



VISION 2020

Indian Council of Agricultural Research
New Delhi

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Foreword

The Indian agriculture in the last 3 decades has witnessed growth and development that has few parallels in the world. The country has emerged from an era of food deficits to that of self sufficiency, and we have become an exporter of some foodgrains as well. The foodgrains production rose from 50 million tonnes during 1950-51 to 203 million tonnes in 1998-99. In addition, an impressive progress has also been achieved in the production of oilseeds, fruits, vegetables, milk, poultry and fish. This all became possible due to the cutting-edge of the science and technologies-generated indigenously. The success of the Indian agriculture has received global appreciation. The Indian Council of Agricultural Research (ICAR), an apex organization for conducting and co-ordinating agricultural research, has been at the forefront to lead these agricultural revolutions in the country.

The ICAR, since its inception in 1929, has emerged as a vibrant organization, comprising 4 National Institutes, 45 Central Institutes, 30 National Research Centres, 10 Project Directorates, 4 Bureaux, 80 All-India Co-ordinated Research Projects, 261 Krishi Vigyan Kendras and 29 State Agricultural Universities (SAUs), serving the needs of the country. In addition, during the last few years, we have seen the emerging role of private sector, nongovernmental organizations and farmers' associations in the field of agricultural technology generation and dissemination.

The research and educational efforts, duly supported by the developmental efforts and the creation of the infrastructure, such as irrigation system, fertilizer and chemical industry, surface transport system, rural credit system, marketing and storage facilities, have ensured that India enters the next millennium as a food-secure nation.

Several issues have arisen lately about the sustainability of the agricultural production and household food and nutritional security. The ever-increasing population, declining and deteriorating trends in soil-health, water availability and its quality, environmental pollution, loss of biodiversity, barriers to flow of knowledge, implications of intellectual property rights in harnessing new science, imposition of non-tariff barriers, economic and environmental access to food, are some of the crucial issues that demand preparedness, and a rather proactive role from the research organization, ICAR.

It is against this backdrop that all the institutions under the ICAR have drawn up their perspective plans for 2020, and now the Council has attempted this Vision 2020 document, elucidating clearly its vision and strategic action plan to make the National Agricultural Research System more responsive and responsible to meet future goals successfully.

The ICAR Vision 2020 document dwells upon the system's strengths, weaknesses, opportunities and threats, while articulating a vision, along with a commensurate blueprint for action. The document enumerates paradigm shifts expected in the system, specially in the organization and management, and identifies several radical changes necessary for the system's efficiency. The research efforts in future would rely increasingly on the frontier sciences, biotechnology, information technology, geographic information system, environmental sciences, social sciences and agri-business management. The research approach will also have to be built around cropping/farming system's mode. Similarly, a major change would be warranted in the system of technology transfer. The technology generation will need partnerships with the advanced institutions in India and abroad. As the future technological developments will be knowledge-and-capital intensive, special efforts will have to be made to develop competent human resource through revamping of our agricultural education system.

I am pleased to see that this visionary document is intended to serve as a guide to shape future of our agricultural research, front-line extension and education system in the country, and to make it more efficient, relevant and globally competitive.

It is hoped that the **Vision 2020** would provide the necessary directions for agricultural research and education in the country to make India a developed nation through progress in agriculture. I congratulate Dr R.S. Paroda, Director-General, ICAR, and his senior colleagues, who have brought out this vision document for the benefit of all concerned with the agricultural and rural development of India, as we enter into the next millennium.

(NITISH KUMAR)
President

28 November 1999

Indian Council of Agricultural Research

Preface

A planning process, based on the unbiased introspection of the past performance and the clear vision of the future, is the key to the success of any vibrant organization. The agricultural revolution in India is one of the best cited examples of sound planning and effective implementation of our post-independence era. The process of the planning is a continuum, and must go on with an eye on the contemporary changes and those in the offing. The ICAR has not only effectively responded to the challenges in the past but has also successfully overcome them.

Despite having attained household food security and impressive gains in the production of other agricultural commodities, the challenges concerning alleviation of poverty, household nutrition security and the conservation of our natural resources are indeed daunting, and require immediate attention of all concerned. In addition, the process of globalization during the last few years has left us with no option to think seriously as to how we should reorient and bring in needed changes to meet the demands of the new world-order in an effective manner.

We need to do forward looking and to be proactive to have appropriate agricultural research agenda and policies in place to generate world-class, cutting-edge technologies for the benefit of our farmers and consumers, while maintaining global competitiveness. It is with this background that each ICAR institution has prepared its perspective plan. Adopting a bottom-up approach, formulation of this Vision 2020 document was initiated. The document is the outcome of the strenuous efforts, discussions, brainstormings and valuable suggestions of the eminent persons, drawn not only from the agricultural research stream but also from other disciplines, administrators, planners, representatives of non-governmental organizations and the private sector and the farmers. Their valuable inputs have helped in shaping this document in its present form, and hence are gratefully acknowledged.

My colleagues in the ICAR, particularly Dr K. L.Chadha, National Professor, Prof. R. B. Singh, Chairman, ASRB, Dr Mangala Rai, DDG (Crop Sciences), Dr J.C. Katyal, Director, NAARM, Dr D. N. Jha, Director, NCAP, Dr Mruthyunjaya, ADG(P), Dr A. K. Bawa, Sr Scientist, and Shri Krishan Kumar, former Director (P&I), deserve special appreciation for their valuable inputs in finalizing this Vision 2020 document. The efforts of the Directorate of Information and Publications of Agriculture in its speedy publication are also worth mentioning.

It is our expectation that this document will set pace for an accelerated growth of Indian agriculture, so as to accomplish successfully our cherished goal of making India a Developed Nation, through overall growth and development in agriculture, while entering into the next millennium.

(R.S. PARODA)

Director-General, ICAR, and Secretary
Department of Agricultural Research and Education

28 November 1999

1 Preamble

Many significant changes are taking place the world over in the economic, political and technological fields. And the science is challenging the boundaries of time, space, knowledge, and in fact, all that threatens possibilities for further human development. Frontier sciences and their applications are dominating research efforts in the fields of immediate relevance. The world, at present, has become highly interconnected and interdependent. Globalization has given a big boost to speed and volume of a two-way trade-traffic among various nations. Resource-and-platform sharing has become increasingly common now in transboundary transactions. Forces of competition are in full command and control trajectory of country's economic growth and its standing in the international market. It is important that India, to remain proactive as a major player in this global-setting, should have a new vision with a resurgent agriculture, which will remain the key sector of growth even in future.

The agricultural performance of the post independence era is one of the most striking success stories. *The President of India, Shri K.R. Narayanan, in his address to the nation on 15 August 1997, on the occasion of the 'Golden Jubilee of India's Independence', cited self-sufficiency in foodgrains production as one of the most outstanding achievements of the independent India.* The Indian Council of Agricultural Research (ICAR), an apex organization for the agricultural research, has been at the forefront to steer through this agricultural revolution. Our country has also a very strong agricultural research, education and extension education system, with the establishment of institutes, agricultural universities, Krishi Vigyan Kendras (KVKs) and Trainers' Training Centres (TTCs). Notwithstanding these remarkable achievements, future challenges are still enormous, daunting and complex.

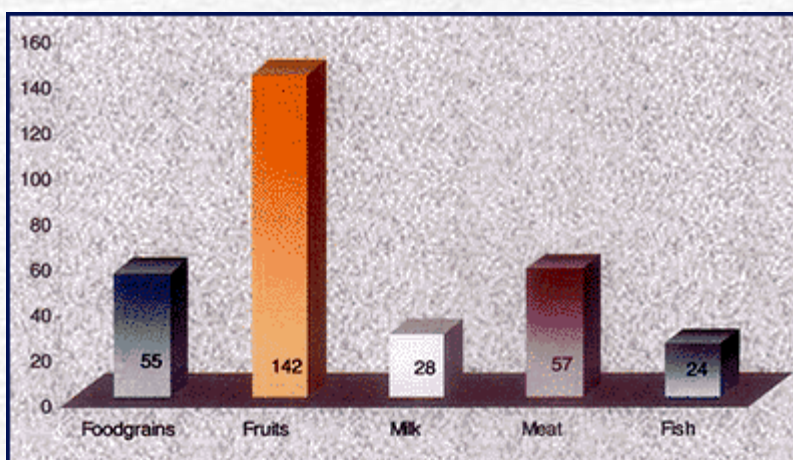
For India, it is critical to utilize the benefits of the new science and the technology for the socio-economic development of the farmers. The ICAR, with its large complement of highly qualified scientific and technical staff and institutional network, has the potential and ability to achieve this. It is believed, that prevailing environment in the country is also conducive to engineer this transformation. This belief has influenced enunciation of a *Vision 2020*. The vision has to be science-based, growth-oriented, multidimensional, people-centred, gender-conscious and committed to empower weaker and vulnerable sections of the Society. It must guide us to act in the ways that will leave for the future generations, as much as, if not more than, what we have inherited from the **mother earth**.

2 Agricultural Scenario

2.1 Global

Global agricultural production has outpaced unprecedented population growth over the past 25 years. Humankind owes this immensely to the foresight of the people, that ensured adequate food production, averting mass deprivation and hunger. While the world has won several important battles in the area of food security, the war is still on. Eight hundred million people, forming 15% of the world population, do not have access to food needed for healthy and productive living. One-third of the all pre-school children in the developing countries are food insecure, and deserve all care and attention. South Asia and Africa are the hot spots, because more than two-thirds to three-fourths of the world's malnourished are located there.

World population is expected to increase from around 6 billion now to around 8 billion by 2020. And more than 95% of the additional will be in the developing countries. The prospects of food security for them, therefore, remain bleak. In South Asia and Africa, two out of five children will remain malnourished, despite distinct improvement in per caput food availability. Thus, food and nutritional security will continue to remain major challenge for developing countries all over the world.



Required percentage increase in production of various commodities in south Asia, over 1994-96 averages, to meet demands for 2020

The demand for cereals, meat and meat products, and tubers is expected to rise in the developing countries by about 58, 18 and 56% by 2020. These countries are projected to double their net imports in cereals, and for the meat and meat products, a 20-fold increase in imports is expected. For poor developing countries, as compared to developed countries, the task of bridging the demand-supply gap would be a daunting one, despite much faster growth in production.

To meet domestic demand in South Asia, it is estimated that the required percentage increase in production by 2020 (over the 1994-96 average productions) will be of the order of 55% in foodgrains, 142% in fruits, 28% in milk, 57% in meat and 24% in fish. This calls for unprecedented growth rate in agricultural sector. And the challenges in non-food crops are equally daunting. The new trade regime rules out many of the past strategies for growth. To meet the challenges, the developing countries have now to make all-out efforts to bridge knowledge and technology gaps and rationalize economic and trade policies.

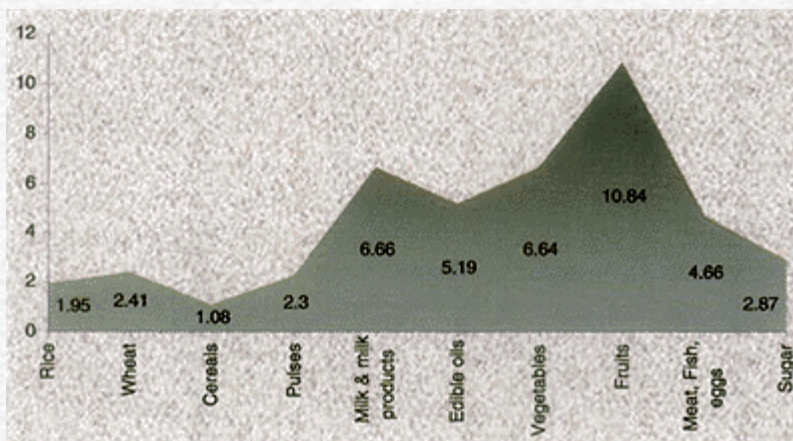
In most developing countries, area expansion is not possible, and in some, yields are beginning to plateau. Besides, growth opportunities are constrained by degradation and over-exploitation of natural resources, such as increasing biotic and abiotic pressures, decreasing biodiversity, soil erosion, land degradation, deforestation, decreasing availability of quality water and global climate changes; resulting in fall in total factor productivity. Moreover, declining commodity prices and priority to high-value, non-food crops may also dampen the incentives for food production. As a consequence, food security in many developing countries will be crucially dependent on the potential surpluses from developed countries. However, several developed countries have been reluctant to open their markets for imports of non-food tradables from developing countries, and are increasingly resorting to non-tariff barriers. Further, the biotechnological advances can potentially erode conventional exports, leading to skewed trade patterns. Thus, developing countries face a tough agenda.

2.2 Indian

The agricultural sector in India, like many developing countries, continues to occupy a pivotal position, and contributes to about one-third of the Gross Domestic Product. Nearly two-thirds of the work-force is employed in this sector. And the overall performance of the economy is largely dependent on this sector.

In the post-independence period, the technology back-up by the agricultural scientists coupled with the positive policy support, greater public funding for agricultural R&D and dedicated work of farmers have contributed to phenomenal increase in agricultural, animal and fish productions in India. The Green, Blue, White and Yellow revolutions bear testimony to the success of this strategy. And a Golden Revolution through significant production increases in horticultural crops is already on the horizon. These have resulted in distinct gains in actual household consumption.

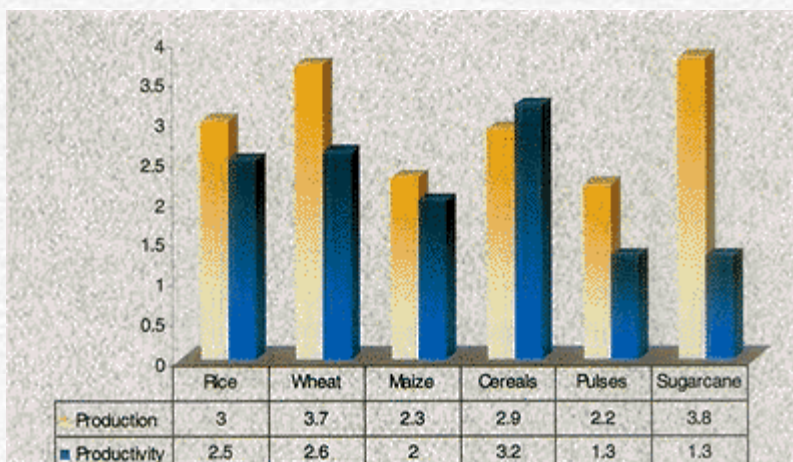
There has also been a qualitative improvement in the diet.



Growth rates (percentage per annum) in per caput consumption of the various food commodities between 1977 and 1993)

Compared to the population growth of about 2%, these accomplishments are remarkable. It is also appreciable that bulk of the gains have arisen from domestic production. Self-sufficiency in food production has thus been achieved, while prophecy of doom has been belied. Despite occasional droughts, famines have been averted. This production increases have largely been productivity driven. And agricultural R&D has contributed significantly to this.

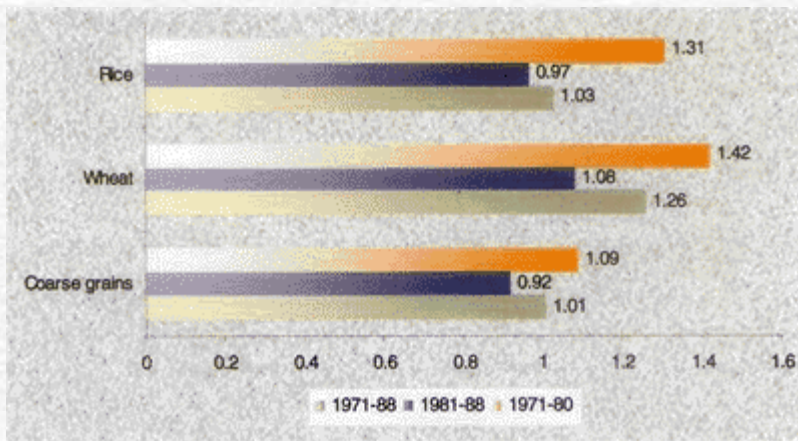
The total factor productivity (TFP) grew at more than 1% per annum over the last 25 years. For this, agricultural research has been responsible for the 33-50%. However, behind these impressive growth rates, lurk massive problems of poverty, hunger and malnutrition. More than a quarter of the world's poor and deprived live in India, and the country faces problem of hunger amidst overflowing food stocks. Economic and ecological access to food still eludes us. Also, there are indications of deceleration in TFP in recent years.



Growth in production and productivity in Indian agriculture Average annual compound growth (%) 1986-96.

Serious imbalances and externalities also underlie the existing scenario. Regional disparities in agricultural performance continue to be the cause for concern. Rainfed areas, including the eastern region, continue to lag behind. In some regions and commodities, a plateauing of yields is emerging. And degradation of land and water

resources, further threatens future prospects of food self-sufficiency.



Total Factor Productivity Growth (in percentage)

Some of these problems stem from the process of intensification itself. As the size of the holdings continues to shrink, the range of the income-enhancing options in agriculture narrows down. Besides, the public systems dealing with irrigation, credit, marketing and extension are finding it difficult to cope with the emerging demands. The changed economic environment, domestic and global, has altered many of the past paradigms and approaches. The National Agricultural Research System (NARS) is at the crossroads, and has to play a decisive role in tackling these problems.

3 National Agricultural Research System

3.1 Milestones

There was no formal and written agricultural research policy to guide evolution of the NARS. However, one can pick-up milestones from looking at the evolution of the agricultural research system, its investments, infrastructure, thrusts and its impact on the country's agricultural scenario. Some important milestones are as follows.

- 1889** • Imperial Bacteriological Laboratory, now Indian Veterinary Research Institute (IVRI), Pune
- 1905** • Imperial Agricultural Research Institute at Pusa in Bihar came into being

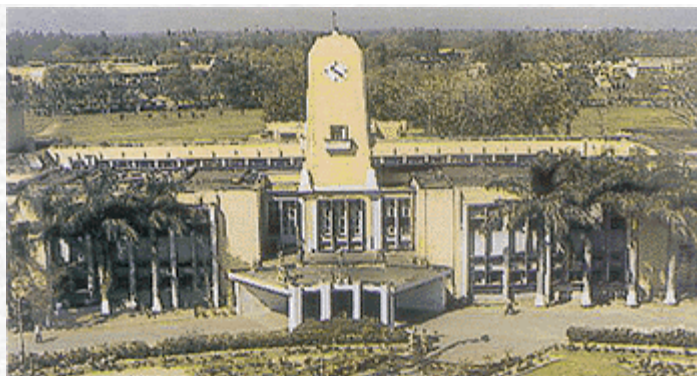


The Imperial Agriculture Research Institute at Pusa, Bihar



ICAR Headquarters, New Delhi

- 1929** • Imperial (now Indian) Council of Agricultural Research (ICAR) established
- 1957** • The concept of the All-India Co-ordinated Research Project (AICRP) introduced, and the first AICRP on maize started
- 1960** • The first State Agricultural University (SAU) at the Pantnagar established on the pattern of the Land Grant Colleges of the USA



The Govind Ballabh Pant University of Agriculture and Technology, Pantnagar

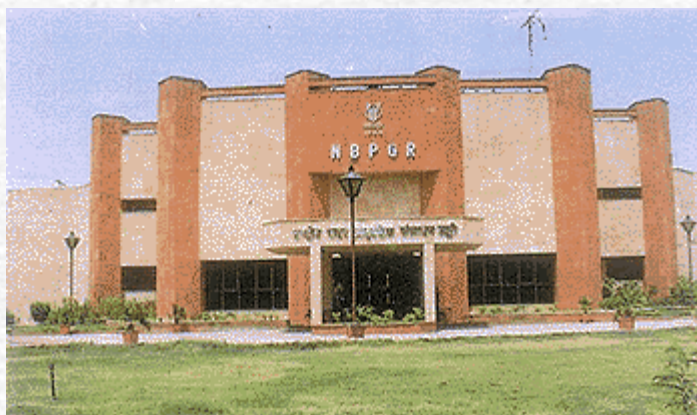
- 1964** • The ICAR became the apex organization for all the agricultural research and education in the country, with the functions of financing and guiding research and its co-ordination
- 1966** • Various agricultural research institutes under the Ministry of Agriculture, placed under the purview of the ICAR
- 1973** • Department of Agricultural Research and Education (DARE) created in the Ministry of Agriculture
 - Director-General, ICAR, given the status of Secretary, DARE, and Chairman of the Governing Body of the ICAR
- 1974** • Established first Krishi Vigyan Kendra (KVK) at Pondicherry



The first Krishi Vigyan Kendra at Pondicherry

- 1975** • An All-India Agricultural Research Service (ARS) established. Also, Agricultural Scientists' Recruitment Board (ASRB) established to recruit scientists for the ICAR institutions
- 1976** • Report of the National Commission on Agriculture published
 - National Seed Project (NSP) launched for production of breeder's seed, with financial assistance from the World Bank
 - Seven Trainers' Training Centres (TTCs) established
- 1979** • The Lab-to-Land Programme and the National Agricultural Research Project (NARP) launched

- 1984**
 - A separate Division of the Agricultural Extension, headed by the Deputy Director-General (DDG), created in the ICAR
- 1987**
 - Separate Divisions for Horticulture and Fisheries, headed by DDGs, carved out of the Crop Science and Animal Science Divisions, respectively
- 1988**
 - GVK Rao Committee, constituted to review infrastructure, personnel policies and functional role of the ICAR, submitted its report. Also the Agricultural Engineering Division, headed by a DDG, carved out from the Natural Resource Management Division
 - Created senior-level research management positions at the ICAR headquarters in the post-harvest management, home science, policy and perspective planning, Intellectual Property Rights (IPR) issues and Agricultural Research Information System
- 1995**
 - Institution-Village Linkage Programme (IVLP) launched for technology assessment, refinement and transfer with farmers' participation. Also launched an Agricultural Human Resource Development (AHRD) Project with financial assistance from the World Bank
- 1996**
 - National Gene Bank, with a holding capacity of more than 1 million seed-samples at - 20°C and 25,000 samples at -150°C to - 196°C in liquid-nitrogen, established for *ex-situ* conservation of agro-biodiversity



National Gene Bank at the NBPGR

- 1998**
 - Launched National Agricultural Technology Project (NATP), funded by the World Bank, to improve efficiency of the organization and management systems of the ICAR, to enhance the performance and effectiveness of the priority research programmes and also of the scientists; and to develop models that will improve effectiveness and financial sustainability of the technology dissemination system

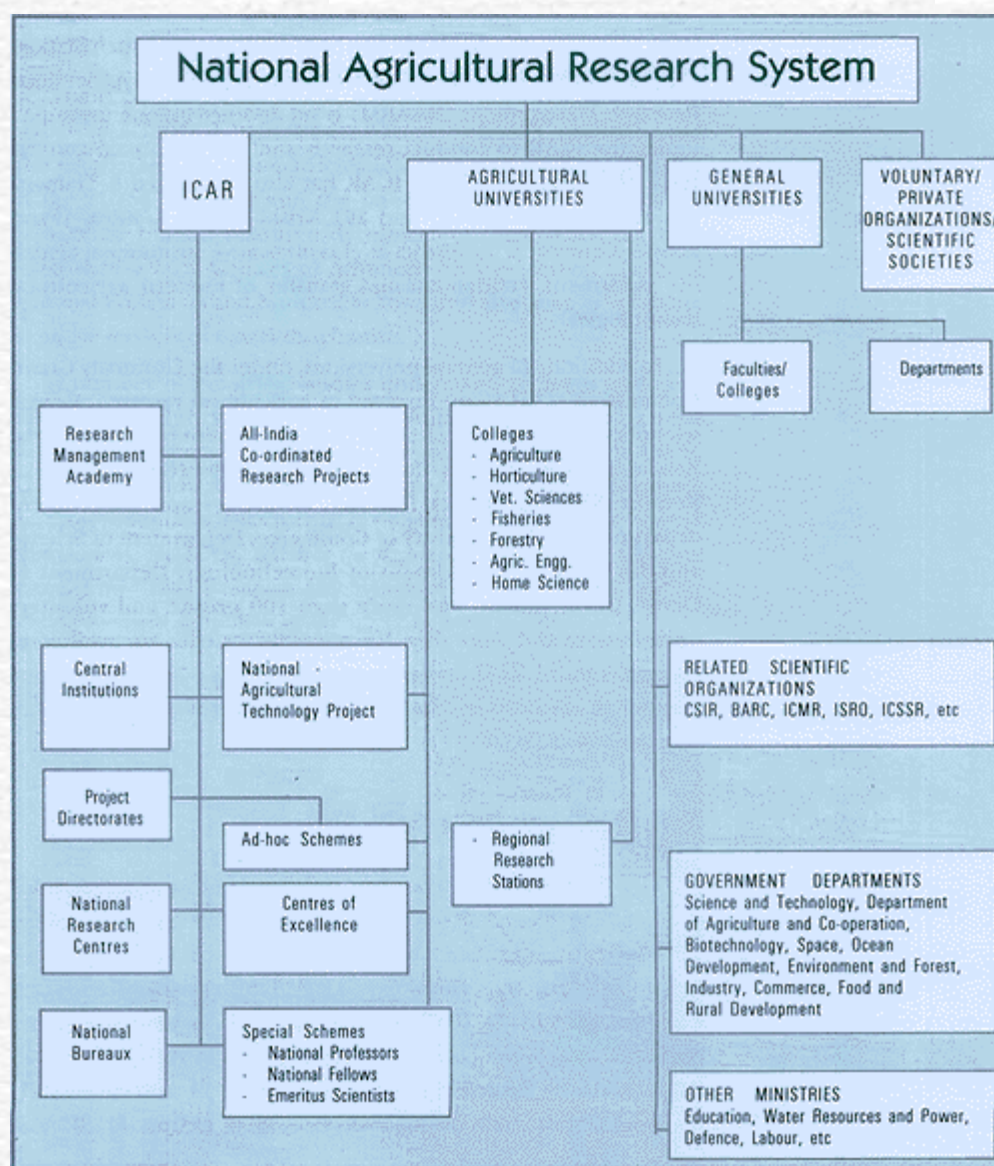
3.2 Institutional Growth

Since independence, the National Agricultural Research System (NARS) has grown considerably (Table 1). From a few central institutes, regional centres, commodity boards and agricultural colleges, addressing regional problems, the NARS at present, led by the ICAR, has 5 multidisciplinary national institutes (four of them are deemed-to-be universities), 45 central research institutes, 30 national research centres (NRCs), 4 bureaux, 10 project directorates, 80 all-India co-ordinated research projects (AICRPs)/networks and 16 other projects/programmes in the public sector. In addition, there are 29 state agricultural universities (SAUs) and one Central Agricultural University, which operate through 313 research stations. The AICRPs are the main link between the ICAR and the SAUs. The number of centres involved in the AICRPs is about 1,300, of which,

Table 1. Number of Institutions under the NARS in India

Institutions	1973-74	1974-78	1980-85	1985-90	1992-97
Indian Council of Agricultural Research					
Institutes	23	35	39	46	49
National Research Centres	-	2	11	20	30
Project Directorates	-	5	5	9	10
All-India Co-ordinated Research					
Projects/Network Projects	69	57	63	71	80
Central Agricultural University	-	-	-	-	1
Others	-	4	8	2	14
Total	92	103	126	148	184
Agricultural Universities					
	17	21	23	26	29

Source: ICAR Annual Reports



about 900 are based in the agricultural universities and 200 in the ICAR institutes. The ICAR has also built 120

Zonal Research Stations (ZRSs) and 200 substations. The National Academy of Agricultural Research Management (NAARM) is yet another unique institution under the ICAR to conduct research and training in agricultural research management. The ICAR has also established 8 Trainers' Training Centres (TTCs) and 261 Krishi Vigyan Kendras (Farm Science Centres) at the district level as innovative institutional models for assessment, refinement and transfer of modern agricultural technologies.

In addition, 23 general universities, under the University Grants Commission (UGC), are involved in agricultural research. Several scientific organizations such as the Council of Scientific and Industrial Research (CSIR), Bhabha Atomic Research Centre (BARC), National Remote Sensing Agency (NRSA), Ministries and government departments such as Ministry of Commerce, Department of Science and Technology, Department of Biotechnology, Department of Ocean Development, and more than 100 private and voluntary organizations and more than 105 scientific societies are involved in the agricultural R&D and form the part of the NARS. The total number of scientists in the Indians national agricultural research system exceeds 20,000.

3.3 Infrastructural Growth

The ICAR over the years has built a strong infrastructure for promotion of research in several frontier areas. This includes, national gene banks on plant, animal and fish resources, National Research Centre (NRC) on Biotechnology, on DNA Fingerprinting, Integrated Pest Management (NCIPM), Weed Control, Women in Agriculture, Agricultural Economics and Policy Research (NCAP); and Project Directorate on Biological Control (PDBC); Phytotron Facility; National Library; National Agricultural Science Centre (NASC) and Museum. Besides, the ICAR provides facilities to the ICRISAT, IRRI, CIMMYT, CIP, ISNAR and CABI and/or their regional centres.

The ICAR also offers junior/senior/post-doctorate fellowships, and overseas fellowships for students from the SAARC countries, and also scholarships for post-matriculation and undergraduate students of the SC/ST category and the national talent scholarships for promoting human resource development. The ICAR has also established several Centres of Advanced Studies, several Chairs of National Professors and National Fellows, and also has a programme to utilize services of emeritus scientists.

A number of empirical studies undertaken to assess costs and benefits of the agricultural research in India have indicated that the returns to investment in agricultural research range from 40 to 155%. These studies show that investment in agricultural research is among the most productive investments. *In recognition of the significant research contributions, the ICAR, which is the flagship of the Indian NARS, was awarded the "King Baudouin Development Prize International" for the best agricultural institution in the world in 1988.*



3.4 Addressing the Second Generation Problems

To keep pace with the emerging needs, the research priorities have been changing, from the export-oriented commercial commodities during the pre-independence period to food-security crops-oriented foodgrains production after independence. In the seventies, the ICAR started addressing the second generation problems relating to natural resource management and uneven regional disparities in agricultural growth and transfer of technology. In the eighties, to provide greater market orientation, thrust was given to diversification through development of horticulture, animal husbandry and fisheries. In the nineties, the issues of biodiversity, sustainability, profitability,

competitiveness, efficiency and organization and management reforms have been given major attention.

To sum up, following the building up of a wide infrastructural network during the late fifties and sixties, a period of massive expansion of research infrastructure took place during the seventies and eighties. This was expansion with a difference. There was establishment of hosts of institutions to cater to diverse needs. Along with the research infrastructure, emphasis was given to agricultural education, to provide needed human resource, by establishing state agricultural universities on the pattern of the Land Grant Colleges of the USA. Thus, the National Agricultural Research System grew in length and breadth. However, the basic problems of food and nutrition security, poverty, employment and equity have continued. Soft options to address these are getting exhausted. Some new issues have also emerged like sustainability of natural resources, increasing and sustaining exports through quality management and trade-related adjustments, following globalization and general agreement on tariffs and trade (GATT). The NARS also started facing system problems like unplanned growth, duplication/overlapping of mandate, loss of complementarity, inadequate financial support, imbalanced staff and mismatch between growth and requirement. This changing scenario mismatch between growth and requirement. This changing scenario raised fundamental questions relating to appropriateness of the structure and functioning of the NARS to meet its present and future needs. To address these changes effectively, need of a process of consolidation on the past achievements for future impact, streamlining and harmonization, for an effective reorientation, was felt, and this has already begun.

4 Resource for Agricultural Research

The ICAR is primarily funded through lump-sum grants from the Government. Other sources of funds include proceeds of levy on certain export commodities and external loans and grants. The international support, particularly, from the World Bank, has been important to create physical infrastructure, and development of human resource and of production systems' research in different agro-ecoregions.

There was an increase in funding (at the current price) for the agricultural research to the NARS from Rs.2,200 million during the IV five-year plan to Rs.48,100 million during the VIII five-year plan; forming 0.22% of the agricultural GDP in the IV plan and 0.46% in the VIII plan (Table 2).

Table 2. Expenditure on Agricultural Research and Share in the Agricultural GDP through Different Five-Year Plans at the Current Price

Plan (Period)	NARS expenditure (Rs. in million)	Share in the agricultural GDP (%)
IV Plan (1969-74)	2,200	0.22
V Plan (1974-78)	4,300	0.29
VI Plan (1980-85)	9,550	0.35
VII Plan (1985-90)	21,450	0.46
VIII Plan (1992-97)	48,100	0.46
IX Plan (1997-2002)*	67,520	0.80
*Budget Outlay		

Table 3. Activity-wise Share (in percentage) of the ICAR Plan Allocations

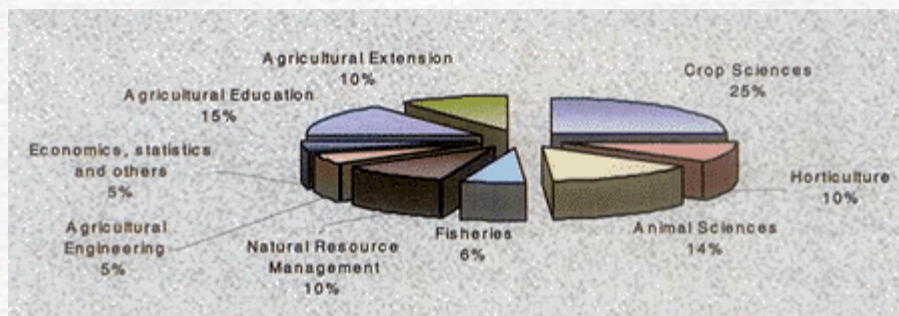
Plan (Period)	Research						Edn	Extn	Others
	Crops	Hort.	A.Sci.	Fish.	Others	Total			
IV Plan (1969-74)	21.9	8.1	16.6	3.8	13.0	63.4	34.6	1.9	0.1
V Plan (1974-78)	20.7	6.1	16.9	5.3	11.7	60.7	34.2	4.6	0.5
VI Plan (1980-85)	20.4	6.5	10.5	5.2	30.6	73.4	21.7	4.4	0.5
VII Plan (1985-90)	21.3	5.6	10.5	4.4	32.9	74.6	16.7	7.5	1.2
VIII Plan (1992-97)	24.8	7.7	10.8	5.0	24.9	73.2	11.9	12.6	2.3
IX Plan	25.0	10.0	14.0	6.0	20.0	75.0	15.0	10.0	**

* Between 1980 and 1997 (at constant prices); **Less than 0.5%

Note: For IX plan, the percentages are proposals. Others in research include natural resource management, agricultural engineering, economics and statistics.

Source: ICAR five-year plan and annual plan documents

An outlay of at least 1 % of the agricultural GDP is successively recommended for the agricultural research by the Standing Parliamentary Committee on Agriculture and other expert committees. A higher outlay is promised to be provided for the agricultural research during the IX plan. The Planning Commission has already allocated to the ICAR, Rs.33,760 million during the IX plan as against Rs.13,000 million during the VIII plan. Among the three major activities of the ICAR, the agricultural research claims nearly three-fourths of the ICAR's resources since IV plan (Table 3)



Proposed allocation of the ICAR during the IX plan

Agricultural education, which accounted for nearly one-third of the ICAR's allocation in the seventies, accounts for only 12% of the expenditure now. During the VIII plan, the growth in the extension and transfer of technology activities has been remarkable, which claimed nearly 13% of the allocation. To provide needed thrusts in the IX plan (1997-2002), the ICAR has planned to allocate 25% of the resources to field crops, 10% to horticultural crops, 14% to animal sciences, 6% to fisheries, 10% to natural resource management, 5% to agricultural engineering, and 5% to social sciences and publications and information and administration. The agricultural education will receive 15%, while the extension education will receive 10%.

5 Addressing the National Goal

5.1 The Goal

Sustainable growth of Indian agriculture by interfacing education, research and extension initiatives complimented with efficient and effective institutional, infrastructural and policy support, that will create a proper fit between the humanity and its habitat

5.2 The Mandate

Existing

- To plan, undertake, aid, promote and coordinate education, research and its application in agriculture, agroforestry, animal husbandry, fisheries, home science and allied sciences.
- To act as a clearing-house of research and general information relating to agriculture, animal husbandry, home science and allied sciences and fisheries through its publications and information system, and by instituting and promoting transfer-of-technology programmes.
- To provide, undertake and promote consultancy services in education, research, training and dissemination of information in agriculture, agroforestry, animal husbandry, fisheries, home science and allied sciences.
- To look into the problems relating to broader areas of rural development concerning agriculture, including post-harvest technology, by developing co-operative programmes with the Indian Council of Social Sciences Research, Council of Scientific and Industrial Research, Bhabha Atomic Research Centre and universities.
- To do other things considered necessary to attain objectives of the Society.

In view of the rapid changes taking place in the national agriculture and global agriculture, and to deal with them effectively, it is felt strongly that the **existing mandate** of the Council should **be revised**.

Proposed

- To plan, conduct, aid, promote and coordinate research, human-resource development and technology generation, assessment and refinement for holistic advancement of the agriculture and allied disciplines/activities.
- To act as a repository and provider of knowledge/ information
- To augment resources through consultancy/ contract research/ training on mandated subjects
- To develop linkages, interface and collaborative programmes with related national and international organizations/ agencies.
- To undertake any other activity considered necessary to attain overall objectives.

6 Performance Par Excellence

6.1 Genetic Resource Conservation

- More than 180,000 germplasm accessions of different agri-horticultural crops and their wild relatives collected/ augmented and conserved *ex situ* in the national base collection (-20°C). And nearly 2,500 accessions of about 50 recalcitrant, difficult or rare species, conserved in *in vitro* in tissue-culture bank (4° to -25°C) or in-cryo-bank (-196°C).
- Conservation programmes of Vechur, Kangyam, Ponganur, and Siri breeds of cattle and Toda breed of buffaloes, facing extinction, taken up.
- Conservation programmes taken up for fish-stocks and endangered coldwater fish mahseer and riverine fish *Tenuialosa ilisha*.



Variability in maize cobs,
collected from the north-eastern India



Variability in mangoes

6.2 Genetic Improvement

- Released a total of 2,300 high-yielding varieties (HWs) / hybrids of various field crops. We are the first in the world to develop hybrid cotton, pearl millet (grain), castor and pigeonpea and are second to develop hybrid rice. Also developed promising hybrids of sorghum and sunflower. Breakthrough in yields of rapeseed and mustard, through indigenously developed varieties, and of soybean, sunflower and oilpalm, through successful introduction and promotion as oilseed crops achieved.



Rice



Sorghum



Pearlmillet

Genetic Improvement



Castor



Pigeonpea



Cotton



Mango

- Released 460 high-yielding varieties/hybrids of horticultural and plantation crops; developed following: red coloured, dwarf, regular-bearing and seedless hybrids of mango, summer cropping acid-lime, gyno-dioecious varieties of papaya, leaf-spot resistant banana and high-yielding, good quality cultivars of grape, pomegranate, *aonla*, coconut, areacanut and cashewnut; F₁ hybrids and disease- and pest-resistant vegetables and high-value spices and tuber crops developed for industrial use; kinnow mandarin and Kiwi fruit introduced successfully in the northwestern plains and hills, respectively.
- Developed high-yielding crossbreds, Karan Swiss, Karan Fries and Frieswal, in cow. Three high-producing strains of sheep Avikalin, Avivastra, and Bharat Merino producing carpet, apparel and greasy wool, respectively, developed. Evolved a strain of Mohair goat by crossing exotic Angora with local Sangamneri. Developed four layer strains, with high level of egg production, ILI-80, ILR-90, ILM-90 and CARI GOLD.

6.3 Biotechnology

- Production of clonal variants in rapeseed, mustard; identification and use of alien cytoplasm for development of stable and commercially viable male sterility-fertility restoration system in rapeseed-mustard; and standardization of shoot-tip grafting technique in citrus.



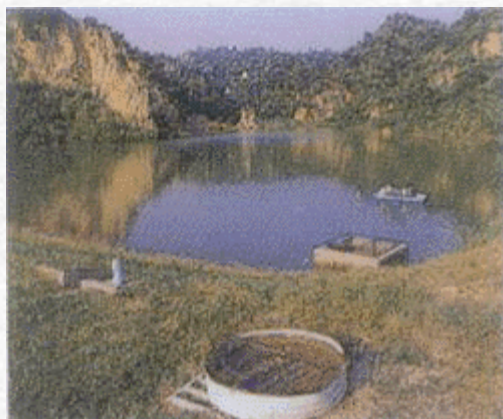
Emro transfer technology in cattle



Conservation of potato germplasm

- Genetic engineering to delay ripening and to prolong shelf-life of fruits, and also molecular testing and hardening of transgenics of tomato.
- Techniques for quick production of calves from superior bovine females, through superovulation, embryo collection and embryo transfer, utilized successfully.
- Development of molecular diagnostic kits and vaccines.

6.4 Natural Resource Management



Harvesting of rainwater transforms degraded rainfed hilly terrain into a highly productive land



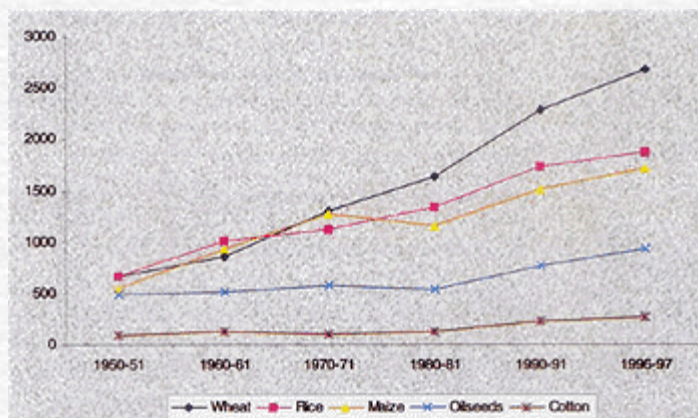
Sand-dunes stabilized through micro windbreaks

- Prepared soil maps of the country in 1:1 million scale and of several states in 1:250,000 scale, and also prepared model land resource atlas for 6 states. Based on the soil and bioclimatological characteristics, delineated country into 20 eco-regions and 60 sub-regions.
- Developed technologies for enhancing water-use efficiency, and evaluated performance of sprinkler, drip and other irrigation systems. Bio-engineering measures developed and applied to reduce runoff and soil losses in hilly and mountain areas. Developed model watersheds and methodology for artificial ground-water recharge for managing rainfed areas. And also developed ground-water models for predicting waterlogging and salinity hazards in irrigation commands, and sub-surface drainage technology for waterlogged saline soils.
- Techniques of sand-dunes stabilization and shelter-belt plantation developed for arresting movement of sand-dunes in the arid zone, besides developing technology for reclamation of alkali soils.
- Alternatives to shifting cultivation developed for the north-east region. And developed and evaluated agroforestry systems such as agri-silviculture, agri-silvi-horticulture, agri-horticulture and silvipasture systems for different agro-ecological regions.

6.5 Productivity Enhancement

- Between 1950 and 1997, significant increases in yields were noticed in wheat (4-fold), rice, maize and cotton (3-fold), sugarcane and sorghum (2-fold), and oilseeds (2-fold). Production of fruits and vegetables tripled during the last 50 years. Breeding for yield stability led to varieties resistant/tolerant to biotic/abiotic stresses in several field and horticultural crops. During the last 50 years significant increase in production in

meat (6-fold) and in fish (7-fold) was recorded from 1950-51 to 1997-98. Milk production increase was 2 folds from 1982-83 to 1997-98.



Productivity enhancement in wheat, rice, maize, oilseed and cotton

- Development of well-adapted, high-yielding varieties for risk-prone rainfed areas, namely, disease-resistant mungbean, early-maturing, drought-tolerant varieties of chickpea and pigeonpea resulted in enhanced productivity.
- Developed promising strains of N-fixing biofertilizers, *Rhizobium*, blue-green algae, *Azolla-Anabaena*, and other free-living organisms like *Azospirillum* and *Azotobacter*.
- Mutton synthetics (Avimanns), weighing more than 30 kg at 6 months intensive feeding, evolved. Broiler-rabbits, Soviet Chinchilla, White Giant, Grey Giant and New Zealand White, attaining 2-kg body weight at 12 weeks of age, developed. Achieved significant productivity increases in egg, poultry-meat and fish.

6.6 Efficiency Improvement

- Soil-test based recommendations for fertilizers formulated and soil fertility maps developed for component crops in different cropping systems, including conjunctive use of organics. Use of *Azotobacter* economized N requirement of potato-crop to the extent of 21%. Identified resource efficiency and remunerative cropping systems for different agro-farming systems.
- Water-use efficient micro-irrigation methods and technologies developed for utilization of available water for horticultural and plantation crops, resulting in 30-50% saving.
- Contingent crop plans and management strategies developed to deal with aberrant weather. Identified critical growth stages for water stress of various crops and cropping systems. Substantial water saving (20-50%) made possible through crop planning. Significant increase in cropping intensity and overall productivity per unit land area achieved through development of relay, parallel, multiple and multi-storey cropping systems and development of short-duration varieties.
- Several strategies utilized successfully for improving yields in horticultural crops such as application of growth retardants in mango, drip irrigation in banana, grape and coconut, and high-density planting in mango, banana, pineapple and kinnow-orange.
- Indigenous cattle breeds (Ongole, Hariana) improved for draught efficiency. Developed urea-molasses mineral blocks (UMMB) to improve digestion of straw. Steam treatment for bagasse developed to improve voluntary feed intake and digestibility. And evolved a number of cheap-and-economic rations for pigs and poultry. Non-conventional feed resources identified and successfully used for livestock feed formulations.
- A new fuel-efficient, 4-blade propeller with fuel saving to the tune of 20-25% designed. Also developed fuel-efficient fishing vessels.

6.7 Pest-Pathogen Management

- Developed region-specific integrated pest management modules for various pest-intensive crops and weeds, and also

developed biological control for *Phytophthora* in citrus, black pepper and cardamom.

- Developed surveillance, monitoring and forecasting programmes for several plant, animal and fish diseases.
- Developed precise, quick and reliable methods and technologies for diagnosis of diseases of various crops, livestock, poultry and fish.
- Developed immuno-biologicals against bacterial, viral and parasitic diseases, making India self-sufficient in preventive veterinary medicine.



Spodoptera liture prefers castor to tobacco. Caster is used as a trap crop near tobacco nursery



Water hyacinth (*Eichhornia crassipes*) can be contained with the release of adults of weevils *Neochetina eichhorniae*, *N.bruchi* and of mite *Orthogalumna terebrantis*

6.8 Post-harvest Management



Prawns



Fish products ready to eat

- High-yielding and high-quality basmati rice, *durum* and *dicoccum* wheat and confectionery-grade groundnut developed to strengthen and sustain exports. Technologies for diversified use of jute, cotton and lac and their byproducts developed. Technologies for harnessing solar energy developed for drying crops.
- Equipment developed for various post-harvest operations of field crops, vegetables and tuber crops. Cost-effective and fuel-efficient machines designed for continuous *khoa*- and *ghee*-making for industrial use.
- Post-harvest technology developed for perishable commodities. Varieties suitable for processing developed in tomato and potato. On-farm storage structures, including a zero-energy cool chamber, developed for fruits and vegetables crops. Precooling and cold storage temperatures standardized for several fruits and vegetables. Carbonated drinks developed from several minor fruits. For cultivation of oyster mushroom, coconut waste has been found a suitable substrate.
- Developed technologies for processing milk, meat, eggs and fibres into quality products.
- Production technologies developed for using spent hen-meat for nuggets, pickles, and quail eggs as pickles. Blended camel and rabbit hair with acrylic fibres for wool processing for blankets, carpets, shawls and knit-wears. Process for Angora rabbit hair blended with acrylic fibres in different proportions developed for yarns, used in shawls and knit-wears.
- Methods to improve quality of marine products for internal and export markets standardized. Technologies developed for extraction and production of chemicals and pharmaceutical products from plants and marine organisms, for absorbable surgical sutures from fish guts; and the technology of chitin/chitosan as haemostatic agent as well as growth promoter commercialized. Seaweed farming achieved, and industrial food chemicals like agar-agar, alginates, and carrageenan attained produced on commercial scale.

6.9 Seed and Planting Material

- Adequate breeders' seed production of different field and horticultural crops to meet national demand.
- Standardized rapid vegetative propagation techniques for several horticultural crops, hitherto propagated by seed. Protocols developed for multiplication of sugarcane, banana, pineapple, papaya, grape, cardamom, orchids and anthurium through micropropagation. Technology standardized for raising potato-crop through true potato seed (TPS), and technology perfected for production of microtubers.
- Techniques for superovulation and embryo transfer in cattle and buffaloes standardized. Techniques of IVM-IVF standardized in buffaloes.



Minitubers

6.10 Farm Machinery

- About 250 tools and implements adopted/developed indigenously for land development, tillage, sowing, interculture, plant protection, harvesting and threshing; 60% of these are commercialized and 25 of them manufactured on a large scale. Value-addition and agro-processing shellers, decorticators, cleaners, graders, dryers, storage and milling equipments developed and commercialized to minimize losses.



Farm Machinery

6.11 Human Resource Development

- Strong education infrastructure turns out nearly 9,000 B.Sc. graduates, 4,900 M.Sc.s and 1,500 Ph.D.s every year. Developed accreditation norms for agricultural institutions to improve quality of education. Large number of scholarships/fellowships created for promotion of excellence in agricultural education. Several awards instituted to promote excellence in teaching, research, extension-work and publications.
- National Professors, Visiting Scientists, Sabbatical, National Fellows and Centres of Excellence schemes launched to promote excellence in science.
- Agricultural human resource development project (AHRD) launched for improving standards of agricultural education and building capabilities. Created facilities for training of various functionaries of the NARS in frontier areas of science.
- Recruitment in the SAUs done on the basis of the National Eligibility Test, conducted by the ICAR, to overcome problems of inbreeding.
- Helping the SAARC, Middle East, African and other developing countries in providing training and skill upgradation.



Dr Borlaug addressing convocation at the IARI

6.12 Transfer of Technology

- Effective technology assessment, refinement and transfer done through 8 Trainers' Training Centres (TTCs), 261 Krishi Vigyan Kendras, and 42 Institution Village-Linkage Programme Centres.



Technology transfer to tribals

6.13 Informatics

- Computer software developed for creating, updating and for retrieval of data. Agricultural Research Information System (ARIS) has been set up.
- Strong infrastructure developed for publication of research journals, ICAR Newsletter, ICAR Reporter, Agricultural data book, handbooks, monographs, technical bulletins on agriculture, and for agri-business to provide latest information.
- Facilities developed for selective dissemination of information, for making CDs and video-films.



Shri A.B. Vajpayee, Prime Minister of India, releasing a book



ICAR Publications

6.14 Partnership and Linkage

- Developed effective partnership with 29 State Agricultural Universities through AICRPs and ad-hoc schemes.

Interface established with other science departments, development departments and scientific institutions for joint programmes in research and extension.

- Enhanced partnership with the non-governmental organizations in research and extension works.



SAARC Technical Committee meeting on Agricultural Perspective - 2015

- MOUs/workplans signed with 15 countries and 16 international organizations, and are in operation now.

6.15 Organization and Management

- "Perspective Plans" for 2020 developed by the institutes and universities in the NARS.
- Several new initiatives such as removal of dichotomy, reconstitution and revival of Standing Policy Planning Committee, reorganization of Publications and Information Division, establishment of the National Agricultural Science Centre (NASC) and National Agricultural Museum and introduction of project-based budgeting were taken up.
- Policy-planning including Intellectual Property Rights and gender issues addressed through special programmes and institutes. Formulation and implementation of rules and guidelines done for resource mobilization through consultancy, contract research, training and revolving fund schemes.
- Financial support enhanced to professional societies in agriculture and related sciences and linked with quality, to promote academic activities.
- Mechanisms for monitoring and review developed through constitution of Institute Management Committees, Staff Research Councils, Research Advisory Councils and Quinquennial Review Teams.

7 Strengths, Weaknesses, Opportunities and Threats Analysis

The National Agricultural Research System has come a long way in building a sound-and-strong institutional infrastructure, capable of addressing national problems. Even after 50 years of independence, India still has one of the lowest HD Index because of the problems of the poverty, illiteracy and poor quality of life. This raises question on the adequacy and effectiveness of the system to meet the present and future needs.

In this context, an examination of the strengths, weaknesses, opportunities and threats (SWOT) of the ICAR vis-a-vis of the general agriculture in the country assumes critical importance for planning of future agricultural strategy.

7.1 Strengths

National

- Indian agriculture has several strengths: Long history and tradition; rich and diverse natural resource-base; wide climatic diversity conducive for the production of a variety of crops, animals and fishes and a vast input-support system; large institutional network manned by qualified human resource; democratic and pluralistic society and a large and diverse domestic market. All these are elements conducive to future agricultural growth

ICAR

- Well organized, diverse, integrated, coordinated research and educational infrastructure
- Strong scientific human resource-base
- Proven track record of technologies with high pay-offs
- Vast network of training and technology dissemination system
- Strong partnership with other departments and NGOs
- Well-developed linkages with other national and international institutions/ organizations
- Ability to anticipate challenges and proven ability to meet them

7.2 Weaknesses

National

- Small and scattered land-holdings and their continued fragmentation; low and declining investment in agriculture; low input-use efficiency; inadequate credit support; weak agro-based industry; adverse terms of trade; inadequate marketing, storage, transportation, agricultural extension and IPR mechanisms. A long-term perspective plan is non-existent. The result is low productivity and yield plateauing in certain commodities

ICAR

- Low investment in research and regional imbalance in resource allocation
- Limited availability of trained human resource in frontier areas of science
- Inadequate involvement of other stakeholders
- Weak interdisciplinary linkages
- Lack of appropriate work-culture
- Lack of system orientation in research
- Inadequate monitoring, reviewing and evaluation system
- Inadequate emphasis on socio-economic policy and gender-related issues

- Poor environment for development of scientific leadership
- Inadequate personnel policies
- Rigid and non-attractive pay structure and lack of suitable mechanisms to attract and retain talent
- Non-formulation of own rules and regulations
- Absence of true autonomy, befitting a scientific establishment of the size and structure

7.3 Opportunities

National

- Vast potential for improving productivity of crops, livestock and fisheries; scope for bringing wastelands, lowlands and other problem soils under cultivation through application of modern technologies; tremendous scope for higher investment in farm mechanization, agro-based industries and rural development; and vast opportunities for export of agricultural commodities through diversification and trade

ICAR

- Exploitation of genetic resources using biotechnological tools
- Exploitation of hybrid vigour in conventional and non-conventional crops
- Introduction and exploitation of underutilized and new crop species
- Increasing cropping intensity and input-use efficiency
- Improving quality of produce
- Minimizing post-harvest losses
- Tapping traditional wisdom of farmers

7.4 Threats

National

- Alarming growth rate of population, it is estimated to reach 1.3 billion by 2020; adverse effects of higher unemployment, poverty and malnutrition on labour productivity; declining resource-base; increasing abiotic stresses; widening land-man ratio and soil degradation; diversion of agricultural land to non-agricultural uses, threatening production-base; inadequate agro-met advisory services for farmers; and rising cost of agricultural inputs, limiting our competitiveness in the global trade

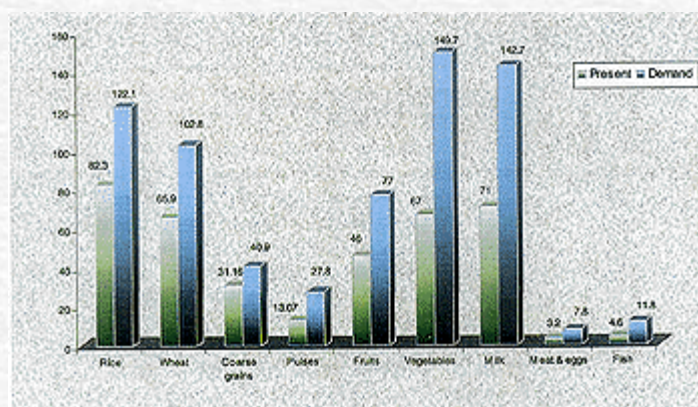
ICAR

- Limited operational resources and outdated equipment in several laboratories
- Lack of performance-oriented personnel and policies
- Insufficient response to implement already initiated O&M reforms
- Lack of synergies and complementarities
- Second generation problems of technology generation and transfer

8 Challenges Ahead

By 2020, India's population is likely to be around 1.3 billion, and the country's overall employment scenario is less likely to diminish significantly. Producing food to satisfy hunger and to provide employment for buying food, remain the key concerns of the agriculture. With opportunities for area expansion being almost exhausted, additional food output of 4-5 million tonnes per annum will have to come primarily through increased productivity. Immense pressure of man and animal support system on India's natural resources has reached a saturation point, when there is an imperative need to develop agricultural activities with a discerning eye on their environmental consequences.

In green revolution areas, intensive use of irrigation, fertilizers and other agricultural inputs for crop production is now seen as the major cause of problem of soil-salinization, ground-water pollution, nutrient imbalances, emergence of new pests and diseases and environmental degradation. In fragile and marginal environments, including rainfed areas, rising biotic pressure, lack of suitable soil-management systems and inputs to realize optimum potential of land appear to threaten sustainability of agriculture. The consequence is the degraded lands, loss of biodiversity, soil erosion, waterlogging, pollution of water resources, deforestation and overall environmental pollution and diminishing farming efficiency, resulting in falling productivity.



Present (1997-98) production of various food commodities and their demand by 2020

For efficient and sustainable agriculture, it will be essential to change-over from a commodity-centred approach to farming systems' approach. This will call for multi disciplinary efforts. Further the challenge is not only to offer solution to raise production but to offer the solution within a time-frame. This paradigm shift will call for designing new production systems aligned fully with carrying capacity of natural resources endemic to the region.

This will require emphasis on efficiency, sustainability, diversification, post-production management, small farm mechanization, marketing and trade. Such an approach will also require forging linkages with all concerned at the regional, national and international levels. To infuse these new approaches of working, present research set-up will require structural and procedural changes. The researchers will have to be empowered to plan and execute their programmes. Major changes will be required in the HRD programmes to train manpower in the frontier areas and to reorient education to develop entrepreneurship. Innovative approaches will have to be adopted to upgrade skills of farmers and for technological empowerment of women engaged in agriculture. Harnessing complementarities and synergies through strong linkages will be required within institutions/ agencies at the national and international levels in public, co-operative and private sectors.

Organizational, structural and procedural changes in the NARS are required to address above challenges. This would call for emphasis on prioritization, monitoring and evaluation, performance-oriented personnel policies, adequate financial support, modernization, use of informatics and functional empowerment to scientists. This demands for a flexible, responsive and autonomous research system. With World Trade Agreement, having brought global perspective to agriculture, it is imperative that research reorients its focus on food quality, consumer preferences, environmental concerns and intellectual property rights, besides others.

**The challenge for 2020 is
"Sustainable development of agriculture"**

9 Vision 2020

9.1 Vision

In India, the future obviously belongs to agriculture. By 2020, our dream is to make India a Developed Nation through agricultural growth. Agriculture is intended to become not merely an efficient, eco-friendly production system, capable of meeting basic demands of the rapidly increasing population, but it has to become a major powerful instrument for a comprehensive socio-economic transformation of the country, including improvement in the quality of the life of every individual. This is an exciting opportunity and a challenging responsibility. As demonstrated in the past, the ICAR has the potential, the ability and the will to make Indian agriculture the most resilient and dynamic, as we move into the next century. A vision is, like a Pole Star which helps navigate routes, even in the rough weather, to the destination successfully. Therefore, in view of the ICAR's commitment to propel Indian agriculture into the 21st century and make it both responsible and responsive to the overall needs of the country, its vision 2020 has been deciphered as follows.

"To harness science to ensure comprehensive and sustained physical, economic and ecological access to food and livelihood security to all Indians, through generation, assessment, refinement and adoption of appropriate technologies."

The objective of the vision is to provide a sense of purpose to our efforts, a sense of urgency for the action, and a common framework that will orient that action. Obviously, it has to be complemented with strategic planning and programming efforts, which eventually must address the issue of how to implement the vision through action.

9.2 Aims

Genetic Enhancement

- Inventonization, characterization and conservation of all agriculturally important bioresources
- Harnessing frontier sciences to achieve technological breakthroughs in crops and animals

Natural

- Promote eco-friendly and sustainable land-use

Resource Management

for varying agroclimatic regions

- Emphasize weather and crop forecasting, climate change and disaster management

Post-production Management

- Reduce post-production losses of perishables by 50%
- Emphasize value-added products
- Promote byproducts utilization
- Develop technologies to support export-oriented agriculture

Efficiency

- Modernization of agriculture to make it more efficient

Transfer of Technology

- Lay emphasis on technology assessment, refinement and transfer by improving interface with farmers
- Increase involvement of scientists in extension work

Enhance Institutional Capability for Single Window Delivery System

- Promote Institution-Village Linkage Programme

Human Resource Development

- Revisit land grant system in the State Agricultural Universities and the ICAR Institutes to improve their efficiency in developing trained human resource
- Strengthening existing infrastructure and human resource to be globally competitive
- Orient agricultural education to encourage entrepreneurship
- Establishment of agricultural education media centres for providing instructional modules for distance education and separate educational TV channel
- Expand and strengthen linkages on long-term partnerships with leading institutions in India and abroad
- Build partnerships with countries in tropics and semi-arid tropics and develop trained human resource to meet their requirements
- Provide opportunities for advanced training to at least one out of five scientists per year in frontier areas of science

Donor Relations and Resources

- Attaining an R&D investment level of 1 % in the short run and 2-3% in the long run

Partnership

- Increased public-private sector linkages
- More mission-mode collaborative programmes with national and international centres and laboratories and general universities, that are reported for their basic and fundamental works

Informatics

- Develop a comprehensive database for sound agricultural research and development planning
- Ensure functional electronic networking of all the stakeholders under the NARS and with other national and international centres of excellence through Agricultural Research Information System

Governance

- Incentives and in-built reward system for performers to achieve excellence in science
- Strengthening planning, priority-setting, monitoring and evaluation mechanism in the NARS
- Provide adequate research contingency support to scientists and institutionalize project-based budgeting
- Generate gradually around 25% of the resources internally.
- Provide research environment for better returns from investment

10 The Strategy and the Road Ahead

10.1 The Strategy

A shift from the supply-driven to demand-driven paradigm implies among other things, a change in focus from increased production to increased efficiency in production. Equity, sustainability, nutrition, employment and trade are the new areas of concern for agricultural research, even as efforts to maintain food security continue. These areas make R&D management more complex.

The key elements for the Strategy to address complex challenges in the next millennium are as follows:

- | | |
|--------------------------------|---|
| Research Relevance | <ul style="list-style-type: none"> • Research planning and prioritization as a bottom-up initiative • Promote participatory approach for conducting research |
| Infrastructure | <ul style="list-style-type: none"> • Develop efficient infrastructure for agricultural research, education and extension education |
| Diversified Agriculture | <ul style="list-style-type: none"> • Diversify agriculture with focus on horticulture, livestock, fisheries and agroforestry • Special attention to post-production technology, value-addition, agri-business management and trade |
| Efficiency | <ul style="list-style-type: none"> • Develop a research system with resources that provide sufficient social benefits per unit of research inputs and add value for investment • Achieve small farm mechanization and precision farming • Ensure technological empowerment of women in agriculture |
| Equity | <ul style="list-style-type: none"> • Bring in decentralization of agricultural research management • Removal of regional imbalance for institutional infrastructure and human resources |
| Environmental | <ul style="list-style-type: none"> • System-based interdisciplinary research thrust |
| Sustainability | <ul style="list-style-type: none"> • Concern for conservation and effective use of life-support systems, e.g. soil, water, flora, fauna and the atmosphere • Organic recycling, and waste and byproduct utilization • Addressing global climate change |
| Enlightened Human | <ul style="list-style-type: none"> • Knowledge-based society |
| Resource | <ul style="list-style-type: none"> • Training in frontier sciences, technologies and agricultural research management • Enhancement in vocational skills • Thrust on manpower planning |
| Partnership | <ul style="list-style-type: none"> • Complimentarity in research efforts among institutions and agencies at the national and international levels |

- Public-private sector linkages
- Effective role of stakeholders (Farmers' Associations, NGOs, Public and private sectors etc.)
- O&M reforms
- Socio-economic and policy research

Governance and

Policy setting

10.2 The Road Ahead

The strategic road map for future must aim at the directional path and at the required O&M back-up to realize the vision and achieve the goals set for 2020. The ICAR's future road map dilates on the triad of harnessing science, engineering NARS and growth-oriented responsive governance.



11 Harnessing Science

While harnessing science to achieve food and nutritional security, alleviation of poverty and unemployment, natural resource management, globalization, the following issues have to be addressed

11.1 Biodiversity

Limited scope for horizontal expansion and need for increased crop intensity and productivity dictate sustainability of agricultural production through judicious exploitation of available agrobiodiversity. Hence germplasm collection, conservation, optimum utilization, and germplasm enhancement have to receive greater attention. Globalization and commercialization of economy may hasten process of monocropping and spread of improved varieties of a few major food and cash crops and animal species, resulting in the replacement of the traditional indigenous germplasm. This may lead to faster erosion of biodiversity and loss of traditional knowledge. Therefore, a national action plan in a mission-mode approach is required to collect, evaluate, characterize, conserve and utilize plant, insect, animal, fish and micro-organism genetic resources of indigenous and exotic origins. The efforts would also help in conservation of biodiversity, bioprospecting of wild species and valuable germplasm for bio-modules, and genes for commercialization. DNA fingerprinting is needed to establish ownership of indigenous materials, and IPR issues will have to receive priority.

11.2 Biotechnology

Application of biotechnology to evolve new genetically engineered strains of plants, animals, fishes and plants of high nutritional quality, resistant to pests and diseases, and healthy, attained to environment-friendly farm practices, will have to be evolved. While doing so, issues such as proper testing of transgenics and biosafety will have to be addressed effectively. Intensified research efforts are also needed in the application of biotechnology for increasing shelf-life and converting food-stuffs into more palatable, nutritious and stable forms. Also public awareness relating to benefits of biotechnology and IPR-related issues will be necessary to harness benefits of the new science.

11.3 Productivity Path

In future, both increased cropping intensity and productivity growth, hold the key to success in agriculture. Use of innovative tools/techniques to break new grounds in productivity and application of frontier sciences have to be given greater attention. Basic research of the top order has to be integrated between the ICAR and the other organizations, national centres, laboratories, general universities, to have "more from less", be it from land, plant, animal or fish. This requires that produce has to be not only linked to quantity but also in terms of quality, with maximum nutrition packed into it; as the food not only should satiate the physical hunger but also the metabolic hunger.

New tools/techniques for precise and rapid evaluation of germplasm against biotic/ abiotic stresses and to overcome inherent productivity constraints need to be developed. The focus will have to be on specific adaptation so as to enhance yield potential.

Input-use efficiency, particularly of fertilizer, water and pesticides, should receive greater attention. The N-use efficiency is as low as 20% and hardly exceeds 50%. In the case of P, the efficiency varies between 15 and 20%. Soil-test based integrated use of nutrients coupled with optimizing time of application, method of applications, nutrient budgeting and modelling will raise their use efficiency at least by 8-10% from the current level. Similarly, increasing overall cropping intensity by 20-30% over the current level, with emphasis on energy efficiency and alternate agriculture, especially with low-water requiring crops, should receive our attention.

In years to come hybrid varieties are expected to replace ho-mozygous plants of many self-pollinated crops and heterogeneous plants of most crops. This will require pursuing a pro-hybrid policy in crop-improvement programmes, so that higher and faster progress could be made. Trained manpower and appropriate policies, to support hybrid technology, both for research and development in public and private sectors, are imperative.

11.4 Natural Resource Management

The necessity to grow enough food, feed, fuel and fibres to meet requirements of the ever-increasing population has put the primary natural resources, soil, water and vegetation under severe stress. There is degradation of resource-base in the form of large scale soil and water erosion in the hilly and slopy areas; appearance of wide-scale secondary salinization and waterlogging in the irrigated and flood-affected areas; over-exploitation of ground-water, resulting in declining water-table and deteriorating water quality; chemical degradation; diminishing forest cover and lower response to costly inputs in agriculture.

11.4.1 Soil. Soil is a vital natural resource. The proper use of which greatly determines the capability of the life-supporting systems to meet the basic human and animal needs. Its capacity to produce is limited. It depends largely on its intrinsic characteristics, agro-ecological setting, and its use management. This resource is under competitive demand for industrial growth and urban expansion. The problem of soil degradation through erosion, pollution and salinization is also growing and needs to be addressed. Since pressure on available limited soil resources will increase with time, effective and rational use of this resource will be the core strategy to increase future productivity on a sustainable bases. Soil health and fertility must also draw immediate attention of all concerned, especially when organic matter content has gone as low as 0.3-0.5%, and several micronutrient deficiencies are now surfacing prominently. Thus, there is a strong need for conserving soil and land resources and preserving natural ecosystem in proper equilibrium so that short-term exploitative measures on our soil resources do not jeopardize long-term sustenance of soil productivity and health. Soil-management research should provide principles and practices for safeguarding this asset.

11.4.2 Water. Water is also a scarce resource. In future less and less of it will be available for agriculture as its demand for domestic, industrial and other uses is increasing from year to year. It is estimated that even after achieving the full irrigation potential, nearly 50% of the total cultivated area will remain rainfed. Such low levels of water availability are considered a severe constraint to socio-economic development and maintenance of environmental quality. Issues relating to management of supplies to improve availability of water in time and space, management of demands through improvement in storage, transport, water allocation, scheduling and application technologies, and preservation of integrity of water-dependent ecosystems through development of decision-support systems for disposal and reuse of waste water need to be addressed. Special efforts will have to be made to evolve technology for prevention and amelioration of salinity in irrigation commands, which are based on harnessing synergy of hydraulics and plant biology. Also technologies that enhance water productivity without consumptive use such as fish production in irrigation storage and conveyance system will have to be planned. Research aimed at capturing the technology-policy interactions in respect of water market, pricing, security for quality and dependability will have to be undertaken to develop water-management options.

11.4.3 Climate Change. Climate change and global warming caused by the emission of greenhouse gases have emerged as important issues in the last two decades. The sea levels are expected to rise between 15 and 94 cm over the next century, and thus, low-lying areas may be more vulnerable to inundation. The crucial requirement is to build up understanding of crop-weather relationship in a way that enables reliable crop yield and disease forecasting, and also helps in developing crop-weather models to devise efficient agricultural production systems. It is projected that South Asia might have an increase in temperature from 0.1° to 0.3°C by 2010 and 0.4° to 2.0°C by 2020. Climate aberrations in terms of temperature rise and ozone depletion have to be tackled by minimizing emission of greenhouse gases.

11.4.4 Agroforestry. In India, large mass of land faces severe degradation on account of deforestation. Forest area is far less to meet growing demands of various tree-products including" fuel, fodder and grazing and for keeping environmental balance. The loss of area under miscellaneous tree-crops and groves has resulted in deficit of firewood supply in rural areas, forcing excessive use of cow-dung as fuel. There is a dire necessity to develop agroforestry systems which are compatible with general agriculture. This requires development of area-specific agroforestry models.

11.4.5 Integrated Plant Nutrient System. The exhaustive cropping systems have hastened the pace of degeneration of soil fertility and its health, by excessive mining of nutrients and with hardly any addition of crop residues. There is also a great concern about the widening ratio of the N:P:K and decreasing organic content of the cultivated soils. This imbalance is bound to affect soil-health, crop yield, quality of produce and sustainability of production in the long run. This continuous nutrient inadequacy will become staggering when we consider our future needs of food production. Therefore, immediate attention is to be given to integrated plant nutrient systems (IPNS) research.

11.4.6 Integrated Pest Management . Indiscriminate use of agro-chemicals has created problems of soil and water pollutants which results in toxic levels in the food chain. To obviate these problems, integrated pest management (IPM) approach, based on the synergistic use of resistant varieties, appropriate cultural practices,

application of biopesticides, use of biocontrol agents and scientific and controlled application of agro-biopesticides, need to be followed. Integrated weed management, which is environment-friendly and cost-effective, has also to be emphasized and research on biochemicals and biocontrol agents needs to be strengthened.

11.5 Farming Systems' Approach

It is now well appreciated that discipline, component or commodity-oriented approach is reaching its limits. Future programmes, therefore, need to be based on a holistic approach which takes into account biophysical, socio-economic and institutional setting. A farming system perspective, built around needs, resources and multiple activities and interdisciplinary, and inter-institutional synergies, should be the hallmark of the new research paradigm. This approach will focus on integrated development of farming systems. This will be based on exploiting growth potential consistent with rational and efficient use of natural and other resources. The twin problems of the past, namely lack of attention to alternative income-growth options and inefficient and non-sustainable use of resources, will thus be addressed through farming systems' approach.

11.6 Rainfed Agriculture

Even when all irrigation potential is developed, one half of the arable area will remain rain-dependent. Therefore, future efforts for maintaining and expanding current level of agricultural production would progressively depend more on the development of rainfed agriculture. Rainfed agriculture is diverse and highly risk-prone. Mixed cropping is a familiar aspect of rainfed farming. In this farming, employment opportunities are confined to cropping season and out-migration happens on a large scale. Concentration of poverty and land degradation are rampant in the rainfed areas. Farmers in these areas integrate arable farming with animal-rearing for income stability and augmentation. Excepting high-yielding hybrid/varieties and to some extent use of fertilizers, other technologies are yet to make a mark in rainfed areas. And rain-water management is the major agenda for all practical purposes. Approaches to address rainfed agriculture would necessitate integrated area development with watershed as the unit of activity.

Tailor-made hybrids with location-specific relevance to raise productivity of rainfed agriculture are a must. Cropping has to be strictly within the bounds of the growing season, which is short. Therefore, need-based mechanization of rainfed agriculture is essential to make most out of the scarce natural resources.

In view of the fragility of the rainfed environment, cultivation of fruit trees, shrub and tree species yielding dyes, drugs, pesticides and timber offer an inexhaustible income potential. Value-addition will greatly appreciate worth of the output. Backward and forward linkages will be necessary for processing and marketing of the produce. Since food remains the primary concern of the farmers in arable areas, intercropping of economically viable perennials and annuals will be more acceptable. Cultivation of annual field crops and trees (agroforestry) is foreseen to enhance income, reduce risk, create more opportunities for employment, bring about efficient and equitable use of natural resources and will aid in soil quality build-up with aesthetics.

11.7 Diversification

As a consequence of the importance attached to growth-oriented research in agriculture, which came mostly from crop research, the vast potential available with other farm enterprises remained largely under-exploited. Changing consumption and demand patterns and new trade opportunities have provided impetus to trends towards greater diversification of farming systems through greater emphasis on horticulture, animal husbandry, milk, poultry and fish and other animal products, non-food crops such as fibres, mushroom, spices and condiments, medicinal and aromatic plants and agroforestry. These enterprises are to be emphasized through scientific land-use planning and resource optimization. In the context of diversified agriculture, value-addition, post-production technology and agri-business aspects would require special attention, as we reorient our research agenda.

11.8 Post-production Management and Value addition

To capitalize on increased market access and remain competitive globally, a continuous upgradation of post-production technology becomes imperative to reduce cost of production and for increasing quality of marketable fresh and processed agricultural produce. This calls for bridging-up critical gaps between technologies available/accessible to end-users and ever-changing needs. We need to identify what has to be grown for linking up to food processing, and in that primary processing should receive priority. Post-production technology with emphasis on on-farm handling and storage systems for different commodities, covering sanitary and phytosanitary measures, packaging, transport, marketing, value-addition, both for domestic and export market, are considered important. Besides, human food we should also exploit rich terrestrial and marine fauna/flora for extracting rare chemicals, drugs, enzymes and hormones of pharmaceutical, medicinal and nutritional importance. Utilization of

crop residues and byproducts for food, feed and industrial products through value-addition is another area which needs to be strengthened.

11.9 Farm Mechanization

With the changing scenario, farm mechanization has become very crucial for achieving higher economic returns. The future thrust of R&D in farm machinery and power will have to take care of the needs of the farming not only on individual ownership basis but through custom hiring also. Improved agricultural implements and equipment are required and for this prototype development and multiplication will have to be expanded through establishment of more regional centres. It is also required to give due emphasis to irrigation and drainage aspects, use of plastics in agriculture, including surface covered/protected cultivation, and the need for matching tools and equipment.

Availability of energy will become a crucial factor in future but the energy needs are likely to expand significantly. The power source (tractor and powertiller) with matching implements and machinery for different operations at pre- and post-harvest levels will require attention. The computer-aided designing and computer-aided manufacturing and agri-electronics are required to be made an integral part of the design and fabrication of the improved farm equipment and machinery. Research on alternate bio-energy resources such as bio-diesel, alcohol for running tractors and engines, gasification of biomass for thermal and mechanical applications should be given adequate impetus. Fuel cell technology for electricity generation and stand-alone power units to run on biomass will have to be given higher priority. The research on the development of low-energy, precision-farming equipment like sprinkler/ drip and other devices as well as the drainage equipment needs to be intensified.

11.10 Precision Farming

Precision farming is an emerging technology. It allows farmers to regulate with precision the application of various inputs (in terms of time and quantity) and for modifying agronomic practices keeping in with the in-field variability of the soil attributes and crop requirements. It has significant economic and environmental benefits, since it helps maximize input-use efficiency, and in minimizing loss of nutrients. This technology, though successful under large farm-holdings, in near future will be useful for small and fragmented land-holdings also. Time is not far when concerns like low input-use efficiency and their harmful effects on our resource-base, which is important to reduce cost of agricultural production and to maintain desired levels of productivity, will gain strategic importance, opening scope for precision farming on a fairly large scale. Our scientists, therefore, need to be adequately prepared through appropriate training in several areas of precision-farming technology, such as interpretation of spatial variability through Global Positioning System, application of precise inputs through computer-aided mechanisms and control systems.

11.11 Socio-Economics and Policy Analysis

Strong socio-economic research will be needed to identify and develop an appropriate demand-driven research agenda based on the current and futuristic projections. Research resource allocations will increasingly have to be driven by expected pay-offs. Studies on constraints for adoption and impact of technical changes are necessary for removing impediments to technology-led growth. Institutional and policy variables also have a bearing on these parameters and need to be kept in view. Analyzing the trade-offs between growth and other objectives of public policy such as sustainability, employment generation, regional balance and poverty alleviation, will be an important agenda for socio-economic research. Further, the strengthening of linkages and partnerships with national and international institutes both in public and private sectors would become more rewarding if the ICAR simultaneously addresses policy research to standardize and harmonize regulatory measures such as IPR, Breeders' Rights, Farmers' Rights, biosafety and phytosanitary issues to promote rational sharing of techniques, technologies, products and knowledge. Accordingly, high priority has to be given to strengthen policy research capacity in the medium-term through targeted HRD initiatives.

11.12 Agri-business Management

From a scenario of food shortage and its subsistence nature, agricultural sector is now poised towards commercialization, food surpluses and trade. To facilitate this paradigm shift, the other sub-sectors of agriculture like processing, marketing, infrastructure and export development are becoming more important. The analysts believe that the agri-business activity will get greater momentum, progressively accounting for higher share of income and higher labour absorption capacity due to the internal liberalization as well as opening up of world agricultural market. Gradual improvements in the purchasing power of the poor sections will strengthen this trend. Agri-business sector has to strive at quality improvement, cost reduction and supply of products at competitive prices, to exploit vast domestic and international demand for quality products. The agricultural research agenda

should be geared up to provide needed scientific back-up to promote the growth of agri-business.

11.13 Globalization of Agriculture

The agricultural scenario all over the world is undergoing a rapid change. In order to take full advantage of the changing global scenario and the WTO provisions, it is imperative to adjust domestic policies. Research prioritization has to be tuned to respond to signals of globalization. The impacts of globalization on private sector R&D for seeds, fertilizer, farm machinery and post-production technology vis-a-vis public sector need to be assessed and addressed.

Greater efficiency of production holds the key for the country's success in the global market. Developing and disseminating cost-reducing technologies for inputs as well as outputs will play a critical role in maintaining and improving competitiveness of Indian agriculture. Development and utilization of wide range of market intelligence and strengthening of our foreign missions with agricultural attaches should receive attention. "Exim" importance is called for to promote trade interests. As we gear up for export markets, research on quality and form of the produce will be required. Establishment of referral laboratories for quality testing will need attention. Similarly environment-friendly packaging and transportation will form a priority. Ways and means to counter non-tariff barriers should also be a matter of immediate concern.

11.14 Gender Equity Issues

Women in rural areas constitute a major work-force in agriculture, contributing significantly to agricultural production. Farm-women spend more time and perform more tasks in agriculture, dairying and animal husbandry, and thus play a vital role. Technology generation and transfer programmes have generally been carried out on the assumption that the technologies are gender neutral. However, women have different technological needs than men due to the differences in their physique, stamina, experience and skills. There is a need to develop equipment and technologies suitable for women-workers for production in agriculture as well as for post-harvest activities. The ICAR has to play a greater role to create data-base on farm-women for understanding women's perspective and their involvement in technology generation and transfer in agriculture and allied enterprises. The ICAR vision for empowerment of women in agriculture will include emphasis on their education and training, encouraging their participation in technology assessment and refinement; spouse training and employment programme; their involvement in education, research, training and extension; and entrepreneurship development and in decision-making process.

11.15 Partnership and Linkages

To meet the future challenges, functional linkages need to be established with other institutions/organizations to undertake research in frontier areas of science and to promote human resource development, both at the national and international levels. Strengthening inter-organizational linkages, therefore, should form a core activity.

11.15.1 National A clear demarcation of priority areas of research projects to be done independently or jointly between the ICAR and SAUs is called for. Similarly, linkages with other scientific departments, institutions, national centres, laboratories, NGOs and farmers' organizations need to be further strengthened to reinforce research programme quality and to help technology spill-ins.

11.15.2 Private Sector. The emergence of the private sector in agricultural research and extension activities has been a significant development. Linkages and partnerships with private sector and industry, need to be fostered and strengthened especially in the sectors of seed, biofertilizers, biopesticides, prototypes of agricultural tools, implements and machinery, food processing and agri-business.

11.15.3 International. A strong partnership will have to be developed with other countries to develop human resource, particularly with the SAARC and other countries in the tropics and sub-tropics. This will be achieved through the exchange of faculty and students and strengthening of international teaching programmes.

11.16 Informatics

Priority for greater investments in information technology (IT) infrastructure and for its appropriate HRD programmes will have to be accorded. Electronic networking will be able to serve the cause of research as well as generation and dissemination of technology, and it should be given a high priority. Under the Agricultural Research Information System (ARIS) launched in the ICAR during the VIII Plan, point-to-point connectivity has to be extended to each scientist in all the ICAR institutions, SAUs including KVKs. The four information modules under the ARIS, namely, management information system (ARMIS), personnel information system (ARPIS), financial

information system (ARFIS), library information system (ARLIS) should be fully developed and become operational. Linking up with global science and technology information system, greater use of network mode, designing improved agro-meteorology and surveillance, and instant processing of information will contribute to efficiency and relevance of the research system. Information technology thus needs to be exploited to add value to research investment.

All the scientists of the NARS will need to be provided with electronic connectivity through computerized satellite-based information network to ensure free flow of information between the institutions in India and abroad. For easy access to information, the libraries in various institutions of the NARS need to be digitized. The faculty will also be trained to use latest multimedia-based instructional technology for quick dissemination of new knowledge and information.

For overall improvement in the educational programme of the NARS, Agricultural Education Media Centres will have to be established, and efforts will be made to have a separate TV channel for agricultural education, which will be very useful in developing programmes for distance education and for disseminating new technologies to the users.

12 Engineering NARS

12.1 Manpower Planning

Effective HRD should be based on appropriate manpower planning and career development. This can be achieved through modernization of courses and curriculae, inservice training programmes for teachers and researchers, performance-based incentives and through encouraging mobility to avoid inbreeding. Human resource development efforts have to be systematically planned and implemented. A greater emphasis will have to be given for training in frontier areas of agricultural sciences.

12.2 Human Resource Development

12.2.1 Skill Development. The Indian agricultural education system is to build talented scientific manpower which is well informed, motivated, creative and committed to conduct and manage research not only for Indian NARS but also for international agriculture. Efforts will have to be made to tune agricultural education curriculae not only to meet present needs but also future demands so that we have at hand a first-rate manpower. The skill development for equipping young graduates for greater participation in agri-business activities will have to be an essential component of the agricultural education programme. New areas like peri-urban agriculture and horticulture, dairy, poultry and piggery, post-production processing, agricultural machinery, software and multimedia development, agri-business and trade, should receive attention. Future curriculae should encourage entrepreneurship and equip our agricultural graduates to become job-creators rather than job-seekers. Training in new science like biotechnology, modelling, environmental science, GIS applications, agri-business management, both in India and abroad, should receive greater and priority attention.

12.2.2 Accreditation. Accreditation of universities will have to be done for quality assurance in education and uniformity in educational standards. Improvement of education in private colleges of the general universities needs to be given greater attention.

12.3 Transfer of Technology

Some factors responsible for technology transfer gaps are inadequacy and inappropriateness of the technology, lack of suitable technology assessment mechanisms, weak research-extension-farmer linkages and lack of suitably trained extension manpower. Technology Assessment and Refinement (TAR) in future will be far more knowledge-demanding, diverse, location-specific and farming systems' based. The farmers are becoming literate, aware and inquisitive while agriculture is becoming more commercial and capital-intensive. Thus, precise and timely advice on input procurement and use, management practices, output handling and marketing will play a decisive role in overall farm profitability. This requires close interaction between the researchers, farmers and the extension-workers.

12.4 Traditional Wisdom

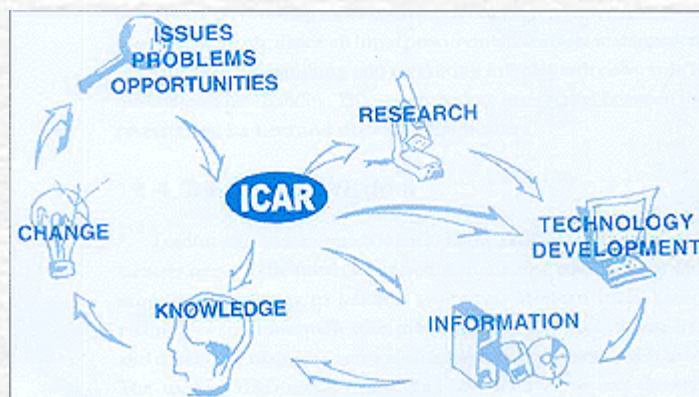
Traditional wisdom which is abundantly available with the Indian farmers needs to be suitably assessed documented and blended with modern technology to harness synergies. Modern information technology and communication methods and networks with research and development departments at all levels have to be extensively used. The surging HRD needs of the staff may have to be met through synergies of different institutions such as NAARM, MANAGE, EEIs, ATCs, TTCs, KVKs and SAUs. Some of the areas where substantial upgradation of skills of the extension-staff are needed include farming systems, organic agriculture, IPM, IPNS, post-production management and value-addition, agri-business and market and trade intelligence. Extension in future would become specialized and competitive job, requiring higher professional skills and full commitment and competence. Widening the range of extension delivery agencies by multi-agency approach, involving private, voluntary and co-operative extension efforts, also needs attention.

12.5 New Extension Approaches

Innovative extension approaches like Agricultural Technology Information Centres, Agricultural Technology Management Agency, distance education, Institution-Village Linkage Programme (IVLP), use of mass media will have to be made complimentary with group-based extension and informatics.

13 Growth-Oriented Responsive Governance

The ICAR had a unique beginning. It was carved out from the personnel of the Ministry of Food and Agriculture and is thus saddled with the administrative practices prevalent in the Government Departments. It follows civil service rules on *mutatis-mutandis* basis. The cultural ethos of the ICAR is somewhat different from that what suites to an R&D organization. The ICAR, a registered society, is yet to frame its own rules and regulations. Some initiatives have been taken in recent years but much remains to be done to achieve the desired autonomy, efficiency and transparency.



Problems - Process - Products pathway in the ICAR

With the changing scenario, bringing in more complex challenges, entry of new stakeholders and, above all, growing funding constraints, the ICAR has to become more dynamic and proactive. It has to do business differently in a more down-to-earth and professional manner. It has to create a new identity and define new roles/paradigms. It is firmly believed that investment in organizational and management reforms is as important as investment in research; as it eventually has strong bearings on the work-environment, efficiency of the organization, productivity of science and its growth.

Expected Paradigm Shifts

Paradigm	<ul style="list-style-type: none"> • Shift
Research Infrastructure	<ul style="list-style-type: none"> • Consolidation, right sizing, renewal and reorientation
Research Prioritization	<ul style="list-style-type: none"> • 'Bottom up' and participatory
Budgeting	<ul style="list-style-type: none"> • Project-based budgeting
Resource Generation	<ul style="list-style-type: none"> • Partial
Investment Pattern	<ul style="list-style-type: none"> • Increased operational budget
Staff	<ul style="list-style-type: none"> • Balanced growth
Career Advancement	<ul style="list-style-type: none"> • Merit-linked-performance-based incentives and rewards
Human Resource Development	<ul style="list-style-type: none"> • Capacity-building through national and international exchanges and networking
Partnership	<ul style="list-style-type: none"> • Public, Private and NGOs
State Agricultural Universities	<ul style="list-style-type: none"> • Improve infrastructure and open up to become strong centres for agricultural development at the state levels
Service Rules	<ul style="list-style-type: none"> • Framing own rules and regulations
Technology Transfer	<ul style="list-style-type: none"> • Research-Extension-Farmer linkage
Administration	<ul style="list-style-type: none"> • Decentralized

Management

- Macro planning, co-ordination and monitoring

With the above paradigm shifts, it is envisioned that by the 2020, the ICAR as an organization will emerge as a *really autonomous, efficient, effective, caring and financially sustainable organization, capable for bringing in work-culture for achieving its goals.*

14 Epilogue

During the last 5 decades since Independence, physical access to food had been the most important challenge. And at present, economic access to food has been the most important concern of all. In the 21st century, ecological access to food may become the most important challenge owing to damage being caused to land, water, flora, fauna and the atmosphere. The Indian NARS has served the nation well in making the country self-sufficient in foodgrains and also as a potential exporter of agricultural commodities. However, there has to be some prioritization of research agenda. As not all the research may fit into a single mode of approach; we may have to adopt programme matrix as well mission-mode approach for conducting agricultural research in future. This would obviously call for a thorough prioritization of researchable issues involving a 'bottom up' approach. Besides support to the national institutes, the state agricultural universities will have to be encouraged to take up their own research programmes suiting to regional needs. The emphasis in future should be on interface, coordination and identifying priorities among priorities.

Ensuring food security may remain unaccomplished dream unless issues like poverty and population are addressed simultaneously. In such a situation, it has to be ensured that ecology and conservation do not work against the interests of the poor while we move towards the sustainability of our agriculture. The motivation for the development and safeguarding our environment should converge and not conflict, thereby rejecting existence of false dichotomy between the two.

For required development and protection of environment, the main tasks are integrated land, water and forest management, conservation of biodiversity, environment awareness, development of non-polluting and renewable energy resources, pollution control, waste utilization through recycling, slum removal and development of healthy human habitats, access to education, population control, and above all, the combined will of the government and the people to bring in a harmonious development through rehabilitation and optimization of the resource-base and environment. In such an effort, effective linkages among intra-and inter-NARS, NARS-ARIs and IARCs and NARS and ARIs would play a significant role to ensure sustainable food security in future. Hence, combined efforts would be the key to our future success and better tomorrow, built on the promise that all NARS will have to strengthen to operate as effective partners in this whole exercise of achieving sustainable food security for all. In the process, Indian NARS, with the ICAR in the forefront, will have to pursue a renewed agenda and a strategy to make the system more relevant, effective and efficient. Obviously, therefore, increase in research investment is the key to our food security. Efforts are being made to ensure proper allocation and generation of required funds to achieve these targets, besides, appropriate strategy in place, to accomplish required objectives successfully. In this context, strengthening of the NARS will have to be our foremost priority.

It is believed that the Vision 2020 of the ICAR will enable us in our mission to have a food secure and a prosperous India, as we enter the 21st century

Acronyms

AHRD	Agricultural Human Resource Development
AICRP	All-India Co-ordinated Research Project
ARI	Agricultural Research Institute
ARIS	Agricultural Research Information System
ARS	Agricultural Research Service
ASRB	Agricultural Scientists' Recruitment Board
ATCs	Advance Technology Centres
BARC	Bhabha Atomic Research Centre
BGA	Blue Green Algae
CGIAR	Consultative Group on International Agricultural Research
CSIR	Council of Scientific and Industrial Research
DARE	Department of Agricultural Research and Education
EEI	Extension Education Institute
GATT	General Agreement on Tariffs and Trade
GDP	Gross Domestic Product
GOI	Government of India
HRD	Human Resource Development
IARCs	International Agricultural Research Centres
LARI	Indian Agricultural Research Institute
ICAR	Indian Council of Agricultural Research
ICRISAT	International Crops Research Institute for Semi-Arid Tropics
IPM	Integrated Pest Management
IPNS	Integrated Plant Nutrient System
IPR	Intellectual Property Rights
IT	Information Technology
IVF	<i>In-vitro</i> Fertilization
IVLP	Institution-Village Linkage Programme
IVM	<i>In-vitro</i> Maturation ,
IVRI	Indian Veterinary Research Institute
KVK	Krishi Vigyan Kendra
MOU	Memorandum of Understanding
MPTS	Multi Purpose Tree Species
NAARM	National Academy of Agricultural Research Management
NAAS	National Academy of Agricultural Science
NARI	National Agricultural Research Institutes
NARP	National Agricultural Research Project
NARS	National Agricultural Research System
NASC	National Agricultural Science Centre

NATP	National Agricultural Technology Project
NBAGR	National Bureau of Animal Genetic Resources
NBFGR	National Bureau of Fish Genetic Resources
NBPGR	National Bureau of Plant Genetic Resources
NBSS & LUP	National Bureau of Soil Survey and Land-Use Planning
NDRI	National Dairy Research Institute
NGO	Non-Governmental Organization
NRC	National Research Centre
NSP	National Seed Project
O&M	Organization and Management
PHT	Post-harvest Technology
SAARC	South Asian Association for Regional Co-operation
SAU	State Agricultural University
TAR	Technology Assessment and Refinement
TFP	Total Factor Productivity
TTC	Trainers' Training Centre
UGC	University Grants Commission
UMMB	Urea Molasses Mineral Blocks
WTO	World Trade Organization
ZRS	Zonal Research Station

Agricultural Universities and Deemed-to-be Universities

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- 25 **Central University**
- 26 **Central Agricultural University**
Imphal (Manipur) 795 001
- 27 **New University**
- 28 **University of Agricultural Sciences**
Dharwad (Karnataka) 580 005
E-mail : root@usad.kar.nic.in
- 29 **West Bengal University of Animal and Fishery Sciences**
Belgachia Calcutta
(West Bengal)

and Technology

45-B, Gandhmagar, PB 37
Jammu Tawi (Jammu and Kashmir) 180004

25 Tamil Nadu Agricultural University

Coimbatore (Tamil Nadu) 641 003
E-mail : vctnau@md3.vsnl.net.in

26 Tamil Nadu Veterinary and Animal Sciences University

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E-mail : tanuvas@md2.vsnl.net.in
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27 University of Agricultural Sciences

Bangalore (Karnataka) 560 065
E-mail : vc@uasbir.kar.nic.in

31 Rajasthan Agricultural University
Udaipur (Rajasthan) 313 001***Deemed-to-be Universities*****1 Indian Agricultural Research Institute**
Pusa, New Delhi 110 012**2 Indian Veterinary Research Institute**
Izatnagar (Uttar Pradesh) 243 122**3 National Dairy Research Institute**
Karnal (Haryana) 132 001**4 Central Institute of Fisheries Education**
Jaiprakash Road, Seven Bungalows,
Versova Mumbai (Maharashtra) 400 061

Division-wise Directory of ICAR Institutes, Project Directorates, and National Research Centres

- **Crop Sciences**

Deemed-to-be University Indian Agricultural Research Institute (IARI)

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e-mail: root@iari.ernet.in

National Bureau of Plant Genetic Resources (NBPGR)

Pusa, New Delhi 110012
Phone: 011-5784835/5783697
Fax: 011-5784835

Central Institute for Cotton Research (CICR)

P B No. 125, GPO Nagpur (Maharashtra) 440 001
Phone: 07103-75536/ 75549/75538
Fax: 91-07103/75529
e-mail: cicr@x400.nicgw.nic.in

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e-mail: crijaf@cal2.vsnl.net.in

Central Rice Research Institute (CRR)

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Phone: 0671-643015
Fax: 0671-641744
e-mail: crri@x400.nicgw.nic.in

Central Tobacco Research Institute (CTRI)

Rajahmundry (Andhra Pradesh) 533 105
Phone: 0488-748995
Fax: 0883-44834
e-mail: root@ctri.ap.nic.in

Directorate of Wheat Research (DWR)

P.B. 158, Kunjpura Road, Karnal (Haryana) 132 001
Phone : 0184-252390/ 271830
Fax : 0184-251390
e-mail : dowr@x400.nicgw.nic.in

Directorate of Maize Research

Cummings Lab, IARI, Pusa, New Delhi 110012
Phone : 5782372
Fax : 91-011-5766420
e-mail : rps@biciari.ren.nic.in

Directorate of Biological Control

Bangalore (Karnataka) 560 024
Phone: 080-3117930

Indian Grassland and Fodder Research Institute (IGFRI)

Pahuj Dam, Jhansi (Uttar Pradesh) 284 003
Phone: 0517-444771
Fax: 0517-440833
e-mail: igfri@x400.nicgw.nic.in

Indian Institute of Pulses Research (IIPR)

Kalyanpur, Kanpur (Uttar Pradesh) 208 204
Phone : 0512-570264;
Fax: 0512-572582
e-mail: root@x400.nicgw.nic.in

Indian Institute of Sugarcane Research (IISR)

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Fax: 0522-451028;
e-mail : iisr@x400.nicgw.nic.in

Sugarcane Breeding Institute (SBI)

Coimbatore (Tamil Nadu) 641 007
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Fax : 0422-48023
e-mail : sbi-coi@x400.nicgw.nic.in

Vivekananda Parvatiya Krishi Anusandhan Shala

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e-mail : vpkas@x400.nicgw.nic.in

Directorate of Rice Research (DRR)

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Fax: 040-4015308
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Directorate of Oilseed Research (DOR)

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(Andhra Pradesh) 500 030
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e-mail: pdoilseed@x400.nicgw.nic.in

National Research Centre for Soybean (NRCS) Rajendranagar, Hyderabad

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e-mail: pdd-bic@x400.nicgw.nic.in

National Centre for Integrated Pest Management (NCIPM)

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Phone: 5765935/5765936
Fax: 011-5765472
e-mail: ncipm@x400.nicgw.nic.in

National Research Centre for Groundnut (NRCG)

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(Gujarat) 362 001
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e-mail : nrcg@x400.nicgw.nic.in

National Research Centre on Rapeseed-Mustard (NRCRM)

Sewar, Bharatpur (Rajasthan) 321 303
Phone : 05644-24688,26855
Fax : 05644-22137,25566
e-mail : nrcrm@x400.nicgw.nic.in

National Research Centre for Sorghum (NRCS)

Rajendranagar, Hyderabad
(AndhraPradesh) 500 030
Phone: 040-4015225,4015339
Fax : 04(M01378
e-mail : nrcsorghum@x400.nicgw.nic.in

Central Plantation Crops Research Institute (CPCRI)

Kasaragod (Kerala) 671 124
Phone: 0499-430333/430894-6
Fax: 0499-430322
e-mail cpcri@x400.nicgw.nic. in

Indian Institute of Spices Research (IISR)

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P.O. Calicut (Kerala) 673 012
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Central Agricultural Research Institute for A&N Groups of Islands (CARI)

Port Blair (Andmand & Nicobar) 744 101
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Fax :03192-51068
e-mail cariangi@x400.nicgw.nic. in

National Research Centre for Citrus (NRCC)

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P.O. Nagpur (Maharashtra) 440 010
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Fax : 0712-527813
e-mail : nrccitrus@x400.nicgw.nic. in

National Research Centre for Arid Horticulture (NRCAH)

• Horticulture

Indian Institute of Horticultural Research (IIHR)

P.O. Hessaraghatta Lake,
Bangalore (Karnataka) 560 089
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e-mail : iihr@x400.nicgw.nic.in

Indian Institute of Vegetable Research (IIVR)

1, Gandhi Nagar (Naria), P.B. 5002
BHU.Varanasi (Uttar Pradesh) 221 005
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Fax : 0542-318504
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Central Institute of Sub-tropical Horticulture (CISH)

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Central Institute of Temperate Horticulture (CITH)

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Central Potato Research Institute (CPRI)

Shimla (Himachal Pradesh) 171 001
Phone: 0177-225073;
Fax: 0177-224460
e-mail: cpri@x400.nicgw.nic.in

Central Tuber Crops Research Institute (CTCRI)

Shreekariyam, Thiruvananthapuram
(Kerala)695017
Phone: 0471-448431,448551-4
Fax: 0471-550063
e-mail: ctcri@x400.nicgw.nic.in
director@ctcri.ren.nic.in

National Research Centre for Cashew (NRCC)

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Phone : 08251-21530/20902
Fax : 08251-24350
e-mail : nrccashew@x400.nicgw.nic. in
root@nrccashew.kar.nic.in

National Research Centre for Oilpalm (NRCOP)

Door No. 1-66-d, Shatvahana Nagar
Gooravarma, Eluru (Andhra Pradesh) 534 003
Phone : 08812-34502, 75409 (farm)
Fax : 08812-31372
e-mail : nrcoilpalm@x400.nicgw.nic. in

National Research Centre for Mushroom (NRCM)

Chambaghat, Solan (Himachal Pradesh) 173213
Phone :01792-30451

Near 10th K.M Milestone National Highway
Sri Ganganagar Road
Phone : 0151-250968,
Fax :0151-526354
e-mail : nrcah@x400.nicgw.nic. in

National Research Centre for Banana (NRCB)

44, Ramahngam Nagar, South Extension
Vaylthur Road, Tiruchirapalli (Kerala) 620 017
Phone :0431-770797,
Fax : 0431-771779
e-mail : nrcbanana@400.nicgw.nic. in
nrcb@trichy.tn.nic.in

National Research Centre for Grapes (NRCG)

PO No. 3, Manjen farm post,
Sholapur Road Pune (Maharashtra) 412 307
Phone : 0212-814245,814246,
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• **Natural Resource Management**

National Bureau of Soil Survey & Land Use Planning (NBSS&LUP)

Shankar Nagar, Amravati Road, Nagpur
(Maharashtra) 440 110
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Central Soil and Water Conservation Research and Training Institute (CSWCRTI)

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Central Soil Salinity Research Institute (CSSRI)

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Central Arid Zone Research Institute

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Fax : 0291-740706
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Central Research Institute for Dryland Agriculture (CRIDA)

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Phone : 0755-730946,733309

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National Research Centre for Onion and Garlic

Rajgurunagar, Pune 410 505
Phone : 02153-24056
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National Research Centre for Medicinal and Aromatic Plants (NRCM&AP)

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National Research Centre for Orchids (NRCO)

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National Research Centre for Seed Spices (NRCSS) Tabiji, Ajmer

Rajasthan

ICAR Research Complex for Goa

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Fax : 0832-286249
e-mail icar@goa.nic.in

Project Directorate for cropping system Reasearch (PDCSR)

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Directorate of Water Management Research (DWMR)

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e-mail : pdwm@x400.nicgw.nic. in

Water Technology Centre for Eastern Region (WTCER)

No VII-H/176-180, SailshreeVihar Chandra
Sekhar Pur Bhubaneshwar (Onssa) 751 102
Phone : 0674-440060,440010
Fax : 0674-441651
e-mail : wtcer@x400.nicgw.nic. in

National Research Centre for Agroforestry (NRCAF)

IGFRI Campus, Pahuj Dam, Gwahor
Jhansi Road (UttarPradesh) 284 003
Phone :0517-442364
Fax : 0517-442364
e-mail : nrcaf@x400.nicgw.nic. in

Fax : 0755-733310

e-mail : iiss@x400.nicgw.nic. in

ICAR Research Complex for North-Eastern Hills Region

Umroi Road, Shillong (Meghalaya) 793 103

Phone : 0364-64257,

Fax 0364-64-64288

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Bhopal (Madhya Pradesh) 462 039

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e-mail : director@ciae.mp.nic.in

Central Institute of Post-harvesting Engineering and Technology (CIPHET)

PAU Post Office, Ludhiana (Punjab) 141 004

Phone : 0161-808669/808827

Fax : 0161-808827

e-mail : cipht@satyam.net.in

Central Institute for Research on Cotton Technology (CIRCOT)

Adenwala Road, Matunga

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Indian Lac Research Institute (ILRI)

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Phone : 0651-520202/520117/520194

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National Institute for Research on Jute and Allied Fibre Technology (NIRJAFT)

12, Reagent Park, Calcutta

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Indian Agricultural Statistical Research Institute (IASRI)

Library Avenue, Pusa, New Delhi 110012

Phone : 091-011-5741479,

Fax : 011-5741479

e-mail iasri@x400.nicgw.nic.in

• **Animal Sciences**

Deemed-to-be University Indian Veterinary Research Institute (IVRI)

National Research Centre for Weed Sciences (NRCWS)

215 Rajendra Nagar, JNKW,

Jabalpur (Madhya Pradesh) 482 004

Phone : 0761-330701,330538

Fax : 0761-332329

e mail : root@nrcweed.mp.nic.in

National Dairy Research Institute (NDRI)

Karnal (Haryana) 132 001

Phone : 0184-252800,254751

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National Bureau of Animal Genetic Resources (NBAGR)

P.O. No.129, Karnal (Haryana) 132 001

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e-mail nbagr@x400.nicgw.nic. in

Central Avian Research Institute (CARI)

Izatnagar (Uttar Pradesh) 243 122

Phone : 0581-447261,4477223

Fax : 0581-447321

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Central Institute for Research on Buffaloes (CIRB)

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Central Institute for Research on Goats (CIRG)

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(Uttar Pradesh) 281122

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Central Sheep and Wool Research Institute (CSWRI)

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National Institute of Animal Nutrition and Physiology (NIANP)

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 Phone : 0581-477284,447185
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Project Directorate on Poultry (PDP)

APAU Campus, Rajendranagar
 Hyderabad (Andhra Pradesh) 500 030
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 e-mail pdpoultry@x400.nicgw.nic. in

National Research Centre on Camel (NRCC)

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 Fax : 0151-522183
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National Research Centre for Equines (NRCE)

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 Fax : 01662-33217
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National Research Centre on Meat and Meat Products(NRCM)

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 Phone : 0581-447069/447185,
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National Research Centre for Mithun (NRCM)

I CAR Research Complex,
 Jharnapani Kohima (Nagaland) 797 106
 Phone : 03862-32340/32341
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National Research Centre of Agricultural Economics and Policy Research (NCAP)

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 Phone : 011-5743036
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• **Fisheries**

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 Mumbai (Maharashtra) 400 061
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 Fax : 022-6361573
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National Bureau of Fish Genetic Resources (NBFGR)

Canal Ring Road, P 0 Dilkusha, Tehbagh, 251/28,
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 Phone : 0522-442403,442441/442443/441735
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Central Institute of Brackishwater Aquaculture (CIBA)

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Central Inland Capture Fisheries Research Institute (CICFRI)

Barrackpore (West Bengal) 743 101
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Central Institute of Freshwater Aquaculture (CIFA)

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Central Marine Fisheries Research Institute (CMFRI)

Ernakulam, Cochin (Kerala) 682 014
 Phone : 0484-39486/3947987
 Fax : 0484-394909
 e-mail cmfri@x400.nicgw.nic. in

Central Institute of Fisheries Technology (CIFT)

Willington Island, Matsyapun
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 Phone : 0484-667727/666880/666845/667039
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National Research Centre for Coldwater Fisheries (NRCCWF)

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 Bhimtal, Naimtal (Uttar Pradesh) 262 136
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• **Agricultural Education**

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