India's agricultural research and education system – the time for change

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Agriculture is one sector of the economy where the returns from investments in science are easily recounted. India's transformation from a country which was a net importer of foodgrains in the early sixties, to one which became an occasional exporter in the eighties is attributed directly, among other factors, to investments in building a large infrastructure by way of agricultural research and educational institutions under the Indian Council of Agricultural Research and under the State-owned Agricultural Universities starting in the early sixties. While India's agricultural research and education system can rightly be credited with ushering in the green revolution of the seventies and eighties, the writing on the wall now is also clear and loud – unless the system now transforms itself in ways which will enable it to face the emerging challenges, the woes of Indian agriculture, already showing up in the form of repeated imports of commodities like wheat and pulses, are bound to increase.

The context of Indian agriculture and its goals is changing and so are the challenges before the research and education system. In the fifties and sixties, the years immediately after independence, the main forcing paradigm for agricultural development was the need and urgency of achieving self-sufficiency in the production of foodgrains in the shortest possible time, to obviate the need of imports in years of calamities and in the context of the growing population. To achieve these development objectives the key strategy adopted by the emerging network of research institutions was to initially focus on the spread of area under high-yielding varieties of selected crops like rice, wheat and maize, and to enhance crop productivity through improved management and use of inputs, including spread of irrigation, fertilizers, crop-protection measures, etc. in the relatively well-endowed regions – regions where irrigation facilities were available or could be created easily. Over the successive five-year plans, the research and education system has expanded to widen the research focus to include an array of field and horticultural crops, livestock species and fisheries. The concept of State Agricultural Universities has also been evolving to emphasize greater focus on livestock health and production, horticultural crops, etc.

Past achievements and expanded research and education infrastructure not withstanding, there are clear and increasing evidences that Indian agriculture is tending to stagnate, productivity growth has slowed and this is a cause of serious worry for the country's planners. The average annual growth of the Indian economy in the 10th Plan period (2002–03 to 2006–07) estimated at 7%, is poised to further pick up in the coming years.

As against this, the annual growth rate from agricultural GDP is unlikely to exceed 1.5%. Even conservative estimates of domestic demand show that growth in annual demand in respect of most agricultural commodities is now outstripping growth in domestic supply, necessitating recurrent dependence on import of foodgrains, pulses, etc. to meet the basic food needs of the still growing population. There appears a general consensus that if India is to move into and sustain double-digit overall economic growth in the coming years, agriculture must aim to grow at a higher trajectory of 4% annual growth. This is then the challenge. The question before us is, how do we go about meeting this challenge?

One thing which should be clear at the outset is that the strategies we adopted to enhance agricultural productivity in the past are no longer working. It should also be clear that the nature and dimensions of the challenges we now face are different from what we faced in the sixties and seventies, and for this reason past strategies are unlikely to work – what we now need are strategies and approaches which take into account the nature and dimensions of the new challenges. The emergence of a new set of challenges can be attributed to a number of factors which obviously include our past agricultural development strategies, current growth patterns and needs, increasing globalization, and new scientific and technological developments worldwide, etc. In the past, our research strategies were largely focused on enhancing productivity for crops in relatively well-endowed irrigated areas. This must change. Productivity growth emphasis must now focus on a greater variety of crops, farming situations and regions as also on other sectors, including livestock, fisheries, horticultural crops and agroforestry to address issues of equity and livelihood. By far the most serious challenge before Indian agriculture is to define and pursue strategies that contribute to the reversal of processes which have caused widespread degradation of natural resources – land, water, biodiversity, following past development strategies. Maintaining and enhancing the quality of resource base is fundamental to improving and sustaining productivity. In the intensively cultivated high-productivity northwest region comprising the states of Punjab, Haryana and western Uttar Pradesh, declining water resource has emerged as the key issue affecting sustainability of agriculture in the region. Declining soil quality and pollution of surface and groundwater resources causing widespread human and livestock health problems due to inappropriate agricultural practices call for a paradigm shift in the ways that agricultural interventions are generated and promoted. In vast areas under rainfed agriculture, issues of resources conservation are a prerequisite to achieving enhanced productivity. Continuing degradation through soil erosion and high run-off rates is adversely impacting resource productivity and in turn the livelihood opportunities of people who depend on these. Issues of biodiversity loss (plant and animal genetic diversity), which form the very basis of sustainable agriculture, have not even been flagged as part of any strategy to address sustainability issues in agriculture. This only spells the seriousness of the future of agriculture. The key challenge before us is to conceive and promote strategies that integrate the concerns of enhancing productivity and resource conservation and sustainable

use. These challenges call for new ways of planning, prioritizing and executing our science agenda. A shift to sustainability paradigm calls for a different way of approaching and solving the problems.

There are also other challenges before the scientific community. With increased productivity and production being the sole objective of agricultural research, the scientific community emerged as the 'givers' and farmers the 'recipients' of technologies developed through research. The technologies were supposed to have been well 'tested' and refined before these were offered for 'transfer' to farmers, so that farmers could adopt new practices with little risk. In this linear process of technology generation and transfer, farmers became mere 'recipients' of prescription – the process taking little account of farmers' perceptions, knowledge and experience of the environment in which they work, their capacity to innovate and their immediate needs. While this process was inevitable when increased inputs-use was the key to increased productivity in relatively uniform and well-endowed regions, our future efforts to enhance agriculture would demand a shift in mind-set, which recognizes the need to view farmers as partners rather than mere recipients of technology. Change in mindset always takes time, but this is the challenge. There are other aspects also in which the scientific community has to change. While advances in individual scientific disciplines will continue to drive future agricultural changes, solving problems facing the farmers often calls for teams of scientists from different disciplines and organizations to work together – and in this we are not good. The way we are organized in science often promotes individual efforts rather than team efforts aimed at finding solutions to the problems. This is a big challenge to live up to. India's agricultural research system must articulate a structured response to new developments taking place locally, nationally and globally.

At the grass roots, a large number of voluntary non-government organizations are working actively with local communities to improve their livelihoods. Similarly, many public-sector undertakings, including banks and private business houses are increasingly investing in activities aimed at helping farming community's access to technologies, advisories, etc. How does the system view these developments vis-a-vis its own agenda? Several private players are already making huge investments in research, particularly in meeting the demands for better quality seeds, planting materials, etc. In the light of intellectual property right implications, these developments call for the research system to redefine its priorities and strategies. There are other developments taking place nationally and internationally, which have serious implications on the ways that the national system must respond. We now have a separate department for biotechnology and one for earth sciences under the Ministry of Science and Technology. A department for land resource under the Ministry of Rural Development will have a major responsibility in evolving strategies for sustainable land use and management. With agriculture continuing to be a primary land user, a strong interaction would be required to evolve future land-use policies. So will be the case with the departments of environment, water resources, etc.

Consultative Group on International Agricultural Research is moving towards the emergence of a global agricultural research system, with the major aim of contributing global public goods. Regional groupings like APARI (Asia–Pacific Agricultural Research Institutions) are aiming to focus on regional issues. India, with a large national agricultural research system, will need to be increasingly proactive in not only defining its own role, but also in contributing to define the rules of the game in which it wishes to be a significant player. Global developments also call for responses at the global level. Being a part of the global family, India is signatory to several international treaties and conventions (e.g. biodiversity, desertification, climate change, etc.), which oblige us to take such steps and actions that will help us protect our resources, while enabling their sustainable use and management. Being a major land user, these developments have a direct relevance to India's agricultural research system. Crop and plant biodiversity has direct relevance to sustainability of agriculture and food security. Climate change and increased weather variability are already of serious concern in Indian agriculture. At the same time the way in which we develop and promote agricultural practices has a direct effect on greenhouse gas emissions, carbon sequestration, resource degradation, sustainable use of water resources, etc. – issues of global concern.

The nature and dimension of challenges facing the national agricultural research systems are indeed varied, complex and daunting. The system's ability to come to grips with these will largely depend on its ability to tap resources and opportunities, but most importantly in chartering a shared vision of 'change' and putting in place mechanisms to steer the system-wide change through stepwise elaboration of the road map which integrates the varied perspectives and concerns of emerging challenges.

Elements of change which will be critical in transforming our operations include understanding and building a systems-thinking and perspective at all levels: What constitutes the system? In what way is the system framework growing, laterally or vertically? Do we need to redefine the roles of the system components and what kind of linkages/complementarities need to be established and how? How does the system increasingly adopt systems-based approaches in conceiving, planning and implementing research for development agenda, moving from individual crop to farming system to landscape and ecological approaches. An important element of change will be to put in place mechanisms for research prioritization at local, regional and national levels. Balancing research efforts towards solving problems of immediate nature and those requiring a longer-term perspective will be essential. Yet another important element of change will be to adopt region-specific approaches which take into account both sustainable use of natural resource endowments and the prevalent socio-economic features in defining and prioritizing research agenda. Adopting integrated approaches, the key to solving increasingly complex system-based problems will call for working in partnership amongst a range of stakeholders. Evolving mechanisms to permit and facilitate new ways of working will constitute an important element of the change agenda. Thus far a major demand on the research system has focused on technology generation for increased crop productivity. While this will continue to be important, the system additionally will be increasingly called upon to address policy research to guide the development direction and in turn be influenced by the emerging development paradigm. It is apparent that the horizons of what we

wish to achieve and where we wish to reach are constantly expanding.

Increasing globalization led by rapid advances in information and communication technologies is resulting in an economy which depends on knowledge creation, dissemination and use to enhance growth and development. India's agricultural research and education system is the primary organ which coordinates and contributes to enlarging the knowledge base required to improve the efficiency and productivity of the agriculture sector whose growth will continue to be a significant factor for improving livelihoods of the vast majority of the poor and the country's overall growth, development and economy. The system's ability to effectively capitalize on its vast physical network for creating, disseminating and utilizing knowledge is what will enable us to be competitive in the emerging global scene.

Success requires that we act now. What we need is to put in place mechanisms which enable building a shared vision amongst key stakeholders, of ways in which the system must transform itself to cope with a multitude of challenges that we face. This will call for bringing on-board the best of expertise from a range of perspectives to collectively bear upon our understanding and to steer the change. System transformation will come about only through a step-wise progress, constantly analysing and seeking the best way forward. No doubt, the task is daunting, but a beginning must be made.

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Three waters – An evaluation of urban groundwater resource in Delhi

Vikram Soni

In the developing world, population pressures are such that cities have swollen beyond their carrying capacity. As uncontrolled urbanization is riding roughshod over their local natural resource, cities like Beijing and Shanghai in China, as well as Delhi and Chennai in India are now in permanent water crisis. Priceless local water resource is not being conserved in these cities.

For these megacities in the developing world, it is no longer a question of importing an essential resource like water, the water is just not there. In the more stable developed world where there is more wilderness, it may be used to water cities. New York, for example, gets its water from the Catskills forest, which is 150 km away. Delhi does not have such an option.

The sustainable carrying capacity of Delhi is about 8 million – less than half its present population! The study found that a third of the city's water was being imported from the Ganga and the Beas, and further import of water from these heavily agricultured river basins will lead to intense conflict. It was also found that the secondary (non potable) recycling of water was not a realistic option, as the cost per person will be close to half the annual per capita income. This makes it urgently necessary to examine the issue in-depth, especially the preservation of local water resource.

Delhi is defined by two natural features, the River Yamuna and the Ridge – a part of the Aravalli range of hills. Both of these are essential water resources – that is why all the ancient or medieval cities were located either on the Ridge or on the banks of Yamuna. The enduring value of such natural resources and local waterbodies is being lost for short-term gain. Water is a local resource and we must have local solutions for our water problems. Here, we illuminate and set values for three of Delhi's groundwater resources.

The Ridge

Our first water resource, the Ridge, Delhi's oldest natural heritage, is sculpted on quartzite deposits, which have cracks from 2 billion years of natural history. This recharges 80% of the rain falling on it[2]. All rainfed aquifers surrounding the ridge are an incredible resource for pure water and must be preserved by protecting their recharge zones. We have already asked the Prime Minister and the Delhi High Court to intervene, to stop the destruction of the Ridge and preserve it as a water sanctuary and a community groundwater reserve. Protection of the entire Ridge is crucial as studies indicate that the only aquifers in Delhi that have good water are those recharged by the Ridge.

Less than half of the Ridge area in Delhi is notified[3] as reserved forest (78 sq. km). We take a conservative 150 sq. km of ridge area[4] with a yet more conservative recharge potential of 60% (not 80% according to the Central Ground Water Authority report[2]) of rainfall. Delhi's average annual rainfall is 60 cm, which gives us an annual recharge potential of about 60 million cubic m. The importance of the Ridge also lies in the fact that it provides us with the purest quality of water. No other source can provide this, whether man-made or natural. At one-fifth the rate of 1 l mineral water bottles, Rs 2/l, this works out to Rs 11,000 crores a year.

The floodplains

Next we take up the largest and invisible water reserves of this ancient city, which lie in utter neglect and ruin. Most rivers in India have a variable flow which peaks during the monsoon, when the river runs its banks and widens considerably, depositing water and silt on the wide floodplains. The floodplains have a soil constitution of silt and sand that is highly porous – it is this soil type that defines the boundary of the flood plains. If we do a small experiment and fill sand into a pot and then fill it with water, the water occupies more than 60% of the volume. In other words, the floodplains are like a pro-