Rural Development and Hypothesis Testing[1]

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I am grateful to Prof. Gautam, Vice-chancellor of G.B. Pant University for the invitation to participate in this inaugural function. My interests as a scientist in BARC are in condensed matter physics and nuclear technology, quite removed from the theme of this Conference. Incidentally Prof. P.C. Mahalanobis, Prof. M.N. Saha and Prof. S.N. Bose were his contemporaries and together they formed a famous trinity - also started as a physicist and moved to statistics. Of course, we use statistics extensively in our physics research; BARC has interest in nuclear agriculture and has produced a large variety of radiation mutant varieties of agricultural seeds. And, in my present position as Principal Scientific Adviser to Government of India, I have also interest in rural development related technologies - both in the farm and in the non-farm sectors.

It is a great pleasure to come again to the G.B. Pant University of Agriculture and Technology which was the first agricultural university to be established in India and has since then emerged as a modern centre of higher education and research in the field of agriculture and allied sciences. The last time I came here was for the DAE Solid State Physics Symposium in 1986. Beginning in 1960 with only 2 faculties, this University, I understand, today has 9 faculties, 9 research centres, 2 out-campuses and a number of KVKs and KGKs. A Faculty of Horticulture has also been established. The research programmes at the University are focused *inter alia* towards attainment of nutritional security, improvement of agricultural productivity, management of biotic and abiotic stresses on crops and conservation of natural agricultural resources.

1. Introduction

All of us want India to become a developed country in the fullest sense of the term in the shortest possible time. And each one of us has perhaps a different definition of a 'developed country'. My definition is : "when the quality of life

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[1] Inaugural Address at the 57th Annual Conference of the Indian Society of Agricultural Statistics held at GB Pant University of Agriculture & Technology, Pantnagar on February 05, 2004.

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in our rural areas becomes comparable to that in the non-urban areas of already developed countries!"

India has recognised ever since independence that its national development will be driven by science and technology and the large governmental effort in this direction has been wide-ranging. And there are achievements to show - indigenous nuclear power plants, our own satellites and missiles, the green revolution of the sixties (in which G.B. Pant University played an important role), etc. but much more remains to be done.

What are the reasons for developing technology? I think they are the following

(i) creating national wealth

(ii) improving the quality of life of the people, particularly those living in rural areas and

(iii) enhancing national security

National security and national development are two sides of the same coin. Furthermore, national security is not just military security but, in a broader definition, includes food & nutritional security. Providing the latter and developing the technologies for doing so are related to national development, particularly rural development. Choosing the right technologies to put the nation on the path of rapid development requires technology foresight.

Technology Foresight involves determination of possible futures, taking into account existing as well as emerging technologies, and of strategies likely to yield the maximum economic, social and security benefits. Technology foresight analysis helps in the selection of critical technologies for development at any point of time and this has to be based on a national perspective. India fortunately does not have to follow the trodden path of technology development; we can learn from the mistakes of others, and we can also leapfrog.

So what are the critical technologies for India today? India is a large country and its technology requirements also correspondingly span a wide range. It has to continue to develop strategic technologies - nuclear, space and defence-related. Technologies related to energy security, food and nutritional security, health and water security, environmental security, advanced manufacturing and processing, advanced materials, etc. are all important for us. We seem to have special talent for the so-called "knowledge-based" technologies (Information Technology and Biotechnology). I also place rural development-related technologies in the category of critical technologies for India.

I have spent my entire professional career in the Department of Atomic Energy. And Atomic Energy is not just nuclear electricity. It is also radiation mutants in agriculture and food preservation by radiation, and the benefits from these technologies are also reaching rural areas. Our nuclear power stations are

located in remote rural areas and the project authorities have always made efforts to help in the development of the neighbourhood. I would like to mention briefly about a very successful project the Department of Atomic Energy has taken up in cooperation with M.S. Swaminathan Research Foundation (MSSRF) in Chennai. When I visited MSSRF in 1998, I was impressed by the work being done there on coastal systems research, the methodology of which involved linking the livelihood security of coastal communities with the ecological security of coastal areas. We decided that the coastal systems research work could be extended to areas where nuclear power plants are located and a joint DAE-MSSRF project on "Nuclear and Bio-Technological Tools for Coastal Systems Research" was initiated in June 1998. DAE also established a Homi Bhabha Chair for Nuclear Science and Rural Societies at MSSRF. The eco-friendly Integrated Sustainable Farming System model in the 10-acre plot at the Indira Gandhi Centre for Atomic Research includes diverse activities related to agriculture, aquaculture and water use efficiency. This demo-plot at Kalpakkam has been used for assessing the suitability of short duration, drought-resistant radiation-mutant varieties of groundnut and pulses. Kudankulam is in a semi-arid region with poor rainfall and severe water scarcity. The 12.5 acre demo-plot at Kudankulam has yielded valuable information on the physical, chemical and biological status of the soil there and enabled testing of crops duration-wise for their adaptation to the existing conditions. The green belting demonstration over a 47 acre plot there, was based on the planting of neem, a superior export-quality tamarind called 'urigam province', etc. A 'genetic garden' has also been developed. The Village Knowledge Centre established in nearby Idinthakarai gives training to local semi-literate women to provide locale-specific demand-driven information, e.g. the conditions in the sea (wave heights) for the benefit of fishermen and information on market linkages like the market price of fish.

2. Rural Agriculture-related Technologies

Two-thirds of Indians live in villages and I do not see a significant demographic shift taking place in India in the foreseeable future. Even if one percent of the population shifts from rural to urban areas, that is ten million people! And at present most of the rural population is involved in agriculture, though there are also rural industries.

Indian agricultural scientists have done a marvelous job and ushered in the (first) green revolution in the country. Now we talk about what Prof. Swaminathan calls an "ever-green" revolution and about freedom from hunger for every Indian.

Apart from continuing the excellent plant-breeding work going on in the country, we should also not shy away from genetically modified crops, the food crops and cash crops-once they have been analysed and found safe. Attention has also been paid to the so-called "precision-farming" and resource-conserving

technologies which will hopefully reverse the trend of soil nutrient depletion caused by intense cropping in some rice-wheat areas.

Inputs from frontier areas of agricultural science and technology - will reach everywhere. But a million tons of additional wheat/rice is cheaper to produce and more valuable, when produced, in a poor part of the country than the same from a part of the country where productivity is already high and where increasing production would require costly inputs. We should turn the current low agricultural productivity in some parts of the country to our advantage!

3. RuTAG-an Evolving Concept

One of the areas of focus of my Office in New Delhi is related to the development and dissemination of technologies for rural development both in the farm and the non-farm sectors. Though there are many entities interested in doing this, the spread of rural technology has been diffused, uneven, and slow and its full potential for generating a rapid multiplier effect in rural economy has remained unrealized. The main constraint preventing advances in technologies for rural application from reaching most villages in India in full measure seems to be the lack of local technology action groups capable of helping in upgrading the assessment of the current technology status, varied technology needs of different occupation groups, i.e. farmers, rural artisans and the landless, to enable them to diversify their incomes and add value to their products & services. Rural Technology support is critical for realizing the vast potential of the rural farm and non-farm Sectors.

There are two possible approaches in this context

(i) Collect all information on successful dissemination of technology in rural areas. The NIRD (National Institute of Rural Development), Hyderabad, has prepared a directory of rural technologies (four volumes) and is now selecting 20-25 among them, which have been most successful in the field. (There are also directories prepared by the CAPART, the ICAR and the CSIR).

(ii) Find the technology needs in the field and identify technology solutions for the problems encountered.

The ideal thing is for the two approaches to converge.

I think that there is practically no technology needed for rural development that is not available among, or which cannot be developed by, Indian scientists or by Indian industry; the problem often is in transferring it or in downsizing it, if necessary. There is no rural industry, for which there is not a modern counterpart. If the experts from modern industry can be encouraged to help their rural counterparts, it can also help transform rural India. This is being done though TIFAC (Technology Information, Forecasting and Assessment Council

of the Department of Science & Technology) for the pottery/ ceramics sector and can be done for the other sectors as well.

Many NGOs (Non-Governmental Organizations), government agencies, district-level administration and initiatives from the industry have been successful in disseminating rural development technologies up to a point. The challenge is to establish synergy among all these efforts, which are often fragmented and needlessly duplicated, in order to nucleate new initiatives and to strengthen existing ones. RuTAGs (Rural Technology Action Groups), that could provide the mechanism and the support needed for this synergy, have, accordingly, been conceptualized; this has been done with the help of Scientific Consultants in the Office of the Principal Scientific Adviser to the Government of India, who are experts in various aspects of rural development.

The entities which are intended to be brought together by RuTAG are broadly

(i) A consortium of S&T Institutions working in the area.

(ii) A consortium of S&T NGOs and voluntary agencies active in the area.

(iii) A consortium of Public Sector Undertakings (PSUs) and Corporate Industrial houses in the private sector committed to rural development and having a presence in the area.

(iv) A consortium of State and Central Government Organizations already working for rural development in the area.

We can also bring in technology inputs from S&T institutions and corporate entities outside the area.

RuTAG is a synergizing and catalyzing mechanism, and not a major funding mechanism. It can, however, also provide help and advice in seeking funds from other agencies. RuTAG is conceived of as a mechanism to provide a higher level of S&T intervention and support, than hitherto achieved.

The Science and Society Division of the Department of Science and Technology (DST), Government of India and the Technology Information, Forecasting and Assessment Council (TIFAC) - a Society of the DST- can play pivotal role in the functioning of RuTAG.

In fact, we have launched the first RuTAG project in Uttaranchal a couple of months back following a brainstorming session in Dehradun in which Prof. Gautam played an important part.

3. Agricultural Statistics and Hypothesis Testing

The country is proud of its eminent statisticians - Prof. P.C. Mahalanobis, Prof. P.V. Sukhatme and others. They have played an important role in the farm sector - from crop survey and forecasting to experiment design (the Indian Agricultural Statistics Research Institute (IASRI) has made recently an

interesting diagnostic study of design and analysis of field experiments, particularly on the importance of validity of assumptions; in another study they have emphasized the importance of on-farm research in order to take into account the realistic farm environment).

Remote sensing and information technology are important new techniques. Development of econometric models, mathematical programming and computer simulation, use of artificial neural networks - perhaps also the use of genetic algorithms - for optimization are exciting areas of research.

Areas of application, where remote sensing and GIS may be effectively used, include land use statistics, soil survey mappings, natural resource management, watershed management, disaster management, forestry and crop forecasting. GIS/GPS, with data collected using hand-held computers, can also be used for micro level planning, particularly for implementing and monitoring of agricultural rural development programs. The amount of computing power and network bandwidth and speed available to scientists in India have grown rapidly in recent years and this is valuable in the use of statistical methodology in agriculture and related fields.

One of my areas of research interest is crystallography. And statistical methods have been used extensively to solve the so-called 'phase problem' in crystallography and to refine structural parameters using least-squares techniques. Sometimes we want to see if two structural determinations, say one by x-ray diffraction and the other by neutron diffraction, are consistent with one other and here the technique of hypothesis testing can be used. And I think this is a powerful technique for the farm sector.

I understand from Dr. Sharma, Director IASRI and his colleagues, whom I met last week in Delhi that hypothesis testing is an important component in agricultural experimentation to identify the superior treatment/genotypes for improvement, but that often its power is lost sight of in contemporary experiments. Much of applied experimental research in the farm sector is devoted to comparison of two or more variants since the object of research is to discover methods for improved production or performance. Such comparisons may also be involved in the analysis of data from sample surveys or farm records. There may be interest in knowing which of the three feeds tried in an experiment is most efficient in its effect on growth of pigs, or whether different breeds of sheep in an area surveyed differ in wool production or whether different grades of crossbred cows in a farm differ in relation of their milk production.

There are many other more general problems, which can perhaps be formulated in a way suitable for hypothesis testing, provided the input data are reliable, the model includes all the relevant parameters and the parameters have been refined fully within the limits posed by the extent and the accuracy of the available data. I see that hypothesis testing has been used in the U.S. to answer questions like whether contract farming benefits small-scale (in U.S.

perspective) farmers and even questions like whether lobbying by U.S. food firms contravenes U.S. farm policy!

Can a crop production pattern be suggested for India, for example, that does not create a surplus in one State and a deficit in another, while maintaining adequate national production, thus avoiding the need for costly storage and transport? Or a strategy to evacuate surpluses in fruits and vegetables which can cause price crashes, through sustainable value addition? Does 'contract farming' help the small farmers in Indian context? What are the farm technologies needed to be developed to achieve all this? Incidentally, it will also be nice to examine if a particular rural development-related technology developed for one region of India can be successful in another region.

If the profits of small-scale producers of agricultural products - primary or processed - are more sensitive to what are called 'transaction costs' than those of large-scale producers, how can instruments like 'cooperatives' help, as it has in the case of milk at Anand, thanks to the initiative of Dr. Kurien? If the rural food processing industry expands, how can we assure quality of the products and their marketing; would link-up with large food processing ventures, with brand equity, help? What are the strategies needed to catalyse demand for food products, ethnic for one region of India, in the rest of the country and the world?

From a study of relative levels of farm sector productivity for U.S. and European countries during the period 1973 to 1993, it was concluded (V. Eldon Ball *et al., Journal of Productivity Analysis,* **15**, 5-29, 2000) that "there is a highly significant inverse relation between the rate of productivity convergence and the initial level of productivity, consistent with the 'catch-up' hypothesis". What are the lessons in this study for India's sustainable rural development in the context of the current variability in farm productivity in various Indian States?

Since there are so many more people in the primary food sector in India - compared to, say, the United States of America, where three percent or less, I understand, feeds the entire population - one has also to consider where one should increase agricultural productivity for maximum social benefit in a national perspective. Increase in agricultural productivity through use of known science and technology in the poorest rural parts of the country can, in my opinion, take the people living there above the poverty line. Interestingly, if you are near the poverty line, your quality of life is a highly non-linear function of your income! An experiment through TIFAC, in eastern U.P. and Bihar by the late Dr. S.K. Sinha (former Director, IARI), clearly shows that this can be done at zero or negative cost through introduction of good agronomic practices and provision of quality seeds. Corresponding, in places where agricultural productivity is already high and further increase would require costly inputs - as I said before - should there be greater emphasis on value addition, rather than productivity increase.

Normally any technology is enlarged to benefit from economy of scale. On the other hand, what one loses in economy of scale by downsizing a technology for rural use, one can gain from the fact that the source of raw material in India - be it leather, milk, grain or anything else - is scattered and distributed. In this context, an international seminar was held during 7-9 October, 2003, in Bhubaneswar at the Regional Research Laboratory, a CSIR laboratory, on 'Downsizing Technology for Rural Development'. The deliberations in this seminar have given valuable insights into this field.

As India moves to the fast growth track, such problems are likely to become increasingly important. It would be nice if India's agricultural statisticians can help in providing a road map for the use of planners in the farm sector and the related non-farm sector in the context of these and other important issues.

Thank you.