Agricultural Innovation Systems and the Co-evolution of Exclusion in India

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Abstract:

This paper[1] contends that the exclusion of millions of poor from agricultural development gains is inexorably linked to the innovation system features that have evolved over time. An oft repeated lament of the Government of India about the inadequacy of reforms in agricultural research and extension, is used to explore the structure and institutions of agricultural innovation. Three main components of the agricultural innovation system, are the agricultural research and extension actors, the farming communities, and policy making agencies. Analysis of their structure and institutional features reveal limited capacities for interaction, learning and change. These features co-evolve with, generate and consistently maintain certain forms and patterns of exclusion – of the drylands, diverse crops and cropping systems, and marginal and small farms. For innovation to enable inclusive development agricultural research and extension reforms are not enough. Iterative institutional reforms are necessary; within and among several actors in the system, along with capacities to assess how institutional arrangements shape the innovation performance of each of these actors and the innovation system.

Key words: *agriculture*, *innovation systems, institutions, inclusion, interactions*

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1. *Innovation for inclusive development – the challenge*

If India's first Prime Minister was to observe India today, would he applaud the recent rapid economic growth, lament the increasing inequality, or reflect on how planned development could lead to such divergent outcomes? Given that Jawaharlal Nehru revered science and technology (S&T), and had faith in its "--- capacity to deliver India from poverty and destitution, out of ignorance, prejudice and superstition," would he also notice how S&T has catered to some sectors, regions and population groups, and excluded many others? There is increasing evidence about the exclusion of rural areas and rural populations from the benefits accrued through applications of modern S&T. So, is S&T to shoulder the blame of neglecting India's poorest living in rural areas?

The innovation systems framework tells us that S&T actors and the rural poor – farmers, non-farm households and agricultural labour, figure as part of a national agricultural innovation system. What are the institutions that shape the ways in which S&T generates knowledge, farmers utilize knowledge and translate these knowledge inputs into economic and social goods? This paper is an attempt to illustrate and analyse exclusion - of the poor, unfavourable regions, certain areas of scientific research relevant to the unfavourable regions, and certain policies that offer better economic opportunities to the poor. The paper demonstrates the co-evolution of exclusion and certain features of the formal agricultural innovation system in India.

Several researchers and policy analysts have started to explicitly use the innovation systems framework to analyse positive cases of innovation in developing country agriculture (See Hall et al 1998, 2004; Clark et al 2003; Biggs and Messerschmitt 2004). In the study of agricultural knowledge, science and technology, the major departure that these studies present from previous measures of 'returns to investment' in research or economic legitimizations for investment in agricultural research, is in the analyses of non-linear processes.[2] They identify the collective wisdom and interactions among several actors in different institutional contexts, which results in innovation and leads to development outcomes for the masses. The innovation systems features that we need to look out for, identify and promote are thereby several interactions and the institutions (the values, incentives, learning capacities, instruments or norms) that facilitate such interactions among several micro-meso-macro level actors (See Soete et al, 2009; Lundvall, 2010).

While economics as a discipline has incorporated S&T as one among the explanatory variables that determine economic growth, the innovation systems literature (though rooted in economics) has opened up the black box, explaining ways in which knowledge is generated, accessed and used in different sectors of the economy, among different populations of firms and farms. In the latter, agricultural or farm innovation systems (despite major contributions to the analyses and explanation of industrial innovation), the innovation systems approach has made little effort to understand innovation actors and processes in rural or marginalized spaces, especially in developing countries. In general, in the debates about regional and sectoral innovation systems, especially for agri-food production and innovation, (i) the institutions that shape the proximate drivers of agricultural growth (say irrigation investments, credit availability, etc.) are either ignored or assumed to be uniform across regions, and (ii) the manifestation of exclusion (or peripherality) is generalized – as in location in rural areas, or extent of integration into value chains.

Institutions, recently re-discovered as "the 'deep' determinants of development", the variables and processes that "shape the proximate determinants of growth: factor accumulation, technology adoption and policy choices," (Adam and Dercon, 2009, p. 174; Rodrik et al, 2004; Nelson, 2008; Commission on Growth and Development, 2008), play a decisive role in the growth and development patterns of an economy.

[2] Yet, the neo-classical framework of linear knowledge flows from public sector knowledge generators to adopting farmers, with little concern about the contexts of and the institutions that govern decisions by both, still thrives within 'agricultural innovation' literature (see for eg., Asenso-Okyere and Davis, 2009).

Theoretically, the demand for institutional reform of a research organization or a firm involves changes in the rules and norms that govern the proximate determinants of its growth. Changes or additions to the proximate determinants - including the funding or number of research personnel or sales officers in the organization- do not amount to institutional reform, but remain mere organizational changes, and need not affect any change in the innovation capacity or economic growth promoted by or involving the organization.

Given our national commitment to inclusive development, as stated in the XI Five Year Plan document (Government of India, 2008), can institutional reform of agricultural research organizations lead to innovation for inclusive development? It has often been stated that rainfed agriculture or the dryland states, small and marginal farmers, tribal populations, rural women, and urban poor have been excluded from the benefits that S&T has brought to the rest of the population. But there is little analysis on how the manifestations of exclusion and the institutions that shape innovation (and growth) relate to each other. Is there a mutual causation? Or a one-way traffic where some forms of exclusion – say rural areas or remoteness, shape the proximate determinants of innovation and economic growth? The quest for solutions to enable innovation and development in areas or among population groups that have been excluded from past growth experiences demand that we understand this relationship between exclusion and the institutions that shape innovation systems. For instance, in order to enable agricultural or rural innovation for development, is it enough to increase funds available for agricultural R&D? Or do we need to understand how the organizations of agricultural research and extension interact with and become part of coalitions of actors who constitute the innovation system? Do the institutions that shape agricultural R&D enable these interactions and learning? Are these institutions and thereby the capacity of agricultural R&D organizations to interact and be part of a ferment of evolutionary learning and change processes, uniform across different agricultural production systems or rural areas, irrigated and dryland agriculture systems? Innovation systems for inclusive development demand that we understand these causal relationships between the features of innovation - the institutions that shape innovation processes and capacities- and the nature of exclusion.

This paper argues that the exclusion of millions, especially the rural poor from development gains is inexorably linked to the innovation system that has evolved over the years. An increasing proportion of Indians -from over 190 million in 1980-81 to over 400 million in 2009- depend on agricultural work for their livelihoods (cultivators + main and marginal workers), in a total of over 740 million classified as rural work force. With the share of agriculture in national GDP declining from 50 percent (1950-51) to 18 percent (2005-06), and with the sector facing unfavourable terms of trade, this increasing population living on a steadily thinning share of the national income is a direct determinant of the consistent poverty and alarming inequality (though Gini co-efficients for the 1999-2005 period show a relative reduction in inequality (Dev and Ravi, 2007). In a national context demanding inclusive development, with a Five Year Plan focusing on the goal, the innovation systems theoretical framework does help as a broad heuristic to identify where and how innovation can lead to inclusive development.

Some features of innovation systems are relatively under-developed or in their infancy in developing countries in contrast to the innovation systems in developed countries. Within developing countries, many innovation systems features like effective labour market institutions, or rules that enable integration with domestic and global value chains, or norms of research management that ensure collaboration with other actors in the potential innovation system, are absent or evolving. Thereby, in India, the core issues in innovation for inclusive development are not limited to exclusion as observed between the mainstream and different population groups, regions, crops or rural industrial clusters. It is the absence of certain features of innovation systems that are crucial in building the capacities and wherewithal, which leads to and simultaneously reinforces the exclusion in outcomes (SIID, 2009). Innovation for inclusive development demands analysis of exclusion as empirically observed and more importantly, discerned within specific spaces, organizations, programmes and the specific institutions or features of innovation systems that enable the generation of relevant knowledge and enhance people's access to and utilization of knowledge.

Following this introduction to the challenges posed by the demand for inclusion, section 2 presents an overview of India's agricultural S&T system and its contributions to food security and its constraints. The oft repeated official lament that research focuses on irrigation and bio-chemical technologies and the extension system is too weak to achieve any meaningful adoption of modern technologies by farmers, is used an entry to explore and diagnose India's agricultural innovation system. In section 3 the interactions and capacities for exchange of information and learning are identified in three major actors in the agricultural innovation system – the public sector agricultural research and extension actors, the farming community and the state or policy actors. The analysis builds up from the institutions that shape the content and nature of scientific research and the processes and extent of extension effort. Then the institutions or norms that determine farm level access to and utilization of knowledge are explored; finally, analyzing the wider institutional arrangements, policies and choices (political choices) that shape sectoral transformation, determining where and how people are employed and how they interact other actors in agricultural innovation systems of local or sub-sectoral relevance. The concluding section presents the key findings about the co-evolution of the exclusion of the majority of Indian farmers from the formal, centralized and organized agricultural S&T establishment as well as the institutions shaping the macro-economic policies and features of innovation systems.

The key message is that 'inclusive development' demands much more than reform of the S&T establishment. That irrigation-chemical fertilizer based technologies are not the brainchild of a vain isolated research system that refuses to be reformed, but the creation of a wider convergence of mainstream state policies, research, extension, input supply mechanisms, price support systems, etc. makes it clear that reform of the agricultural research system will not work unless accompanied by fundamental institutional reform of several other actors in the innovation system. Presented as a canvass of institutions shaping the agricultural innovation systems and actors therein, this last section discusses some enquiries into (i) the ways in which the institutions –rules, values and norms, shape the proximate determinants of the economy and innovation performance of the sector, and (ii) the options for policy making using the multi-and trans-disciplinary nature of the innovation systems framework. The latter will entail iterative policy processes based on interactive policy research taken up by coalitions of innovation systems actors who are willing to learn and evolve.

2. Agricultural S&T, achievements and concerns

India, like many other developing countries in the 1950s, made a commitment to agricultural S&T. The objective, in a new and young democracy free from colonial rule, had changed from research on commercial crops used as industrial raw material (in the West or within), to research on food crops to cater to the national policy goal of achieving food security. Between the period 1960-61 and 1973-74, with the intervention of some international philanthropic organizations (Rockefeller, Ford, and Kellogg Foundations) and governments (especially of the USA), and the launch of the green revolution by the Government of India, public investment in agricultural research had grown at over 12 percentage per annum (Rajeswari, 1995).

By the end of the 1970s all the public sector organizational components to address food security were in place. The Agricultural Prices Commission (to announce Minimum Support Prices – especially for the major cereals), the Public Distribution System, the Food Corporation of India, the National Seeds Corporation, the State Trading Corporation, the Central Water Commission and the Agricultural Produce Market Committees and regulated markets were among these. Minimum Support Price, subsidized inputs (fertilizers and farm machinery), credit (including politically motivated waiver of loan repayment), irrigation and electricity costs, and procurement processes (especially for rice and wheat) were the key issues addressed by the large farmer led peasant politics, and provided by the state. The evolution of scientific research for agricultural development must be seen in the context of this national articulation of food security.

Table 1: Net Availability of Foodgrains in India 1951-2008
(kgs. per capita per annum)

Years	Rice	Wheat	Other cereals	Cereals	Gram	Pulses	Food-grains
1951	58.0	24.0	40.0	122.0	8.2	22.1	144.1
1956	68.7	22.5	40.7	131.9	10.6	25.7	157.6
1961	73.4	28.9	43.6	145.9	11.0	25.2	171.1
1966	59.1	34.8	37.5	131.4	6.7	17.6	149.0
1971	70.3	37.8	44.3	152.4	7.3	18.7	171.1
1976	68.5	29.1	39.2	138	7.4	18.5	155.3
1981	72.2	47.3	32.8	152.3	4.9	13.7	166.0
1985	68.9	50.6	32.1	151.6	4.7	13.9	165.5
1991	80.9	60.0	29.2	171.0	4.9	15.2	186.2
1996	74.6	64.3	22.6	161.5	4.1	12.0	173.5
2001	69.5	49.6	20.5	141.0	2.9	10.9	151.9
2006	72.3	56.3	22.1	150.7	3.9	11.8	162.5
2007	70.8	57.6	20.3	148.7	4.3	12.9	161.6
2008(P)	64.0	53.0	19.7	136.7	3.9	15.3	159.2

Notes :- The net availability of foodgrains is estimated to be Gross Production (-) seed, feed & wastage, (-) exports (+) imports, (+/-) change in stocks.

The net availability of foodgrains divided by the population estimates for a particular year indicate per capita availability of foodgrains in terms of kg/year. Net availability, thus worked out further divided by the number of days in a year I.e., 365 days gives us net availability of foodgrains in terms of grams / day.

For calculation of per capita net availability the figures of net imports from 1981 to 1994 are based on imports and exports on Government of India account only. Net imports from 1995 ownwards are the total exports and imports (on Government as well as private accounts)

Cereals includes rice,wheat and other cereals

Pulses includes all kharif and rabi pulses

Foodgrains includes rice, wheat,other cereals and all pulses

Source: *Agricultural Statistics at a Glance,* 2009

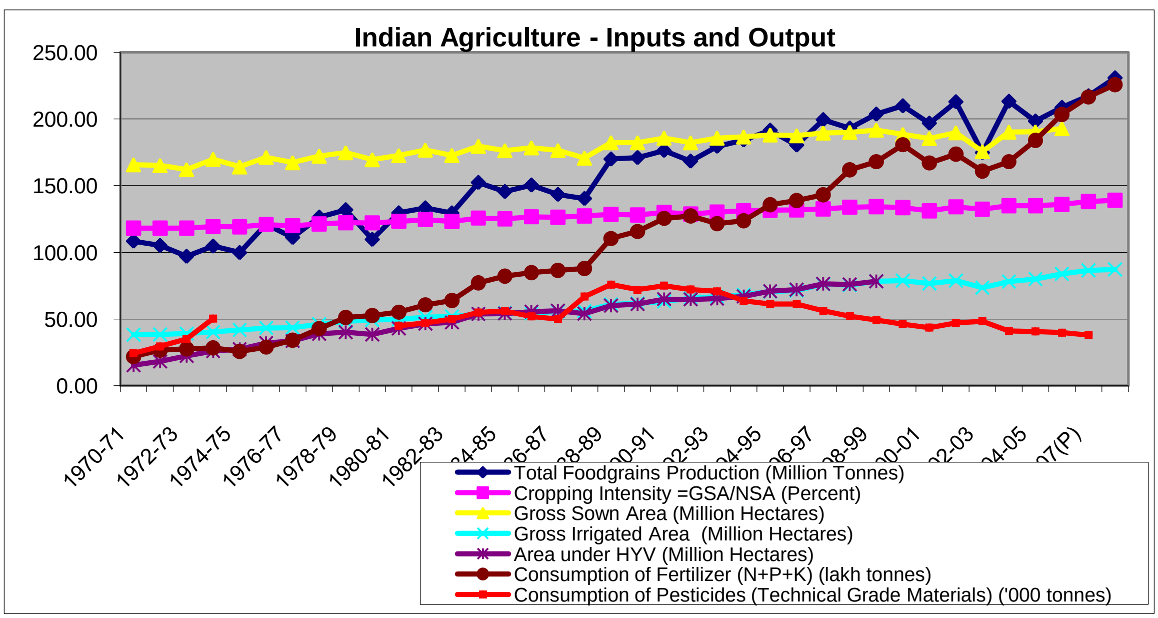
The achievements of Indian agricultural research are significant in the contemporary history of development. Tomes have been written about the increased foodgrain production, though foodgrain (cereals and pulses) availability per capita has increased only marginally in the past 60 years (See Table 1). Overall, foodgrain availability percapita reached a peak in the early 1960s and the early 1990s, and has fallen steadily since the latter period. In effect, this Table 1 tells us about the exclusion of certain sections of the population from access to food – especially pulses. India with its highly applauded green revolution technologies and policies is now dubbed the 'republic of hunger' (Patnaik, 2007), with a stagnant agricultural growth rate despite significant – (Vaidyanathan, 2010) .

The country today hosts a public research system with almost 20,000 scientists. It has had the most successful green revolution among all developing countries. The need for modern technology to shift the production frontier was a felt need in the 1950s and 60s. But the political, administrative and scientific actors (both domestic and international) effectively steered in the green revolution only when the US Government threatened to cut the PL 480 shipment of food to India (Sivaraman, 1991; Subramaniam, 1972; Swaminathan, 1993; 2006). The National Agricultural Research System (NARS), mainly the public sector components of the research system, takes credit for these achievements (See DARE/ICAR Annual Reports). Burgeoning food stocks in the public warehouses (Food Corporation of India), increasing agricultural exports – especially fruits and vegetables and some processed foods, and a spate of modern technologies (biotechnology being the most eye-catching), are all marks of success in agriculture attributed directly to agricultural S&T.

2.a. Inclusion – research on water and bio-chemical inputs

Agricultural growth in the post-reform (post-1991) period has slowed down, especially compared to the growth of non-agricultural sector (Chand et al, 2007). While growth in fisheries and horticulture kept pace during the early 1990s, all the sub-sectors in agriculture witnessed a deceleration of growth since the late 1990s. This deceleration of growth is accompanied by changing cultivation patterns and input use. The most notable being an increasing trend towards cultivation of low value low risk crops and a decline in the rate of growth of fertilizer use, irrigation and energy use in agriculture in most states and a stagnation and real decline in some (*ibid*). Why are Indian farmers moving towards low value low risk crops?[3]

Figure 1: Irrigation and fertilizer based production



Source: Government of India, 2009; RBI, 2009.

[3] This may seem an anomaly in a country that is increasing its share in global trade in vegetable, fruit and cereal products (raw and processed). The contract farming systems involving small farmers (Calypso Foods, Morarka Foundation), medium and large farms (Reliance, Bharti-Rothschild, A.P. Todd, SAB Miller India or even the public sector PAICO), or region-specific co-operatives, constitute less than 7% of Indian farms.

India, with a successful green revolution has over 300 million living below the poverty line, mainly in rural areas. With 86% of India's operational holdings being marginal and small (less than 2 hectares), largely unviable due to increasing input costs (Acharya and Jogi, 2007), technology fatigue with increasing input prices and declining factor productivity (Swaminathan, 2005), increasing soil and water problems –both quantity (declining arable land) and quality(soil degradation) (ICAR, 1998; Government of India, 2005; 2008), limited rural employment opportunities (NCEUS, 2006), and rate of growth of income per worker in the agriculture sector falling from 1.15% per annum (1980-81 to 1990-91) to 0.48% per annum (1990-91 to 2000-2001) (Sen and Bhatia, 2004; Bhalla and Hazell, 2003), the picture of agriculture in India is no longer green.

Though rather reticently, with a marginal decline in net sown area, gross sown area has been growing. Figure 1 reveals two significant dips for the 1987 and 2003 - the drought years, when the total cropped area declined sharply. But cropping intensity remained steady, ensuring that all the second or third crop was taken even during the drought years; the decline in foodgrain output coming mainly from the decline induced by a failed monsoon in regions dependent on rainfall and with not enough water for a second or third crop in the year. The drylands of India are evidently the excluded regions in this picture of Indian agriculture.

Gross irrigated area, fertilizer and pesticide consumption, and use of high yielding varieties (HYVs), the key production inputs – all technology based, are evidently the proximate determinants of food grain production. Against the backdrop of increasing ICOR, the investments in the key inputs (irrigation and fertilizers), do not add to agricultural productivity. Moreover, irrigated agriculture being limited to a few states and some pockets in others, these investments are useful only in a fraction (about 46-48 percentage of the GCA) of Indian agriculture, with rainfed areas (about 17 percentage of GCA with assured rainfed cropping for at least one season per year) and low potential drylands (about 35 percent of GCA) accounting for little or no irrigation and fertilizer use (Golait and Lokare, 2008; NRAA, 2009). Going by these intangible yet, evident rules, certain areas, about 52 percentage of NSA in the country, are excluded from the development investments (say, irrigation and chemical fertilizers) made by the state. The share of gross irrigated area in gross cropped area ranges from 98 percent in Punjab to 23, 17, 11 and 5 percentage in Karnataka, Madhya Pradesh, Bihar and Assam respectively (2003-07)[4]. It then follows, logically, that the generation and utilization of knowledge and technologies – say, the investments and content of agricultural research, focuses on the areas that receive these development investments. Similarly, development policies, for instance on fertilizer production, import, consumption and on fuel or irrigation subsidies, include only the concerns of the irrigated cultivation systems – mainly the green revolution states. Planned exclusion, governed by the norms of irrigated-chemical input based production, brings no benefits to rainfed agriculture in eight major states (Andhra Pradesh, Gujarat, Karnataka, Madhya Pradesh, Maharashtra, Orissa, Rajasthan and Tamil Nadu) in India.

While much has been said about Indian agriculture and the generation of new varieties meant for irrigated agriculture, Figure 1 also reveals how S&T and development investments have co-evolved –evident here as area under HYVs and gross irrigated area. Even data on area under HYVs is available (all-India and state-wise) only till 1998-99. Following this year, area under HYV is collected and reported only for select crops

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[4] That the figure was not very different, in 1996-97 and more or less as it was even in the 1980s, when public sector capital formation in agriculture was focused on canal irrigation (in the 1980s and 1990s) is evidence of the exclusion that these dryland states are subject to. The growth of tubewells in the canal irrigated states, and growth of dug wells (relatively less in proportion) in the dryland states, as well as subsidies and support systems for tubewell irrigation (including lack of regulation) are being analysed as organizational and spatial exclusion of rainfed agriculture (SIID working paper- Kulkarni and Vijayashankar, forthcoming).

in select states – mainly, the cereals crops (in all canal irrigated green revolution states and some groundwater irrigated dryland states). This evidence of government making development investments and even collecting and reporting data on development indicators, according to the 'accepted' paradigm of irrigation-chemical fertilizer based cereal production, points to the rules or norms that govern these proximate determinants of agricultural production and growth.

2.b. Reforming agricultural S&T for inclusive development?

When it comes to credit for food production, the agricultural research organizations take it all. When it comes to the blame game – about persistence of rural poverty and hunger, child and adult malnutrition, environmental and social disruption, it is the other organizations and policies – the Food Corporation of India and the Public Distribution System, state and national level schemes for rural employment and poverty alleviation, input subsidies, rural credit, irrigation policy, international trade and the WTO, that are accused of exploiting the farmers, rural labour, national agriculture, etc. (Ghosh, 2005; Bhatia and Dreze, 2002; Dev, Kannan, Ramchandran, 2003). Very few (like Vaidyanathan, 2000) question agricultural research and point out emerging concerns that must be addressed.

Table 2: Trend Growth of Inputs in Agriculture (1999-2000 prices) (Percentage)

Agricultural Inputs	1980-81 to 1990-91	1990-91 to 1996-97	1996-97 to 2005-06
Credit Supply	3.7	7.5	14.4[b]
NPK use	8.2	2.5	2.3
Electricity Consumed in Agriculture	14.1	9.4	-0.5[c]
Technology[a]	3.3	2.8	0.0
Cropping Intensity	0.5	0.4	0.1
Public Sector Net Fixed Capital Stock	3.9	1.9	1.4[b]
Private Sector Net Fixed Capital Stock	0.6	2.2	1.2[b]
Total Net Fixed Capital Stock	2.0	2.1	1.3[b]
Terms of Trade	0.2	1.0	-1.7[b]
Total Cropped Area	0.4	0.4	-0.1
Net Sown Area	-0.1	0.0	-0.2
Gross Irrigated Area	2.3	2.6	0.5[b]

[a] Yield potential of new varieties of Paddy, Rapeseed/Mustard, Groundnut, Wheat, Maize
[b] Up to 2003-04. [c] Up to 2004-05.
Source: Economic Survey 2007-08.

Among all the inputs that go into agricultural production, it is the knowledge inputs (proxied here as yield potential of new crop varieties) that have stagnated in the past decade (Table 2 above). There is little discussion about the relationship between the slowing growth rates of fertilizer use, electricity consumption, irrigated area, and the negative trends in growth of net sown area. What prompts a deceleration in the growth of area irrigated? And how does that affect crop choices, varietal choices, input use patterns and agricultural markets? Is the consumption of electricity and chemical fertilizer slowing down because of lack of availability, limited affordability, or because there is no yield response to increasing irrigation and application of chemical fertilizers?

There has been an increase in capital intensity of agriculture in the 1990s, "doubling the incremental capital output ratio (ICOR) from about 2 to 4" (Golait and Lokare, 2008). In the field, farmers do realize this change in the ICOR as increasing costs of production and decreasing profitability. Their response is to produce low risk, low input consuming crops (Chand et al, 2007). Some economists do make a demand for input price supports (subsidies) to make farming a viable option for 86% of Indian farmers (Vyas, 2007). What is the contribution of agricultural research to farming in about eight major states in India- the dryland states, which produce over 60 percentage of the foodgrains (cereals and pulses) output of the country (Shah, 2006; Vijayashankar, 2006). The designated research organizations to address dryland agriculture the Central Arid Zone Research Institute (CAZRI) and the Central Research Institute for Dryland Agriculture (CRIDA), are among the two least funded research institutes within the ICAR. It is increasingly clear that on poverty and environmental grounds, as well as on the basis of scope for development more attention needs to be given to development requirements of the drylands – the less favoured low potential rainfed areas and the rural areas in general (Cook, 2006; Fan and Hazell, 2000; IAASTD, 2009)- areas, crops and people who have been excluded from development choices made consciously by the state and the S&T it sponsors. Should this attention and investments be more of the same, or is there a need for institutional change?

The need for inclusive development in Indian agriculture is perhaps best captured in the lament that 'India's greatest living industry is yet to receive the attention it needs, especially when compared to the non-living industries of our country.' (Government of India, 2005, p. 2). The need to reorganize agricultural research to cater to the policy goal of inclusive development was made explicit during the preparation phase of the XI Five Year Plan of the Government of India.

> The Eleventh Plan Steering Group on Agriculture (Planning commission 2007) has noted that technology has become a crucial constraint on growth of agriculture. It points to the two aspects of this constraint - development of new technologies and the gaps in the application of existing technologies. Extension services can serve as a critical tool in closing this gap. The Steering Group has noted that public extension services have become extremely weak. This conclusion has been echoed in a number of other reports including those by the National Farmers' Commission. (NCEUS, 2007, para 9.36, p. 142)

The concern, articulated here is for new technologies, ways to reduce the gaps in the application of existing technologies, and strengthen agricultural extension. The XI Five Year Plan document also focuses on the nature of technologies generated (water and chemical intensive production technologies) and methods necessary for sustainable agriculture, adding that corrective measures have been ineffective:

> Thus far, research has tended to focus mostly on increasing the yield potential by more intensive use of water and bio-chemical inputs. Far too little attention has been given to the long-term environmental impact or on methods and practices for the efficient use of these inputs for sustainable agriculture. These features are widely known but efforts to correct them have not been adequate; at any rate they have not made much of a difference (Govt. of India, 2008, Vol. 3, p. 13).

These recommendations for reform suggest that technology fatigue or constraints, the exclusive focus on intensive water and chemical inputs and the weak extension system are independent and disparate events or variables, and that these can be 'corrected' by addressing them as such. So, research funding increases, or private agricultural extension, or contract farming or other magic bullet solutions to individual problems are recommended and taken up at the national agricultural policy level. None of the institutions that shape the proximate determinants of agricultural growth or the relationships between these institutions and the determinants of growth like irrigation or subsidized fertilizers are questioned or analysed. Why aren't institutional changes like capacity for interaction with other components of the agricultural innovation system recommended? There is no mention of why 'corrective measures' recommended are confined to research and extension funding or research priority setting or post-harvest technologies or market development.

As a point of departure from many other assessments of agricultural S&T, the National Knowledge Commission demanded 'an analysis of the institutional rigidities' within the formal agricultural research establishment. Yet, there is a pervasive inability to perceive and change these institutional rigidities within the agricultural research and extension system in the country. [5] Prescriptions for reform of all components of the agricultural innovation system - all except the hallowed research and extension structures, as well as the narrow S&T reform recommendations (above), both reveal valid concerns. But both fall short of an institutional understanding, which explains how the components of the innovation system perform and relate to each other. This lack of institutional understanding leads to confusion about whether we want more of the same (increased funding of R&D, more irrigation and subsidies, etc.) or whether we need institutional reform.

Agricultural S&T is one among several components of a larger set of innovation system components (ARD, 2008) and has over time evolved with them. The lament that it focuses on irrigation and chemical intensive production, however legitimate, is determined by these processes of evolution and co-determination. Thereby, the measures to reform agricultural S&T as an individual component will always remain inadequate because there are overarching rules or norms that govern the nature, conduct and interactions of S&T with these other components of the innovation system. For the excluded (rainfed agriculture or coarse cereals or pulses or soil and water quality or small farm production problems…) to receive the attention due to them, in a Five Year Plan dedicated to inclusive development, an understanding of these institutions that shape the co-evolution of agricultural innovation and exclusion is essential.

If these institutions were tangible and spelt out clearly, then changing or reforming them would have been easy. But they are intangible, are not discrete quantitative variables, and evolve mainly through processes of cumulative causation (See Kapp, 1977). This makes direct one-to-one causal relationships or impacts difficult to measure and thereby institutional reforms difficult to prescribe as silver bullet policy recommendations. If institutional reform is to enable better performance of agricultural S&T, especially better ways to cater to the agricultural knowledge demands of the excluded spaces and populations, then we need to identify and analyse the evidence of institutions that currently hinder such desired performance.

3. Exploring India's Agricultural Innovation System:

This section presents a brief analysis of the formal agricultural innovation system in India. With responses ranging from 'does it exist?' to 'the innovation hubris!' planners and donors in India have now come around to asking 'what does an innovation system mean' and 'how is it different from R&D and technology transfer'?[6] The innovation systems framework helps us understand the Planning Commission's lament about

[5] This inability draw the political will for reform was noted in the 1950s and 1960s too (Lele and Goldsmith, 1989). The report of the NKC and the recommendations made to the Prime Minister (NKC, 2009) has received little policy attention. We will argue (later) that this is *because of* the recommendations for institutional changes, for new norms and ways of working.

[6] That this change has happened over a span of less than an year, is evident from two events, one an International Workshop on Benchmarking Rural Innovation in South Asia, organized by the Centre for Policy Research (CPR, New Delhi) and Center for Research on Innovation and Science Policy (CRISP, Hyderabad) 19-21 August 2009, and the Multi-country Research Dialogue on Emerging Economies in the New World Order, organized by the International Council for Research on International Economic Relations (ICRIER, New Delhi), in 12-13 April 2010, both supported by IDRC, Canada, and held in New Delhi.

a research system that has over-indulged in water and chemical intensive production technologies. It helps us explore why this research system seems to be un-reformable.

Agricultural research organizations, farm households, and the government - central and state governments, make decisions as components of the innovation system, shaping their own actions and the proximate determinants of agricultural growth. Because these are the three components that figure in all linear technology generation and adoption studies, in the standard economic explanation of the green revolution or any other technological change in agriculture, these three major components of the innovation system are analysed here. What are the institutions or norms that govern the generation of technologies for irrigated, chemical intensive cereal production? What rules or norms help farmers access and decide to use these technologies from formal S&T or from other sources? And how do state governments and the central government make policies and investments that enable changes for agricultural and overall economic growth? The institutions that govern the evolution of and behavior of these actors – agricultural S&T, farmers, and governments, and their interactions, are intangible and cannot be measured as discreet variables. But there are indicators of and processes of interaction and learning in the agricultural innovation system that can tell us how S&T organizations, farmers and farm policy makers make certain decisions that include or exclude certain regions, crops or technologies, and capacities.

3.a. Researching and extending technological knowledge

India's agricultural research system, re-organized in 1965, is a fairly uniform and standardized system. The ICAR was given direct responsibility to co-ordinate and conduct research, with a focus on food grain production, with a six fold increase and direct funding from the Central Government, as well as control over all the research institutes under the Ministries of Agriculture and Animal Husbandry. Centralization became the hallmark of Indian agricultural research from that point in history (Raina, 2009). From an attached office in the Department of Agriculture, with limted funds and co-ordination capacities, the transformation of the ICAR to a separate well funded Department of Agricultural Research and Education (DARE) in 1974, consolidated scientific and bureaucratic authority. Interactions were not deemed necessary – what was needed was 'a central line of authority and control' (The Agricultural Production Team, 1959).

Increasing centralization, with the heavy hand of ICAR administration and accreditation of even local agricultural education syllabi, with the ICAR accounting for over 70 percentage of the national agricultural research expenditure and – SAUs accounting for the rest, has been discussed widely (Jha, 2002b; Raina, 2003).[7] Historically, the period beginning 1966-67 marks the consolidation and centralization of agricultural research under the ICAR, and the shift of total central government expenditure on agricultural research from a mere 40.43 percentage (1960-61) to 66 percentage (1986-87) and over 70 percentage since, of total national agricultural research expenditure (Rajeswari, 1992;1995). This trend of growth within centralized research councils supported by the Central government, at the expense of growth within research and teaching universities (SAUs here) in the states, conforms with the overall pattern of S&T growth in India (Raina and Jain, 1994; Desiraju, 2008). In the 1990s, almost all the growth rate of 6.4 percent per year in public sector agricultural research investment (1991-2003) (Beintema et al, 2008) took place in the ICAR or its co-ordinated research projects (AICRPs) located in ICAR institutes and SAUs (funded in different proportions – of 75:25 or 50:50).

During the same period the growth rate of full time equivalent (fte) professional staff in public agricultural research grew at 1 percent per year (*ibid*). Though this does indicate an increase in research resources per

[7] Beintema et al (2008) report a share of 43 and 50 percentage respectively for the ICAR and the SAUs in the total public agricultural investments in India. In this paper, we do not present or analyse agricultural research investments and allocations (presented in another paper- forthcoming, 2011), but focus on the variables indicating capacities for interaction.

professional scientist in public agricultural research, the implementation of the new (Pay Commission recommended) salaries meant that much of this increase per head went into the salary account and increased the red-tapism within the Council instead of bringing in the financial and administrative decentralization and flexibility that was to accompany the new National Agricultural Policy (Ministry of Agriculture, 2000; Jha, 2002; 2003). Among the reasons why this impressive growth rate in public sector expenditure in agricultural research does not translate into relevant research results are, centralization (with the ICAR deciding the guidelines and norms for all research, education, extension, and (even international travel of scientists- within ICAR and in SAUs) publication), the weak extension system, administrative overload, inadequate linkages between research and extension, and a state-supported isolation of the agricultural S&T and extension components from other components of the innovation system.

It is in this context of increasing centralization that the overwhelming focus on crop research – with more than half the ICAR research and almost 70 percent of SAU research devoted to crops (rice, followed by vegetables, pulses, wheat, fruits, sugarcane and cotton), is maintained (Beintema et al, 2008; Rajeswari, 1992; 2006), with decades of no impact of this research on agricultural productivity (see Table 1 here). A simple illustration of the characteristics of rainfed regions and irrigated regions (NRAA, 2009- in Table 1, p. 8), puts the 'predominant crops' in the two regions as more than 34 and 1 or 2 (rice-rice in South India; rice-wheat or rice-cotton in the North) respectively. A national agricultural research system focused on crop research, and a few crops that are cultivated in the irrigation-chemical fertilizer consuming tracts, excludes the cropping systems and crop-livestock systems, and the knowledge base that are 'predominant' in the drylands.

While the ICAR faculty are mainly engaged in research, the SAU faculty have anywhere between 40-70 percent of their time committed to teaching (Beintema et al, 2008; Rajeswari, 1992; and interviews, 2002).[8] Thereby, the limited research in SAUs, with state government support, also follows the dominant research focus on one or two crops, with little research time and resources devoted to the multiplicity of 'predominant crops' grown in the state. The argument that the 'package of practices' (published by each SAU for the extension departments to train farmers about production technologies) does include regional location specific crops holds no weight because these publications (a sample of 35 publications over time from different SAUs) over the past two decades reveal the same recommendation repeated year after year for these regional crops.

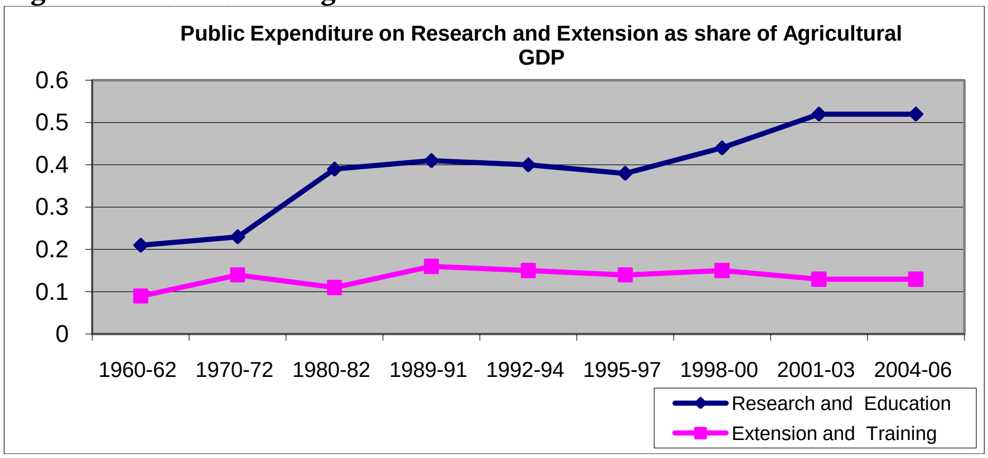
While this paper will not analyse the weaknesses of research and extension, it must be noted that extension, which has been under-funded and inadequately supported by personnel (in both competence and capacity for learning and knowledge management) is most often accused as the prime reason for the non-performance of agricultural S&T in India (for instance, Government of India, 2008; Balakrishnan et al, 2008). The few studies available on agricultural extension indicate not only a major disjuncture between research and extension, but also unproductive hierarchies and a chronic lack of learning capacity (called feedback in conventional linear technology transfer paradigm) within agricultural research organizations (Sulaiman and Hall, 2002).

India has one of the lowest research intensity figures (ratio of research expenditure to agricultural GDP) though the country is among the leading developing countries investing in public sector agricultural research (Beintemma et al, 2008; Balakrishnan et al, 2008). The decline in investment (in real terms) in agricultural

[8] The research set-up of ICAR comprises 53 Central Institutes, 32 National Research Centres, 12 Project Directorates and 62 All-India Coordinated Research Projects (AICRPs). For higher education in agriculture and allied fields there are four deemed to be universities, 39 State Agricultural Universities (SAUs) and one Central Agricultural University at Imphal. (ICAR, Annual Report, 2006)

extension, especially with reference to the massive growth of investment (infrastructure in particular) in agricultural research starting from the 1970s (Figure 2), is a consequence of India's green-revolution euphoria. The need to increase funding for and strengthen research-extension linkages in order to deliver

Figure 2: Public sector agricultural research and extension in India



Source: Using data from Balakrishnan et al (2008)

knowledge about modern technologies has been a consistent refrain in every single review of agricultural research and extension, agricultural policy, trade and development since the 1970s. But is that enough? Is the current state of affairs a result of the research-extension discourse which can be resolved with better linkages between well funded research and extension components? The centrally controlled and operated agricultural research, the state owned and operated extension departments, the over-emphasis on crop sciences (a few crops in particular) and on production technologies, the extremely low level of funding for agricultural extension (which in effect limits the extension agents capacity to travel to villages in her/his own jurisdiction, are problems internal to research and extension. These features of research and extension are there by design, legitimized by the infallible faith in technological solutions to enhance crop productivity, irrespective of contexts – ecological, social or economic. And these features affect the capacity of research and extension to interact with and learn from other components of the agricultural innovation system – the farming communities and the policy making actors.

3.b. Accessing and utilizing agricultural technologies and knowledge

Farmers are a far more diverse set of actors in the innovation system, compared to research and extension actors. It is increasingly evident that a good majority of them receive little or no information about modern technologies from the public sector extension or other public sector agencies. That the investments in research and extension do not meet the requirements of the farmers for information about new technology or help in adopting them, is not surprising (Table 3). Even in a 'green revolution' state like Punjab, less than 5 percent of small farmer households have access to information on or inputs of modern agriculture. If some states like Kerala and Himachal Pradesh – with plantations - agricultural and horticultural, are taken as outliers, then the overall picture is one of very poor access by small farmers throughout the country. The other outlier here is Gujarat where the access to information from state agencies (including state supported co-operatives) is very high in the dairy sector.

Table 3: Access to Government Agencies as a Source of Information on Modern Technology by size of Holdings (Percentage of Farmer Households) 2003

State	Farm size in Hectares			
	Sub-Marginal & Marginal	Small	Medium & Large	Total
Andhra Pradesh	10.7	10.9	14	11.4
Assam	4.3	6	9.6	5.3
Bihar	1.2	2.6	4.1	1.5
Chhattisgarh	4.9	8.1	9.7	6.7
Gujarat	12.3	15.8	17.1	14.2
Haryana	5.5	7.9	15.1	8
Himachal Pradesh	10.9	29.1	29.2	14.8
Jammu & Kashmir	2.5	0.9	1.6	2.2
Jharkhand	2.6	4.8	2.4	2.9
Karnataka	11.6	13.2	16.1	13.1
Kerala	16.6	32.7	27.2	18.3
Madhya Pradesh	7.6	10.1	16.3	11.1
Maharashtra	6	7.4	14.4	9
Orissa	3.9	3.1	6.2	4
Punjab	4.6	11.2	17	8.4
Rajasthan	2.4	5.6	4.5	3.7
Tamil Nadu	11.4	15.3	26.8	14
Uttar Pradesh	2.5	7.5	8.1	3.8
Uttaranchal	0.9	9.3	19.6	2.5
West Bengal	4.4	6.5	8	4.7
All India	**5.4**	**8.9**	**12.5**	**7.2**

Note: Sub-Marginal: <= 0.40 hectares; Marginal: <= 1 hectare; Small: 1 - 2 hectares; Medium: 2 - 4 hectares; Large > 4 hectares.
Source: NCEUS, 2006, Appendix A 9.6, p. 280

Given the features of research and extension discussed above, and a context where marginal and small farms constitute 86 percent of all operational holdings cultivated in the country, there is little that the research and extension system can deliver as public goods for marginal and small farmers. (Table 3 above) There is no dearth of empirical evidence about the productivity per unit of land, water, resources – biological, chemical and physical energy use in small farms.[9] But the natural environments and production systems that these small farmers work with, mainly rainfed lands, mountain ecosystems, and coastal inundated systems, have been least understood by formal agricultural R&D and have received little of the subsidized fertilizers, chemicals, modern varieties, agri-machinery, irrigation, electricity or infrastructure that have been supplied amply to the irrigated cereal monocultures. As size of land holding increases, so does access to information and knowledge supplied by government agencies (Table 3).

State level allocations to agricultural extension are dominated by crop husbandry, followed by animal husbandry and horticulture (Goliat and Lokare, 2008) – we note here that extension and some seed farms account for almost the entire budget head 'agriculture and allied'. That this matches the pattern of

[9] See for instance, Pretty, et al, 2005. Globally, marginal and small farmers produce almost 40 percent of the global cereal production and over 70 percent of all minor millets, tubers, fruits and vegetables (Altieri, 2009; Murphy and Ugarte, 2008).

agricultural research allocations, with crop sciences (foodgrains followed by horticulture) and livestock research cornering a large share of the pie, is not surprising (Jha and Kumar, 2006; Beintema et al, 2008). Marginal and small farmers in the drylands who cultivate anywhere between 16-34 'pre-dominant' crops in their small holdings, definitely have little to gain from the technologies piped through public sector research and extension focused on foodgrains (mainly the two or three cereals and pulses).

Table 4: State-wise share of small and marginal farms

States	Share of Marginal and Small holdings in total number of operational holdings(percentage)		Share of Marginal and Small holdings in total area operated (percentage)	
	1995-96	**2000-01**	**1995-96**	**2000-01**
Andhra Pradesh	80.75	82.73	42.67	46.31
Gujarat	55.33	60.27	21.34	25.58
Karnataka	69.39	72.91	30.79	34.40
Madhya Pradesh	64.46	65.07	23.44	25.81
Maharashtra	69.86	73.42	33.67	38.68
Orissa	81.97	83.82	50.27	53.12
Rajasthan	50.26	52.57	11.04	12.41
Tamil Nadu	89.68	89.99	53.83	55.52
Assam	83.12	83.33	44.33	44.77
Bihar	90.92	93.42	55.13	62.29
Haryana	66.72	65.31	23.86	20.82
HimachalPradesh	84.47	86.32	47.10	50.77
Jammu&Kashmir	91.92	93.83	65.15	70.58
Kerala	98.11	98.57	73.71	75.40
Punjab	35.41	29.69	8.73	7.96
Uttar Pradesh	89.98	91.13	57.59	61.25
West Bengal	93.23	95.30	71.99	78.71

Note: Dryland agriculture states (with less than 25 % irrigated area) are the first eight ones listed here.
Source: MoA, Land use statistics (various years)

It is small producers in states like Gujarat (mainly marginal dairy farms with one or two heads of cattle), Kerala (with plantation crops like rubber, cardamom, coffee, pepper, etc.) and Himachal Pradesh (horticultural crops – apple, cherry, and even tomatoes) who have effective linkages to their co-operatives and markets who access information from the public sector. The dominance and steady increase in number of small farms in almost all the states in the country, is a significant feature of the farming community (Table 4). Except in Punjab and perhaps Rajasthan, where there has been a decline in number of marginal and small holdings (in Punjab contrary to an increase in all other states), Indian agriculture is characterized by small holdings. It is again, only in Punjab that the small farmers cultivate a small share of the total cultivated area (35.4 % of operational holdings covering 8.7 percent of the total area sown). In all the other states, smallness is a feature of the farm sector – in states like Bihar more than half the area sown is cultivated by 90.9 percent of the total operational holdings in the state. In Kerala, Himachal and J&K, predominantly small garden lands and horticulture-cum-plantation agriculture, account for 98, 84, and 92 percent of all the holdings in the state and 74, 47, and 65 percent of the total cultivated area in the state. The topographical and agro-ecosystem features notwithstanding, irrespective of the nature of small farm operations (crops/ fruits/ spices), these states have little to gain from the dominant foodgrain (cereal) crop research and extension content in the public sector. The small farmers in the major dryland states, in the cereal producing regions cultivate rainfed rice, other coarse cereals and minor millets (under-researched), with low or no use of purchased inputs; by default they are the excluded majority in India's farming community.

Given the capital intensive inputs that go into irrigation-chemicals-HYVs based cultivation (Golait and Lokare, 2008), the additional feature is that of access to credit for marginal and small farmers. Since this is an issue that has been analysed and recommendations made to implement changes in agricultural credit, ranging from re-finance to rural bank operational procedures, loan recovery mechanisms to co-operative reforms (Shah, 2007; Vaidyanathan Committee, 2004), we will only point out the exclusion of the marginal and small farmers in yet another component of the agricultural innovation system.

Marginal and small farmers, with little or no capital to invest in a tubewell (majority of this category being located in Eastern India), and with their mixed and multiple crop stands, are also farmers who produce rainfed crops using low or no chemical inputs. We witness here a convergence of a different sort, between farming systems that are rainfed-organic or local farm yard manure based, using local and other (non-public sector) knowledge flows and inputs. These are the farmers who produce a significant proportion of India's agricultural trade – whether it is cotton, soya bean, meat (beef) or vegetables[10] are part of another set of non-public sector actors. Despite lack of support from the public sector research and extension agencies, they seem to be linked to local and global markets as part of coalitions of private and civil society actors, international and domestic donor or input supplier networks. They are components in large and a wide range of 'informal' innovation systems.

The secondary information available points to two features of the formal agricultural innovation system. The first, is the weak funding and lack of linkages in the knowledge generation and dissemination components (research and extension) of the innovation system. The second, is the existence of other sources of knowledge and information, to which the formal organized public sector led innovation system has little access or entry into. Farmers (besides the 7.2 percent that access information through government or public sector sources), 86 percent of them operating marginal and small holdings are still producing and adding value to the national income. The public sector research (relying mainly on central government support) and extension (organized by state governments) seem to have little interaction and exchange of lessons with these other sources of information – about technologies, practices, markets, inputs, etc. that the majority farmers access. This exclusion of other actors who are crucial to farmers as suppliers of inputs, technological and institutional information to farmers, is an important feature of the formal public sector agricultural research and extension systems. There is reason to believe that there are several other (perhaps parallel) innovation systems in which these farmers (the ones excluded from the irrigation- bio-chemical inputs based systems) participate, with production and productivity levels that range from very high to very low, depending on the nature of the agro-ecosystem (ideal for plantation crops or horticulture crops like apples), and the enabling policy environment.

3.c. Enabling policies and agricultural innovation systems

In this sub-section we explore the innovation features – interaction and pro-active initiatives of a third and crucial component of the innovation system, the state government.[11] What are the forms of inclusion or

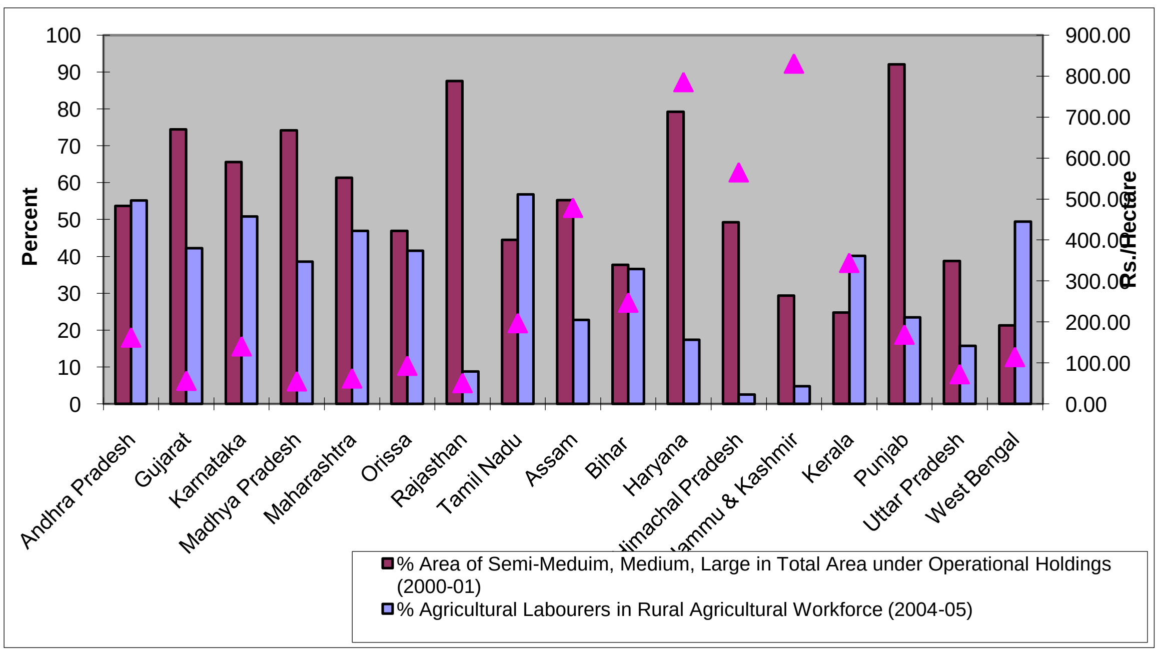
[10] Agricultural trade statistics from DGCIS (2007), CMIE (2007).

[11] The choice of the state governments as the crucial policy actors instead of the central Ministry of Agriculture or the Planning Commission, is partly because constitutionally, agriculture remains a state subject (it is not in the central or concurrent list) and also due to the direct investment in and responsibility that the state governments have to extension and agricultural education and research. Moreover, in all the linear R&D analysis, it is the government that provides the incentives for adoption of technologies – by subsidies, market assurance, cheap and accessible input supply, etc.

exclusion that the local government enables? Let us recall that 'an enabling policy framework with accountability' is an important principle evident in all successful innovation systems.

The centralization and standardization of the agricultural S&T system has in effect enabled the emergence of several other local or regional agricultural innovation systems, marked by the presence and pro-active roles of several (private and civil society based) other actors. But the constitutionally assigned role of the state governments – agriculture being a state subject, has been gradually appropriated by the central government, and centrally designed instruments for agricultural production, research, education, extension, pricing and input supply. Let us recall here, how the need for modern technology to shift the production frontier was a felt need in the 1950s and 60s. It was argued that "far-reaching central authority and a clear line of command and execution alone could meet the challenge of growing more food," (The Agricultural Production Team, 1959, p. 6). The Central government, having taken on the political commitment to food security, decided to engage directly with modern technology and the provision of inputs and incentives to sustain food production, contrary to its stipulated constitutional role of enabling development (see Sivaraman, 1991). A direct consequence of this centralization and consolidation was the weakening of state level capacities for and resources devoted to agricultural research and (most particularly for) agricultural extension – which is entirely a state level line-department activity.

Figure 3 : Agricultural research and education expenditure – dryland vs. irrigated states



Note: The eight major dryland states have been placed together for illustration
Source: NCEUS, 2007; Land use statistics (various years), RBI (2008).

Given that state governments do need and offer jobs to agricultural science graduates to become agricultural extension officers in agriculture departments, it is a requirement that each state has its own SAU producing trained manpower to deliver extension services. The lack of correlation between the users (mainly large farmers as seen in table 3) of the products and services of the agricultural research system, and the state's own investment to this end, is as expected (Figure 3). Given that the Central government invests more than double the total investments made by the state governments, state level support for agricultural research and education is an indicator of their commitment to technology generation. The eight dryland states invariably spend less on agricultural research and education (less than Rs. 200 per hectare of NSA), while the states with irrigated agriculture and those with significant horticulture/fisheries sectors invest three to four times as much per hectare of sown area (See Figure 3). The exceptions, states like Punjab, UttarPradesh and West Bengal, are all irrigated rice-wheat cropping system states, which do have a significant investment from the Central research institutes, especially, the Directorates of Research for Rice and that for Wheat, as well as the Rice-Wheat Consortium of two international agricultural research institutes, CIMMYT (the International Wheat and Maize Research Institute) and IRRI (the International Rice Research Institute).

The dryland states' giving relatively low priority for agricultural research and education allocations, reflects the state government's acknowledgement of the relative contribution of this investment to their respective economies. For instance, a major state like Maharashtra which is home to four SAUs and eighteen state experiment stations and farms, has 175,00,000 ha of net sown area, and produces Rs.62,362 crores worth of agricultural SDP (2006-07), spends less on agricultural research and education per hectare than Orissa does (with less than half the NSA and one third the agricultural SDP for the same year) (NAS, 2007; Land use statistics, various years). Maharashtra, Tamil Nadu, and Gujarat, among the dryland states account for the largest volume and ratio of private capital investment in agriculture and allied sectors (RBI, 2008). These dryland states are also the ones who have made the structural transition from agri-based to industry or manufacturing based economies. That their dependence on agriculture has declined sharply since the 1970s, after the launch of the green revolution is a historical fact. These state governments (at times with Central support) have provided several incentives to establish industries in 'backward districts'.

Table 5: States ranked in order of share of agriculture in State Domestic Product

State/UT	1980-81
Haryana	53.4
Uttar Pradesh	50.4
Orissa	50.2
Punjab	49.1
Madhya Pradesh	48.9
Himachal Pradesh	46.8
Bihar	46.0
Assam	45.4
Arunachal Pradesh	44.5
Karnataka	43.1
Andhra Pradesh	42.9
Rajasthan	41.6
All-India	**38.1**
Gujarat	37.3
Kerala	36.6
West Bengal	30.1
Maharashtra	26.7
Tamil Nadu	24.3
Goa	19.1

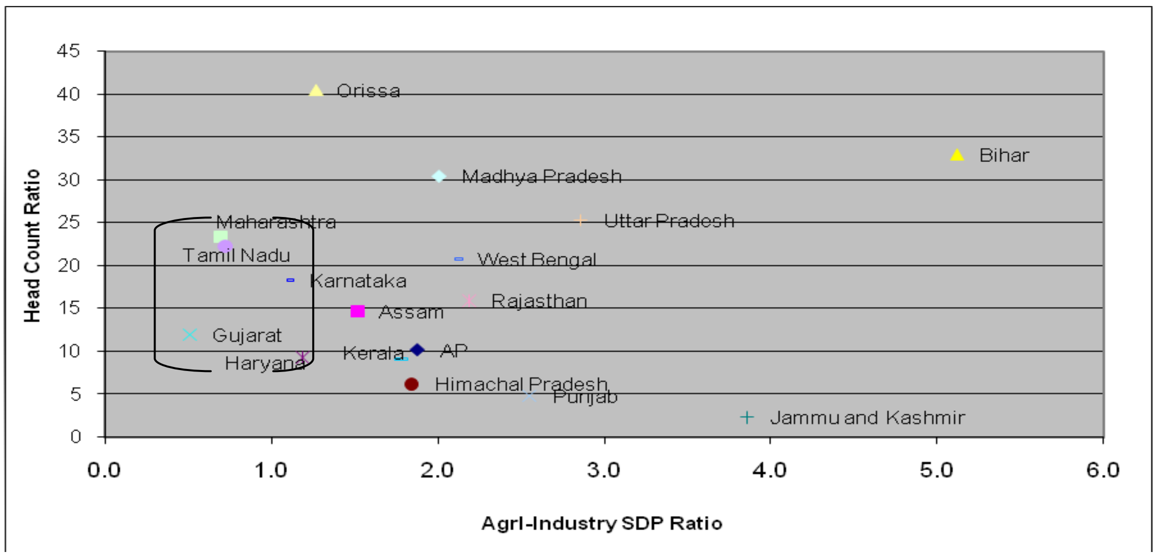
State/UT	2005-06
Punjab	32.4
Uttar Pradesh	28.5
Assam	26.7
Bihar	25.9
Rajasthan	24.4
Madhya Pradesh	24.4
Andhra Pradesh	22.6
Haryana	22.6
Orissa	21.9
Himachal Pradesh	21.1
West Bengal	20.6
Arunachal	20.4
All-India	**19.6**
Karnataka	17.8
Gujarat	16.8
Kerala	14.8
Maharashtra	12.0
Tamil Nadu	11.6
Goa	6.4

Source: EPW Research Foundation (2008)

In this ranking of states according to their dependence on agricultural incomes (Table 5 above), it is evident that the dryland states – Gujarat, Maharashtra and Tamil Nadu have steered a non-farm growth path. They figure as states with their share of agricultural income in SDP accounting for less than the average share of agricultural income in national GDP. The outliers are Kerala, Goa (remittance/tourism based service-sector led economies) and West Bengal (industrial production in the era of strong PSUs in the 1980s – falling back to agricultural income based growth by the end of the 1990s), all known for poor industrial performance. The three dryland states here, however, have chosen a conscious industrialization policy. For them, investments in industrial avenues were to ensure employment to rural and urban populations (though the proportion of agricultural workers in total rural workforce continues to be high in Tamil Nadu –compared to Maharashtra and Gujarat).

Overall, the current trend of deploying labour saving technologies in agriculture and the low and declining employment elasticity indicate that agriculture will not be able to generate enough jobs for the rapidly growing rural populations (Palanivel, 2006). With the ICOR being unfavourable and forcing farmers to resort to low risk and low purchased inputs, labour using agricultural technologies can be the answer; but the irrigation-chemicals based technology generation system has few labour using technologies to offer. It is in this context that the non-farm income opportunities created by some of the dryland states deserve attention.

Figure 4: Headcount poverty ratio and ratio of Agricultural: Industrial SDP (2004-05)



Source: EPW Research Foundation Data Series, Dev and Ravi (2007)

In terms of proportion of poor people in the state, both Maharashtra and Tamil Nadu fare worse than Gujarat (Figure 4 above). But the rates of change in poverty reveal that these three states have made significant reduction in the number and percentage of rural poor, with improvements in the Gini co-efficient over time (Dev and Ravi, 2007). Increasing employment elasticity in agriculture – compared to other states, increasing co-operative credit and co-operative movements for production and production investments (dairy in Gujarat and sugarcane as well as other fruits like grapes in Maharashtra, are outstanding examples), along with rural industrialization and rural service sector growth (however marginal), have steadily reduced the dependence of rural households on agricultural incomes (State Human Development Reports – UNDP). Structural transformation in these three states is striking, with the ratio of agricultural SDP to industrial SDP being less than 1 in all three – a conscious policy choice. In terms of lower number of rural households in total number of households, lower number of farmer households in total rural households and lower farm income share in total farmer household income, all the three states fare much better than the national average (with Tamil Nadu accounting for the least farm income as a share of farmer household income) (based on NSSO Reports 497 and 522)[12]. What this indicates is more than just a structural transformation. This indicates state government policies that have enabled innovation trajectories that are not the same as those in irrigated-cereal cropping states. Investment in non-farm rural and urban industrial projects seems to have taken precedence over investment in agricultural research and extension of knowledge that was of little relevance to the range of predominant crops and cropping systems in these states.

Precious little has been analysed or even recorded of the history of these choices in agricultural and non-farm growth made by these state governments. What role did the state governments play in the face of exclusion of dryland agriculture research and weak extension, to create private and civil society investments and capacities? What were the institutional arrangements that shaped the proximate drivers of economic growth and structural transformation in these dryland states? Political values or norms, of creating and sustaining employment were among the key drivers of the policies in the history of these states. In the 1970s and 1980s both Maharashtra and Tamil Nadu conducted experiments with Employment Guarantee Scheme (EGS) and the subsidized food (rice) programme. Currently, India's flagship programme for rural employment generation the NREGA and the Food Security Act – both going beyond mere schematization, and enacted as legal commitments to development, have been copied from the experiences from these programmes in these very states which were ridiculed by planners who used conventional economic theory for development planning (interviews, May 2009). A detailed analysis of development choices at the regional or state level, in contrast to the dominant development investments made by the Central government, is necessary. Structural transformation choices and the spatial dimension (drylands) of this structural change, helps us understand what an enabling policy means for agricultural innovation. Though a pro-active state government is crucial for agriculture and for agricultural innovation, there is little mention of any of the crucial centre-state issues in agriculture in the Task Force report (Commission on Centre-State Relations, 2009).

To sum up, the three major components of the agricultural innovation system in India, reveal limited capacities for interaction and learning, and are governed by the norms or institutions of water and chemical based socio-technical systems. These institutions then determine why only certain technologies are researched and generated for outreach, why majority of Indian farmers without access to the proximate drivers of agricultural growth (irrigation and chemicals) do not find these technologies relevant, and why certain state governments consciously steered a path of non-farm and industrial investments for development. Lack of interaction with the agricultural research and extension organizations of the formal agricultural innovation systems characterizes the majority of the farming community and the state governments responsible for local agricultural research, extension and education. Structural transformation in India, seems to have occurred in the dryland states, as a conscious development strategy that enables farm and non-farm rural households to participate effectively in production systems in rural and peri-urban areas. In these states, the lack of interaction and exchange of learning experiences with the mainstream agricultural S&T establishment seems to have driven state governments to invest in alternatives - the mainstream S&T establishment focused on crop research (70 percent of research effort) and that too a few select crops and traits (only yield and a few select traits) have co-evolved with the conscious exclusion of the predominant crops and cropping systems of the dryland states.

[12] Currently, roughly a third to half the income of cultivator households in rural in Asia, Africa and South America comes from non-farm or peri-urban labour or services (Reardon and Vosti, 1999; World Bank, 2008). Interestingly, the share of farm income in total cultivator household income is 61.56 percent in Punjab, and 61.3 percent in Bihar, for very different reasons (NSSO Reports, 497 and 522).

4. Understanding the co-evolution to enable inclusive development

Despite several attempts at reform, and the emergence of new models (including some successful private extension models), the basic provisioning patterns and linear model of the public agricultural extension system have not changed during the last 20 years. Overall, it is acknowledged that the R&D and extension systems need new investments, actors, linkages and capacities to be able to respond to the changing technology demands of farmers and the challenging socio-economic contexts of farming (Government of India, 2005; NKC, 2009; IAASTD, 2009). The analysis above illumines the 'unreformable' agricultural research system (Government of India, 2008; Vol. 3; p. 13). Agricultural innovation, which takes place when there is a convergence of relevant stakeholders, technological and institutional changes, and continuous policy learning, seems to be confined to the irrigated cereal mono-cropping tracts in India. That this excludes many other forms, locations and processes of agriculture from participating and gaining as part of the innovation system is not an aberration that can be corrected by recommending changes in agricultural research and/or extension. Institutional reform of the agricultural research system alone (whether it is banal addition of new funding, new research priorities and evaluation methods or new research organizations or even new ways of working within R&D) will not work unless accompanied by fundamental institutional reform of several other actors in the innovation system.

The analysis shows how the norms or institutions that govern the generation of irrigation-chemical fertilizer based technologies arise not within the S&T establishment but in the political and economic arena. The focus on irrigation and bio-chemical technologies and the exclusion of the drylands are not the brainchild of a vain isolated research system that refuses to be reformed, but the creation of a wider convergence of mainstream state policies, research, extension, input supply mechanisms, price support systems, etc. It is imperative for policy makers and planners to acknowledge the role of institutions and to relate to the ways in which an institutional commensurability has to be sought among the various actors in the agricultural innovation system, if inclusive development offering employment/livelihoods and incomes to the rural poor is to be realized.

This paper highlights the institutional incommensurability between the major actors in the agricultural innovation system that generates and maintains the exclusion of the drylands and its farmers. Is the exclusion of millions of rural poor in the agricultural sector created by the conventional development theories and the design of linear modes and instruments of knowledge generation and transfer? In conventional macro-economic theory and the tools of analysis therein, there exists little scope to "include" the creativity, learning and innovation capacity of an economy. What is theorized is therefore, either (i) an exogenous and invariably linear explanation of technology entering and transforming the production processes and the economy, or (ii) an endogenous equilibriation of demand and supply of a particular commodity or input, leading to the search for, generation of and deployment of new technologies. [13] Thereby, either technologies for irrigation and chemical intensive production processes are generated by the research system (international and domestic) and transferred to farmers by public sector research and extension organizations, or technologies or knowledge about particular commodities, say a new pesticide or a new cattle feed formulation is generated in response to the market drivers of demand and supply for specific commodities (say, cotton or beef). In both the formulations and variants therefrom, there is a denial of the centrality of institutions in shaping innovation systems. Thereby, the central thesis of innovation, that processes or incentives for interaction and learning among actors is key to successful innovation systems (Soete et al, 2009; Lundvall, 2004; 2010), is lost. Most critically, the capacity of the innovation systems framework to explore and explain the dynamic processes of evolution and change that accompany

[13] We must recall that the terms exogenous and endogenous carry different meanings (epistemic content and significance) within the theories of economic growth, knowledge systems, history of science, and innovation systems literature. An over-simplified ahistorical economic explanation of knowledge and creativity is not enough to capture the institutions that work to shape both agricultural S&T and its impact on the economy.

technological change, as well as question the normative elements hidden in conventional economic analysis remains unutilized.

Globally, the paradigm shift from economic growth to inclusive development occurs in the context of resurgence and rapid economic growth in China, India, Brazil and South Africa where exclusion is manifest in different forms and appears to have co-evolved with the ways in which these economies have used innovation for development. Governments have in the past enabled the institutional arrangement that generate pro-poor growth, provide public goods and ensure social protection for the weakest (Cook, 2006). But this role of the state to harness innovation and the on-going processes of structural and demographic transformation is lost on governments committed to the 'growth first' paradigm. Because the forms and magnitudes of exclusion of people, regions and sectors from innovation and development gains there from, are embedded in the institutional arrangements that lead to high growth confined to select segments of the society and sectors of the economy, it is difficult for the state to generate the range and scale of institutional reform necessary.

To ensure inclusive development, there is no other option but to experiment with institutional changes. Going by past experiences these institutional reforms must begin at the state level in order to cater to the local range of predominant crops, marginal and small farmers, local and regional markets for agricultural commodities, rural and urban employment and investment opportunities, and policy learning capacities. It is evident that silver bullet solutions of more research funding or new extension methods are not enough to enable innovation for inclusive development. Iterative institutional reforms are necessary; within and among several actors in the system. Contrary to past linear technology generation and transfer modes, an effort to enable agricultural innovation, involving coalitions of actors, will also demand capacities to assess existing institutional arrangements and experiment with ones that shape the innovation performance of each of these actors. There is a dire need for further analysis to understand and explain the ways in which institutions shape innovation performance in historically and socially specific innovation systems in different spatial contexts; this paper is a minor beginning.

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