitable development. Hence inclusion and equity was their key concern.

4. S&T Policy Statements, Priorities and Institutional Architecture

Science and Technology Policy Statements (STPS) are the policy tools for the Government of India for stating technology policy objectives and approaches. Since Independence, three TPS have been issued in 1958, 1983 and 2003. Incidentally, the 1958 statement was called as Science Policy Statement (SPS) while that of 1983 as Technology Policy Statement (TPS) and that of 2003 as Science and Technology Policy Statement (STPS). These three documents have provided overarching frameworks for S&T policy and have guided its societal linkages. The 2003 document has acknowledged the importance of linking up modern technology with indigenous knowledge base. S&T was part of a framework for an independent industrial base to be achieved through planned economic growth. This led to the creation of huge institutional base of R&D funding organisations and research institutes. In 2013, the DST came out with a new S&T and Innovation Policy. The emphasis on innovation is obvious and understandable in the context of importance given to innovation by the Government of India by forming National Innovation Council and by calling National Innovation Decade. This policy makes break with the previous policies by its emphasis on innovation and by giving an important role for private sector in innovation. It indicates that Public-Private Partnerships would be promoted and one of the assumptions is that private sector will contribute significantly to R&D and innovation.

Besides such measures India used Mission mode to apply S&T with specific objectives like addressing an issue like lack of access to water, facilitate access to a service like telecommunications and to increase output in food items that are critically important. Although AIE was not the explicit objectives in them, they indirectly facilitated that. This is true of the recent initiative by DST on water. The record of these technology missions is mixed and an extensive study on that is beyond the scope of this paper. For example, Nanotechnology mission has clear cut objectives but AIE is not explicitly stated there. But Nanomission supports R&D in products that could result in better AIE or serve a social need or meet a development goal like providing purified water. It can be argued that these two concerns have had an impact on AIE but only recently inclusion has been explicitly mentioned in the STI policy. How this is translated in policy execution and in various programmes is yet to be seen. While the two concerns are broad and focus is on national needs and objectives, AIE is more contextual and helps us to get a different perspective on impacts of S&T policy.

The economic development policies adopted in India had a major bearing on S&T strategy and on the strategies for agricultural and industrial sub-sectors.[23] The core elements of economic development policy constituted of import substitution oriented industrialisation which laid out a roadmap for heavy, medium and light industries along with emphasis on development of agriculture. The idea of self-reliance ran across all the initiatives in these areas. This emphasis on self-reliance in one sense was an outcome of the colonial experience and was an affirmation of the Swadeshi principle. But both import substitution and self-reliance did not result in India acquiring the capacity to make significant breakthroughs in global S&T. The post-reform period experience is mixed. Sunil Mani points out while innovative activities in the private sector have increased in the post-reform period that is confined to few hi-tech areas, particularly in pharmaceuticals, and the increase in FDI in D&D has also contributed to this.[24]

Our brief analysis of the discourses and narratives of S&T policy and the critiques indicate that there has been a debate on the role of S&T in national development and the strategies for using S&T for socio-economic development. But AIE was not debated explicitly in this. On the other hand, the S&T policy has undergone changes, particularly since 1991 and the new thrust on linking innovation with S&T policy gives opportunities to address concerns over AIE and contribute to inclusive and sustainable growth.

5. AIE Framework: Results and Analysis

The analysis of changes in the infrastructure for science and technology (S&T) and in social conditions in 14 states of India is based on an examination of a number of indicators.[25] These indicators are aggregated to form an S&T index and a social index (SI) using a technique based on principal components (described in the appendix). We calculate the index for various dates. We use Pearson's rank correlation to analyse the changes that might have occurred over the years as well as to analyse the interrelation between the S&T index and the SI. We also examine the relation between these two indices and economic growth to see how these are related- whether states with better indicators have performed better economically, viz. have had a faster growth in per capita incomes, or whether better economic performance has preceded improved indicators.

Science and Technology Indicators

In general there is a weak tendency towards convergence. For each of the indictors we calculated the growth rate of the indicator 1985-86 and 2009-10. We then calculated the rank for the growth rate for each indicator. We added these individual ranks to get an overall value and we ranked the states by the overall value. This sort of analysis is called the Borda count.[26] We then calculated the correlation between the rank of the indictors for the different years of our analysis. We also calculated the correlation between the ranks of the indictors in 1985-86 and the ranks of the Borda count which gives the rank according to the growth in the different indicators between 1985-86 and 2009-10. The rank of the Borda count gives a indication of the effort made by the states in improving their S&T facilities as it based on the growth of each of the different indicators.

The overall finding is that the rank correlations between the aggregate index of the indicators for the different years are very high so that the same states do well at over the entire period. However, there is some evidence that states with poor indicators have improved their infrastructural facilities. But their better performance while narrowing the gap has not enabled them to catch up with those States that had initial edge.

Rank correlations for consecutive decades are between 0.6 and 0.7 which are more than three standard deviations. But the statistic for rank correlation between the 1990s and the 2000s is only 0.4, which is about twice the standard deviation. Over a longer period there is a weaker tendency for the ranks to persist, namely there is some tendency for change in the relative ranking of the states. This is borne out by the growth rate data. The rank correlations between the ranks of the growth rates and the initial values of the indicators are about a third to two thirds, showing at least a weak tendency for convergence. But what the ranks based on growth rates and the indicators together show is that while the states with poor initial facilities have made efforts to close the gap their initial state was so poor that they have not been able to close the gap.

The states can be divided into a number of sub-groups. There are states that have improved their rank according to the Science and

Technology index. By and large these are states that show a good growth performance. These states are AP, Haryana, TN, Kerala and Maharashtra. Of these states, Kerala and Maharashtra had very good educational facilities at the beginning of the period in 1985-86 and they have maintained that edge despite slower growth in the facilities. Then there are states with poor ranking in Science and Technology and low growth. These are West Bengal and Punjab. Of these two, WB had relatively good facilities at the beginning of our period of analysis but it has slipped down the ranks over the years in the quality of its facilities. Gujarat performs well in terms of some of the indictors such as filing of patents, perhaps a reflection of its industrial strength and growth in number of newspapers published. But in terms of increases in enrolments and number of institutions it lags behind. Then there are states like Rajasthan, Madhya Pradesh, Uttar Pradesh and Bihar which are quite stable at the bottom of the rankings. They have low growth and low levels of S&T. In case of Bihar even the higher growth in the first decade of this century has not resulted in any substantial improvement in its S&T parameters. However, despite their continued low ranks Rajasthan and UP show high rates of growth on most of the indicators but obviously they started with such a poor base that despite their considerable growth commensurate improvements in absolute ranks have not occurred.

Later we examine whether expenditures on R&D can explain the ranking on the S&T index, viz. whether the improvement in Andhra Pradesh is because of substantially higher R&D expenditures and the poor performance of Gujarat is because of lack of spending on R&D.

Social Indicators

The social indicators were also aggregated to form a social index (SI). The rank correlation between the ranks of states according to the index in the different decades is very high, 0.8 and 0.9. This is over 3 times the standard deviation.

There are a couple of significant changes in the ranks even though there is no large overall change in the ranks. The position of AP worsens from the 5th rank in 1990-1 to 8th rank in 2000-01 and 10th rank in 2009-10. On the other hand West Bengal improves from the 10th rank in 1990-91 to the 4th rank in 2000-01 and the 3rd rank in 2009-10. Delhi, Kerala, Punjab and TN rank high throughout the two decades. MP, UP, Bihar and Rajasthan consistently show a poor performance.

Economic Performance: Growth of Per Capita State GDP

There is considerable variation over time in the performance of the states. Even when we take the average annual increase in per capita GDP over a decade we find considerable fluctuation in the growth rates and in the ranks based on growth in per capita income. The rank correlation between the average growth rates for the different decades, the 1980s, the 1990s and the 2000s, is almost zero, not at all significant.

However, there are some patterns. The growth rate in some states, Bihar, Kerala and West Bengal has increased while the growth rate in Maharashtra, Punjab, Rajasthan and UP has declined. In AP and TN the growth rate has fluctuated in the different decades, first increasing and then decreasing. But the overall trend is a worsening of the growth rate.

Relation between Growth and the S&T Index

Table 1: Rank Correlation between Growth and S&T Index

S&T Index / Growth Rate	1990-91	2000-01	2009-10
1980s	0.3	0.2	0.5#
1990s	0.4	0.7^	0.3
2000s	0.3	0	0.2

Note: # Almost significant at the 5 % level; ^ Significant at the 5% level.

A high S&T Index does not lead to high growth. For instance, the rank correlation between the S&T index for 1990-91 and growth in the

1990s or in the 2000s is very weak as also the rank correlation between the S&T index in 2000-01 and growth in the 2000s. But there is a weak linkage between high growth rates leading to a better S&T Index. High growth in the 1990s is correlated with the S&T index in 2000-01 and the growth rate in the 1980s is related to the S&T index in 2009-10. But the correlation is weak as the growth rate in the 1980s is not correlated with the S&T index in 1990-91 or 2000-01 nor is the growth rate in the 1990s related to the S&T index for 2009-10. The weak correlation reflects presumably that growth provides the resources to raise the level of S&T in the state.

Relation between Growth and the Social Index

Table 2: Rank Correlation between Growth and Social Index

S&T Index / Growth Rate	1990-91	2000-01	2009-10
1980s	0.05	0.05	0.2
1990s	0.5	0.4	0.4
2000s	0.2	0.2	0.3

None of the rank correlations are significant. Neither do better social indicators lead to higher growth nor does growth lead to better social indicators. This suggests that growth in the states is not inclusive. This bears out other evidence which has found that the rate of improvement in social indicators because of growth is lower in India than in many other countries (Agarwal, 2014).

Relation between the S&T Index and R&D expenditures by State

We next analyse whether the S&T index of a state is related to the R&D expenditures undertaken by the state. The rank correlations between the ranking of the increase in R&D expenditures between 2005-06 and 2009-10 in the states and the ranks of the S&T Index for 2000-01 and 2009-10 were calculated. Neither of the two rank correlations was significantly different from zero. So R&D expenditures do not seem to be related to the level of the S&T Index. Of course the period of the analysis is very small and that may explain the lack of a relation.

Relation between the S&T Index and the Social Index

Table 3: Rank Correlation Between S&T Index and Social Index

S&T Index / **Social Index**	**1990-91**	**2000-01**	**2009-10**
1980s	0.8	0.7	0.6
1990s	0.7	0.4	0.2
2000s	0.7	0.5	0.3

Rank correlation between the S&T and Social Indices for the same year has weakened over time. The diagonal terms are getting smaller and have become not significant.

The relation between the two indices weakens over time. Thus, S&T policy impact on social inclusiveness weakens over time—the values of the column or the row tend to decline. The relation between the two has become insignificant. This suggests that the S&T policy is not leading to inclusiveness. These should be considered as preliminary results based on values of indicators used to measure different concepts. The idea is to develop a set of indicators that could be used to measure AIE rather than to judge the performance of the states or effectiveness of policies.

VI. Way Forward

Our efforts to develop statistical indicators for assessing AIE bring out some important implications. As economic growth by itself does not ensure AIE in outcomes, special programmes and efforts are needed to ensure AIE. The experiences of the states provide a framework for comparative analysis for inferring the features of policies that lead to better AIE. Special programmes and policies to address access and inclusion have to be revisited by measuring their impacts. It is important that data be collected according to important social categories to enable a proper evaluation of AIE. As establishing causality for assessing developmental outcomes is difficult we need both qualitative and qualitative analysis. Depending upon data availability and selection of S&T indicators a better understanding of socio-economic impact of S&T policies could be researched. There are studies which have focused on evidence from technological innovations best suited for development challenges, legal and social norms to support innovation and inclusion and access within the ambit of S&T decision making for various stakeholders. In this regard we call for a wider debate on Socio-Economic (SE) assessment of S&T policies and projects and stress that SE assessment should go beyond typical Cost-Benefit Analysis or technology assessment.

New methodologies and models have to be developed, particularly in case of emerging technologies. There are several efforts to link these indicators with socio-economic indicators. For instance, bibliometric database are used for correlation analysis along with R&D expenditure and Gross National Product (GNP). As pointed out elsewhere in this paper the challenge is two fold – one is to revise and improve the current indicators and the other is to develop indicators that could measure AIE and open up space for policy interventions. DST can form a working group to study these.

The Organisation for Economic Cooperation and Development (OECD) has made an effort to harmonise initiatives by some member countries like Canada, New Zealand, France, Germany and Australia.[27] The OECD Biotechnology Statistics, an initiative of OECD and its Working Party of National Experts of Science and Technology Indicators (NESTI) has come up with various surveys since 2006 and the latest one is out in 2011. They have launched national surveys to assess the status of biotechnology and its contribution in their economies. The OECD is evolving a consensus on the very definition of biotechnology along with identifying a set of issues for developing a conceptual framework for collecting statistical data.[28] This involves, largely, putting together various indicators, including a model survey, which incorporates social responses to biotechnology. R&D allocations, export-import of biotechnology goods, the number of biotechnology patents and total employment in the biotechnology-related industry are some of the other indicators chosen for this purpose. A dialogue with OECD on specific concerns and relevant indicators may help in consolidating our ideas and in establishing their linkages with appropriate indicators. Besides this there is a need to work with other institutions like UNESCO Institute for Statistics (UIS) in Montreal, Korea Institute on Studies in S&T (KISST) in Korea and learn from initiatives in Latin America in STI indicators. Recent literature on S&T indicators points out that efforts are being made to expand the scope of indicators, develop indicators for emerging technologies and to measure user innovation.[29] Appropriate lessons from these can be used in the Indian context also.

AIE research should become a part of the S&T policy process and major technology initiatives and policy proposals should allot 3 to 5 per cent of the proposed budgets to such research. In case of Mission mode programmes like Nano-mission AIE research should be initiated in the beginning itself. The Ethical, Legal and Social Issues (ELSI) research should be undertaken on a broad scale involving institutions outside ministries and departments and should involve institutions that represent stakeholders. India should propose a network of institutions in developing nations working on AIE issues and S&T policy issues and this can be integrated with multilateral S&T collaboration framework. This will enable developing a 'Southern' approach in AIE issues and will strengthen the capacity in S&T policy making in developing nations. As new issues like big data, technological convergence demand more studies on STS issues within India, there is an urgent need to build capacity in doing AIE and STS research.

While such a capacity cannot be created in a short span of time, a beginning should be made by assessing the work being done in Science

Technology Studies (STS) and AIE and ELSI in India and plan for new initiatives so that over the next five years or so, sufficient capacity is developed in this.

Endnotes

[1] ADB (2011), McKinley (2010).

[2] Papaioannou (2013), Duff (2006).

[3] Zachariah (2005). See also Sinha (1992).

[4] Abrol (2012) provides a comparative analysis of Gandhian perspective, Nehruvian perspective and other perspectives . According to Abrol,"The 'Gandhian', 'Nehruvian' and 'Left' political traditions differed radically with each other in terms of the conception of 'socio-technical imagination', 'vision of path of development' and 'social carriers of innovations' to be encouraged".

[5] See Evers (2001).

[6] For example, see Leigh (2011), Schiebinger (2010), and Mercado (2012).

[7] See Thomas and Fressoli (2011); Sutz (2011); Hall, Matos, and Langford (2008); Sutz and Tomassini (2013).

[8] Cozzens and Wetmore (eds.) (2011).

[9] Thomas and Fressoli (2011) and Serafim and Dias (2010).

[10] Woodhouse and Sarewitz (2007).

[11] Cozzens (2007).

[12] UNCTAD(2014).

[13] Although they articulate this in the context of USA it is possible to extend or adopt their model in developing countries also, taking into account the national contexts and the socio-economic factors that determine equitable access or its lack.

[14] Chaturvedi and Srinivas (2012), and Gault (2011).

[15] ADB (2011), and McKinley (2010). On marginality and its various dimensions of see Braun, and Gatzweiler (2014).

[16] For further details see Chopra (1940)

[17] Elizinga and Andrew Jamison (1986). Also see Kumarappa (1960).

[18] Ninan (2009)

[19] Hardiman (2004) argues that ideas of Gandhi and Kumarappa have had wider impact among thinkers in Europe and the USA, including Illich and Schumacher.

[20] See Rajan (2005), and Prasad (2006).

[21] But academics have used Gandhian perspectives for criticising techno-science. See Shah (2013) for a Gandhian critique of Synthetic Biology.

[22] Prasad (2011).

[23] Parthasarathi (1979). See also Parthasarathi (2007)

[24] Mani (2009).

[25] These states were chosen on the basis of data availability and by and large the sample consists of the larger states.

[26] See Emerson (2007), and Saari (2001).

[27] Chaturvedi (2003).

[28] OECD (2009).

[29] Gault (2013).

References

Aant, E., Jamison, A. 1986. "The Other Side of the Coin: The Cultural Critique of Technology in India and Japan" in E. Baark and A. Jamison (eds) Technological Development in China, India and Japan: Cross Cultural Perspectives. London: Macmillan.

Abrol, D. 2012. "Pro-poor Innovation-making: Critical Reflections on the Indian Experience." Paper presented at the First CDEIS-Indialics International Conference on Development and Innovations in the Emerging Economies, Punjabi University, Patiala.

Agarwal, M., and Whalley, J. 2014. "The 1991 Reforms, Indian Economic Growth and Social Progress" in Agarwal, M. and Whalley, J (eds) India and China: Comparative Experience and Prospects. Singapore: World Scientific

Asian Development Bank (ADB). 2011. Framework of Inclusive Growth Indicators. Manila: Asian Development Bank.

Bozeman, B, Slade, C.P, and Hirsch, P. 2011. "Inequity in the Distribution of Science and Technology Outcomes: A Conceptual Model." Policy Sciences, 44 (3): 231–248.

Braun, J.V., and Gatzweiler, F.W. (eds.). 2014. Marginality, Addressing the Nexus of Poverty, Exclusion and Ecology. Berlin: Springer.

Chaturvedi, S. 2003. "Developments in Biotechnology: International Initiatives, Status in India and Agenda before Developing Countries." Science, Technology and Society, 8 (1).

Chaturvedi, S., and Srinivas, K.R. 2012. "Science and Technology Indicators: New Issues and Challenges." Current Science, 102 (12): 1640-1644.

Chopra, R.N. 1940. "Need of Planned Research for Industry." Science and Culture, 5 (8).

Cozzens, S., and Wetmore, J. (ed.). 2011. Nanotechnology and the Challenges of Equity, Equality, and Development. New York: Springer.

Cozzens, S.E. 2007. "Distributive Justice in Science and Technology Policy." Science and Public Policy, 34 (2): 85-94.

Duff, A.S. 2006. "Neo-Rawlsian Co-ordinates: Notes on A Theory of Justice for the Information Age." International Review of Information Ethics, 6: 18-22.

Emerson, P. 2007. Designing an All-Inclusive Democracy - Consensual Voting Procedures for use in Parliaments, Councils and Committees. Berlin: Springer.

Evers, K. 2001. Standards for Ethics and Responsibility in Science: An Analysis and Evaluation of their Content, Background and Function. Paris: International Council of Science Unions.

Gault, F. 2011. "Social Impacts of the Development of Science, Technology and Innovation Indicators."WP 2011-008. Maastricht: UNU-MERIT.

Gault, F. (ed.). 2013. Handbook of Innovation Indicators and Measurement. Cheltenham: Edward Elgar.

Hall, J., Matos, S., and Langford, C.H. 2008. "Social Exclusion and Transgenic Technology: The Case of Brazilian Agriculture." Journal of Business Ethics, 77 (1): 45–63.

Hardiman, D. 2004. Gandhi in His Time and Ours: The Global Legacy of His Ideas. New York: Columbia University Press.

Jacob, T.G. 2010. "The Contemporary Relevance of J C Kumarappa's Life and Works." Frontier, 43 (12-15): 1-11.

Jospeh, K.J., Singh, L., and Abraham, V. (2014) "Dealing with the Innovation–Inequality Conundrum: The Indian Experience" in Soares, M.C.C., Scerri, M. , Maharajha, R. (eds) Inequality and Development Challenges. London: Routledge, pp 149-189.

Kumarappa, J.C. 1960. Why the Village Movement? New Delhi: Akil Bharat Sarva Seva Sangh.

Leigh, P.R. (ed.) 2011. International Exploration of Technology Equity and the Digital Divide. PA: Hershey: IGI Global.

Mani, S. 2009. "Is India Becoming More Innovative since 1991? Some Disquieting Features."

Economic and Political Weekly, Vol. xliv, No. 46 Pp 41-51

McKinley, T. 2010. Inclusive Growth Criteria and Indicators: An Inclusive Growth Index for Diagnosis of Country Progress. Manila: Asian Development Bank.

Mercado, A. 2012. "Social Inclusion or Social Illusion: The Challenges of Social Inclusion, Social Participation and Social Cohesion in Venezuelan S&T Policy." Science and Public Policy, 39 (5): 592-601.

Ninan, S.A. 2009. "Gandhi's Technoscience: Sustainability and Technology as Themes of Politics." Sustainable Development, 17 (3):183-196.

OECD. 2009. OECD Biotechnology Statistics. Paris: Directorate for Science, Technology and Industry, OECD.

Papaioannou, T. 2013. "New Life Sciences Innovation and Distributive Justice: Rawlsian Goods versus Senian Capabilities." Life Sciences, Society and Policy, 9 (5): 1-13.

Parthasarathi, A. 1979. "India's Efforts to Build an Autonomous Capacity in Science and Technology for Development." Development Dialogue Special Issue 1.

Parthasarathi, A. 2007. Technology at the Core: Science and Technology with Indira Gandhi. New Delhi: Pearson Longman.

Prasad, A. 2006. “Beyond Modern vs Alternative Science Debate: Analysis of Magnetic Resonance Imaging Research.” Economic and Political Weekly, 41 (3): 219-227.

Prasad, C.S. (ed.). 2011. Piloting Knowledge Swaraj: A Hand Book on Indian S&T. Hyderabad: KICS/CWS.

Rajan, R. 2005. “Science, State and Violence: An Indian Critique Reconsidered.” Science as Culture, 14 (3):1-17.

Saari, D. 2001. Chaotic Elections! A Mathematician Looks at Voting. Providence,RI: American Mathematical Society.

Schiebinger, L. 2010. Gender, Science and Technology. Paris: UNESCO.

Serafim, M., and Dias, R. 2010. “Brazilian Science and Technology Policy: Why Is It Not Socially Oriented?” Central European Journal of Public Policy, 4 (2): 18-37.

Shah, E. 2013. “Ethics of Technological Modernity: Reading Hind Swaraj towards Critiquing Craig Venter’s Synthetic Biology” in G. Shah (ed) Re-reading Hind Swaraj: Modernity and Subalterns. London: Routledge.

Sinha, J.N. 1992. “Origin of India’s National Science Policy: ML Sircar to MK Gandhi, 1875–1935.” Indian Journal of History of Science, 27 (2): 171-182.

Sutz, J. 2011. “Innovation and Social Inclusion.” In GLOBELICS Academy, Tampere.

Thomas, H., and Fressoli, M. 2011. “Technologies for Social Inclusion in Latin America: Analysing Opportunities and Constraints; Problems and Solutions in Argentina and Brazil” in Melkers, J.,Monroe-White, T. and Cozzens, S.E. (eds) Atlanta Conference on Science and Innovation Policy Proceedings. Georgia Institute of Technology, Atlanta, U.S.A.

UNCTAD. 2014. “Science, Technology and Innovation for the post-2015 Development Agenda (E/CN.16/2014/2).” Geneva: UNCTAD.

UNESCO. 2007. Asia-Pacific Perspectives on Ethics of Science and Technology. Bangkok: UNESCO Asia and Pacific Regional Bureau for Education.

Woodhouse, E., and Sarewit, D. 2007. “Science Policies for Reducing Societal Inequities.” Science and Public Policy, 34 (2):139-150.”

Zachariah, B. 2005. Developing India: An Intellectual and Social History, c. 1930-1950. New Delhi: Oxford University Press.

Annex 1: Data Sources

Index	Indicators	Data Source
Socio-Economic Index	Death Rate	Statistical Abstract of India various issues (1987, 1992, 1997, 2003, 2007, 2013)
	Birth Rate	Statistical Abstract of India various issues (1987, 1992, 1997, 2003, 2007, 2013)
	Infant Mortality rate	Statistical Abstract of India various issues (1987, 1992, 1997, 2003, 2007, 2013)
	Number of Population below poverty line (%)	Handbook of Indian Economy, RBI
Science and Technology Index	Number of recognised general educational institutes — arts, commerce and science (in number)	Statistical Abstract of India various issues (1987, 1992, 1997, 2003, 2007, 2013)
	Number of Recognised special educational Institutions — Polytechnic, agriculture, medicine, veterinary, engineering, architecture, vocational (in number)	Statistical Abstract of India various issues (1987, 1992, 1997, 2003, 2007, 2013)
	Number of Scholars/ enrolment from general educational institutions — arts, commerce, and science (in number)	Statistical Abstract of India various issues (1987, 1992, 1997, 2003, 2007, 2013)
	Number of Scholars/ enrolment from special educational institutions— agriculture, medicine, veterinary, engineering, architecture and vocational (in number)	Statistical Abstract of India various issues (1987, 1992, 1997, 2003, 2007, 2013)
	Patent application by state (in number)	Directorate of Science and Technology
	Telephone exchange lines (in 000)	CMIE, Infrastructure, various issues

Annex 1 continued....

Annex 1 continued....

Index for Basic Needs	Electricity consumption per capita(kWh)	Statistical Abstract of India various issues (1987, 1992, 1997, 2003, 2007, 2013)
	Total Number of Registered motor vehicles (in number)	Statistical Abstract of India various issues (1987, 1992, 1997, 2003, 2007, 2013)
	Total Road Length (in Km)	Statistical Abstract of India various issues (1987, 1992, 1997, 2003, 2007, 2013)
	Number of Hospitals and dispensaries (in number)	Statistical Abstract of India various issues (1987, 1992, 1997, 2003, 2007, 2013)
	Number of beds ('000)	Statistical Abstract of India various issues (1987, 1992, 1997, 2003, 2007, 2013)
	Households with safe drinking water facilitiies (%)	Economic Survey, various issues
	Enrolment/Scholars in Primary, Secondary and high secondary (in numbers)	Statistical Abstract of India various issues (1987, 1992, 1997, 2003, 2007, 2013)
	Literacy Rate (%)	Economic Survey, various issues
	Statewise population	Economic Survey, various issues

Annex 2: List of Indicators

S&T Indicators	**Socio-Economic Indicators**	**Index for Basic Needs**
Number of recognised general education institutions	Death Rate	Health — hospitals, dispensaries and beds
Number of scholars enrolled in general education institutions	Birth Rate	Access to drinking water — percentage of households with safe drinking water
Enrolment in Professional Educational Institutions	IMR	Education — schools and literacy rate
Patent Applications by state	Population below poverty line	
Telephone exchange lines		

Annex 3: Summary of Indicators in Various Studies

Author	Objective	Composition of Index and Indicators
Archibugi and Coco (2004)	Technological Capability Index (TCI)- Technological Capability at country level.	Creation of technology □ Patents, Scientific Articles. Technological Infrastructures □ Internet penetration, Telephone penetration, Electricity consumption. Development of Human Skills □ Tertiary science and engineering enrolment, Mean years of schooling, Literacy rate (percentage of people over the age of 14 years).
Shukla and Kakar (2006)	Scientific, technological and socio-economic development of Indian States.	Economic Index □ per capita State Domestic Product, Debt burden of states, FDI, employment in organised sector. Scientific Manpower□ Number of graduates enrolled in proportion to total population, share of science graduates to total, skilled manpower as proportion of total manpower, share of science stock to total stock of higher education, human resource in science and technology by education, human resource in science and technology by occupation and human resource in science and technology by education and occupation. Health- Birth rate, infant mortality rate, life expectancy at birth (Female), population served per government hospital, population served per beds in the hospital, proportion of children immunised between 0-6 years, proportion of women immunised, per capita expenditure on health and proportion of households' access to safe drinking water. Infrastructure Physical Infrastructure: urban population ratio, the ratio of total area irrigated to grossed-cropped area, per capita electricity-installed capacity, per-capita electricity generated, the proportion of cities and villages electrified in the state, surfaced road length per lakh population, distance to primary school, distance to college, distance to post office, distance to public telephone, distance to commercial banks and distance to medical care.

Annex 3 continued....

		S&T Infrastructure: Industrial R&D units per lakh population, total research institutes per million population, research institutions in agriculture, engineering research institutes, medical science research institutions, defence research institutions, per capita infrastructure availability, distance to computer training centres and internet kiosks. Asset Index households own four wheelers, two-wheelers, television, computer, telephone, mobile, access to internet, access to cable TV. Well-being Index □ people below poverty line; literacy rate; per capita consumption expenditure; per capita expenditure on health, education telephone, mobile, internet, and cable.
UNCTAD (2003)	ICT Development Index-Development of Information and Communication Technology (ICT)	Connectivity □ Internet hosts per capita, Number of PCs per capita, telephone mainlines per capita and cellular subscribers per capita. Access □ Internet users, literacy, GDP per capita, and cost of a local call. Policy □ Presence of internet exchange, competition in local loop telecoms, competition in domestic long-distance, and competition in ISP market.
Desai, Parr, Johansson, and Sagasti (2002)	Technological Achievement Index (TAI)- To demonstrate the level of technological progress and capacity of a country to participate in the network age.	Creation of New Technology □ Number of patents granted per capita, and receipts of royalty and license fees from abroad per capita. Diffusion of Recent Innovations □ Internet and exports of high- and medium-technology products as a share of all exports. Diffusion of Old Innovations □ telephones and electricity. Human Skills mean years of schooling and enrolment in tertiary education in science, mathematics and engineering.

Annex 3 continued....

UNIDO Industrial Development scoreboard (2002)	Competitive Industrial Performance and its drivers	Technology Effort Index □ patents, enterprise financed R&D. Technology Imports □ foreign royalty payments, capital goods. Infrastructure telephone main lines. Skills □ tertiary technical enrolment. Competitiveness Industrial Performance Index □ manufactured value added, medium- and high- technology share of MVA, manufactured exports, medium- and high-technology share in manufactured exports.
UNDP (2004)	Impact of ICT on human development for achieving the MDGs.	ICT Indicators □ Internet users, internet hosts, personal computers, telephone mainlines, televisions in use, cellular subscribers, radios in use. Economic and Human Development □ GDP per capita, Human Development Index. Poverty Undernourished people, population surviving on less than one dollar per day, poverty gap ratio, share of poorest 20 per cent in national income or consumption, children underweight for age. Education adult literacy rate; children reaching grade; net primary enrollment ratio; net secondary enrolment ratio; combined primary, secondary and tertiary gross enrollment ratio; tertiary level students in science, mathematics and engineering; youth literacy rate; and scientists and engineers in R&D. Gender equality and empowerment of women □ ratio of literate females to males; seats in parliament held by women; female share of non-agriculture wage employment; ratio of girls to boys in primary education, secondary education, and tertiary education.

Annex 3 continued....

Annex 3 continued....

		Indicators pertaining to Health infant mortality rates, life expectancy at birth, births attended by skilled health personnel, physicians, population with sustainable access to affordable essential drugs, one-year-olds fully immunised against measles, maternal mortality ratio, under five mortality rate, tuberculosis-related mortality rate, malaria-related mortality rate (all ages, children aged 0-4), malaria cases, tuberculosis cases, tuberculosis cases cured under direct observation treatment, tuberculosis cases detected under direct observation treatment, adults with HIV/AIDS, women living with HIV/AIDS, children living with AIDS/HIV. Environmental Sustainability consumption of ozone-depleting chlorofluorocarbons; carbon dioxide emissions per capita; GNP per unit of energy use, land area covered by forests; ratio of protected area to surface are; urban population with access to improved sanitation; population with sustainable access to an improved water source in rural areas and urban areas. Global Partnership for Development FDI; overseas development assistance as percentage of gross national product.

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