TFYP WORKING GROUP Sr. No. 41/**2001**

REPORT OF
THE WORKING GROUP ON

AGRICULTURAL RESEARCH
AND
EDUCATION

FOR
THE TENTH FIVE YEAR
PLAN

सत्यमेव जयते

GOVERNMENT OF INDIA
PLANNING COMMISSION
AUGUST, 2001

Chairman's letter to Member (Agri.), Planning Commission

Suresh K. Sinha
FNA, FASc
Former Director & National Professor
Chairman,
Xth Five Year Plan Working Group

Indian Agricultural Research Institute,
New Delhi-110 012

Shri Sompal,
Member (Agriculture)
Planning Commission
Yojna Bhawan, Parliament Street,
New Delhi-110 001.

Dear Shri Sompal ji,

This has reference to the letter No. M-12043/9/2000 Agri, Govt. of India, Planning Commission (Agriculture Division) dated 12th January 2001, through which I was asked to serve as Chairman of the Working Group on Agricultural Research and Education for the Xth Five Year Plan (2002-2007).

(ii) The Working Group met once informally and three times formally. Fifteen Sub-Groups were constituted Chaired by eminent scientists, with each Sub-Group consisting of a number of scientists from the ICAR system, State Agricultural Universities, Non-Agricultural Universities, Private Sector and Indian Institute of Management to delibrate on the various broad themes. Some of the Sub-Groups met more than once.

(iii) Reports of the Sub-Groups were presented and discussed by the Working Group. These reports indicate a linkage among the past present and future of the various aspects of agricultural research and education.

(iv) I have attempted a broad statement of Objective, Outlook and Recommendations based on delibrations in the Working Group. After all agriculture and agriculture research and education are so important for the destiny of the country that they are the business of all those who would like to bring a change, and not necessarily depend alone on the perception of those who operate the system.

Objective

The country's main objective in the coming years has to be achieving an annual growth rate of 4 per cent or more in Agriculture to meet the targeted 8 per cent growth rate in GDP.

Outlook

National

- There is a need for greater emphasis on sustainability of natural resources, animal wealth, fisheries, horticulture, efficient use of inputs, energy management, climate change, and post-harvest management, while keeping in view the requirements of food grains.
- Agriculture Extension is essentially the activity of the States and SAUs, the ICAR should be only a motivating and guiding force.
- Agriculture Research and Education in the States shall be strengthened by earmarking funds for Agricultural Research and Education in State Plans.

International

- India should play an important role in world agriculture by extending expertise, for improving agriculture to achieve food and nutritional security and export of commodities in the countries of Africa and Asia by establishing the Indian Centre for International Agriculture Research and Development on the pattern of the Australian Centre for International Agriculture Research.

Recommendations

1. To promote systems/multidisciplinary/interdisciplinary approaches in research, while retaining the importance of disciplinary approach, the country should be divided into five zones for integrated development of agricultural research in the country. A senior functionary of the Council with adequate financial powers be responsible for each zone.
2. As early as possible, collect, characterize, evaluate, use and conserve our greatest asset of agrobiodiversity by involving SAUs, Life Science, Botany and Zoology Departments of non agricultural universities, DST, CSIR, DRDO, MOEn, DOD, DBT, NGO Institutes etc. through contract research/project funding. Establish an Agrobiodiversity Advisory Committee for monitoring progress of this work.
3. Biotechnological approach based on DNA technology needs to be extended to crops, livestock, fisheries and microorganisms, by establishing a lead research institute per sector with specific objectives. These Institutes should have strong research network programmes with other research institutions for better utilization of resources.
4. Every institution, wherever relevant, should address the problems of post-harvest management and marketing.
5. Include International Agriculture as a part of our education and policy. NAARM should organize courses on International Conventions, Treaties, and Commitments.

6. To enable the country to compete in future, IARI, IVRI, NDRI and CIFE be recognized as Central (National) Universities and be given the autonomy like that by the Tata Institute of Fundamental Research and the Indian Institute of Science. These institutes should generate new knowledge which could make Indian agriculture more competitive.
7. Develop and institutionalize effective methods for monitoring and impact assessment (both internal and external) of our programmes.
8. SAUs to address problems of integrated rural development in a holistic manner.
9. SAUs should have close linkages with other Universities and IITs. A Standing Committee of Scientists should regularly review and recommend programmes of the Education Division. Standing Committees should also be established for other sectors of the Council.
10. ICAR to operate All India Coordinated Projects of commodities of all India nature such as wheat and rice and the rest be transferred to one or more states. Establish an independent testing agency, now onwards.
11. Some of the proposed new institutes in essential specific areas could be part of the existing institutes. ICAR can open some new centres in SAUs. Some of the existing NRCs be part of the larger institutes with full financial autonomy. Attempt cohesion rather than fragmentation.
12. KVKs and Zonal Centres be transferred to States and the Department of Agriculture and Cooperation.
13. Help development of a Service Sector in agriculture by supporting self-employment. This would gradually take over extension.
14. ICAR to organize missions and studies for identifying demand for various commodities, quality and the time of requirement in the target countries of Africa and Asia.
15. Support establishment of Referral Laboratories at National Institutes for meeting the SPS (Sanitary and Phytosanitary) requirements for exports and also having a check on imports. These Laboratories should generate resources for becoming self-supporting. Intensify research on plant protection.
16. Support Private Sector for the development of agro-processing, agro-machinery, and other programmes which can help the farming community and agro-industry, through active linkages and tranfer of technology programmes.
17. Restructure the ICAR for meeting emerging scenario, from food grain and food security to economic growth, economic prosperity and employment generation by strengthening institutes. A Senior level Committee consisting of external and internal members be formed to overse implementation of the GVK Rao Committee recommendations already accepted by GOI.

18. Implement the 1988 GVK Rao Committee Report on ICAR in letter and spirit making the organisation tall, slim and healthy. There is a need for extensive use of Information Technology in Education and Extension Programmes. Implement all other recommendations regarding Research, Education, Extension and Organizational Management.

19. Provide 1 per cent of the GDP of Agriculture and Allied Sector (Rs. 25,000 crores now) for agriculture research and education. Out of this, allocate Rs. 15,000 crores to States by providing a budget line in the State Plan for their agricultural research and education programmes, of which 50% should be through project funding

I would like to thank and express my gratitude to Chairman and members of the various Sub-Groups who responded in a very short time to delibrate and give recommendations in different areas of agricultural research and education. I am grateful to the members of the Working Group for their active participation. The officials of the Planning Commission were kind and extended their support for which I am thankful to them. I thank Dr. Mangla Rai who served as Member Secretary of the Working Group.

The report is presented for your kind consideration.

With my respectful regards,

Yours sincerely,

(**S.K. Sinha**)

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Recommendations of Sub-Groups

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RECOMMENDATIONS

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SUGGESTED MAJOR INSTITUTIONS

NATIONAL BUREAU OF GENETIC RESOURCES

1. Bureau of Plant Genetic Resources
2. Bureau of Animal Genetic Resources
3. Bureau of Fish Genetic Resources
4. Bureau of Microbial and Fungal Genetic Resources
5. Bureau of Insect and Nematode Genetic Resources
6. Research Centre-DNA finger printing

CROP INSTITUTES

1. Central Rice Research Institute
2. Directorate of Rice Research
3. Project Directorate of Wheat Research
4. Directorate of Maize Research
5. Directorate of Sorghum & Millet Research
6. Indian Institute of Pulses Research
7. Indian Grassland and Fodder Research Institute
8. Indian Institute of Sugarcane and Sugarbeat Research
9. Sugarcane Breeding Research Institute
10. Central Institute of Cotton Research
11. Directorate of oilseeds Research
12. Directorate of Research on Non-Traditional Crops

PLANT PROTECTION

1. Directorate of Biological Control
2. Directorate of Research on Integrated Post Management

HORTICULTURE, VEGETABLE & FLORICULTURE

1. Indian Institute of Horticulture Research
2. Central Institute of Sub-Tropical Horticulture
3. Central Institute of Temperate Horticulture
4. Central Institute of Arid Horticulture
5. Indian Institute of Vegetable Research
6. Central Potato Research Institute
7. Central Tuber Crops Research Institute
8. Central Plantation Crops Research Institute
9. Indian Institute of Spices Research
10. Centre for Research on Orchids

NATIONAL RESOURCE MANAGEMENT

1. National Bureau of Soil Survey and Land Use Planning
2. Indian Institute of soil Science
3. Central Soil Salinity Research Institute
4. Central Soil and Water Conservation Research and Training Institute
5. Water Technology Centre for Eastern Region

CROPPING SYSTEMS/ FARMING SYSTEMS

1. Central Research Institute for Dryland Agriculture
2. Central Arid Zone Research Institute
3. Cropping Systems Research Institute
4. Vivekanand Panvatiya Anusandhan Shala
5. Centre for Research on Weather, Climate and Agriculture
6. ICAR Research Centre for Goa
7. ICAR Research Centre for NEH Region
8. ICAR Research Centre for Eastern Region
9. Central Institute for Research on Jute and Allied Technology

AGRICULTURAL ENGINEERING

1. Central Institute of Agricultural Engineering
2. Centre for Energy Management in Agriculture
3. Central Institute for Research on Cotton Technology
4. Central Institute for Research on Jute and Allied Technology

MULTIDISCIPLINARY INSTITUTE

1. Institute of Post-Harvest Science and Technology

ANIMAL HUSBANDRY AND DAIRYING

1. Project Directorate-Cattle Research and Management
2. Central Sheep and Wool Research Institute
3. Central Institute for Research on Goats
4. Central Institute for Research on Buffaloes
5. Central Institute on Animal Nutrition and Physiology
6. Central Avian Research Institute

FISHERIES

1. Central Marine Fisheries Research Institute
2. Central Inland Capture Fisheries Research Institute
3. Central Institute of Fresh Water Aquaculture
4. Central Institute of Brackish Water Aquaculture
5. Central Institute on Cold Water Fishes
6. Central Institute of Fisheries Technology

AGRICULTURAL STATISTICS & ECONOMICS

1. Indian Agricultural Statistics Research Institute
2. National Centre for Agricultural Economics & Policy Research

AGRICULTURAL EXTENSION

1. Institute of Agricultural Extension
2. Research Centre for Women in Agriculture

EDUCATION

1. National Academy for Agricultural Research Management
   Or National Academy for Agriculture Management
2. Central Agricultural University

NATIONAL UNIVERSITIES (RESEARCH & EDUCATION)

1. Indian Agricultural Research Institute
2. Indian Veterinary Research Institute
3. National Dairy Research Institute
4. Indian Institute of Fisheries Education.

Constitution of Working Group on Agriculture Research and Education for Xth Five Year Plan (2002-2007)

1.	Dr. S.K. Sinha, Former Director, IARI, New Delhi N-14/29 B, DLF, Qutub Enclave, Phase-II, Gurgaon-122 002, Haryana	Chairman
2.	Dr. R.S. Paroda, D.G., I.C.A.R. & Secretary, DARE, ICAR, Krishi Bhavan, New Delhi-110 001	Convener
3.	Dr. V.L. Chopra, former Secretary, DARE and D.G., ICAR, A-3/210-A, Janakpuri, New Delhi-110 058	Member
4.	Dr. H.K. Jain, former Director, Indian Agricultural Research Institute, New Delhi, 40, Surya Niketan, Vikas Marg Extension, New Delhi-110 092	Member
5.	Dr. Mangla Rai, D.D.G. (Crop Sciences), I.C.A.R. Krishi Bhavan, New Delhi-110 001	Member- Secretary
6.	Dr. S.L. Mehta, D.D.G. (Education), ICAR, Krishi Anusandhan Bhavan, Pusa Complex, New Delhi	Member
7.	Dr. S.P. Ghosh, D.D.G. (Horticulture), ICARI, Krishi Bhavan, New Delhi-110 001	Member
8.	Dr. Kiran Singh, D.D.G. (Animal Sciences), ICAR, Krishi Bhavan, New Delhi-110 00	Member
9.	Dr. A. Alam, D.D.G. (Engineering), ICAR, Krishi Bhavan, New Delhi-110 001	Member
10.	Dr. J.S. Samara, D.D.G. (Natural Resource Management) ICAR, Krishi Bhawan-110 001	Member
11.	Dr. K. Gopakumar, D.D.G. (Fisheries), ICAR, Krishi Bhavan, New Delhi-110 001	Member
12.	Dr. P. Das, D.D.G. (Agriculture Extension), Krishi Anusandhan Bhavan, Pusa Complex, New Delhi	Member

13.	Dr. P.L. Gautam, National Director, National Agriculture Technology Project (NATP), Lal Bahadur Shastri Building, Pusa Complex, New Delhi	Member
14.	Financial Adviser, Department of Agriculture Research and Education, Krishi Bhavan, New Delhi-110 001	Member
15.	Joint Secretary, Plan Finance, Department of Expenditure (Plan Finance Division), Ministry of Finance, North Block, New Delhi-110 001	Member
16.	Vice-Chancellor, Punjab Agriculture University, Ludhiana	Member
17.	Vice-Chancellor, G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarachal Pradesh	Member
18.	Dr. Deepak Pental, Director, South Campus, Delhi University, Dhaula Kuan, New Delhi	Member

TERMS OF REFERENCE

1. To make critical review of research achievement and technology development in the fields of agriculture, animal husbandry, dairy development, fisheries and fodder and impact of education during the IX Plan as per the goals objectives set.

2. To suggest proposals for formulation and implementation of Tenth Plan with regard to ongoing activities, their modification and new activities.

3. To recommend strategy and approach on research, education and training for agricultural development with reference to target groups, specific problem areas, hills, tribal areas, NE Region, problem soils, etc. and infrastructural development.

4. For Agriculture Research and Education, the country has a strong National Agriculture Research system. Today there is a network of Research Institutes, National Research Centres, Project Directorates, State Agriculture Universities, Central Agriculture University and large number of All India Coordinated Research Projects involving more than 24,000 Agriculture Scientists, teachers and technicians. The Working Group will critically review the existing staff strength and its efficient utilization. Simultaneously, necessity for creation of new staff should also be reviewed. These steps are necessary to check up the ever-increasing Plan and non-Plan expenditure of the ICAR. Committee may also try to find out if any kind of duplication of efforts and funds is taking place, even though unintentionally since the ICAR have a very vast network spread over the country.

5. Critically review the performance of NATP in stimulating the research activities and development of research infrastructure at different Institutes/Centres. The performance and impact of Agriculture Technology Management Agencies (ATMA) on technology transfer may also be reviewed.

6. Critically examine the impact of technologies developed in improving the productivity of rainfed lands and suggest the new research areas.

7. Various research organizations are carrying out research on genetic engineering for improving the productivity, quality, disease resistance etc. of the crops. The working group may suggest the ways and means for coordinating them for better commercial output.

8. To suggest measures for effective coordination in the field of agriculture research in the State sector as well as in other Central organizations / departments with the ICAR system.

9. The Working Group may critically review the status of Biotechnology and Genetic Engineering Research and suggest appropriate measures and policy initiatives in the field of Transgenics.

10. To examine the status of technology for cultivation, production and processing of medicinal and aromatic plants produce in the country.

11. Working Group may examine the technology advancement to design for fabrication of trawlers for fishing under different fathoms of Indian waters.

12. To review the development of low cost technologies for improvement of existing indigenous technologies for organized development of milk and meat processing industry with emphasis on quality control for export.

INTRODUCTION AND PERSPECTIVE

Agriculture has always been an important constituent of Indian culture and Indian economy. The success or failure of agriculture in India has generally been assessed in terms of production and availability of food grains. Accordingly we can identify different phases of growth in agriculture

(i) Pre-independence to 1966-67: The period marked by acute food shortages caused by biotic and abiotic stress leading to frequent famines followed by short term mitigation measures through import of food grains. There was no serious concern about other commodities.

(ii) 1966-67 to 1980-81 when adequate food grain production was achieved by recognizing and introducing the role of science and technology in agriculture, reorganisation of the Indian Council of Agricultural Research, establishment of new organisation and institutions such as The National Dairy Development Board, The National Seed Corporation of India, The Food Corporation of India, Fertilizer Industry, State Agriculture Universities and others by the Government of India. This was the period in 1966-67 when policies for procurement of food grains, buffer stock and public distribution system were put in place along with the Commission On Cost and Price in agriculture (Agriculture Price Commission). All these policy changes and advancement in science brought the country to a stage when the impact of the severe drought of 1979 was not felt nationally and internationally.

(iii) The period from 1981-82 saw increasing growth rates in most cereals, but shortages of oilseeds and pulses. The research and public policies of 1965-67 and beyond paid off. However, the demand of agricultural commodities started getting diversified but because of our historical experience the emphasis of research continued mostly in environmentally well endowed regions. The establishment of State Agricultural Universities meant to be the Rural Universities, in fact apparently adopted the Land Grant System of the USA, but made agriculture production synonymous with rural development. There are no agricultural Universities in USA and all land grant Colleges & Universities are multifaculty including Science, Medicine & Health, Mining & Metallurgy, Arts, Humanities etc. The SAUs have not made any significant contribution to rural development though this was the vision of Radhakrishnan Commission in recommending establishment of Rural Universities. Nonetheless, the phase between 1981 to 1990 was a period of boom in growth in crop based agriculture, except pulses. The oilseed

mission resulted in reducing import of vegetable oils. A change in seed policy enhanced the activity of private sector in horticulture. This is one important factor which led to success of horticulture sector in the country.

(iv) From 1991 - onwards: this phase coincided with economic liberalisation. The agriculture institutions were largely unaware or unconcerned with the demands on agriculture by the new economic paradigm. The demand for livestock and fisheries products along with vegetables and fruits increased. The private industry contributed significantly but it is difficult to assess the contribution of national research programmes in the growth of these sectors. The emphasis, however, continued on crop based research (very clearly brought out by the objectives of research in the VIIth and IXth Plan). Many Centres and Projects came up to address problems which should have been the concern of States, with only advisory, training and some financial support from ICAR. The production of rice and wheat has continued to increase albeit in other than traditionally high productive regions. Environmental problems, particularly soil degradation, change in water table, contamination of water, micronutrient deficiencies, loss of soil carbon etc have become more visible in Punjab, Haryana, and some other regions. Economic cost of environmental degradation has yet to find a place in agriculture cost and price determination. Appropriate methodology suitable for Indian conditions need to be developed. The quality of the produce has not been according to international standards. While there are successful results in Integrated Pest Management (IPM) but these have yet to become widespread. Therefore, there is considerable use of pesticides on crops which have potential for indigenous marketing and export. There are almost no laboratories, public or private for estimating various chemicals and biological contaminants for meeting the standards of sanitary and phytosanitary requirements for internal consumption or export. A target of a few million hectare need to be fixed for spreading IPM, particularly on crops which now receive more pesticides and have both internal and export market.

Post harvest science and technology including decentralized storage has yet to take roots in agricultural institutions. All major institutions whether agriculture or others need to intensify research on pre-harvest and post harvest physiology, biochemistry, molecular biology, genetics and pathology including microbiology, to develop appropriate technology for perishables. We can appreciate the importance of this from some multinationals which import even the seed of a particular variety for meeting the stringent demands of processing. In addition the use of agromachinery in agriculture has been beyond expectation. This trend will continue with a greater vigor in the coming decade. This means increasing demand for energy in agriculture. Some estimates suggest

that energy accounts for about 60% of the cost of production, though it may not be valid for all regions. The socio-economic analysis of energy on agriculture along with energy saving mechanism or energy management should receive a serious attention by agriculture institutions. Furthermore, the agromachinery now has a turnover of Rs. 30,000 Crores (Thirty thousand Crores), and the agricultural institutions need to make some innovative contributions towards the unorganised sector.

Broad Objectives of Xth Five Year Plan

1. Agriculture and Allied Sector is a core sector of Indian Economy, not only because it contributes significantly to GDP, but because it involves the largest population of the country, through direct or indirect employment, self-employment or partial-employment. Indeed agriculture supports even unemployed also. This sector in fact is a component of rural employment and development which needs a considerable scientific and technological input. There has been a significant improvement in agricultural production., particularly of food grains and other commodities, and yet the contribution of agriculture and allied sector to GDP has declined. This is expected because of increased contribution by other sectors. However, maintenance and enhancement of contribution of agriculture in coming decades would remain important objectives. Hopefully, appropriate indices would be developed for accounting the cost of employment in agriculture, as a component of services in agriculture.

2. The National Policy on agriculture (2000) seeks to actualise the vast untapped growth potential of Indian agriculture, strengthen rural infrastructure to support faster agricultural development, promote value addition, accelerate the growth of agro-business, create employment in rural areas, secure a fair standard of living for the farmers and agricultural workers and their families, discourage migration to urban areas and face the challenge arising out of economic liberalization and globalization. Over the next two decades, it aims to attain:

- A growth rate in excess of 4 per cent per annum in the agriculture sector.
- Growth that is based on efficient use of resources and conserves our soil, water and biodiversity.
- Growth with equity i.e. growth which is widespread across regions and farmers.
- Growth that is demand driven and caters to domestic markets and maximize benefits from exports of products in the face of challenges arising from economic liberalization and globalization.

- Growth that is sustainable technologically, environmentally and economically.

3. The IXth Five Year Plan had some objectives which were to address these issues. (see section 2.1)

Emerging Scenario

4. According to various estimates including that of the United Nations the World Population would increase by 2755 million by 2020, of which the developed countries would have increase of only 176 million. Therefore the demand of food would increase several fold in developing countries, while the developed countries would reach a saturation limit for imports by 2010 or 2015. It is only quality that would matter for the developed world. Therefore, India should target the developing countries by meeting their quality standards.

5. The consultative Group on International Agriculture Research (CGIAR) through its review in 1998 have identified productivity improvement and natural resource management as the twin pillars of CGIAR research, food crops, conservation of genetic resources (biodiversity), forestry and agroforestry, livestock management, aquatic resources, soil and water nutrients and water management as the major objectives.

6. The CGIAR Centres may not in future have the same emphasis on commodity research as until now. There was at one time criticism of CGIAR for helping the developing countries in increasing food production, and in the process reducing exports from the developed countries. Therefore India as a leader of the developing countries will have to assume the role in commodity improvement which has generally been played by CGIAR Centres. In turn, the major institutes of ICAR would have to generate and distribute genetic material to the State Universities as was/is being done by International centres. However, such an effort would have to be confined to only a few crops identified as the basis of priority considering area and value at the national level. The States would have to take up programs for improvement of crops important for their regions. The ICAR may help them technically.

7. The growth rates of production of cereals, rice and wheat have declined substantially between 1991-2000 in the World, Asia, China and India, but India has fortunately maintained a more than 2% annual growth rate in these crops. This implies that in the span of Xth Plan and beyond India may find markets for the various cereals in developing countries including the countries of Africa, East Europe, Former Soviet Union and Asia. This should influence the direction of research on crops in India.

8. The latest NSSO round (1999-2000) shows that direct consumption of cereals is now about 12 kg per capita per month. With increasing economic growth, as envisaged in Xth Plan, this may further decline marginally. There would, however, be increased consumption of pulses, vegetable oil, livestock and fisheries products, fruits, vegetables and others. Thus the demand of food should not be considered as cereals, and hence cereals production alone cannot be the only criterion of food security.

9. Internationally, there is a serious concern about climate change, which could express in a greater degree of climate variability and extreme events such as droughts, variations in temperate regimes, flood, cyclone etc.

10. There is an emerging private sector in agriculture in India which is mostly involved in the following:

(a) Seed production, largely confined to hybrids in various crops.
(b) Seed production or important vegetable crops
(c) Development and propagation of transgenic crops.
(d) Agriculture machinery
(e) Agroprocessing
(f) Post harvest technology
(g) Livestock products

We will have to develop a complementary relationship between public and private research which serves the public cause.

11. Some of the high productivity regions of the country have stagnation or decline in productivity of major grain crops. There is considerable degradation of natural resources soil, water, loss of micronutrient, soil carbon and associated soil biota. In addition, there are changes in the pattern of crop disease. The sustainability / unsustainability indices for different agroecological regions are yet to be developed

12. While the farmers are getting subsidies in the form of free electricity and water, but they use these resources in an unscientific manner and they are expecting better price of produce from the Government.

Meeting the objectives

13. We need to consider the objectives of 4 per cent or higher growth rate in agriculture in view of the emerging scenario. Will increase in production of wheat and rice result in a 4% growth rate in economic terms? This is unlikely. Should allocation for research in different sectors be anyway related to the contribution they make towards agriculture GDP?

14. There are estimates that livestock, horticulture and fisheries sector contribute more than 70% of the GDP in agriculture. If oilseeds, fiber crops, tobacco, sugarcane and others contribute even 10%, this amount to saying that agriculture can grow faster if emphasis is placed on non-grain crops, livestock, fisheries and horticulture crops However, the natural and monetary resources including energy are common to all sectors, and hence must receive a serious attention. The importance of research on crops should continue for providing food security in traditional sense.

15. The agriculture Policy also envisages growth with equity i.e. growth across regions and farmers. The VIIth Five Year Plan had envisaged agroecologically based agriculture development. This was taken up by assessing and describing natural resources by the Indian Council of Agriculture Research and Agriculture Universities. The agroecological Zonal development without creation of a new bureaucratic setup was to asses through modelling and validation the agricultural production potential of field crops, livestock, horticulture, fisheries etc in a farming systems mode to offer options to farmers and the States both as volumes of the produce, economic return, and employment generation. This programme would establish sustainability of both natural resources and economy of each region.

16. The implementation of a long term agroecologically based programmes of the plan for agriculture development would require the various modern tools which are now available but a more active role of the States for the benefit of their people would be an essential requirement.

17. India being a vast country with a larger number of agroclimates is suitable for specific crops and livestock production in specific regions. Many of them are adaptable to the region because of co-evolution of agriculture and the society and yet, the Planning Commission established a large number of All India coordinated Projects in various crops including horticulture crops, livestock, fisheries and other sectors. The United States where there is a large variation in agricultural system, the USDA has created USDA Centres in Universities (There are no Agriculture Universities in USA) which reduces expenditure on infrastructure, and yet provides a greater interaction between the USDA scientists and University Professors. They share equipments, thereby making a wider and more efficient use of resources. The Planning Commission may like to consider an alternate system to the existing mechanism.

18. The greatest asset is our biodiversity kept in National Bureaux of plants, animals, fisheries, microorganism and others. However, the characterization and utilization of this biodiversity is the most important requirement if we have to develop strength. No single institution will be able to complete this work. Therefore, new strategies have to be contemplated. How to involve scientists and

departments of not only agriculture universities but other Universities and institutions of CSIR, DST, DRDO, MOEn and non-Government laboratories? There could be different mechanisms through a contract system or Project funding. Some of the Institutions may evaluate germplasm in a particular agroecological environment. The country must spend a substantial amount of money on this. A Board of Trustees for Agrobiodiversity characterization and utilization need to monitor the work at monthly interval for different institutions. This evaluation will bring us a higher bargaining positions in WTO regime.

Farming Systems Research

19. The farming system in India and other tropical or sub-tropical countries is a way of life and a part of culture. The exposure of a large number scientists from the developed countries through CGIAR system has brought awareness of our system in developed countries. It is indeed very gratifying that worldwide interest has been invoked in farming system and many CGIAR Centres now advocate it.

Farming system is a collection of human activities at a given place, influenced by natural resources and available monetary and non-monetary inputs for meeting the household needs and income through various activities of agriculture including production of crops, livestock, fish etc. This involves interaction of the various processes and activities primarily with the objectives of growth and development of household and the society. Thus the processes and activities (sub-systems) which eventually are basic to a farming system have to have excellence in research in each discipline which constitute the system, in this case the farming system. Therefore, the disciplinary research has to have interdisciplinary and holistic view to meet the requirements of farmers who practice different modes of farming systems. However, there would be no Farming System Research without disciplinary research which need to be supported and strengthened.

Plant Protection

20. In the tropics and subtropics, pests and plant disease result in upto 40% reduction in the yield of crops and horticulture plants. If the post harvest losses, including impairment of quality are added, the situation becomes even more serious. India with its diverse agroclimate areas and intensive agriculture provides ideal conditions for the perpetuation of pests and pathogens which cause enormous losses annually. The past experience shows that with concerted efforts it is possible to minimize such losses for example, in the fifties and sixties rust disease of wheat used to cause nearly 10% reduction in yield annually, but now the rust disease are being judiciously managed through an

aggressive research programme for the management of wheat rust disease. But for this effort, today we would have been economically in a difficult situation. With the globalisation of agriculture, we now face another danger in the form of introduction of 'invasive species' which could cause devastation. Added to these is the factor of climate change which would also have adverse affect due to the increased abiotic and biotic stresses. To adequately face the changing scenario of pests and disease we have to not only develop infrastructure for the integrated management of pests and diseases currently prevalent but also to take up futuristic research to prepare ourselves for tackling new and emerging problems. It is high time that the country strengthens infrastructure for research in all areas of Plant protection.

Biotechnology

21. Biotechnology has emerged as a strong scientific tool for advancement in agriculture research. In India, there have been efforts to develop transgenic technology, especially for the generation of Bt cotton. There have also been efforts at the laboratory/greenhouse level to develop Bt-rice, vegetable etc. There are also efforts to improve the quality traits such as "00" Brassica, transgenic potato with amaranthus gene coding for a storage protein with high lysine and sulphur amino acids. The success stories at best can be described as promising. Overall, we are not really close to introducing any transgenic material for serious coordinated trials, except perhaps in one or two cases.

22. There is a general tendency to lump all biotechnologists together ranging from plant tissue culture, biological controls, biofertilizers to transgenic and the impact of anyone of these technologies on productivity is not clear. While all these technologies have a place the main concern should be genetic engineering as applied to agriculture. However, it would be relevant to examine independently as to what extent tissue culture, biological control and biofertilizers have influenced Indian agriculture, and what is their scope. If these technologies have not become widespread despite several promising claims, we need to examine the factors that limit the spread and use of these technologies by farmers.

23. Biotechnology would also play an important role in animal disease and production, as also in fisheries, but not enough seems to have been put on these areas. These areas need encouragement.

24. Conventional crop improvement progammes need to be injected with newer gene/gene pools for expanding the genetic base. It is of paramount importance because our current breeding efforts, in almost all crops have a very narrow genetic base. The following biotechnological approaches in my opinion, will help in overcoming this melady.

(i) Genetic engineering : Strengthening/augmenting the on-going efforts in isolation, characterization and deployment of gene/s for tolerance to biotic stresses, reducing post-harvest losses and value addition.

(ii) Integration of molecular breeding in conventional breeding with special emphasis on abiotic stresses and molecular tagging of genes for yield and quality attributes. This can be further extended to heterosis.

(iii) Characterization and cataloguing of the germplasm for probable donors of genes of economic importance. This could be achieved by

(a) Field evaluation
(b) Homology search at DNA level
(c) Search for orthologoue taking clue from Arabidopsis and rice genomes
(d) Bioprospecting following conventional biochemical route.

(iv) Functional Genomics : The rough draft genome sequence of rice will be made public by the first quarter of 2020. The ICAR in association with DBT must expand the research efforts in the area of Genomics on the following lines:

(a) Gene annotation based on the published rice and Arabidopsis genomes sequence.
(b) Creation of gene mutations, to start with, in rice using retrotransposon/ transposon mutagenesis route and deployment of these mutants for assigning the function to the DNA sequences
(c) Initialisation of genome sequencing (whole genome or ESTs) of pigeonpea (work on chickpea has been initiated at the National Centre on Plant Genome Research) or one of the millets.

25. Many Departments of Biotechnology have come into existence with inadequate scientific, technical and financial support. It is now time that only 5-10 centres with strong scientific competence are created with adequate financial support along with desired financial powers delegated to the Head and scientists. Such institutions should have guaranted power and water supply. They may be put on uninterrupted power supply wherever they exist to save work of days and months, and also chemicals worth lakhs of Rupees.

26. Such centres should become places of excellence providing facilities to young and desirous scientists to work for varying periods. The centres should have authority to offer fellowship and other facilities including residential for promoting biotechnology in crops, animals and livestock production, fisheries and microorganisms. Above all we should not expect miracles, but scientific output of relevance to the country.

27. Animal Science through its various programmes of livestock production, dairy, wool, hide and others has the potential to grow at a growth rate of 7 to 8%. This sector is the one with fisheries and horticulture that can help achievement of 4.0 % growth rate of agriculture sector to GDP to enable the country to achieve a target of 8% growth in GDP. A very significant aspect of this sector is its potential to provide rural employment including the landless people. This sector has not yet achieved its export potential because of several reasons which require attention to veterinary education, disease management, post harvest technology and above all feed technology and management. While the scientist bureaucrats and politicians have talked about Dolly, we have yet to make a real beginning in animal biotechnology. Now many vaccines, diagnostic kits and other tools are needed for field workers. While we have now vaccines but we have yet to achieve the status of marketing vaccines like Hepatitis B for human beings which is all Indian, and is capturing international market. We do need to give a serious push to this sector in rainfed areas where livelihood is strongly supported by livestock. Several priorities in education and research have been identified for the Xth Five Year Plan.

Essentials for Export - Import in agriculture Commodities

28. Export - Import in agricultural commodities is a important aspects of economic globalization, and India has to prepare to meet both tariff and non tariff barriers. The latter is often operated through sanitary and phytosanitary measurers. We have not adequately prepared for this. There is not only need to ensure that products get easy acceptance in terms of various chemicals and their matabolies but also various biota (biological) contaminants. The irradiated and GM food articles will be common in future. Whether we accept them or not, we have to develop appropriate methology and tests for determining the quality of products. Are soybeans and their products from GM or irradiated sources that are being imported? The country could benefit from the label Non-GM or Non-irradiated agricultural products in our efforts to promote exports. High quality private/public laboratories need to be established in different parts of the Country, which should be supported through research by ICAR, CSIR and other organizations

Human resource Development

29. There are 29 State Agricultural Universities in the country - at least one in each State, except the North Eastern Region where there is one Central University. In addition, there are four deemed to be Universities. Three Universities (two for veterinary and one for Horticulture and Forestry) also have been established . One might say that they are not too many in comparison with a country such as Japan where they are not necessarily funded by Government.

The State Agricultural Universities were established when the country had shortages of food grains and some of them made important contributions to meet the objectives. In early stages the faculty of some Universities was trained in the counterpart Universities in USA, and most of them maintained a national character of the faculty. Most of this has changed. Many faculty members from different Universities go for training programmes ranging from a few weeks to three months. This is only an exposure, but not really any training. While we may take pride in saying that we are second to none, but our publications or citations in international literature do not substantiate this. Therefore, the time has come when an assessment of agriculture Universities in teaching and research standard, governance and funding is necessary to bring in changes for making them comparable and competitive internationally.

The main concerns of agricultural education to be addressed by the Xth Five Year Plan relate to globalization, changing mix of the food basket and ensuring sustainability. Two related factors hold the key to the strategy that will allow the configuration of agricultural education to address these concerns. These are:

(i) Ensuring quality of products and services and

(ii) Ability to undertake and adapt to change

These two must form the basis of any strategy for agricultural education of the future. The focus of the strategy for the Tenth Five Year Plan should also therefore be on these factors. A point to be kept in mind is the Central Plan funds form a relatively small share of the total investment in agricultural education in individual States. It is therefore important that the Central Plan Strategy works more to motivate and catalyze the State systems towards the desired national vision and goals for agriculture, than attempting to monitor and control the SAUs (as some recent studies have indicated). What can be insisted upon is the common set of guiding principles to protect the interests of stakeholders. Also common features of the overall strategy can be identified.

(i) Providing for solid grounding in disciplinary skills, basic sciences, environmental science, communication skills and computer skills

with focus on developing problem solving abilities. Problem solving skills need to be differentiated from providing for practical classes and field experience training. They can result only from a solid grounding in the theory.

(ii) Providing access to self learning facilities (both for students and faculty) to enable people to learn to understand and adapt to change. These facilities include well equipped libraries and laboratories, and access to the world wide learning resources through information technologies. Specific training and formal evaluations in self learning are required. (In the SAUs, with their internal evaluation systems, learning by rote is in order and not problem solving through self-learning).

(iii) Specialization is best left to Master's and Ph.D levels. The problem solving skills need to developed further at this level through self learning and case studies. (Attempts at introducing a few courses in business management, entrepreneurial skills etc at the B.Sc. stage are unlikely to provide skilled specialists in these areas. This is also the reason universities in US and Europe focus more on general and problem solving skills at the BS level. In these countries, management education usually follows some experience in industry.

(iv) There is no need for further extension of the agricultural universities system, as the present system is likely to lead to surplus graduates in the conventional area of agriculture. What is needed is change of focus to address the changing food basket, methods to ensure more flexible operations, and adherence to declared standards

(v) *Each university must identify at least one niche area during the plan period where it can rise to international standards and attract international clientele.* The area must be identified after careful consideration of its strengths and weaknesses. Support for this must be provided from the Central plan only after a detailed proposal is received and evaluated.

(vi) India has acquired for itself leadership role in international agriculture, particularly in the developing world. At least one National institution must be developed to focus on international agricultural development (on the lines of University of Wageningen, Netherlands). The proposals for this need to be initiated in the Tenth Plan.

International Commitments

30. India is a signatory to some important Conventions and Treaties in addition to WTO which have relevance and significance to agriculture. Amongst these are UNFCCC (United Nations Framework Convention on Climate Change) Kyoto Protocol, Convention on Desertification, Convention on Biodiversity, Convention on Afforestation and others. There is a need to create awareness among agriculture scientists, agriculture institutions of these Conventions so that they could respond to these International commitments. There is need to generate reliable data by international standards on various aspects related to these Conventions. It would be necessary to have our own data for policy options for agriculture and in international perceptive and discussion.

Agriculture Extension

31. (i) Agriculture is a State subject and every State has a department of Extension, which has a considerable staff from Director to the Block level. It is only agricultural extension research, which essentially has been transferred to Agricultural Universities. The Indian Council of Agriculture Research through its institutions and programmes demonstrates the value of various research outputs as technologies which can help farmers and agriculture. Thus the ICAR develops principals and programmes for extension. These demonstrations are essentially through Zonal Centres and KVKs (Krishi Vigyan Kendras). The creation and management of these should be in the purview of the Department of Agriculture & Corporation or the State Governments. The ICAR may confine to demonstrate technologies in their Institutes and Programmes.

(ii) Extension essentially involves the transfer of knowledge and materials according to the time and place. Therefore, the knowledge acquired is to be applied for meeting different demands and needs updating. Since a farmer (most of them) is not doing one thing, a holistic demonstration and experience becomes essentials.

(iii) The proposal of the Government of India for creating Agriculture clinics can bring a vital change in rural India by providing services of the various kind. In the process such trainees could be self-employed, and become useful partners of farmers than extension workers or officers. The SAUs may like to develop suitable training programmes, irrespective of the trainees being graduates or matric pass, for meetings the demands of farmers.

Organization and Management

32. A research organization normally consists of the office of the Chief of Organisation and Directors of the constituent institutes, providing a direct linkage between the institutes and the Chief of the Organisation without any layers in between (see Memoires of C. Subramaniam, The Hand of Destiny, 1993). This is true of CSIR, ISRO, Atomic Energy, DRDO and other organizations in the country. The same is true of research organisations in other countries. The Indian Council of Agriculture Research is the largest organization of its own kind. But in the process this organisation has acquired many activities and programmes which truly belong to the States. The present structure was created to dismantle the administrative bureaucracy in the 1966 by creating a small national organisation but it is now the organisation with a bureaucratic set up operated by scientists. Therefore, the role model is now to become a bureaucratic scientist instead of emulating the role model of scientists who have acquired reputation through research and academics nationally and internationally. Indeed the system of a scientist bureaucrat also provides an opportunity to acquire apparently academician status though inclusion of name in the work of subordinate scientists. Therefore, it should not be a surprise that the **WEBSITE OF ICAR DESCRIBES THE CONSTITUENT INSTITUTES AS SUBORDINATE OFFICES OF ICAR**.

The time has come in the new millennium to restructure ICAR, by shedding some functions and bringing convergence and coherence among smaller institutes/directorate/centres many of which have not enough critical scientific mass to undertake modern science of agriculture for developing appropriate technology.

33. The Indian Agricultural Research Institute, The Indian Veterinary Research Institute and The National Dairy Research Institute in pre-independent and post independent India made outstanding contributions to agriculture research and education. Innumerable number of their researches could have been patented in today's economic regime but they continue to serve a public cause with dedication. A number of scientists and students from these have occupied senior positions in agriculture research and education in India and Abroad. However with the increasing demands for meeting the needs of crops, livestock and fisheries, horticulture, natural resources and other new institutions were created. There are now institutions for each crop, natural resources, livestock engineering etc. The role of IARI, IVRI and NDRI is being debated. When the Plant Breeding Institute at Cambridge was sold the Cambridge University enlarged its scope in life-science research and continuous to be a leader. The time has now come to implement the cabinet committee decision of 30th March 1965, taken under the Chairmanship of Prime Minister Lal Bahadur Shastri and in the presence of Sri C. Subramanian the then Agriculture Minister and other

Union Ministers, according to which IARI, IVRI and NDRI deemed to be National Institutes on the pattern of Tata Institutes of Fundamental Research, Mumbai and Indian Institute of Science, Bangalore. These Institutes and the Central Institutes of Fisheries Education should be made Central/ National Agricultural University, National Dairy University and National Veterinary University and the National Fisheries University. The budget of these Universities should be reflected in the annual budget of the Government of India.

The Directors of major institutes such as the Central Rice Research Institute, Central Potato Research Institute, Indian Institute of Horticulture Agriculture Research, CAZRI, CRIDA, IISS, CSSRI etc should report directly to the Director General ICAR. In the process the reorganisation should be such that Institutes like the Indian Institute of Horticulture Research or the Central Rice Research Institute enlarge their work on the pattern of IARI and do not remain confined to a sector alone. The same may be considered for Animal Sciences However many small establishments which came up in the last one decade or so, having sub-critical human and other infrastructure resources need to be linked with major institutes in their sectors. This needs to be worked out. The scientists for an Institute should be selected at the Institute on the same pattern as in CSIR. The Directors of the Institutes should also be selected on the same pattern as in CSIR

The coordinated projects played a vital role for a considerable long time when the coordinators were essentially only facilitators in identification and release of varieties. However in 1992 a discussion was organised by ICAR at Hyderabad where it was realised that coordinating system had fatigued, and hence required a change. The ICAR may like to operate only those coordinated projects which indeed are really of All India character.

OBJECTIVES OF THE IX FIVE-YEAR PLAN

The corporate objective of DARE/ICAR in the IX Plan will be to enhance productivity, profitability, stability and sustainability of the agricultural systems so that the quality of life among every segment of current and future generations could be improved. The IX Plan has to lay a strong foundation for second Green Revolution in Indian Agriculture. To achieve this major objective, the following specific objectives are proposed :

- Conservation, planned enhancement and utilization of agro-biodiversity.
- Enhancing productivity through evolution of high-yielding hybrids and varieties.
- Research on diversification, quality improvement, post-harvest technology, value addition and export-oriented commodities.
- Sustaining enhanced productivity of irrigated agriculture and judicious development and use of energy, especially renewable sources of energy.
- Characterization and development of sustainable land-use models for rainfed agriculture in high-rainfall areas.
- Development of the Integrated Pest Management (IPM) and Integrated Nutrient Management System (INMS) approaches and systems for sustainable agriculture.
- Fostering excellence in relevant basic and strategic research.
- Generating research and technologies geared to promote equity among regions, sectors of society and gender.
- Strengthening social science, policy planning, agri-business, research monitoring mechanisms, administration and personnel reforms, and publication and information dissemination system.
- Strengthening Agricultural Research Information System (ARIS).
- Promoting the Agricultural Human Resource Development (AHRD).
- Linking scientists with the farmers through Institute-Village Linkage Programme (IVLP) as an innovative technology transfer model.
- Institutionalization and strengthening linkages/partnerships with CGIAR and other national and international agencies and research and

development establishments, non-governmental organizations (NGOs), farmer organizations, private sector, etc.

- Optimization of resources through planning, prioritization and co-ordination.

Perspective

Agriculture continues to be the backbone of the Indian economy. The future of country's economic and social development is largely dependent upon the technological improvements in agriculture. A massive application of science and technology can enable the Indian agriculture to face the serious challenges of poverty and malnutrition by ensuring a food security system, and ensure an enviable place for Indian agricultural product-mix globally by enhancement of value-addition processes.

The country has made substantial progress in agriculture in terms of increased production and productivity. Despite its achievements in the past, the Indian agriculture continues to face serious challenges due to ever-increasing population, limited land and water availability, degradation of natural resources, and shrinking non-renewable energy sources.

ACHIEVEMENTS OF THE IX FIVE-YEAR PLAN

CROP SCIENCE

Plant Genetic Resources

- A total of 349 explorations were undertaken in diversity rich under explored areas and 22,194 new samples in cereals, vegetables, fruit crops, ornamental and aromatic plants were collected.
- A total of 36,381 accessions of 171 species of plants were stored in National Gene Bank for long term storage. In addition 180 species were planted in biodiversity Park at NBPGR, New Delhi.
- A total of 37,77,875 germplasm samples of various crops and 483 transgenic samples were examined and processed for quarantine clearance.
- DNA profile of 80 rice cultivars was completed. Forty aromatic rice cultivars were also profiled.
- RADP profiling of 50 Indian Barley cultivars was also completed.

- DNA finger printing of 30 different important species was initiated to safeguard the indigenous diversity.

Biotechnology

- Two high yielding varieties of Indian mustard 'Pusa Jai Kisan' and 'Pusa Gold' were developed through exploiting tissue culture technique.

- A semi dwarf of somaclone selection of Basmati rice, Basmati 370 was identified.

- A commercially exploitable cytoplasmic male sterility was developed through interspecific hybridization in Brassica species.

- Transhgenics for abiotic stresses have been developed in mustard and pigeonpea with lactic and protease inhibitor gene. Some other transgenics have been developed through use of Bt genes. Two molecular markers (RAPD) linked with gene AC-2 that control white rust in mustard have been identified.

Rice

- Seven hybrids, namely KPRH2 for Karnataka, DRRHA1 for Andhra Pradesh, Pant Shankar Dhan 1 and Narendra Shankar Dhan 2 for Uttar Pradesh, CORHA-2 and ADTRHA1 for Tamil Nadu and PA6201 for West Bengal, Tripura, A.P. and Karnataka were released.

- Eight varieties were released at the national level for different agroclimatic situations like usar soils, deep water, shallow lowland, hilly and irrigated ecologies. In addition 80 varieties have been released by different states for different ecologies.

Wheat

- 25 wheat varieties including one Dicoccum type, were released for cultivation in different agro-climatic regions. During this period India emerge as the second largest producer of the wheat, both in terms of quantity and per hectare of productivity.

- Technologies have been developed for zero-tillage cultivation and furrow-irrigated-raised-bed sowing, it saves seed and fertilizer upto 25% and water upto 60% without sacrificing productivity of wheat.

Maize

- Seventeen hybrids and one composite were released for cultivation in different agro-climatic zones.

- More emphasis was given on breeding single cross hybrid breeding as they show higher yield potential than double cross, double top cross and three way hybrids. This has resulted in release of number of single cross hybrids like Vivek Hybrid-4, Prakash, Pusa Hybrid 1 and Pusa hybrid 2. Besides 3 composits (Gaurav, Jawahar Composit Makka 12 and CoBC-1 (Baby corn) were released for different agro ecologies.

- During the IX Plan period a special emphasis was laid on development of nutritionally superior maize genotypes, accordingly a composite under the name Shakti-1 was released, besides high Tryptophane and lysine content, the composite is as high yield as the normal maize.

Sorghum

- Seven hybrids and four varieties covering adaptation to both kharif and rabi seasons were released.

- CSH-13 which has earlier been released for cultivation for grain purpose has also been recommended as forage sorghum throughout the country.

Pearl Millet

- Twenty one cultivars, including both hybrids and varieties, were released for cultivation in Rajasthan, Gujarat, Haryana, Uttar Pradesh, Madhya Pradesh, Maharashtra and Tamil Nadu.

- New cultivars are maintaining genetic resistance to disease downy mildew.

Small Millet

- Seven high yielding varieties of finger millet, three varieties each in foxtail millet, two varieties in kodo millet and one variety each in little millet and barnyard millet were released for cultivation.

- Profitable intercropping systems with grain legumes as component crops has been developed.

Under Utilized Crops

- Two varieties namely RBL 6 of ricebean and PRA 2 of grain amaranth were released for cultivation in Northern Plains and Himalayan Region, respectively.

Forage Crops

- Five new varieties : Bundel Berseem 2, Bundel Berseem 3, Bundel Jai 851, Bundel Guar 2 and Bundel Guar 3 were released.

- Desirable traits from *Avena sterilis* and *A. maroccana* successfully transferred to *A. sativa.*

- In vitro regeneration protocol developed in *Cenchrus, Dichanthium Panicum, Medicago* and *Trifolium.*

  A final prototype of "improved IGFRI tractor front mounted grass seed harvester" was fabricated.

Oilseeds

- A number of improved varieties and hybrids were released for cultivation. Some prominent varieties are given below :

Groundnut	:	HNG 10, CSMG 884
Rapeseed and mustard	:	CS 52, Pusa Agrani, Kiran, PCR 7, VSL 5
Soybean	:	MACS 450, Ahilya 4 (NRC 37), Parbhani Sona (MAUS 47), Hara Sona (Himso 1563)
Sesame	:	TKG 55
Sunflower	:	PAC 1091, LS 11, MLSFH 47, DSH-1, TCSH-1
Safflower	:	DSG 129, MKH 11, JSI-73, NARI-6, A-2
Castor	:	DCH 32, DCH 177, JHB-665, TMVCH-1, Kranti, PCH-1
Linseed	:	Shikha, LCK 9216, LMH 62

- For the first time safflower hybrids DSH 129 and MKH 11 were released in the country. These are suitable for irrigated as well as rainfed areas. These hybrids are first released hybrids in the whole world.

- A number of superior groundnut genotypes have been identified for various purposes. These include PBS 24004, PBS 24001 and PBS 11023 for summer cultivation; PBS 1039 for large seeds, early maturity and high protein content and PBS 23019, PBS 1057, PBS 12032 for resistance to major diseases.

- Genetics of male sterility has been studied for the first time in groundnut and was found to be governed by recessive gene.

- Six wild species of *Helianthus* were identified as resistant to alternaria which is one of the important disease in sunflower. The interspecific hybrids involving these species have been prepared.

- Castor genotypes RG 2659 and RG 2661 were identified as resistant to wilt and jassids.

- GMU 5097, SSF 200, SSF 90-16-10 and SSF 90-16-14 were identified as stable aphid tolerant germplasm accessions in safflower.

- Soybean genotypes NRC 7, NRC 25, JS 335, JS 71-07 and L 129 were found tolerant to general insect-pest complex besides high yield.

- Two varieties of soybean PK 1024 and PK 1029 were found resistant to most destructive disease of rust in soybean. The seed production of these varieties have been taken up on large scale to multigate the problem of rust in soybean.

- Imidacloprid @ 7.5 g/kg seed was found to reduce the jassids and thrips population leading to reduced incidence of necrosis disease in sunflower.

Pulses

- A number of improved varieties were developed and released in different pulse crops. Some of the important varieties are given below :

  Chickpea : DCP 92-3, KDG 1168 (Alok), Vishal, PDG 3, CSG 8962 (Karnal Channa-1), GCP 101 (Gujarat Gram-1), Pusa 1003 (Kabuli), BGD-72 (Pusa Pragati), BG 1053 (Pusa Chamatkar), JG-11, GCP 105.

  Pigeonpea: COPH-2 (Hybrid), Amar AKPH 4101 (Hybrid), Narendra Arhar-1, AKPH 2022 (Hybrid), Paras (H 82-1), MA-3 (Malviya Vikalp), Durga (ICPL 84031).

  Mungbean: Pant Mung 4 (UPM 92-1), HUM-1, Co 6, PBM 2, Pusa 9531, Pusa Bold-1 (Vishal).

  Urdbean: Vamban-2, Shekhar-1 (KU 301), TU 94-2, IPU 94-1 (Uttera), KU 92-1 (Azad Urd-1), RBU 38 (Barkha), WBG 26.

  Lentil: Narendra Masoor-1 (NDL 92-1), DPL 62 (sheri), JL 3, IPL 81 (Noori).

  Fieldpea: KFP 144-1, HUDP 15(Malviya Matar 15), DDR 23.

  Lathyrus: Bio L 212 (Ratan), Prateek.

  Mothbean: RMO-257, RMO-225, RMO-96, CAZRI Moth-1.

  Cowpea: V-585, GC-3, Vamban-1.

Horse gram: PHG-9, AK-21.

Guar: RGC-1003, RGC-986, RGC-1002.

- Many of the above mentioned varieties are resistant to important diseases such as wilt and sterility mosaic in pigeonpea, wilt in chickpea and yellow mosaic virus in green gram and black gram.

- Commercially exploitable cytoplasmic mole sterility (CMS) and its restorer has been perfected in pigeonpea for the first time. These CMS lines are likely to make hybrids in pigeonpea r reality.

- Pollen germination tests at 5^0C was found to be the best indicator of tolerance to low temperature in chickpea. Genotypes ICCV 88506 and ICCV 88503 were found to set pods at low temperature.

- Physiological characters namely relative water content, leaf area at flowering, specific leaf weight at podding and sucrose synthase activity alongwith canopy temperature and root length density were found important for drought tolerance in chickpea.

- Sources of resistance for major diseases and pests were identified and integrated pest management technology for *Helicoverpa armigera* in pigeonpea and chickpea was standardized.

- Technology for utera cultivation of urdbean and mungbean in rice fallows was developed for coastal areas of Andhra Pradesh, Tamil Nadu and Orissa.

Commecial Crops

- A total of 18 varieties / hybrids in cotton, 14 in sugarcane, 2 in jute and 45 in tobacco have been released / notified for commercial cultivation. These improved varieties / hybrids possess higher yield potential, resistance to important diseases / pests and / or better quality characteristics.

- Initial success in developing transgenics in cotton and tobacco has provided confidence for using this approach, in near future, for developing resistant / tolerant variants against important insects / pests, which should be ultimately contributing to reduction in prevailing excessive usage of pesticides.

- Among efficient crop / production technologies developed the following merit - special mention : (i) paired row planting and drip irrigation in cotton (ii) closure spacing, paired row planting and / or intercrops in sugarcane, (iii) application of growth promoters in improving jute fibre

production; and (iv) suitable cropping systems developed for different agro-climatic zones in tobacco.

- In crop protectio-releated researches, important achievements were : (i) IPM module comprising tolerant variety, seed treatment, release of parasites, balanced fertilizers, using soft and selective insecticides and hand-picking of eggs, larvae and damaged fruiting parts proved superior in cotton; (ii) lowering down disease incidence of cotton leaf curl virus in north zone, (iii) red rot pathotypes identification and spreading mechanism of smut disease in sugarcane; (iv) use of biocide, neem oil and *Beauveria bassiana* (an entomogenous fungus) against spiral borer larvae in Mesta; and (v) IPM technology for control of *Spodoptera litura* in nursery in tobacco etc.

Plant Protection

- Refinement of Integrated Pest management (IPM) methodologies specially biological control for important crops particularly cotton, pulses, sugarcane and rice was done. Biointensive (IPM) approach based on use of natural enemies and biopesticides proved as effective as chemical control in large scale trials.

- Mass production techniques for *Trichogramma, Chrysoperla, Coccinellids* and *Trichoderma* were further refined to make them cost effective.

- Endosulfan tolerant strain of bioagent *Trichogramma chilonis* has been developed and technology has been recommended. The strain has been named as ENDOGRAM and is the first of its kind in the world.

- The method for production of royal jelly from the European bee, *Apis mellifera* has been standardised. This species has also been shown to be superior in pollination in hybrid sunflower.

- Third generation rodenticides particularly, difethialone has proven effective for all economic species of rodents. A bait box “Robox” was developed for safe application of baits and tracking powder.

- Monitoring of pesticide residues in various commodities particularly vegetables was continued. At the farm gate 22 per cent samples of beans and peas were found to have residues above the MRL values. Endosulfan residues were detected in fish collected from fresh water lakes in West Bengal, while HCH was detected in samples from Kerala.

- The entomopathogenic fungus, *Metarrhizium enisopliae* was shown to have promise against white grub in ground nut crop. A pheromone isolated

from female beetles of *Holotrichia consanguinea* was successfully used for trapping and killing adult beetles.

- Biological control of nematodes was achieved by use of different species of *Trichoderma.* The importance of healthy nematode free nursery has been demonstrated for various vegetable crops.

- A bio-intensive IPM (BIPM) module was validated in cotton over a large area of 450 acres at village Ashta in Nanded District of Maharashtra. The module comprised of seed treatment with imidacloprid and reliance on bioagents and biopesticides and some altered crop management practices. The pest management schedule consisted of release of egg parasitoids *Trichogramma,* spray of HaNPV and use of botanicals (NSKE 5%). The most important achievement was the reduction in pesticide use and no insecticide residues were detected in both the BIPM and non BIPM villages.

Seed Technology Research and Breeder Seed Production

- About 20,000 to 25,000 quintal breeder seed of different crop varieties was produced every year for production of quality seed.

- Diagnostic characteristics of crop varieties parental lines of hybrids have been prepared and documented.

- Optimum planting ratios and isolation distances to maximize hybrid seed production of different crops were undertaken.

HORTICULTURE

- India is the second largest producer of fresh fruits and vegetables in the world. India ranks first in the world for production of mango and banana. The five fruits namely mango, banana, citrus, guava and apple account for 75 per cent of total fruit production in the country. Concerted research efforts have led to the development of dwarf, regular bearing mango hybrids, free from spongy tissue; thereby leading to marked increase in production and export of mango. *Dasheri* 51, a regular bearing and high yielding cultivar, has been developed by selection. Rejuvenation technology has been developed for old and unproductive mango trees for different regions of the country. A new mango variety, CISH M-1 has been identified for release as an export potential. In guava, variety Lalit maintained its superiority in production and quality of fruits. In citrus, Rasraj hybrid of acid lime has been released for cultivation. In banana, 18 improved varieties have been identified for commercial cultivation. A computer software has been developed for forecasting incidence of downy

mildew, powdery mildew and anthranose diseases. In pomegranate, variety Amlidana has been released for *anardana* purpose.

- In vegetables, improved hybrids of tomato, cabbage, cauliflower, onion, radish, brinjal and chilli have been developed to ensure their availability round the year. *In vitro* method has been developed for multiplication of a superior line (VRPS-101) in pointed gourd. The DNA fingerprints of all commercial cultivars and 14 old indigenous varieties of potato have been developed. Forecasting models for late blight have been developed for Western Uttar Pradesh, predicting disease appearance within 10 days of the forecast. In tropical tuber crops, two cassava hybrids (Sree Rekha and Sree Prabha), isolation of early maturing sweet potato grown are some of the salient achievements. The know-how for starch based biodegradable plastic technology; its demonstration and training have been imparted to four licensees. In mushroom, two high yielding strains of summer white button mushrooms (NCB-6 and NCB-13) yielding 15 kg fresh mushroom have been released for commercial cultivation. Mushroom ketch-up with an excellent taste/ aroma can be prepared from fresh mushrooms. In floriculture, eight varieties of rose, two hybrids of gladiolus and seven varieties of chrysanthemum have been released for cultivation.

- In plantation crops, a process for making snowball tender nut has been developed involving dehusking of the nut, groove making in the shell and scooping tool. Cashew Goa-1 has been identified for release in Goa. In spices, two varieties of black pepper (Panniyur-6 and Panniyur-7), one variety of cardamom (RR-1), three varieties of coriander (RCr-684, RCr-453, RCr-436), two varieties of fenugreek (Guj Methi 1 and RMt-303) and one variety each of cumin (Guj Cumin-3) and fennel (RF-101) have been identified and recommended for release. In medicinal and aromatic plants, four cultivars of *asgandh* has been found promising for total root yield and alkaline content. Four accessions of Safed Musli are found promising for root yield.

- Curing of onion during the rainy season with forced ventilation, followed by storing in cool chamber (without water supply), significantly checked rotting and storage losses. Pusa Gaurav and Sel 17 tomato were found ideal for preparation of dehydrated slice and *puree* respectively. Post harvest losses in grapes and Nagpur Mandarin have been significantly reduced through new packaging systems.

NATURAL RESOURCE MANAGEMENT

Resource Inventory

- Soil maps of Arunachal Pradesh (1:250,000 scale) and Bankura district (1:80,000 scale) of West Bengal have been digitized and analyzed. The National Bureau of Soil Survey and Land Use Planning has generated data for 18 states in digital format till date. Soil resource surveys of Madubani district of Bihar on 1,50,000 scale has been completed and soil based thematic maps have been prepared. The resource information of Bihar, Lakshadweep and Goa were digitised. Total 21 states/ Uts soil data have been digitised and can be used for planning.

- Bulletins of "Soil Climatic Database for Crop Planning", and 'Agro Ecological Sub Regions of India for Crop Planning and Development" have been released for macro-level agricultural planning of the country.

Water Management

- Under limited water supply, only one irrigation of 6 cm of wheat (cv Lok-1) at 31 days after sowing produced 3.78 t/ha grain yield at Powarkheda (M.P.) in clay loam soils. Water-use efficient, micro irrigation methods and technologies were developed for irrigation of horticultural, vegetable and plantation crops resulting in 30-50 % saving of water ane 20-40 % increase in crop yields. Feasibility of sub-surface drainage technology for waterlogged saline soils has been demonstrated. Technology consisting of farm pond and skimming wells has been developed for coastal saline areas.

Soil Management

- Bench terracing in 16 to 35 % slopes of red and lateritic soils reduced runoff from 15 to 30% and soil loss from 45 to 0.5 t/ha. Off-season tillage coinciding with pre-monsoon showers helped in increasing moisture. Conservation and efficient weed control. This resulted in up to 35 % increase in crop yields on Alfisols.

- Recharging of aquifers through watershed management raised the ground water table of Aravali foot hills by 2 meters.

- In Vertisols kharif-cropped, medium to high unimodal rainfall regions (mean annual rainfall < 750 mm) raised and sunken bed system was found most appropriate to provide drainage and storage of runoff.

Agro-forestry

- Information on existing agro-forestry techniques and identification, evaluation of peak performing multi-purpose trees (MPTs) has been compiled. Improvement of neem (*Azadirachta indica*), shisham (*Dalibergia sissoo*), *Anogeissus pendula* and tamarind has been intimated.

- Collection of 38 provenance and 28 plus trees of neem (*Azadirachta indica*), 33 plus trees of shisham (*Dalbergia sissoo*) and 28 provenance of *Anogeissus pendula* have been made and planted in the field for evaluation. Provenance of tamarind was collected from different parts of Karnataka state. Among the 40 provenance MTO-19, NTI-14, S-4, NTI-7 and NTI-15 recorded higher pod yield and also performed better.

- Difference agro-forestry systems such as agri-silviculture, agri-silvi-horticulture, agri-horticulture, silvi-pasture systems have been developed and evaluated for different agro-ecological regions.

Agro-Meteorology

- Agro-climate characterization of the country based on moisture, thermal and sunshine regimes has been acccomplished. Agricultural production strategies were developed for agromet advisories based on weather forecasts.

ANIMAL SCIENCE DIVISION

- Livestock census data bank integrated with the information system on Animal Genetic Resources of India. Cattle and Buffalo breed calendars of indigenous breeds developed.

- Systematic field surveys undertaken to assess the population status of the breeds, socio-economic condition of the farmers, production performance and interaction of the local ecology with the breeds. *In situ* conservation models for different species developed.

- Genetic fingerprinting profiles successfully used for establishing biological relationships, linkage analysis and phylogenetic relationship among related species. DNA finger printing analysis carried out. Biochemical polymorphism studied. Emphasis given on collection, evaluation and documentation of available germplasm in the country.

- First lactation milk yield in 300 days and less in Frieswal cows averaged 2837.4 kg.

- Conservation and genetic improvement of 4 important Indigenous breeds of cattle (Hariana, Ongole, Gir and Tharparkar) undertaken in their native tract through Associated Herd Progeny Testing Programme.

- Top ranking sires of Murrah buffalo bulls identified. Semen of proven bulls used for nominated matings and for sale to breeding agencies. Improvement programmes for other important buffalo breeds initiated.

- Indigenous sheep breeds improved through selection for increased mutton, carpet and fine wool production.

* Indigenous goat breeds improved through selection for milk and meat. Elite bucks of Jamunapari, Barbari and Sirohi breed produced.

- Indigenous pig breeds studied for improved production and feed efficiency.

- Rabbit improvement for Angora wool and meat undertaken with success.

- Research work undertaken on conservation and utilisation of indigenous fowl.

- Development of synthetic broiler male line with white colour plumage undertaken.

- Commercial test cross (KRISHIBRO) from coloured pure line developed. New synthetic coloured control broiler population developed to measure the environmental trend for the selected lines.

- Parents of VANARAJA chicks selected with special emphasis on colour combination besides other traits of economic importance.

- A national level data base information system to access the livestock feed resources on existing situation initiated.

- New byproducts resources which may become potential feed supplement are under trial in different states. Area specific mineral supplements suggested for the states of Kerala and Tamilnadu.

- Semen freezing protocol for higher posts thaw motility and fertility developed in goats. Technique of semen preservation for field condition evolved which has a potential of commercial exploitation. Semen studies undertaken in Camel, Mithun and Yak. Physiological behaviour of Yak, Mithun and Double Humped Camel of Ladakh the three rare animals of North, Western and Eastern Himalayan region studied.

- Major nutrient requirements of indigenous cattle and buffalo determined. Feeding standards for energy and protein developed for cattle buffaloes, sheep, rabbits and poultry. Newer technologies relating to manipulating rumen microbes especially defaunation and by pass protein supplementation and protection of protected fat in the getting of high producing animals used.

- Embryo transfer technology used among buffalo, cattle, sheep and goat. Standard protocols for superovulation and embryo transfer for faster multiplication of females in breeding technologies standardised. *In vitro*, buffalo calves successfully produced.

- A new mineral mixture developed to compensate the deficiency of minerals, area wise.

- Developed various immuno-biological and immuno diagnostic for livestock and poultry disease using conventional and biotechnological approaches.

- Monoclonals developed against variety of disease agents and for hormones being used for the diagnosis if reproductive disorders.

- African Horse Sickness (AHS), Equine infectious Anemia (EIA) an Equine Influenza (EA), Rinderpest and other livestock and poultry disease of economic importance controlled successfully by precise and early diagnosis and incidence of FMD reduced through proper diagnosis of effective vaccination.

- Effective disease simulating model and reporting system developed.

- Detailed epidemiology of various diseases undertaken.

- Technologies for milk products namely kheer mix, mozzarella cheese, edam cheese, dehydrated paneer ready to serve soft drink (butter milk) developed.

- Technologies for milk products namely kheer mix, mozzarella cheese, edam cheese, dehydrated paneer ready to serve soft drink (butter milk) developed.

- Technologies of buffalo meat products (restructure rolls), sheep and goat meat products (patties and nuggets) and rabbit meat products (patties, nuggets, sausages, meat balls and boty kababs) developed.

- Harshil wool as a substitute for imported merino wool for blending with Angora rabbit hair.

FISHERIES

Estimation of Marine Fish Production

- The marine fish production in India during 1999 has been estimated by CMFRI at 2.44 million tones which is 8.6% (2,30,000 t) less compared to 1998. The pelagic group formed 52.7% of the total landings and demersal finish, crustaceans and mollusks together 47.3%. The landings by mechanized sector accounted for 66% of the production, motorized sector 26% and artisanal sector 8%. Kerala contributed 23.8% of the production closely followed by Gujarat (23.6%). Tamilnadu accounted for 15.4%, followed by Maharashtra (12.2%), Andhra Pradesh (9.6%), Karnataka (6.8%), Orissa (2.4%) and West Bengal (2.3%) and Goa, Pondicherry and Island Territories (3.9%). Among the commercially important varieties of fish, shrimps formed 13.2%, oil sardine 9.9%, other sardines 5.2%, sciaenids 6.9%, perches 6%, mackerel 8.6%, crangids 5.2%, ribbonfish 5.1% and bombayduck 3.8%.

- In an effort to understand the production of Indian reservoirs and their classification into various types so as to formulated guidelines for their development, CIFRI through a rapid survey, characterized the reservoirs based on their ecological characteristics, biodiversity and fish yield potential. The study suggested need for optimum stocking rate (250 fingerlings/ha) and appropriate harvesting practices. Suitable steps need also be taken to check fish escape through spillway and channel mouths, for development or reservoir fishery in the state. It further emphasised need for conservation of snow trout and masheer in Nangal lake, along with checking the growth of macrophtes. In Himachal Pradesh, intensification of ongoing stocking of coldwater fishes has been recommended for the fishery development of Chamera reservoir. In Tamilnadu nine reservoirs were surveyed which revealed low to medium productivity and poor fish species diversity. Survey of reservoirs in these states indicated much lower fish production than the estimated production potential. This gives enough scope for enhancement of fish production from these reservoirs through judicious stocking and exploitation.

Environmental impact assessment studies in rivers and associated ecosystem

- To assess the environmental perturbations and its impact on ecology of river Ganges, Yamuna, Hooghly, Haldi and Tapti at various points, studies were undertaken on hydro-biological, bio-chemical, micro-biological parameters. Bioassay with fish in the laboratory and in situ experiments were undertaken with industrial wastes to suggest minimal

standards permissible for industrial wastes discharge into aquatic system to safeguard aquatic resources of riverine systems.

Brackishwater Aquaculture

- The CIBA achieved a major breakthrough in the captive broodstock development, induced breeding and seed production of the Asian seabass *Lates calacrifer*. Hatchery-produced seabass seed were sold to progressive fish farmers.

- The CIBA has conducted extensive investigations on white spot virus disease of shrimp. A simple diagnostic technique was developed for diagnosis of white spot virus disease in shrimp which employs histological methods. Validation of the technique was done through polymerase chain reaction (PCR) test. Studies on virulence status of white spot disease virus showed that shrimp *P. monodon* and *P. indicus* were able to accommodate the virus in the body without much effect on growth and survival of shrimp.

Multiple Breeding Catfish, Heteropneustes Fossils

- "Singhi" is a seasonal breeder in natural condition, with the peak breeding activity found during July to August. By careful management practices coupled with hormonal manipulation, the fish could be bred during the pre-monsoon season. With the hormonal and management practices manipulation, the same fish again rematured and bred in the month of June and August. Thus with the successful multiple breeding one can obtain more than thrice the number of juveniles as compared to single breeding.

Optimisation of carp production through intensive aquaculture and multiple cropping

- Under the intensive carp culture programme a production level as high as 17.3 t/ha/yr has been achieved. It is known that feed accounts for over 60% of the total recurring cost in fish cultures. Through multiple cropping, it will be possible to reduce the cost at least by 20-30% besides providing revenue from the harvest at regular intervals. The experiments conducted through double cropping recorded production levels of 719 kg/ha/yr against mean production rates of 6011 kg/ha/yr and 6488 kg/ha/hr. Under single cropping and single stocking and multiple harvesting respectively. Introduction of prawn and magur in the carp polyculture system provides for diversification.

Carp seed production and culture

- Multiple cropping of carps with 10,000 fingerlings/ha stocking and 6 species combination (catla, rohu, mrigal, silver carp, grass, carp & common carp) yielded 46.1% higher production than three species combination with same density and 103% higher than three species combination at 5000 nos/ha stocking density. With single stocking and multiple harvesting techniques, culture of *Cirrhinus* reba, 50,000 and 100,000/ha, together with prawn *M. rosenbergii* @ 20,000/h gave a total production of 1.13 and 1.14 t/ha respectively within 7-8 months.

- Cap milt from selected milter from Indian major carps were cryopreserved in bulk and tested in different states like Tamil Nadu, Karnataka, Orissa, Haryana and Madhya Pradesh. Milt samples form improved rohu, Jayanti were also cryopreserved.

Genetic improvement and biotechnology

- An average of 22% selection response per generation was observed after two generation of selective breeding in first line population rohu, while 47.5% selection response was observed in second line base population after first generation of selection breeding. A total of 1.14 million of CIFA-IRI spawn was produced and reared in nursery ponds. Field testing of improved rohu was initiated in four different ORP centers of CIFA and state farms. Viz. Ludhiana (Punjab), Bangalore (Karnataka), Vijayawada (Andhra Pradesh), and Kausalyagang (Orissa).

Seed production of golden Mahseer Tor Putitora

- Having standardised the technique for artificial propagation of *Tor Putitora*, the NRCCWF is continuing its efforts in the seed production of this important coldwater fish species. The seed produced is being supplied to different clinents for its germplasm evaluation and related studies to different R&D organization in the uplands states of the country.

DNA studies

- DNA was isolated from Rohu collected from Punjab, Mahanadi and Tapti, Catla from Punjab, Mrigal from Yamuna, Gomti and Sutlej.

***In situ* Conservation**

- Survey were carried out in 2 selected sanctuaries viz., Samaspur Bird Sanctuary and Katerniaghat Wildlife Sanctuary. The information on the fish genetic resources, habitat parameters and socio economic data were collected. The experimental fishing indicated availability of endangered

fishes like *Notopterus chitala, Ompak pabda* along with Indian Major Carps. Remote sensing images and SOI toposheets of the above sanctuaries were also collected.

Fish Processing Technology

- An inovative value added product from the dark meat of tuna (Euthynnus affinisf) was developed as a means of effective utilisation of the under exploited fishery resource. Procedure was standardised for preparation of battered and breaded products from cultured oyster. Technology was also developed for canning crown conch meat and its optimum conditions standardised. An HACCP plan for production of frozen while fish steak and fillets was also standardized.

- The CIFT in collaboration with Naval Physical and Oceanographic laboratory, Cochin has developed a Net Height Meter with wide beam transducers (Beam width 70^0C) for measurement of vertical opening of a trawl net under tow, in the range 0.5 m - 9.9 m with an accuracy of + 5 cm. The light weight of the transducer (Less than 500 g), portability of the instrument and cable winch, accurate, consistent and foolproof method of measurement of vertical opening of trawl nets and low cost import substitution are the advantages of this acoustic telemetering system. The instrument is found reliable for monitoring the performance of trawl gear. Steps are underway for patenting the technology.

Fish Processing Technology

- Curry prepared from *Chanos Chanos* stored in -35^0C for eight months and then at -20^0C for four months were in acceptable condition. Cutlets were prepared from minced thread fin bream by incorporating mint and coriander leaves. The ready to serve Rohu in curry in retortable pouches after 15 months of storage had good acceptability. Storage studies on sausages packed in synthetic edible casins also showed good acceptability. Vacuum packed ready to serve fried mussels were found to be superior to air packed samples.

Fisheries education

- The CIFE continued to offer doctoral, masters and post-graduate diploma and certificate courses in fisheries through its headquarters and research / education / training centres. The CMFRI continued its M.Sc. and Ph.D. programmes in Mariculture in collaboration with CIFE. New M.F.Sc. courses in Fish Processing Technology and a total of 83 students successfully completed the various Post-graduate and certificate programme of CIFE during the year under report in the fields of Fisheries

Resource Management, Inland Aquaculture, Maricuilture, Freshwater Aquaculture, Post-Harvest Technology. A total of 89 students have beena dmitted during year 200-2001 for various post-graduates and certificate courses offered by the CIFE.

Biodiversity

- Setting up of 4 marine parks, 2 in east and 2 in west coast for consumption and stock enhancement of depleted fish stocks by sea ranching. This includes construction of hatcheries, grow-out systems and releasing fingerlings to sea. The parks also will house endangered species.

AGRICULTURAL ENGINEERING DIVISION

Farm Implements and machinery

- Zero-Till Drill used on more than one lakh hectare for wheat sowing after rice.

- Raised Bed Planter, Rice Transplanter, Drum Seeder, Sugarcane set cutter planter introduced and used on large areas.

- Pneumatic planter developed at CIAE taken by a Tractor company for commercialisation.

- Animal/Tractor operated inclined plate planters designed, developed and released for extension.

- Spiked clod crusher, lugged wheel puddler, garlic planter, groundnut thresher for green crops and high capacity multi-crop thresher designed and developed.

- Self-propelled power weeder developed and commercialised.

- Riding type vertical conveyor reaper design refined and commercialised.

- Six Prototypes Production Workshops established in different parts of the country. Twenty one Revolving Fund Schemes for Production of newly developed equipment established.

- About 5000 prototypes of different types of newly developed equipment manufactured and supplied for front line demonstration.

- Anthropometric and physiological cost data of men and women collected so that the agricultural implements could be modified to suit Indian population.

- Data on accidents due to agricultural machinery are being collected to suggest remedial measures.

- Selected equipment identified for operation by women workers were modified on ergonomic considerations.

- A computer aided design facility has been created at CIAE Bhopal which has helped in reducing time for designing of agricultural machines.

Post Harvest Engineering and Technology

- Seed extractor for chillies, Groundnut pod grader, Bengal gram stripping-cum-shelling machine, Battery-operated smoker, Radial honey extractor, Power ribboner, Solar fruit and vegetable dehydrator, Pin mill, Cylindrical dryer, Low cost green house have been designed and developed.

- Tamarind Dehusker Deseeder developed and commercialised.

- Noise and air pollution of dal mills studied and remedial measures suggested.

- Model Agro-processing centres developed in different regions.

- Bio-pesticides for grain storage developed and patented.

- An efficient indigenous device for lac-insect pest management has been developed. A trivoltine quick growing lac insect species discovered and an economical varnish, based on dewaxed lac developed for wood.

- Natural coloured cotton evaluated for technological properties. Effect of drip irrigation on yield and quality of cotton assessed. A two-step process for making pulp from crop residues has been standardized. Efforts made to reduce stickness of cotton. A foot operated cotton gin and a portable laghu otai yantra for quick and accurate estimation of ginning percentage developed. Drying techniques for dyeing viscose-cotton blended fabrics with natural indigo developed.

- Method of retting of green jute ribbons standardised. Diversified jute products, improved ribboner and geo-textiles developed. Use of needle-punched non-woven fabric for reducing soil erosion of river banks demonstrated.

Energy in Agriculture

- Solar dryer for onion flakes, Double mirror solar cooker and Step type solar dryer for cocoon stifling developed.

- Biomass gasifiers and solar dryers specifically designed for different enterprises were adopted which helped in reducing their energy cost by more than 50%.

- Simple farm level bulk esterification system for methyl esters of linseed, sunflower, rice-bran and jatropha curcas oils developed and plant oil ester used for running diesel engines and tractors (without any change in the engine)_ for more than 1000 hours without any difficulty are loss of power.

Irrigation and Drainage Engineering

- In Coastal saline soils, use of subsurface drainage resulted in removal of dissolved salts.

- Surface drainage in acid sulphate soils of Kuttenad region of Kerala which is below sea level, have made possible for the farmers to successfully raise paddy.

- Multiple well point system for controlled pumping of ground water in regions with limited fresh water aquifer found acceptability among the farming community.

- The optimum depth and spacing of subsurface drainage system for a village of Faridkot district of Punjab established in saline sodic soil and for paddy wheat rotation.

- Subsurface drainage system complete with design specification and method of planting eucalyptus in saline sodic soil developed.

- In Dankuni basin in Hoogly district of West Bengal, a raised bed-pond system of changing the local topography has been found useful for the farmers to achieve higher yield of the subsequent rabi crop by utilizing this stored water.

- A computerised modern Pump testing facility has been developed at CIAE Bhopal.

EDUCATION DIVISION

Development and Strengthening of SAUs

- During the IX Plan development grants are being released on college wise basis. The contingency grant has been enhanced to @ Rs. 1,000 and Rs. 3,000 per student in agriculture and veterinary sciences respectively as against @ Rs. 2,000 in the VIIIth Plan. RAWE has been made integral

component of all degree programmes in Agricultural and allied Sciences. During the period students undergoing RAWE will be paid stipend of Rs. 500/- p.m. by ICAR and Rs. 250/- by the State. In addition, Rs. 250/- per student per month will be paid by ICAR to the institutes for operationalising the scheme. Further, support is being provided for infrastructural development of UG practical, development of practical manuals, computerisation for UG teaching, faculty competence improvement, strengthening of libraries, renovation of laboratories and construction of girl's hostels. All SAUs have been provided support for VSAT connectivity so that faculty members are able to provide latest state of art technology to graduates. Besides this, the ICAR also extends financial support in respect of

- Development and strengthening grant for Central Universities (HBU, AMU and Viswa Bharati)
- Strengthening PG Education in Deemed to be universities.
- Agricultural education outside SAUs system
- Centre of Advanced Studies
- All India Coordinate Research Project on Home Science
- Establishing Agri-poly clinics in all State Agricultural Universities for providing hands on experience in soil plant analysis, disease diagnosis and other services which would allow them to be technological agents in villages.
- Strengthening Instructional farms (Agriculture, Horticulture, Cattle, Sheep and Goat, Poultry) in all State Agricultural Universities for skill development.
- Home Science curricula have been completed restructured. The new curriculum consists of two years of the course work and two years exclusively utilized for skill and entrepreneurship development in chosen area of study.
- Fisheries Education opens new opportunity for global competitiveness. Special grants have been provided for infrastructure development for new courses.
- A policy decision has been taken that State Agricultural Universities will start non-formal need based vocational programmes.

Central Agricultural University

- The Central Agricultural University of Imphal was established in 1993 to develop agricultural human resources for the states of North Eastern region. The College of Agriculture, Imphal (Manipur) has completed its second batch of B.Sc. (Ag.) graduates. The university has also started Post-graduate teaching programme in Agronomy, Plant Pathology, Entomology and Extension. The B.V.Sc. and Animal Husbandry Programme at Veterinary College, Selesih in Mizoram and B.F.Sc. Programme at Lembuchera in Tripura have started their academic activities. The second batch of students of B.V.Sc. and A.H. of CAU have admitted.

Accreditation Board

- After the establishment of the accreditation Board (AB) in 1996 new accreditation process has been developed, which is comprehensive, rigorous and periodic.

- Four SAUs with their 32 constituent colleges have been accredited under new process of accreditation. Eight more SAUs with their 40 college are under accreditation.

- The Accreditation Board has developed and implemented uniform academic regulations and curricula for UG and PG education in the country.

- Norms and standards for different colleges/faculties have also been developed.

- A national symposium on Accreditation for Quality Assurance in Agricultural Education was organized successfully on 23-24 November, 2000. Several useful recommendations have been made which are being examined by the Accreditation Board for implementation.

Capacity Building for Human Resources Development

- Modernisation of students laboratories and class-rooms including provision of audio-visual aids.

- Library strengthening by providing support for journals, computers, photocopiers and CD-ROM.

- Computerization and computer training to faculty members and students.

- All colleges provided computers.

- Establishment of students computer laboratory at college level.
- Students counselling and placement cell established in all SAUs.
- Full financial support to CIFE and participating Universities for construction of Girls Hostel for women empowerment.
- Foreign students admission increased by four colds.
- Support to institutions outside SAU's system which have strength, infrastructure facilities and commitment was recommended and institutions which lacks requisite facilities to be converted to KVKs or vocational polytechnics (Dr. Kirti Singh Committee Report).

Publications

- Fifty years of Agricultural Education in India.
- Accreditation for Quality Assurance in Agricultural Education
- M.S. Swaminathan Committee Report on Education for Agriculture : Bridge to a Century of Hope on the Farm Front.
- Academic Regulations and Curriculum for Degree Programmes.
    - Diary Technology
    - Agricultural Engineering
    - Fisheries
    - Agriculture
- Brochures on achievements of AHRD
- Academic regulations and curriculum for PG programmes in Agronomy, Agriculture Physics, Agriculture Meteorology, Soil Science and Agriculture Chemistry.
- Highlights of Centres of Advanced Studies.
- AICRP on Home Science
- Manual of Accreditation of Higher Agricultural Education
- Proceedings of the vice Chancellors Conference 1990-99.

AGRICULTURE EXTENSION

- During the IXth Plan the Division continues to implement 261 KVKs the activities of which include on-farm testing to establish location specificity

of technology, frontline demonstration to establish production potentials on farmer's plots, training of farmers to update their knowledge and training of extension personnel to update their knowledge in frontier areas of technology.

- The Division continues to implement 8 Trainers Training Centres (TTC) to impact training to the trainers on specialised areas like Dairying, Dryland Agriculture, Agricultural Engineering, Hill Agriculture, Horticulture, Marine Fisheries, Fresh Water Acquaculture and Women in Agriculture.

- The Council has proposed for establishment of 66 new KVKs and 2 TTCs during this year including 25 KVKs exclusively for North-Eastern region.

- The Council has strengthened 52 Zonal Agricultural Research Stations (ZARS) to take up the additional functions of KVK.

- Established 40 Agricultural Technology Information Centres (ATIC) in SAUs and ICAR institutes as single window delivery system for technology project, services and information.

- Established pig breeding cum extension centres in ten KVKs.

- Ten energy parks have been sanctioned for its establishment in ten KVKs.

- Taken up project by 38 KVKs under centrally sponsored scheme of Intensive Cotton Development Programme (ICDP- Cotton) under Mini-Mission-II of Technology Mission on Cotton for the year 2001-2002.

- Implementation of Mission-Mode Project on Collection, Documentation and Validation of Indigenous Technical Knowledge (ITK) under NATP.

- Implementation of Mission-Mode Project on Validation and Promotion of IPM Technology in Selected Crops in Different Agro-Ecological Regions under NATP.

- Strengthening of 29 Directorate of Extension and 8 Zonal Coordinating Units under NATP

- Implementation of Technology Assessment and Refinement through Institution - Village Linkage Programme (IVLP) in 70 centres of SAUs and ICAR institutes under NATP.

Salient achievements during IXth Five Year Plant (1st 4 years)

- Organised 41,636 training programmes benefiting 9.5 lakh farmers and farm women.

- Organised 9773 long term vocational and skill oriented training programme covering 1.91 lakhs rural youths.
- Conducted 4550 training programmes for 1.01 lakhs in service personnel.
- Extension activities organised include kisan mela (1068), field days (3621), kisan gosthi (2479) Radio and TV talk (5543), film show (3008), exhibition (1429) beside various other activities.
- TTCs organised 634 training programmes benefiting 4899 participants.
- Frontline Demonstration on oilseed and pulses crops were conducted covering 14,926 ha with the participation of 37-57 farmers in oilseed and 9440 ha with 27,525 farmers in pulses crops.
- On farm trials on important problem based under farmers perspectives were conducted.
- The KVK produced 1900 tonnes seeds of important cereals crops, besides 460 tonnes of oilseeds and 126 tonnes of pulses, besides 18.00 lakhs of vegetables seedlings, fruit, forest and tea saplings.

AGRICULTURAL ECONOMICS AND STATISTICS

- Research in Agricultural Economics has focused mainly on technology policy; impact assessment; sustainable agricultural systems; markers and trade including liberalization and WTO; and institutional changes. Though, the benefits of research in agriculture have percolated down to the poor people, more efforts are required for speedy transfer of benefits to rural poor through development of irrigation facilities and bio-mechanical technologies and increasing cropping intensity and productivity of rain fed agriculture. Studies have brought out that erratic input supplies, lack of access to institutional credit and insurance and high price risk need to be alleviated through policy. Adoption of integrated post-harvest management has proved favourable in generating additional income and employment. There is enormous potential to raise brackish water aquaculture production through area expansion. In A.P. and Karnataka tanks are found to be important source of irrigation in the rainfed regions. The implementations of W.T.O. Agreement would have a mixed impact on Indian agriculture. There is a sufficient potential to raise export of livestock products. Improved agricultural technologies have helped increase calorie intake of the farm households. In U.P., agricultural diversification towards high value crops has enhanced potential to generate income and employment. There are disparities in per capita agricultural income across Indian States. The studies indicate

that there is a need to encourage private investment for sustainable growth of Indian Agriculture which includes crop, horticulture, fisheries and livestock sub-sectors. Besides technology assessment, agricultural labour problems, nutritional security, feasibility of IPM, rural poverty, export of livestock products and ICAR-Industry interface have been studied. A number of policy papers and briefs have been published by the NCAP.

- In Agricultural Statistics, sample survey techniques for estimation of parameters relating to crops, livestock, fisheries, and allied fields have been developed. Remote sensing Technology was used in crop yield estimation surveys. Satellite data in the form of vegetation indices were used for post-stratification of crop areas and yield. Some methods of construction of design were suggested along with a catalogue of efficient design. Forecasting techniques from early warning system have been developed. Database Management System Group has developed a national information system on Agricultural Education. Project Information and Management System (Sandalone Versioln) was designed and is being developed in 5 modules. The existing LAN has been strengthened by extending connectivity to 68 nodes using the structured cabling. A number of training programmes for various levels of end users in computer application have been conducted. A website (www. Isc. 2001. nic.in) has been created and maintained in connection with computerisation of the work of Indian Science Congress, 2001. Junior Certificate, Senior Certificate and Professions Statisticians' Certificate courses have been conducted by the IASR Institute. Some specific designs and analytical tools used by the scientists of NARS have been developed. Research priority setting and prioritizations Project monitoring and Evaluation (PME) and under NATP has been running successfully). At IASRI, M.Sc. (Agril. Stat. and Computer Application) and Ph.D. (Agril. Stat) courses, in collaboration with IARI, are being conducted.

CONSTITUTION OF SUB-GROUPS

Agriculture Research and Education is not only a very broad area but very vital for creating a knowledge base and developing technologies that should result in enhancing contribution of agriculture and allied sector to the national economy while maintaining and preserving natural resources for the posterity. Since agriculture includes a variety of subjects the Chairman constituted the following Sub-Groups chaired by eminent scientists and personalities in India. Each sub-group consisted of several scientists some of whom should be the witness to the change which the Xth Five Year Plan can usher in. The sub-groups were as follows :

		Chairman	Member Secretary
1.	Climate and Agriculture	S.M. Virmani	P.K. Aggarwal
2.	Resource Management	S.S. Prihar	R.L. Yadav
3.	Rainfed Agriculture	J.C. Katyal	H.P. Singh
4.	Agromachinery and Energy	B.S. Pathak	N.S.L. Shrivastava
5.	Crop Science	E.A. Siddiq	O.P. Govila
6.	Animal Science	P.N. Bhat	Arun Kumar
7.	Horticulture & Protected Agriculture	G. Kalloo	Pitam Chandra
8.	Fisheries	K. Gopakumar	B.N. Singh
9.	Biotechnology	G. Padmanabhan	K.R. Koundal
10.	Education & HRD	H.K. Jain	Anupam Varma
11.	Agriculture Extension	A.G. Sawant	Mrs. Tej Verma
12.	Agroeconomics & Rural Development	Abhijit Sen	Mruthyunjaya
13.	NATP & ATMA	H.K. Jain	P.L. Gautam
14.	Organization, Finance & Management	Anil Gupta	Murthyunjaya
15.	Plant Protection, Sanitary and Phytosanitary Measures	Anupam Varma	Amerika Singh

All Sub-Groups discussed the various issues and came up with their reports which are included as a part of this report.

ISSUES IDENTIFIED

1. The Planning Commission envisages a growth rate of 9% to which agriculture sector would be required to have a growth rate of 4.7 % in Xth Plan. This is against 0.7 % and 0.9 growth rate in 1999-2000 and 2000-2001 respectively.

2. The decline in growth rate of agriculture could be because of many factors, but we need introspection about agriculture research and education, the important factors providing knowledge base to agriculture. This is despite the fact that the number of ICAR Institutes and State Agriculture Universities (SAUs) has increased considerably in last decade or more. Have we spread our resources too thin, and our emphasis on different aspects of agriculture has been uneven. This is a larger question, which this Working Group can not address in such a short time. This would also require expertise outside agriculture in life science research and education, particularly in the context of globalisation and competitiveness of agriculture.

3. With the above background, the following issues were identified :

   (a) Identify reasons for declining in productivity and growth rates in agriculture sector, either of individual crops or cropping systems if any. Assess the efforts of ICAR institutes and SAU to meet the above problems, the latter particularly in the region of their operation.

   (b) Degradation of natural resources — land, water, air, biodiversity etc. Assess the present status and research objectives for future for overcoming the degradation processes while maintaining productivity of crops, livestock and fisheries.

   (c) Assess progress in the application of agroecological zones concept in planning for crops, livestock, fisheries, input efficiency and other factors for providing, productivity, production and economic options to farmers.

   (d) Integration of disciplinary research for a common objective (Research mission) such as improvement in productivity of pulses, oil seeds, rainfed, cropping and farming system research - present status and future plans.

   (e) Assessment of losses caused by biotic and abiotic stresses in crops, livestock, fisheries and agroforestry system, control/reduction of losses with/without chemical pesticides and natural products,

biopesticides and other means. Evaluation of sanitary and phytosanitary measures in agricultural products for use nationally and for exports. Measures for research application and plans for monitoring losses. Research for identification of seasons and regions for quality control.

(f) Critical assessment of IPM (Integrated Pest Management) in individual crops and various cropping systems. Identify factors that limit its spread, research, production, education or transfer of technology mechanism.

(g) Critical assessment of INM (Integrated Nutrient Management) with or without water. What progress has been made in reproducibility of results of biofertilisers in field (Rhizobium, growth promoting bacteria, phosphate solubilizing bacteria, Blue green algae or any other). Assess area covered by biofertilisers, reasons for limited use if any.

(h) What is the prospect of private sector contributing to agriculture research, and what mechanisms are needed to bring collaboration and complementation between private and public sectors.

(i) Biotechnology and genetics engineering in crops, animals, fishes etc. are internationally emerging new tools for improvement and management of crops and livestock productivity. What is the present status of research and what mechanisms are needed to make this technology effective in life science and agriculture.

4. Centre-State relationship in agriculture research, education and extension.

5. Relationship among different institutions of ICAR for addressing the emerging problems in agriculture and the possibility of merging some of them with other Institutes or Universities.

6. Projections and research needs of mechanization and energy in agriculture and role of organised and unorganised sectors (small-scale industry) in mechanisation.

7. Relationship of ICAR, SAU and UAHS (Universities of Arts, Humanities and Science) for meeting the needs of life science, environment and natural resources related to agriculture.

8. Assessment of technology transfer in general, but particularly in tribal areas, hills, rainfed and other disadvantaged regions for their economic growth and human welfare - research and education needs.

NATP

- Projects sanctioned 28, 41, 263, 70 and 269 under ToE, MM, PSR, IVLP and CGP respectively

- Three cropping systems identified for research under Irrigated agro-ecosystem. Biotic, abiotic and socio-economic production constraints identified and prioritized in rice-wheat; Azotobactor strains HT 57, E-12 and AC-18 proved useful in wheat in cotton-wheat based; and an intercropped dual-purpose cowpea showed scope of mid-season income generation in sugarcane-based cropping systems

- In Coastal agro-ecosystem, baculovirus release through infected beetles showed promise in IPM strategy for rhinoceros beetle; extraction technique of DNA from coconut palm tissue standardized.

- Researchable issues identified and prioritized for sustainable NRM to increase agricultural productivity in Hill and mountain agro-ecosystem.

- 44 Project Centres started activities in 151 villages, covering 36,914 farmers with 1,428 technological interventions for Technology Assessment and Refinement.

- of the 28 ToEs, eight exclusively relate to HRD activities.

- Two mission mode programmes (Plant bio-diversity and Household food and nutritional security) considered as national priority programme hence brought under *jai Vigyan National Science and Technology Mission*

    - Pearlmillet hybrids Pusa 605, Pusa 415, RHB 909, HHB 94 released; GT 288A, CMS-based pigeonpea hybrid, performed 100% across different locations; successful *in vitro* regeneration of pigeonpea and genetic transformation of Indian genotype of cotton.
    - Protocols standardized for purification of citrus ringspot, citrus mosaic and potato virus Y; Viriods diagnosed in citrus and potato; male-sterile (MS) lines developed in brinjal for hybrid production; genetic and cytoplasmic MS lines of chilli also introduced from abroad
    - Watersheds identified selected and mapped; PRA in Almas Watershed (Dehra Dun) completed
    - Methods standardized for microbial and antimicrobial titre, pesticide residues and adulterants in food from livestock and poultry; 'F' gene-based PCR technique standardized for diagnosis of PPR
    - Samples of fish species collected for DNA studies; survey on fish germplasm carried out in Western Ghats streams, covering five river basins

- Whiteness and brightness of jute fibre improved
- Agricultural Technology Information Centres (40) started functioning to provide services for farmers' benefit
- Remandated 20 Zonal Agricultural Research Stations initiated actions
- Strengthened Directorates of Extension Education of 29 SAUs and 8 Zonal Coordination Units
- A good deal of work done in NCAP's component of macro-level priority, impact assessment and networking social scientists
- Comprehensive Training Plan finalised, a number of training programmes held including international ones.
- Technical and financial evaluation for two consultancies (Review of National Institutes and Personnel Policies of ICAR) completed; World Bank approved the TORs for commercialization of ICAR Technologies.
- Institutions interested in availing facility of Competitive Grant Programme invited to submit research proposals from prioritised area.

ISSUES TO BE ADDRESSED

1. Identify Projects / Programmes, which should continues and their approximate cost.
2. Identify Projects / Programmes that need to be dropped and their approximate cost.
3. Identify Projects / Programme that need to be merged with their Projects / Programmes.
4. Identify Projects / Programmes, which should be transferred to the State Agricultural Universities.
5. Identify Projects / Programmes, which should be taken up in view of the national need and international demands, particularly considering the requirements of globalisation. What should be the mechanism, requirement of training, location etc. for such Projects ? What would be the approximate cost of such Projects / Programmes ?
6. How Public Sector and Private Sector research could be more interactive and complimentary for meeting the needs of the society ?
7. How agricultural research and education could address the problems of rural development ?

MAJOR RECOMMENDATIONS OF THE SUB-GROUPS

Biodiversity

- India has a great asset of biodiversity in crops and wild relatives, animals, fishes and microorganisms. This needs to be collected, evaluated, documented, used and conserved on an urgent basis. Since this is an enormous task it would be necessary to involve other institutions in this effort.

- Involve institutions of CSIR, DRDO, DOD, DST, DBT, IITs, Science Institutes, University departments (Agri. and non-Agri.), Non Govt. Institutes and others through contract research or through project funding.

- Establish an Agrobiodiversity Advisory Committee to plan, implement and monitor progress on a regular monthly interval.

- Directors of the National Bureaux be provided autonomy for their operations.

1. Climate and Agriculture (7 Recommendations)

- Impact of climate variability and climate change on agriculture, forestry, livestock, aquaculture and allied sector, for assessing response if the various components on the economic contribution of agriculture and allied sector.

- Place a greater emphasis on integrated research programmes in different agroecological zone for identifying options for production, economic return and employment generation.

- Assess the impact of seasonal weather on commodities in the countries with which we compete in international markets, such as coffee, tea, spices and commercial crops.

- Attempt to understand the contribution of agriculture on climate change and sequestering carbon dioxide, change of technologies etc. For meeting the demands of international conventions and protocols.

2. Resource Management - Natural and Monetary (Soil Management - 9, Water Management - 10 and Biodiversity - 4)

- Research on restoration of the productivity of degraded lands by adopting conservation measures and check future degradation.

• Integrate use of inorganic and organic fertilizers including legume based green manuring, biofertilizers and micronutrients for achieving sustainable individual crop and cropping system.

• Emphasize and develop technologies for efficient recycling of agrowastes and crop residues in crop production system. Effort should be made to develop technologies to avoid residue burning and environmental pollution by identifying and promoting and diversifying soil microbes.

Water Management

• Improve ground water recharge by identifying agricultural systems (crops and live stock) and maintenance of water table.

• Develop integrated technologies (crops and livestock, horticulture) for efficient water harvesting conservation and use in a water shed based system in different agroclimates.

• Generate water production functions to permit optional allocation among competing crops, horticulture and livestock systems so as to optimize the returns per unit of water.

New Initiative

• National Institute for Farming Systems Research

• National Institute for Water Management.

3. Rainfed Agriculture Research (7 activities)

• Risk management is central to land management leading to sustainable rainfed agriculture (economically satisfying and ecologically benign) development. While the importance of all components of productivity and production is paramount the central issue is water (both deficit and excess).

• Disease and insect management should be important in crops, agroforestry and livestock.

• Livestock research improvement of quality of fodder and processing, relation between crops, and agroforestry and livestock should receive greater emphasis in research.

• Agriculture production systems including crops, horticulture, livestock etc. need to ... in relation to precification in different

agroclimates. It is time to evaluate indigene biological systems for adaptation to temperature, rainfall and soil resource.

• Evaluate and improve the traditional systems of production and consumption for sustainability of natural resources and economic returns.

4. Agromachinery & Energy (7 Thrust Areas)

• Agriculture is being mechanized at a fast pace hence research should address the problems of unorganized sector, by developing new and efficient implements. This should have the removal of women draggery as an important objective.

• Improve energy efficiency and energy management in the rural sector and renewable energy research. How the crop residue instead of burning could become a source of energy ?

• Improve the life of agricultural implements through research on material science.

• Post harvest technology development should be the concern of all institutions.

• Develop CFC free rural cold storage systems.

5. Crop Science

• Estimated demand for foodgrains and edible oils in India (Million Tons)

Items	Area in Million ha	Production TE 1997-99	Demand in the year 2007-08	Annual growth in growth during 2000-2001 (%)
Rice	42.2	85.7	97.0	1.31
Wheat	26.2	39.1	72.1	1.16
Coarse cereals	30.7	30.4	34.7	1.03
Pulses	21.7	13.8	18.7	1.68
Foodgrains	120.8	199.0	222.4	1.25
Edible oils	26.6	6.4	9.1	1.61

• Priority States for Increasing National average of yield of crops, India.

Crops	Target growth per cent	Priority states	Per cent share of priority states in total crop area
Rice	2.35	BH, OR, AS, WB, UP	66
Wheat	2.22	UP, MP, BH, RJ	68
Sorghum	1.36	MH, KN, MP, AP	82
Pearl millets	0.43	RJ	47
Maize	2.00	BH, UP, MP, RJ	60
Chickpea	4.34	MP, RJ, UP, MH	83
Pigeonpea	4.28	MH, GJ, KN, AP, MP	72
Groundnut	2.51	AP, GJ, KN, MH	76
Rapeseed & Mustard	2.11	RJ, UP, MP, WB	74
Soyabean	1.11	MP, RJ	83
Sugarcane	3.07	UP	51

• Put research emphasis on pulses and oilseeds — Disease and Insect pests tolerance / resistance, intercropping.

• Improve crops for meeting export requirements in quality, sanitary and phytosanitary needs.

• Characterization and Improvement of crops for abiotic stresses and their interaction (Water deficit, temperature, waterlogging, nutrient deficiencies of Zn, Fe, Mn, B, etc.).

• Develop hybrids in crops for meeting the requirements of the various cropping system, response to inputs and abiotic stresses for enhanced production.

6. Sub-Group animal Science (Recommendations 24)

• Livestock sector will be a major sector for contribution to GDP of Agriculture and allied sector in the Indian Economy.

• Animal Science and livestock sector can make a significant to employment in rural India, as well as in urban regions through production and processing industry in livestock.

• Education in Animal Sciences and Veterinary and Dairy Sciences needs to be encouraged as per the notification of the Veterinary Council of India.

• Important areas identified are - Animal production, Animal genetics and breeding, Animal health, Encourage livestock production in rainfed regions.

• Research priority on improving oil meals and oil cakes in respect of quality particularly making it free from toxins, antigrowth factors and oxidants. The 35 million tons feed will be an asset in livestock production and export. Involve chemists, biochemists and nutritionists in this programme.

• Establishment of new institutes / centres are recommended.

7. Sub-Group Horticulture

• Collection, evaluation and documentation of gemrplasm using conventional and molecular techniques in fruits such as mango, citrus, guava, papaya, litchi, sapota, banana and grapes; vegetables specially indigenous and minor vegetables tubes crops, plantation crops and spices and housing plants.

• Development of package of practices for improved varieties of all horticultural crops for different agroclimatic zones and cropping systems.

• Understanding the processes leading to ripening.

• Development of rural based post-harvest technologies leading to :

1. Reduce loss during storage and transport
2. Improved shelf life of all perishable horticultural commodities and
3. Enhanced employment of rural youth.

• Develop appropriate protected cultivation techniques for environmentally disadvantaged regions.

8. Sub-Group fisheries

• Capture Fisheries
• Culture Fisheries
• Fish Genetic Resource
• Fishing and Fish Processing

a) Harvest
b) Post-harvest
c) Engineering

- Fisheries Education
- New Initiatives
  a) 3 All India Co-ordinated Research Projects
  b) 4 Network programmes

9. Sub-Group Biotechnology

- Biotechnological approach based on DNA technology needs to be extended to crops, livestock, fisheries and microorganisms, but with specific objectives.

- Major transgenic have been developed in corn, soyabean, cotton and canola for herbicide tolerance, Bt and herbicide tolerance + Bt. These traits account for 99 % of the total transgenic area.

- The research should be broadened through a network programme including ICAR Institute, Universities, SAUs and other laboratories so as to take advantage of the all available expertise.

- Some important projects have been identified that need to be supported.

- Develop biotechnological inputs for organic agriculture for managing soil health, plant health, water quality post-harvest technology and Animal health.

10. Sub-Group : Education and Human Resource Development

- The State Agricultural Universities have made a significant contribution to agricultural production, particularly of foodgrains, but now take up problems of rural development, diversification of agriculture, agroprocessing and agroindustry. The Universities should help development of service sector for self-employment.

- There is a need of raising standard of teaching, competence of teaching staff, establishment Advance Centres and Centres of excellence with National Professors and National Fellows who can contribute for 10-15 years. also there is a need to develop programmes of distance education and women empowerment.

- There is a need to either establish a University Grant Commission for Agricultural Sciences or to create a position of Joint Chairman UGC (Agriculture Sciences).

11. Sub-Group : Agricultural Extension

X Plan Budgetary Requirements - Agricultural Extension

S. No.	Items	Rupees in crores
New Initiatives		
1.	Establishment of agribusiness centres & Agro-clinics	60.00
2.	Establishment of a National Research Centre for Agricultural extension	15.00
3.	Distance education and computer aided extension	10.00
	Total budget for new initiatives	**85.00**
Existing Programmes		
4.	For existing programmes including 327 KVKs, 10 TTCs and 8 Zonal Coordination Units	600.00
5.	Support for continuation of 53 ZARSs to take up the additional functions of KVKs (first year of the plan to be funded from NATP)	40.00
6.	Establishment of KVKs in the remaining districts (182) emphasis on participatory mode	182.00
7.	Special TOT programmes for the farmers of tribal and Hill areas	5.00
8.	Co-ordination and monitoring through Directorate of Extension of SAUs and Roving team of Zonal Advisory Committee	1.50
9.	National Research Centre on Farm Women	8.00
10.	Implementation of IVLP as a mandate by all the Existing KVKs	10.00
	Total budget for existing programmes	**848.50**
Non-Plan Budget		
1.	Pay and allowances, TA for the existing 28 KVKs, 9 TTC, 8 Zonal units under ICAR institutes	58.00
	Grand Total	**991.50**

12. Sub-Group Agro-Economics and Rural Development

• Policy and planning have become critical for co-ordinated, long range planning, monitoring and impact assessment. There is, therefore, a need to establish a full pledged Division of Policy and Planning at ICAR (Headquarter). Such a Division is necessary to provide an umbrella framework for guided changes in cross cutting

areas like policy and planning, economics, statistics, and marketing, IPR, etc.

• The Council should organise involving also economists from outside NARS time bound network research programmes in a mission mode, as is done in other areas of agricultural research. Some ideas for such projects include : comparative efficiency and risk studies in different regions for important agricultural activities (crops, horticulture, fisheries, etc.); developing sustainability indicators environmental stress and its economic impact; marketing of high value perishables; etc.

• Concerted efforts must be made for involvement of agricultural economists, sociologists, anthropologists, political scientists and experts in management science in all the major agro-biological research programmes. This may need raising cadre strength of social scientists in the ICAR.

• National Centre for Agricultural Economics and Policy Research (NCAP) should be strengthened and developed as a nodal and coordinating Centre for agricultural economics and policy research, training and networking of agricultural economists working in the NARS and other institutions. Further, 5 regional advanced research centres (SAUs) should be identified to co-ordinate agro-economic and policy research at the regional level and impart training to agricultural economists in the NARS.

• A program should be initiated at the Indian Agricultural Statistics Research Institute (IASRI) to examine existing agricultural statistics for their consistency, reliability, comparability and adequacy. Further, IASRI should have strong research programmes to address methodological/statistical problems relating to temporal changes, farming system and other complex technical aspects like on-farm trials, perennial crops, livestock, fishery enterprises etc.

13. Sub-Group NATP (including ATMA)

• NATP has supported projects through the teams of excellence (TOE), Mission Mode (M.M.), Competitive Grant Programme (CGP) and the five Production System Research (PSR). The latter are i) Rainfed Agro-ecosystem, ii) Irrigated Agro-ecosystem, iii) Coastal Agro-ecosystem, iv) Arid Agro-ecosystem and v) Hill and Mountain Agro-ecosystem.

• The NATP finding has helped creation of infrastructure in SAU as well as in the extension system.

• This infrastructure should help in growth of research in the States if adequately qualified and committed scientific human resource becomes available.

• There is need for a strong monitoring system, and many projects need to be evaluated at the site.

• If the State agriculture research and education is funded as proposed earlier then the NATP should be concentrating only on TOE, MM and CGP in the Xth Plan.

14. Sub-Group Organization, Finance and Management

• Raise the level of funding for agricultural research to at least one per cent of agricultural GDP in the 10th Plan. Further, one time catchup grant of Rs. 500 crore is also recommended.

• ICAR to evolve its own rules and regulations, redefine relationship with DARE, modernize the systems of governance with emphasis on system based and multi-disciplinary approach (E.g. Project based budgeting, research prioritization, monitoring and impact assessment, modernization of office and management process, incentive structures etc.).

• Integrate subject/commodity sectors within ICAR to address eco-regional concerns.

• Promote strong HRD programmes for faculty/staff upgradation by international training.

• Strong collaboration with sister organizations (CSIR, ICSSR, CFTRI, etc.), private sector, NGOs, FOs, and promote growth of professional bodies like societies, National Academy of Agricultural Sciences, etc.

15. Sub-Group Plant Protection and SPS Requirement

• There has been increase in the number of diseases, insect pests, nematodes, virus, bacteria and weeds which cause considerable loss in crop production.

• Many of these pathogens also cause post-harvest losses. Therefore, a vigorous effort is needed for enhancing production by controlling pests.

- Pesticides used judiciously can reduce losses but their persistence in the produce can cause health problems in human beings and livestock. Therefore, we must enhance surveillance of pests in different regions and in different crops.

- Assess the relative loss by different pests and diseases in different crops, regions and seasons so that a planned approach can be adopted.

- Establish Referral Laboratories for pesticide residue and biological material for both export and import assessment for meeting the needs of Sanitary and Phytosanitary measures following WTO (CODEX) Standards. These laboratories may be operated by private or self-employed people.

Proposed New Institutes/Centres/AICRP/Network Programme

	sInstitutes	Centres	AICRP	Network
Climate & Agriculture	–	–	–	1
Resource Management	2	–	1	–
Rainfed Agriculture	–	–	–	–
Agromachinery & Energy	2	–	–	–
Crop Science	–	–	–	–
Animal Science	6	2	–	–
Horticulture	–	1	–	–
Fisheries	–	–	3	1
Biotechnology	–	–	–	–
Education Animal Science	–	–	–	–
Agroeconomics	–	–	–	–
Agricultural Extension	1	–	–	–
NATP –	–	–	–	
Plant Protection, S&PSM	4	3	9	–
Organization & Management	–	–	–	–

Proposed Plan Requirement (in crores)

Biodiversity	250
Climate & Agriculture	55
Resource Management	500
Rainfed Agriculture	100
Agromachinery & Energy	400
Crop Science	800
Animal Science	850
Horticulture	500
Fisheries	440
Biotechnology	500
Education Animal Science	5000
Others	1205
Agroeconomics	100
Agricultural Extension	991
NATP	1500
Plant Protection, S&PSM	300
Organization & Management	100
	13591

1. Climate and Agriculture

The relationship between agriculture and climate is well known. Droughts, which have frquented different parts of India through the history, have been responsible for many famines, rural poverty and migration despite development of impressive irrigation potentials. Similarly abnormal temperatures, high velocity winds and humidity during critical stages are known to significantly affect crop growth and development, pest incidences and epidemics, demand on irrigation resources and finally food production. Although the importance of agricultural in the national GDP growth has now gradually reduced, the climatic variability still palys a very important role in India's food production and nutritional security.

The climate of earth has a pervasive effect on food production. While its dynamic nature on the one hand promotes the evaluation of various living forms and changing the structure and chemical composition of the non-living matters, and on the other its, regional manifestations in terms of global climatic changes have on many occasions affected the behaviour the human societies. Over the past few decazdes, the man-induced changes in the climate of the earth due to multifarious human activities linked to development have become the focus of scientific and social attention. The most imminent of the climatic change of the earth is the increase in the atmospheric temperatures due to the increased levels of CO_2 and other greenhouse gases. The quantity of rainfall and its distribution has become increasingly more uncertain. In some places, climatic variability and the frequency of the occurrence of extremes of weather events such as droughts, floods, timing of rainfall and snowmelt have also increased. The sea level has risen by some 10-20 cm with regional variations. Similarly, snow cover is believed to be gradually decreasing at places. These global changes are primarily due to the increased emissions from the combustion of fossil fuels and land use changes. The 190s were, on an average, the warmest decade of the earth since instrument measured records of weather have been maintained since 1860's and the 1900s has been the warmest century during the last 1000 years. At least seven warmest years globally have occurred in 1990s. The global mean annual temperatures at the end of the 20th century are almost 0.7^0C above those observed a century ago. Diurnal temperature range has also decreased, with night time temperature increasing at twice the rate of day time maximum temperature.

Such global climatic changes are bound to impact agricultural through their direct and indirect effects on crops, soils, livestock and pests. While increases in carbon dioxide content in the atmosphere have a fertilization effect on C_3 crops and thus promotes their growth and productivity, but CO_2 induced temperature increase dpending upon the current ambient temperature, can

reduce crop duration, increase crop respiration rates, alter photosynthate partitioning of economic products, effect the survival and distributions of pest populations thus developing a new equilibrium between crops and pests, hasten nutrient mineralisation in soils, decrease fertilizer use efficiencies due to increased gaseious losses and increase evapotranspiration. Indirectly, these may considerably effect land use due to snow melt, availability of irrigation, frequency and intensity of inter- and intra-seasonal droughts and floods, and availability of energy. All of these climatic events can have tremendous impacts on agricultural production and hence food securityof any region.

The possible impacts of global climatic changes on the quality of life of human beings, could be alarming and therefore, is a matter of serious concern all over the world in understanding the possible effects for developing strategies to mitigate the negative effects. Developed countries have been in the forefront of this concern and have invested considerable sums for research and management initiatives to understand the implications of global climatic change on their agro-ecologies and have developerd frontline strategies to mitigate its adverse impacts. International pressure cartels have evolved over-time to safeguard the interests of the vested groups. At the same time, agricultural research world over has been boosted to increase our understanding of the effects of climate change, carbon cycle and its sequestration in biosphere and of late in carbon trading.

In the developing countries including India, there has been relaively less attention paid to this topic. In policy negotiations, where different pressure groups force adoption of international policy measures that could have an impact on different parts of the world differentially, negotiators of our own country as well as many other developing countries look forward to locally generated research backups.

Agricultural production in India has increased considerably during the last three decades due largely to the development and large-scale cultivation of new higher yielding, dwarf varieties, and increase in area under these crops in early sixties and greater applications of water and nutrients. These increases in food production have made us self-sufficient, and have contributed tremendously to our food security. Despite surplus buffer stocks currently available, it is projected that food security of the country may azgain be at risk in the near future due to increasing population and increasing pressure for alternate land uses. Indian subcontinent is now home for almost one quarter of the world population. It is projected that about 3.8 billion more people will be added to the world's population by 2050. At that time, India's population is expected to grow to 1.6 billion people when it will outpace China as the most populous country of the world.

This rapid and continuing increase in population implies a greater demand for food and water. Although the world as a whole may still have sufficient food for everyone, it would need to be produced where needed due to socio-economic and political compulsions. In India, food will have to be produced from same or even shrinking land resource because there is no additional arable land available for cultivation. Water availability poses another serious concern.

The rising temperatures and carbon dioxide and uncertainities in rainfall associazted with global climatic change are bound to have serious direct and indirect consequences on crop production and hence food security. We have recently witnessed such as impact of climatic events on food availability in 1998 in the form of a crises of onions, potatoes, cauliflower and tomato, which triggered some unprecedented social and political changes. This crises has once again demonstrated how little we understand the integrated relationships of weather and agriculture and how little we hazve developed the backup for policy support in such unfortunate and unforeseen circumstances. It is, therefore, important to have a firm base of assessment of the direct and indirect consequences of global climatic changes on different crops contributing to our food security. It is also necessary to develop a policy response to address in future such concerns with a more mature scientific understanding and also to provide backup support for our negotiations in the international fora. Future agricultural planning, thus has to take note of the overall goal of attaining congruence in productivity, stability, sustainability, profitability and equity in Indian agriculture in the coming decades.

The sub-group on climate and agriculture constituted by the Planning Commission and ICAR met on 13th May, 2001 to consider these issues. The meeting was attended by the following members :

Dr. S.M. Virmani	Chairman
Dr. V. Thapliyal, IMD	Member
Dr. S.V. Singh, DST	Member
Dr. P.C. Bhatia, ICAR	Member
Dr. S.A. Saseendran, DST	Member
Dr. V.R. Rao, CRRI	Member
Dr. P.R. Gajri, PAU	Member
Dr. P.K. Agarwal IAR	Member Secretary

The recommendations of the groups are attached.

Recommendations of the sub-group on Climate and Agriculture

Thrust Area	Recommendation	Infrastructural requirements/changes	Budgetary allocation needed, crores
CLIMATE CHARACTERIZATION			
• Climatic impacts on agriculture, forestry, acquaculture and allied systems needed to be reassessed because of the significant global changes that are taking place. There is a need to develop stratgegies fora rationale use of climatic resources. Real-time weather information is needed by the decision-makers; the farmers, planers and researchers at all levels.	• A network of inter-linked automated weather stations be established in 127 NARP zones. In order to ensure high quality of the data and its relevance, the required sensors may initialy be imported but local industry should be encouraged. • To periodically calibrate, maintain and collect automated wather data in a digital format, the existing staff of NARP will have to be retrained toupgrade their skills. • A networked communication system to transmit, store and provide weather data will have to be installed. This would ensure that the required weather data are available on internet, ona real time basis, to the bonafide stakeholders. • As far as possible, private sector may be involved with the establishment and maintenance	• Acquisition and installation of weather stations for NARP. the calibration and standardization of the instruments and the training of the staf to be done by the suppliers under supervision of IMD. • Establishment of communication, data storage and internet based distribution networking system to be established by the private sector. • Storage of weather data by IMD of countries that are important for India in terms of agricultural trade • Storage of weather data by IMD of countries that are important for INdia in terms of agricultural trade	• Purchase and installation of 127 automatic weather stations =10.0 • Installation and establishment of network communication system = 8.0 • Establishment of distributed data supply nodes and coordination of weather data gathering function=2.0 • Total = 20.0 crores

	of automatic weather stations and for data transmission, storage and distribution. ● A system should be developed to acquire and store weather data of countries that are important for India in terms of agricultural trade		
AGRO-ECOLOGICAL ZONES BASED PLANNING			
● Increasing concerns today about equity, environmental degradation and stagnating productivity in several regions are partly a result of lack of harmonization of agro-ecological characteristics, socio-economic resources and stakeholders goals in our planning process. ● In order to sustain agricultural production, the economically viable optimal solutions have to be determined at different scales based on the consideration of the biophysical potential of the resources available, environmental implications and the socio-economic constraints ● Although the Planning Commission and ICAR have established agro-ecological zones at	● Knowledge based systems be developed for each AEZ to address various developmental and environmental objectives. These would be in the form of decision support systems integrating modern tools of systems research such as remote sensing, GIS, dynamic crop and livestock models and spatial and temporal databases. This should make available the following information to the policy makers; ● Estimates of biophyusical production potential of different land use systems in the various AEZs, inuts needed to attain that, and the impact of productio practices on land degradation. ● Yield gap analysis and the opportunities available to bridge	● Establishment of a Task Force to oversee and support the development and utilization of the knowledge based decision support systems. ● Mechanisms to facilitate involvement of district administrations, NGOs and private sector in development, evaluation and operatilnalisation of DSS. ● Identification of 50 pilot districts in different AEZs	● Task Force establishment and functioning =0.5 ● Development of DSS and service sector to feed this initiative=5.0 ● Implementation in the pilot districts=20.0 Total = 25.5 crores

various levels of refinement, their use in planning has been inadequate.	them in different AEZs (as determined by the use of crop and livestock models). ● Environmental and natural resource costs of the various land use systems. ● Such an initiative should be funded to cover atleast 50 pilot districts during the plan period to support utilization of knowledge based DSS. this initiative should be jointly taken up by the ICAR in collaboration with NGOs SAUs and private sector		
MEETING WTO CHALLENGES			
● In the post-WTO era, agriculture in India will see rapid transformation due to increasing trade opportunities. Due to lowering of QRs, we shall see import of many agricultural commodities effecting domestic production. Similarly there may be unexplored opportunities abroad for our commodities. ● Despite impressive progress in developing agricultural infrastructure, there is still a large dependence of agricultural production all over the world on precipitation, temperature and radiation. Gluts of production are	● Establishment of an AGricultural Intelligence System to assess the impact of real-time changes in weather and other production resources on agricultural production in India and competing countries. ● Whether Watch Groups be established in different commodity based ICAR institutes (including horticulture, livestock and fishery) to continuously monitor the impact of real-time weather on production of differnt commodities, who, in turn, will provide this information to MOA for necessary action.	● Establishment of an Agricultural Intelligence Cell in the ICAR or MOA to be manned by commodity specialists, meterologists, remote sensing, crop modelling specialists, food storage and trade experts. ● Increased presence of Agricultural Attaches in important countries for agricultural trade. They should also facilitate collection of weather and other important data for determining crop prospects and trade opportunities	● Agricultural intelligence Cell = 2.0 ● Higher number of posts of Agricultural Attaches in our Missions abroad ● Storage and retrieval of agricultural important data for trade important countries = 2.0 Total = 4.0 crores

most often caused by the favourable weather (good and timely precipitation, optimal temperatures, etc.) whereas are shortages are most oftenly caused by climatic extremes such as droughts, floods, abnormal temperatures and cyclones. Assessment of these changes and their impact on production of different agricultural commodities within INdia as well as in countries that are important for our trade will very much help Indian farmers and ultimately economy.			
ENVIRONMENTAL SECURITY			
• Global climate change is a relity and needs to be taken seriously. Although, we can not fully prepare ourselves to face global climate change at present because of the large uncertainties in the magnitude of climate change, all efforts need to be made to quantify the uncertainties, track the magnitude of changes and evolve measures to study and adopt crop responses. • There is a growing pressure now in the international community to take several mitigation measures for reducing global	• ICAR may immediately establish an inter-disciplinary Task Force with to : (1)review and monitor continuously the sources and sinks of greenhouse gases in agriculture, (2) evaluate the impact of climatic variability and climatic change on Indian agriculture on a real-time basis, and (3) provide scientific and technical response suited for the national interest to the Indian policy negotiators. • ICAR institutes with mandate for coastal and hill areas should make a comprehensive evaluation of the possible impacts of	• To establish an inter-disciplinary Task Force in ICAR	

climatic change. There is very little research support available at present to support negotiations on global change. Many developing countries took forward to India to provide them learership and arguments for negotiations in the international bodies managing climate change. ● Coastal and hill agriculture is surely to get significantly effected by global warming. the ingressing coast line and receding snow / timber line may throw up new opportunities for agriculture in these areas.	global warming on agriculture in these areas and based on this, develop an appropriate action plan for the protection of food and livelihood security of the farmers.		
AGRO-SYSTEMS MODELLING			
● The increased population pressure is placing tremendous stress on natural resources, together with increased utilization of marginal agricultural areas. The package of technoloogy approach is not likely to work in future but instead considerable modellilng efforts will be need to make integrated impact assessment of spatial and temporal climatic variability and climate change on agricultural production in different AEZs	● Develop simple decision support systems for determining inputs in accord with natural resources endowments including climatic resources. Global models provide such a framework but may not be adequate for tropical, resource poor Indian agro-situations. We urgently need to develop our own capabilities to assess climatic impacts in agriculture.	● A nucleus for modelling research exist at IARI and some SAZUs. This work needs to be strengthened by the establishment of a Systems Modelling INitiatives. The knowledge base of the scattered modeling resources needed to be pooled and research studies / application need to be harmonized.	● Establishment of the Systems Modelling Initiative and for conducting workshops = 1.0 Total = 1.0 crores
WATER RESOURCES AND CLIMATE			
● Establishment of the Systems	● A series of 20 lysimeters	● Installation of lysimeters in	● A grant of 1.25 crores to support

Modelling Initiative and for conducting workshops = 1.0 Total = 1.0 crores	stations of international accepted standards should be installed in 20 agro-ecological zones, one per region. Lysimetric data, together with the real-time weather information would be helpful in forecasting the long-term sustainability for water of different land use systems. The implementation of such a research project would help avoid mistakes of the past, which resulted in, over-use of water resources.	SAUs/ICAR institutions where adequate research staff and infrastructure facilities for agro resarch exist ● A networking coordination unit will have to be established at one of the cooperating centers	10 grants per year @ 250,000 rupees per grant per annum Total = 1.25 crores
HUMAN RESOURCE DEVELOPMENT			
● Integrated assessment of climate impact on different sectors of regional economy is very important to determine future strategies for sustainable development, adaptation and other policy decisions. Such an assessment will not be complete unless the biophysical, environmental and socio-economic sectors of agro-ecosystems are studied together ● More and more agriculture problems today need holistic advice. Such integration needs establishment of very cohesive, interdisciplinary groups cutting across the usual divisional themes of crop simprovement, resource	● To meet the growing needs of interdisciplinary research, education and training, a relook is needed in the admission procedures of the Universities. ● Post-graduates should be encouraged to get trained in other areas of research besides their own specialization at the PG level. ● Advanced training facilities in modelling and quantification of sources and sinks should be established. ● Coordination among various agencies doing agro-met research is very necessary. An Apex body should oversee these academic and	● Institution of fellowships/assistanships and grants for attracting the best available talent to undertake research on climatic resources on agriculture.	● A grant of 1.25 crores to support 10 grants per year @ 250,000 rupees per grant annum Total = 1.25 crores

management, horticulture, animal sciences and socio-economics. the present discipline-based organizational system of ICAR and the institutes needs to be reorganized to meet these challenges	research efforts.		

2. Natural Resource Management

The Challenge

In view of the shrinking land resources the future increases in production have to come through productivity enhancement route based on intensive use of inputs. The inputs like agricultural chemicals, fertilizer and irrigation threaten the quality of environment, if not used judiciously. therefore, the challenge before us today is to devise means to substantially increase agricultural productivity and production at reduced cost to meet the rapidly growing needs for food, fiber, fodder and fuel without compromising on the quality of environment and of the natural resource base.

Current Scenario

Although in the last few decades a considerable progress had been made in increasing productivity and production, yet the production resources namely soil and water are subject to degradation.

1. It is estimated that at present nearly 174 m ha area is potentially exposed to various degradation forces like water and wind erosion. An area of about 25 m ha is affected by soil acidity, and 34 m ha is degraded because of specific problems of waterlogging, sodicity, salinity, shifting cultivation, ravine and gullies, and riverine and torrent lands.

2. The multiple nutrient deficiencies are emerging and expanding due to exhaustive cropping and imbalanced fertilizer use.

3. The utilization and use efficiency of applied fertilizer continues to be low.

4. Although water is a renewable resource, it is in perpetual motion through hydrological cycle. The major concerns are lowering of water table in good quality ground water zones, nitrate pollution of ground water resources and water quality deterioration in coastal areas due to ingress of sea water into ground water aquifers.

5. The unit productivity of agricultural inputs, termed as factor productivity, is declining as evident from recent analysis of long term fertilizer experiments and on-farm trials. This is indicative of deterioration of soil quality in terms of physical, chemical and biological health.

6. The scenario in plant biodiversity in terms of collection and characterization seems quite satisfactory. However, their conservation and efficient management need to be sustained on long-term basis.

7. The inventorization of resource is by no means complete. There is a need to make an inventory of resources at micro-scale to permit effective planning of cropping patterns and practices.

8. Burning of crop residues, particularly, in the intensive cropped areas is a severe health hazard and also environmental risk because it adds to the green house gases.

Achiving the goals

Soil Management

To improve the degraded resources and to ensure sustainable use of the remaining resources, it is suggested that :

1. There is a need to refine the inventories of soil resources, indicating the area affected by various maladies like soil and water erosion, water-logging, salinity and soil acidity. Moreover, there is a strong need for efficient land use planning involving social scientists, soil scientists, geographers and others in each agro-climatic zone. The domains for different Resource conserving technologies will have to be identified to harvess full benefits of the scientific developments in the area of NRM.

2. There is a need to restore the productivity of degraded lands by adopting conservation measures and to check future degradation.

3. The benefits of resource conserving technologies (e.g. 0-Tillage, bed planting and the practices associated them need fine tuning such as to increase cropping intensity and increased productivity in eastern India. The benefits of conservation tillage (including no-tillage) needs to be investigated, evaluated and extended to erosion prone hilly and other regions.

In order to reduce environmental risks and improve productivity it will be desirable to develop effective technologies for integrated nutrient management practices by combining organic and inorganic resources and including legumes in the crop rotation. Efforts will be made to put some of the On-self technologies in to practices (e.g. Rationale use of fertilizers, USG, LCC, Enriched composts and mopping up of residual N from getting lost or leached during the monsoon season. Fertiliser application methods suited to RCTs will be developed. Fertilizer practices that help in reducing/ overcoming protein malnutrition will be developed.

4. To avoid possible objections to quality of produce for export purposes, it will be worthwhile to investigate the possibilities of using indigenous

plant products like neem seeds kernel extracts and other botanicals for control of pests and develop other integrated pest management practices.

5. The site-specific crop management practices should be developed for predominant cropping/ farming systems in each agro-climatic/ agro-ecological zones developed by Planning Commission or NBSSLUP.

6. A strong need was felt by the group for development of suitable options (including, agro-forestry systems) for crop diversification in intensity cultivated irrigated lands to address the specific issues of degradation of soil and water resources, and build up of weeds/ insect pests caused due to continuous cereal-cereal cropping in these areas. Efforts would be made to provide options of tillage and crop establishment to the farmers that help him diversify his cropping/ farming systems.

7. Due emphasis has to be given for development of technologies for efficient re-cycling of agro-wastes and crop residues in crop production systems. All out efforts should be made to seed crops in 4-6 t/ha residues to avoid burning and environmental pollution and provide better niche to soil microbes.

8. In order to improve productivity and provide sustainable livelihoods to farmers of the flood prone areas in the eastern India (Tal and chor lands, diara lands etc.) it is crucial that crop cultivars suited to these environments and to inter-cropping/ mixed cropping system are developed urgently to face the challenge due to vagaries of nature.

9. Critical area approach to treatment of watershed will be given a fair trial for speedy rehabilitation of degraded lands and cover more area expeditiously and using modern scientific tools. The strategy will give a sense of partnership to farmers in watershed programs.

Water Management

1. There is a need to intensify steps for increasing ground water recharge by following the watershed approach and other modern recharge techniques. The crop establishment techniques that promote rain water conservation and crop diversification and save water shall be given a high priority in irrigated and rainfed areas.

2. Studies should be undertaken on water harvesting and *in situ* moisture conservation for enhancing agricultural productivity and livelihood of inhabitants.

3. Technologies should be developed for efficient use of rain, surface and ground water for enhancing agricultural production.

4. Micro-level integrated planning of soil, water and nutrients for sustainable crop, fish and animal production needs to be investigated.

5. Integrated use of water bodies for economically important aquatic crops, such as water chest nut, *Makhanna*, and Lotus, and fish.

6. Effects of conjunctive use of poor and good quality waters on long-term changes in soil quality should be studied.

7. In order to increase productivity in eastern India, the benefits of ground water development in timely seeding of crops, enhanced system productivity and promoting the adoption of new soil and crop management practices will be studied in participatory mode with farmers.

8. There is a need to recycle wastewaters like municipal wastes for use in agriculture.

9. It will be desirable to generate water production functions to permit optimal allocation of water among competing crops so as to maximise the returns per unit water.

10. Bring out a paradigm shift in water management research to save on irrigation water through a farmer friendly land leveling approach that promote better crop stands and interactions of nutrient and water etc. in promoting productivity.

Biodiversity Conservation

1. There is a need to sustain on-going biodiversity conservation efforts on long-term basis at the national level.

2. Application of space technology / Geographical Information System (GIS) on biodiversity conservation and management to be strengthened particularly for resource inventorization, resource management and resource deployment.

3. Efforts should be made to promote use of crop genetic resources in a system-wide network with NBPGR as the nodal organisation in collaboration with AICRPs.

4. Complementary conservation strategies particularly *in situ* on-farm conservation of land races (Farmers') need to be undertaken.

Human Resource Development

1. In view of the need for sustainable agriculture and emphasis on conservation of resources and environment quality, there is need to re-orient the course curricula in SAUs to include greater component of Natural Resources Management, efficient input use, and systems approach.

2. In view of the changing scenario of information technology and space age, scientists need to be exposed to advanced training on use of the new techniques in their areas of specialisation.

3. There is a need to develop / strengthen institutional capabilities, trained human resource and mass awareness on biodiversity management and conservation in view of emerging IPR regime.

Budget Requirement

1. The above programmes will be undertaken in the existing 13 Research Institutes and 15 on-going All India Coordinated Research Projects of NRM Divisions in ICAR. The infra-structural facilities should be adequately strengthened in the emerging areas of space applications, GIS and simulation modeling.

2. The Project Directorate for Cropping System Research may be upgraded to National Institute for Farming Systems Research with four Regional Centres to address the regional problems pertaining to natural resources and production systems.

3. The Water Technology Centre for Eastern Region, Bhubneshwar, may be upgraded to 'National Institute for Water Management' to widen its mandate.

4. To undertake the proposed activities during the Xth Five Year Plan, a sum of Rupees five hundred crores will be required.

3. Rainfed Agriculture

The Indian Council of Agricultural Research has constituted a Sub-Group on Rainfed Agriculture Research consisting of the Members listed in the Annexure I. The Sub-Group has been mandated to prepare an approach paper on rainfed agriculture focusing specific recommendations on the following terms of reference:

- To suggest new thrust areas and programmes for the X Five Year Plan to improve and strengthen rainfed agriculture duly keeping also in view the National Agricultural Policy,
- To advise on any specific infrastructure requirements/changes to give effect to the suggested thrust areas and programmes and
- To propose an appropriate budgetary requirements for the suggested thrust areas and programmes.

The Sub Group met at the Central Research Institute for Dryland Agriculture on May 12, 2001 under the Chairmanship of Dr. J.C. Katyal, Director,NAARM and Chairman of the Sub-Group. The List of Participants is enclosed as Annexure II. The Group, among others, considered the problems encountered by the dryland farmers, state-of-the art research in the country, functioning of the research network, technology diffusion, impact, desired linkages and resource availability. After a thorough discussion, the group arrived at key research strategies and the resources required to attain their objectives.

Problem

Even after realizing the complete irrigation potential in the country, nearly 50% of the cultivated land will continue to remain rainfed. At present, about 66% of the net sown area is rainfed. Bulk of the cereals, pulses, oilseeds and cotton are produced in these tracts. Rainfed areas also support two out of every three heads of livestock in the country. Faced with recurrent risk and uncertainities, the most impoverished sections of the farming community live in these areas. Technology adoption in rainfed regions, where farmers are known to have very low risk bearing capacity, cannot be over-simplified. The central issue of rainfed farming is not necessarily package of technologies, but building up the capacity of farmers to support a decent livelihood through enhancement in their economic condition.

To support a growth rate of 4% per annum in agriculture during X Plan, keeping in view the need for conservation of natural resources and meeting

the market demands, as envisaged in the National Agricultural Policy, rainfed agriculture has to play a pivotal role. Significant increase in productivity, improvement in resource quality, diversification of production system and generation of additional employment are needed in rainfed areas to achieve the overall objectives on eradicating poverty. This requires a renewed focus on research, new and innovative approaches in development and support to do so with matching resource allocation.

Current Status

Rainfed areas are characterised by recurring climatic risk, over-exploited natural resources, and exacerbated land degradation and under use of restorer inputs leading to low and uncertain productivity. Added to this, poor transportation facilities, scant marketing infrastructure and high rate of unemployment are plaguing the rainfed farmers. Over the years, a wide variety of technological solutions have been suggested to address some of the above problems. However, this knowledge and technology pool has been and is not being applied in an effective manner to produce visible results.

The mismatch between promise of available technologies and its actual performance may be explained by a number of factors like risk persistence, inadequate communication, inappropriateness of technologies (in terms of economic viability and incompatibility with the client needs and resources), poor credit availability and market infrastructure and inadequate development efforts. Risk management, therefore, remains central to achieve the goal of sustainable rainfed agriculture.

Despite non-boisterous research achievements, there have been some successes at different levels of technology generation and dissemination in the past. These have hardly been able to contribute to growth in agricultural GDP, which remains static or even declining. Land degradation continues unabated and growth of allied sectors uninspiring. Therefore, a radical shift is needed in our approach to the problem. Prioritization, new client-oriented research, technology transfer, and above all end-user involvement, in order to produce a visible economic and social impact. To achieve this, the following Research Agenda is suggested for the X Five Year Plan.

Research Agenda

Risk management is central to land management leading to sustainable rainfed agriculture (economically satisfying and ecologically benign) development. Since risk to agriculture is fundamentally related to water scarcity, all strategies to sustainable development of agriculture must be based upon the potential to build water resource and its management. Rainwater conservation,

harvesting and reuse, are, thus, the principal routes to fashion water-secure, risk-free economically advantageous and ecologically beneficial agriculture. Since union of rainwater patterns and land characteristics has been the basis for development of diverse native land uses, scientific land use planning must complement and not contrast with what farmers have been doing and living with since ages.

Measured in terms of time and space, rainwater availability varies across regions, so do the management options. It means technologies developed for one location are not transferable directly to another. It is primarily the interaction of rainfall distribution pattern with soil quality characteristics and farmers' management practices that forms the basis for arriving at location-specific production systems. Accordingly, the new research initiatives will have a define the growing environment specific to a production system, identify constraints and opportunities from farmers' view point on future diversification. Integration of conventional natural resource inventorization techniques, socio-economic conditions and modern tools like modelling, GIS and remote sensing will facilitate up scaling of point information into area action plans. Since natural resource (Physical and social) register is the basis for long-term capability-based land use planning, initiation of this activity should receive top priority with a focus of purpose (rainfed agriculture development - productive, profitable and stable).

Activity 1

Describe natural resource endowments by superimposing the socio-economic capability and framework to construct new production systems that can eradicate poverty by narrowing the gap between the potential productivity and what is being actually realized.

While characterising the climatic variables (rainfall, sunshine and temperature), it will be necessary to prepare a long-term inventory, typically of rainfall. This is emphasized, since of the three climatic variables, influence of rainfall on plant growth and yield is the most unpredictable. This aggressive behaviour of rainfall arises from its common tendency to deviate from the normal (described as coefficient of variation or CV). Although extent and frequency of rainfall deviations increase with falling rainfall, long-term data are necessary to determine the base-line normal rainfall and to model the pattern of its variability (amplitude and periodicity). It is this ability to capture the nuances of rainfall oscillations that helps in evolving and instituting permanent strategies on risk / drought management.

Activity 2

Model long-term rainfall across regions to develop reliable forecasts on drought incidence at least 1 to 2 seasons in advance. Along with this study, it will be valuable to establish whether increasing variability is associated with consistent fall in rainfall. So that entire effort yields wholesome results for early warning and planning, studies forecasting the influence of abnormal rainfall availability in the next season or permanent shift in its pattern on agricultural productivity will be necessary. In this effort linkages with IMD, WMO and other institutions of excellence will be highly relevant.

In arid areas (annual precipitation to potential evapo-transpiration ratio ranging between 0.05 to 0.20), where rainwater harvesting for irrigation is generally non-promising, animal based systems dominate. These regions suffer from maximum uncertainty generated by year to year variations in rainfall. Research will have to invent safety net that yield greater stability from the native production practices.

While in situ-rainfall conservation remains of primary importance, agroforestry systems offer many advantages. They optimize natural resource use and minimize risk by distributing it between annuals and perennials and thus helping to stabilize productivity and income. A fair mix of dual purpose (fodder and grain yielding) annuals and multi-purpose trees that serve the primary human needs on food, create livelihood security, sustain animal support system and strengthen ecological endowments is the principal research strategy suggested to adapt to these otherwise environmentally difficult regions. No doubt, any attempt to upgrade the prevailing practices has to be non-exploitative, since the endemic natural resources have already been exploited to such an extent that any further exploitation will not be without disastrous consequences.

Development of farmer-accepted in-situ rainwater conservation techniques, and progressive build up of native agroforestry systems by infusion of appropriate sectorial technologies (hybrids in place of local crop varieties, plus tree types substituting the native species, elite livestock taking over non-descript breeds, use of restorer inputs to counter exploitive practices) is the proposed research agenda.

Activity 3

Identification and development of superior types of trees and bushes from the indigenous species known to farmers. The parennial component of the agroforestry system should support the annual crop in that productivity of the latter is maintained, if not enhanced. Tree species that meet varied needs of the farmers and their produce exhibits distinct market acceptance with favourable

economics need greater focus. Since farms are small and farmers are many, research processes will have to interface farming and marketing objectives.

Activity 4

Raising productivity of annual crops will require greater dependence on dual-purpose varieties having short duration and built in tolerance to biotic and abiotic stresses. Harnessing heterosis by conventional techniques or reengineering appropriate plant types by biotechnology offer wide prospects for infusing characteristics of earliness, yield advantage and stress tolerance.

In semiarid and better rainfall areas (ratio of annual precipitation to potential evapo-transpiration > 0.2), where potential for rainwater harvesting is quite promising, emphasis should be placed on investments in small-scale water-harvesting structures. Runoff harvesting has been pursued as a community activity since time immemorial. These community-based techniques have proved their value in sustaining the livelihoods of all the stakeholders. In the recent past they have fallen into disuse due to a breakdown of community institutions and government takeover. There is a need to revive these traditional participatory systems because they harmonize natural opportunities with community wisdom. Since harvested water is less likely to bear the pressure of all stakeholders, its expert use by instituting water saving techniques and efficient crops is necessary to optimize the outcome and impact.

Keeping in view the prospective scarcity of water and degradation arising from its misuse, it will be imperative to link water use with economic and environmental benefits. Efficient use of water will thus be judged by the economic productivity (value of produce per unit of water) and the potential it offers to halt or even reverse land degradation. Apparently, business as usual approach involving cheap methods of inefficient use (flood irrigation) will have to shift to costly but efficient techniques of application (sprinkler or drip). No doubt initial investments and subsequent operation costs will be high, so are the stakes in terms of alleviating human misery, economic returns and saved land from degradation.

Efficiency of harvested water will increase further, if side-by side, self-accepted and community-supported regulation on cultivation of water-inefficient crops is imposed strictly. This approach will aggrandize saved water; a favourable step ensuring equal access of all stakeholders to harvested water.

Activity 5

Futuristic research on creating a permanent resource of water will have to be formatted to link rain and terrain characteristics. The near and long term objectives will be to develop area-specific decision support systems that integrate

water-adept and economically and ecologically sound agricultural production techniques. Whether the programme is on rainwater harvesting or investigations are focused on water adept and economically and ecologically sound alternative water and land use systems, people participation will be necessary. It means the full involvement and endorsement of local populations in the development of decision support systems relevant to their situation i.e. right from the identification of problems up to arriving at solutions and their assessment and impact with teams of scientists. Since, success of people participation hinges on interdisciplinary teams of scientists working shoulder to shoulder with the farmers, it will be necessary in the future that scientists allocate at least 50% of their time in joint research with farmers. The proposed arrangement will expectedly reduce the research lag time (time taken for research findings to become a technology), and increase level and sustenance of adoption. Currently, research lag time is 5 to 15 years, technology acceptance level is around 30% and adoption lasts as long farmers receive financial incentives.

Activity 6

Whether the research is conducted on institute, farms or in the farmers' fields, economic prudence necessitates discouraging individual-working on routine projects but seeking research solutions to formally prioritized activities and following their outcome with pre-targeted indicators of success through regular monitoring and evaluation procedures. In essence, what is being suggested is development of wholesome strategic research plans and institution of regular auditing on their progress and impact by researchers and farmers.

Next to water, no threat other than soil fertility decline will impede the sustainable development of rainfed agriculture. Although fertilizers have definite role in halting soil fertility decline, improving productivity and imparting yield stability, it is their integrated use with organic manures and useful soil biology that better matches with the economic limitations faced by the dryland farmers. Creating a permanent trust of organic matter, which is non-competing with existing uses, is a critical element of research strategy on building soil fertility/quality. Because of limited availability and competing uses, farmers are likely to accept organic manures if their economical potential is distinctly higher than the existing practices. Raising foods of direct human consumption with organic inputs is one such avenue. Organically grown foods carry a premium on their price.

Activity 7

Keeping in view the general paucity of organic manures there is urgent need to search for options that support building a store for organic matter. Use of solar energy and conversion of dung into biogas for cooking and cultivating

green manure plants on wastelands offer, respectively indirect and direct opportunities to generate organic matter. Development of efficient methods of organic manure application and conservation is an important research activity that needs vigorous pursuing. Lessons from the traditional manure-saving methods of application should be the base to build research objectives. Also there is need to assess a sound market basket of crop that can be grown exclusively on organic inputs.

Development Departments of Government will have to play a significant role in taking the findings of research to a logical end i.e. sustainable development of rainfed agriculture. Financial support in setting up small-scale irrigation schemes based on rainwater management is considered a high priority. Similarly, institution of strategies for (1) strengthening information dissemination and communication systems (ICT-based), (2) building people's skills through education and training to decrease dependence on agriculture as source of employment (3) creating infrastructure for value addition, mobility and trade and (4) implementing pro-farmer land tenure policies.

People participation in research and development, as suggested above, will have to be rooted in community action on a landscape basis. Transfer of administrative and monitoring responsibility to grassroots institutions (Panchayat Raj) will be necessary. So that government functionaries evolve a mindset that supports this process of democratization and decentralization, appropriate training programmes will need to be launched for them.

4. Agromachinery and Energy

It may be mentioned here that ICAR had constituted a working group under the chairmanship of Dr. B.S. Pathak to identify thrust areas for research and development during the 10th Five Year Plan for its Agricultural Engineering Subject Matter Division. This working group met on 26th February, 2001 and had identified the thrust area which were brought to the notice of the present Sub-Group. The sub-group agreed with the thrust areas identified in February 2001 meeting and decided to endorse the same after some reorganisation of the listing of these thrust areas. The members made some additional suggestions keeping in view the terms of reference of the sub-group and observations of Dr. S.K. Sinha, Chairman of the 10th Plan working group. The thrust areas recommended by the sub-group for the Agricultural Engineering Subject Matter Division of ICAR are as under :

Thrust Areas Identified for the Xth Five Year Plan

Farm Mechanisation Research

Development of equipment and practices for :

- Precision agriculture for efficient use of inputs to achieve high productivity and low production cost;
- conservation tillage
- mechanization of horticultural crops;
- management of crops residues;
- efficient utilization of animal power;
- greater operational safety and comfort, particularly for women

Industrial Extension and Transfer of Mechanizaztion Technology

- training users, service providers and manufacturers of farm equipment;
- performance evaluation of equipment;
- demonstration of equipment to potential manufacturers and users;
- transfer of technology with complete documentation to the selected manufacturer / manufacturers.

Post-Harvest Engineering and Technology Research

Design, develop and demonstrate on pilot scale processes and equipment for

- traditional and new products from cereals;

- improved dal milling and oil expelling;

- protein rich products from soybean and other plants for food, feed and other uses;

- handling, grading and packaging of horticultural products;

- low cost temperature controlled storage for fruits, vegetable and other perishables;

- Development of equipment and technologies for efficient pre-cleaning, ginning and post cleaning of cotton, high speed spinning, eco-friendly dying, garment production and quality improvement, by-product utilization and effluent management;

- Development of equipment and technologies for retting of jute, jute geotextile, jute blended products and jute composites.

- Enhancement of lac productivity, mechanization of lac cultivation and value addition, processing of seed lac, development of new products of lac and alternative uses of lac for electrical, pharmaceutical, cosmetic, rubber and plastic industry.

Industrial extension and transfer of post harvest technology

- HRD in post-harvest engineering and technology and entrepreneurship development;

- performance evaluation of processing equipment;

- quality testing of processed products.

- demonstration of technology on pilot scale to potential suppliers and users;

- transfer of technology with complete documentation to selected suppliers.

Energy Management in the rural sector and renewable energy research

- conservation and efficient use of energy;

- forecast energy requirements of rural households, production agriculture and agro-processing and identify energy constraints;

- thermo-chemical conversion of biomass for thermal and power applications;

- non-destructive (biological) conversion of biomass to produce fuel gas and compost;

- treatment of agro-industrial effluents to produce fuel gas and safe for irrigation water;

- use of solar energy for product drying.

- conversion of conventional IC engines into dual fuel/bio-fuel engines.

Transfer of Renewable Energy Technology

- HRD in renewable energy technology;

- Pilot scale demonstration to potential suppliers and users of stand alone renewable energy systems in rural sector;

- transfer of technology to selected suppliers with complete documentation.

Irrigation and drainage engineering research

A. Development of equipment and practices for

- conservation and enrichment of water resources;

- drainage of agricultural land;

- efficient pumping and utilization of water;

- precision land levelling;

- reduction in initial and operating costs of irrigation and drainage systems.

B. Technical back up and transfer of technology

- HRD in water management engineering;

- testing of irrigation, drainage and land levelling equipment;

- pilot scale demonstration of developed equipment to potential suppliers and users;

- transfer of technology to selected suppliers with complete documentation.

Strategy

In order to do R & D on all the identified thrust areas following strategies are suggested.

(i) Development of processes and equipment should be market oriented.

(ii) Engineering research, to be productive, requires a critical mass in terms of facilities and investment in tools, plants and machinery, Adequate funds should be made available for this purpose.

(iii) There should be close monitoring and mid-term reviews of all the programmes identified for the X Plan and corrective measure taken by SMD when and where required.

(iv) Adhoc research projects should be encouraged in the identified thrust areas to support continuing and coordinated research.

(v) Closer linkages should be developed with the industries to have their involvement in collaborative R & D and promotion of technology.

(vi) Transfer of technology arrangements should be put in place to promote the newly developed and successfully tested technology.

(vii) In the area of soil and water engineering many of the findings of the Council have not been utilized by the farmers. It is suggested to take up some pilot projects to demonstrate the benefits of the outputs of such research and to convince the policy makers about the positive impact of scientific water management.

(viii) Allocation of resources should be according to the nature and needs of projects and not on blanket rates.

(ix) Training of scientists should be organised in frontier areas and new technologies to enhance their skills and knowledge to perform better.

Suggestions Regarding Improving Standards of Research and Education

The sub-group deliberated on the general complaint that the standards of research and education are going down. Exceptions were pointed out as in case of development of farm equipment and machinery. The number of farm implements and machinery designed, developed and transferred to industry by ICAR institutes and SAUs during last 10 years has been far greater than in all the previous years starting from 1960. However, the sub-group felt that there was scope for improvement and made following recommendations in this respect.

(i) Potential users of equipment/process should be identified and their requirements should be clearly identified before taking up new R & D projects.

(ii) In order to meet the desired requirements, product specifications should be finalized very carefully. Time frame and details of activity should be worked out and monitored properly. Any deviation from the original schedule should be reported with reasons.

(iii) If BIS approved test procedures and performance standards are not available for some equipment/process, ICAR should develop interim procedure and standard and it should be ensured that the newly developed equipment/process meets the performance standards before it is released or transferred for commercialisation.

(iv) Continuous monitoring of technological developments in other countries should be done. Whenever any promising machine is identified, it should be imported and evaluated for usefulness/adaptation.

(v) As in most other fields of research, the distinction between good and poor performance has faded in agricultural (and Agril. Engg.) research also. ICAR should lay down criteria for career promotion which act as a source of motivation for the researchers to give of their best.

(vi) In order to keep with technological developments and advancements in Instrumentation and research techniques intensive workshops of research workers including Principal Scientists should be organized at appropriate institutions as frequently as needed.

The Sub-group did not have adequate representation of agricultural engineering teachers on it. Its deliberations on standards of education were more limited. However, it felt that as in research, there was insufficient motivation for good teachers to perform at their best. It was decided to make the follow two general recommendations :

(i) Course curricula for graduate and post-graduate programmes should be reviewed every 5 years and when required the content revised to update the curriculum and courses.

(ii) Short duration training / workshops should be organised to upgrade skills of teachers and to keep them abreast with new developments.

Need for Convergence of Programmes

The sub-Group examined the ongoing programmes of Agriculture Engineering subject matter division. It felt that the suggestions made by the Committee chaired by Dr. H.K. Jain should be implemented and that if it is done, sufficient convergence could be achieved in the current programmes. The sub-group further suggested that the performance of the cooperating centers of the coordinated projects should be thoroughly reviewed and those centers which have failed to perform upto the required level may not be continued during the 10th Plan. Further, new proposals for multi-location / institution research should preferably be considered for implementation through networking rather than as All India Coordinated Projects.

Manpower Requirement During Xth Plan

The sub-group discussed the man power requirement to implement successfully the programmes of research, demonstration and transfer of technology in the Xth Plan Thrust Areas of Agricultural Engineering. Some strengthening of the man owner will be necessary. It is recommended that an additional strength of about 100 scientists in Agricultural Engineering disciplines including Farm Implements and Machinery (35 scientists), Agricultural Energy and Power (20 scientists), Post Harvest Engineering and Technology (30 scientists) and Irrigation and Drainage Engineering (15 scientists) should be provided in the Xth Plan. ICAR should recognize agricultural energy and power as a discipline and prescribe a qualifications, experience, etc. for recruitment of scientists in this discipline.

Budget

The sub-group assessed the budgetary requirement to do R & D on all the priority areas identified during the Xth Plan and recommended that about Rs. 300 crores should be allocated for Agricultural Engineering research during the Xth Plan. Another suggestion was that 8% of ICAR budget should be earmaked for Agricultural Engineering research in the Xth Plan.

5. Crop Science

India has high population pressure on land and other resources to meet its food and other essentials. The natural resource base of soil, water and genetic diversity is under severe pressure. The massive increase in population and substancial income growth demand an extra 2.5-3.0 mt of foodgrains annually, besides sizeable increases needed in the supply of livestock, fish and horticultural products. Food demand in the year 2007 will be around 222 mt (Table 1).

Table 1. Estimated demand for foodgrains and edible soil in India (Million Tons)

Items	Area in million ha	Production TE 1997-99	Demand in the year 2007-08	Annual growth in demand during 2000-2001 (%)
Rice	42.2	85.7	97.0	1.31
Wheat	26.2	69.1	72.1	1.16
Coarse cereals	30.7	30.4	34.7	1.03
Pulses	21.7	13.8	18.7	1.68
Foodgrains	120.8	199.0	222.4	1.25
Edible oils	26.6	6.4	9.1	1.61

In order to attain an overall GDP growth rate of about 9 per cent as targeted for the Tenth Five Year Plan, the agriculture sector must attain an annual growth rate of about 4.0 per cent or so. Crop sector must attain an annual growth of 1.8 per cent, while horticulture, livestock and fisheries sectors about 6.5 per cent.

Confined to crop science, in the present exercise, the following have been identified as the issues / areas for research thrust during the Tenth Plan period :

Sustained Productivity Growth of Major Cereals Towards Food Security

Most of the crops need to improve yield per hectare by about 300 kg in the next 5-7 years to meet the demand of growing population. To remain truly food secure the following are some of the potential opportunities and strategies that would help achieve the targeted production :

(i) Narrowing the yield gap of major food grain crops viz. rice and wheat in **low and medium productivity** areas under the irrigated ecology and in the mainly irrigated and rainfed rice, millets and pulses through diagnosis and correction of key yield limiting factors (states where yield levels are below the national average i.e. Bihar, Orissa, Assam, Uttar Pradesh) (Table 2).

Table 2. Priority states for increasing national average yield of crops, India

Crops	Target growth	Priority states per cent	Per cent share of priority states in total crop area
Rice	2.35	BH, OR, AS, WB, UP	66
Wheat	2.22	UP, MP, BH, RJ	68
Sorghum	1.36	MH, KN, MP, AP	82
Pearl millets	0.43	RJ	47
Maize	2.00	BH, UP, MP, RJ	60
Chickpea	4.34	MP, RJ, UP, MH	83
Pigeonpea	4.28	MH, GJ, KN, AP, MP	72
Groundnut	2.51	AP, GJ, KN, MH	76
Rapeseed and Mustard	2.11	RJ, UP, MP, WB	74
Soyabean	1.11	MP, RJ	83
Sugarcane	3.07	UP	51

Note : AP : Andhra Pradesh; AS : Assam; BH : Bihar; GJ : Gujarat; KN : Karnataka; MP : Madhya Pradesh; MH : Maharashtra; OR : Orissa; RJ : Rajasthan; UP : Uttar Pradesh; WB : West Bengal.

(ii) Sustaining ecologically and economically rice-wheat and rice-rice systems in the areas of very high productivity by yield

optimization, system diversification, adoption of technologies of high yield threshholds. This covers the rice-wheat in Indo-Gangetic Plains and rice-rice in the Penninsular India which accounts for the countries 60% production.

(iii) Maximization of productivity of rainfed eastern India by bringing the relatively favourable shallow lowlands (4 million hectares) under high yielding varieties of rice, the semideep water areas (6.0 million ha) under rice + fish farming system and over eight million hectares of saturated soils under lowland ecologies for crop intensification with quick maturing pulses and oilseeds.

(iv) Replacement of low yield open-pollinated varieties of maize with early maturing hybrids/composites in the predominantly rainfed maize areas such as in the states of Bihar, M.P. and U.P.

(v) Development of early maturing hybrids/composits of pearl millet for western Rajasthan and dual purpose rabi sorghum for Maharashtra.

Improvement of Nutritional Quality of Staples Towards Nutritional Security

Aside the fact that over 20% of our population remain undernourished, over 65% largely women and children suffer from one or the other nutrient deficiency related health disorder, which include Protein Energy Malnutrition (PEM), nutritional anaemia, vision impairment, goitre etc. The following are some of the potential areas that warrant accelerated research :

(i) Production/ productivity breakthrough by hybrid technology (pigeonpea), new plant type chickpea, management of devastating insect pests and diseases (Helicoverpa, viral diseases) in pulses, intercropping short duration pulses with wide space planted crops.

(ii) Development of quality protein rice, wheat and maize (QPM).

(iii) Enrichment of rice, wheat, sorghum and mustard with high content of β-carotene (provitamine A), iron and zinc using both natural and novel genes available.

(iv) Development of neurotoxin-free *Lathyrus* using natural and novel gene sources.

(v) Development of rapeseed mustard of low erucic acid and glucosinolate.

(vi) Research for utilization of soyabean meal as a source of rich protein.

Raising the Ceiling of Genetic Yield in Prospective Crops

(i) Tailoring of new plant type for enhancement of genetic yield level in rice, wheat, chickpea and groundnut.

(ii) Tailoring of plant types of pulses and oilseeds for productive intercropping.

(iii) Extension of hybrid technology to new crops and niches (Rice, maize, sorghum, wheat, pigeonpea, brassica, sesame, sunflower and cotton).

Expansion and Sustenance of Export of Agricultural Commodities

(i) Breeding for consumer quality needs of importing countries in respect of wheat (Karnal bunt free), non-basmati rice (besides basmati rice), cotton, oilcake (rapeseed mustard) and confectionery grade groundnut, sesame etc.

(ii) Development of cost reducing crop production packages, specially for sugarcane.

(iii) Development and adoption of ecofriendly crop production packages with special reference to pest / diseases management (pesticide residue-free commodities).

(iv) Special effort for wheat export : Augmentation of breeding programme for development of export quality (A-category) wheat in *aestivum* and *durum*, keeping in view the varied quality demands in the international market.

Meeting the Feed and Fodder Needs

Development of high yielding varieties / hybrids of fodder sorghum, dual purpose millets and degraded lands for development with plantations of fodder value.

Accelerated Seed Production and Research to Take Full Benefit of Improved Varieties

(i) Seed production, storage and seed health research should be integrated with advanced testing of varieties/hybrids so as to ensure that a fool-proof seed production package for the newly released varieties is available to the industry.

(ii) Increase in seed replacement rate in all major crops with 15 per cent in pulses and oilseeds, 20 and 25 per cent in wheat and rice, respectively.

(iii) Improvement of quality seed in terms of genetic purity, health and vigour.

(iv) Initiation of action to prepare the country for plant variety registration with respect to testing of varieties for Distinctness, Uniformity and Stability (DUS).

Conservation and Optimal Utilization of Natural Resources

(i) Evaluation in phases the germplasm of major crop plants for traits of economic significance.

(ii) Collection and conservation of wild species of crop plants.

(iii) Establishment of field gene banks for perennials with special reference to horticulture and clonally propagated plant species.

Basic Research

(a) Innovative genetic engineering and biotechnology for progressive crop improvement (drought, salinity, weather extremes, susceptibility of pests like Heliothus, Helicoverpa, viral diseases), poor shelf life of perishable fruits and vegetables, and nutritional limitations.

(b) Anticipatory research on crop adaptability to changing global climate:

(i) Identification of genotypes adapted to high CO_2 level and increased temperature in major crop plants.

(ii) Study of response of genotypes to abiotic stresses and their interactions in various crops and identify tolerant types.

(iii) Understanding the basis of adaptability and stability of varieties for wider acceptance particularly in pulses and oilseeds.

Post-harvest Management for Minimizing Storage Losses of Agricultural Produce

Strengthening of Basic and Applied Research on Plant Protection

(i) Further exploitation of resistant gene source to contain pest and diseases.

(ii) Strengthening the areas of biosystematics.

(iii) Survey / Surveillance and weather data based forecasting of diseases / pest outbreak using satellite image for crop loss assessment.

6. Animal Sciences

The Planning Commission has constituted a Working Group on Agricultural Research and Education for Xth Five Year Plan under the Chairmanship of Prof. Dr. S.K. Sinha. Under this group Planning Commission has also constituted 14 subgroups on different subjects to examine the subject matter in depth. The subgroup under the Chaimanship of Prof. (Dr.) P.N. Bhat has been constituted for formulating recommendations in the Animal Science Sector with special focus on Animal Science, Research, Education and extension. The recommendations of the subgroup has been compiled in thre volumes, volume I contains recommendations of the subgroup, volume II comprises of compilations of papers, presentations and proceedings which formed the basis for recommendations and the volume III contains all the basic data which were utilized in formulating the recommendations of the said group.

The sub group held a number of meetings and was assisted by staf of the Animal Science in examining the achievements and performance of various schemes under this sector and looked at various gaps in achievements while reviewing the past performance. It also examined the future needs of animalscience and its various sub-sectors and requested outstanding leaders in the field to give presentations. It recognised that the GDP growth rate in the agricultural sector has declined to about 1% by the end of the present decade. The reasons for decline in the growth rate of the overall agricultural sector were examined. It was realized that the growth rate in the Animal Science had been consistently around 4.5% and in some of the sub-sectors like poultry, it was around 15% for broilers and 10% for layers and in the dairy sector. The overall employment growth rate in the livestock sector was about 5%. The prsent scenario called for an aggregate growth rate of 9% which has been targeted by the Planning Commission.

The group is of the opinion that even if investment was tripled in agriculture than that of the previous plan, it would not be possible for this sector to either absorb the investment or for the sector to generatemanagement skills and human resources to manage the investment. The subgroup feels that if a growth rate of 4.5% can be targeted for agriculture, it is possible to target 7 to 8% growth rate in the livestock sector. If comprehensive changes are made in the current dispensation in the sector. The report has in principle been drawn in a manner that a GDP growth rate of 7 to 8% is obtained such that the overall agriculture growth rate can be pulled up to 4.5%. To achieve this growth rate in the livestock sector, this report looks at available technology options and human resource development plans required to be implemented by the ICAR. This has been the central focus of the present report.

Animal Science Education

1. The current scenario demands that the present educational system should be able to meet the knowledge needs of the commercial farmers besides small and marginal farmers. The service and goods sector should be so developed that the subsidised government efforts should be dispensed with completely by the end of the Plan. Therefore, it is necessary that the future veterinarians should be able to be knowledge intensive and practical oriented in order to effectively sevice three arms of livestock sector (Animal Production, Animal health and Livestock Product Technology). He should be able to utilize the knowledge for meeting the needs of the two livestock production systems those of (i) commercially viable and wealth and employment generating entrepreneurships and also (ii) the low input small units systems which should be converted into an entrepreneurial system through intensive knowlege and technology drivensystem. In order to obtain these it is recommended that veterinary and dairy science educaztional systems should be made autonomos with respect to governance of educational systems and should be given an autonomous status by implementing the Swaminathan's Committee's recommendation in leter and spirit.

2. Following Veterinary Council of India Notification on regulationof veterinary education which came in force in 1994, the veterinary colleges under the ICAR system were supposed to strictly follow the minimum standards of veterinary educaztion - Degree Course BVSc andAH - Regulation 1993. The subgroup had noted that none of the veterinary colleges is at the present moment following the regulations. The situation is so bad that deregulations of these colleges both under SAUs as well as under State Veterinary Universities is imminent. They will have their degrees de-recognized by the Government. This may create a major crisis in the country in the near future. It is therefore, recommended that during the Xth plan each veterinary college should be provided a sum of Rs. 3 lacks for upgrading its facilities and faculties to be at par with the government regulations in order to avoid de-recognization by IVC.

3. The Post Graduate Educational programme needs to be completely revamped and broken up into two streams (i) the current stream which prepares candidates for research and teaching; and the second stream which caters to the clinical and para-clinical aspects of the vegterinary profession. This stream will be based on hospital / clinic / diagnostic center focused programme, leading to a professional masters and Ph.D. degree. It will be necessary therefore to develop this second stream as the primary stream for training at post graduate level.
Cost estimate : Rs. 3,000 million including Resident Doctors Scheme.

4. Professional Eficiency Programme : In order to meet the professional upgradation needs of vetgerinarians in private and public sector employment essentially managing clinical, para-clinical and prophylactic aspects of livestock sector, it is necessary that programmes in veterinary colleges be initiated to upgrade the skills of these professionals through a series of PG diploma courses which can spread over a period equivalent to Masters or Ph.D. level. This should become a major post graduate activity in the veterinary colleges.

Cost of the scheme : Rs. 1,000 millions.

5. Continuing Veterinary Education : It is already too late that the veterinary and dairy curriculum has no relationship with the graduates who have passed out of their institutins while the technology platform has undergone tremendous changes, no efforts by the system has been made to upgrade the skills of 40,000 veterinarians in the field and 10,000 dairy, poultry and other specialists involved in livestock sector. It is necessary that every college starts a continuing veterinary education programme in the state (Rs. 1,000 million).

6. Animal Science Education at school level should be the major focus in the present schools in the country. It is proposed that ICAR should take up this matter with the Central Board of Secondary Education and emphasize the importance of introducing the Animal Science Education (Poultry breeding, pig breeding, dairying, sheep, goat etc) as subjects from grade VI to grade XII of our educational system so that after class XII these people become livestock entrepreneurs and do not look for jobs in the national pool of unemployed.

7. Vocational Training : At the present time in the livestock sector, the training programmes for para-veterinarians and similarly placed personnel like pharmacists, AI technicians, X-ray and Scan Analysis programmes, Laboratory technicians are either not available nor are they organized. While emphasis is being laid on lay inseminators and similarly placed other extension workers, their training seems to be not been taken seriously. It is therefore, recommended that each veterinary college should start vocationazl training courses varying from one to two years on a regular basis to train this cadre of technicijans on a regular basis (Rs. 1,000 million).

Regulatory System

8. The sub group is of the opinion that in order to maintain international standards in dairy, and other livestock sector educational programmes, it is the time for the government to establish the regulatory bodies for maintaining the minimum standards of education in these programes. This may be taken up by the Indian Veterinary Council or a new Regulatory Body may be constituted for this purpose by the Indian Parliament (Rs. 500 million).

9. Non-formal education programmes currently driven by NDDB, BAIF, AFPRP, KVKs and TTCs on subjects like marketing of milk, procurement and handling and related subjects like disease control, credit and insurance etc. need to beorganized sectorally and should fall in line with the country's basic policy on these and other issues (Rs. 200 million).

Manpower Requirement for R&D and Teaching

10. Estimates of Manpower Needs : Institutes of Manpower App (IMAR-1999) has given a preliminary data on generation of veterinary graduates and their absorption in the country. Their study has revealed that all the veterinarians are employed by the government. Only 6% go in to private and commercial sectors. The position has undergone a major change. It is being observed that progressively from a number of commercial zones like Tamil Nadu, 27% of veterinarians are absorbed by the private sector and an estimate of present admission scenario has revealed that about 1,878 new admissions in the veterinary colleges have taken place. This requirement is not enough even to meet the teaching requirements of these coleges. It has been suggested that a minimum of 3,000 to 4,000 veterinarians will be required in the country annually in order to meet the growth rate of 10% by the year 2020. Current vacancy levels of 6,000 veterinarians will be filled within the next three years and in the next ten years the required number of veterinarians will be produced; such that by 2024 we will reach self sufficiency target of 1:5000 (one veterinarian for 5,000 adult units of livestock) for effective animal health care and production a target fixed by the government.

In 2025 we will need to re-examine and readjust the admission requirements of colleges to be syncronus with the animal outflow. IN addition we would require an input of 3,560 of dairy graduates in order to sustain a growth rate of 10% in the sector. This would call for an institutional growth of higher than 10% by the year 2020. Consequently, it would be necessary to have an input of a minimum of 5,000 crores in the

sector of livestock development in education alone if the targets given by the government are to be realized.

The details of implementation platform for each of these recommendations are available in the body of the report.

Animal Science Extension - Research and Developmental Methodologies

11. Animal science education has been variously defined as veterinary extension educatioin, poultry, sheep and goat and dairy extension. Notwithstanding the nomenclature, there seems to be a basic misunderstanding regarding the premises of extension platform in Animal Sciences. While in the crops, the assumption is transfer of knowledge from science to the farmer through an extension medium; in animal sciences the knowledge transfer is the least while the services made available are the main platform for action. A farmer has a sick cow and all that he has to do is to take it to the veterinarian/vetgerinary hospital. It is a model which is primarily fixed in location and the farmer is supposed to take his animal to the hospital if the animal is sick or it is to receive artificial insemination or there is a diagnostic follow up for pregnancy or problems with regard to milk and milk products. The primary concern of the doctor/the farmer is not only the health of the animal but also safety and quality of the product, which is used, in human health. Unfortunately the current programmes of extension research are not taking this basic structure in to account. The emphasis is on knowledge transfer where the client is not identifiable.

    The group recommends that the extension division of ICAR may constitute a working group to examine this issue and get the impact studies commissioned in respect of the two models currently being used in the field (a) Fixed midel of the government (b) Farm door model of dairy cooperatives and NGOs. It would also be ideal to examine the linkage model, which has been successful for poultry production in the country. The subgroup is of the view tha the extension in veterinary and the livestock sector should be driven by technology underwriting in addition to technology transfer.

Research Programmes and Thrusts

Infrastructure : The available infrastructure comprises of two deemed universities, 4 species oriented institutes, one Bureau on Genetic Resources, one institute on Nutrition and Physiology, and 5 NRCs and 4 Project Directorates.

There are 17 network programmes and a few cooridnated projects. These are manned by 1,044 scientists.

Funding : An examination of funding has shown that from the 4th plan to 8th plan the funds allocated to this sector for research, education and extension have reduced from 16% to 10% by the 8th Plan as against a GDP contribution of 23-25%. In the IXth plan, the allocation has been increased to 14%. While the contribution to Agricultural GDP has been increasing, the research allocation has been decreasing. IN the crop sector while the GDP contribution is decreasing the allocaztion has increased from 30% to 35%. The figures in absolute terms give an impression that livestock sector research is being given the lowest priority within the system when in terms of assets in 1966, the government contribution from the livestock sector to the ICAR assets was 60%.

12. The subgroup recommends that Xth Plan allocation should redress the injustice done and should allocate 35% of the total allocation given to ICAR by Planning Commission to livestock sector.

13. The subgroup view is that there is general dissatisfaction in the sector both within the ICAR and NARS in respect of emphasis on the growth of livestock sector and its potential in poverty elevation and rural prosperity. The employment generation capabilities of this sector are not given any priority in the ICAR system nor ot their any efforts being made to bridge the gap in HRD inputs to ICAR institutes and NARS. The 1,044 scientists looking after this large sector while keeping the positions vacant not addressed. It has not been immediately considered necessary to give attention to reasons for low input into this system and the phasing out of scientists by 2005. It is believed that about 300 scientist would have retired leaving just 700 scientists to look after this sector within the SAU the division of capital grants reviewed by the SAU from ICAR are divided on the basisof grant received divided by number of colleges and not on the basis of requirements of the colleges, with the result that all veterinary colleges cannot even maintain their building and laboratories and teaching is substandard. Due to this kind of treatment the subgroup has been asked to make a recommendation that a separate council on Animal Sciences be established during the Xth Plan which it does to address the basic problems.

14. Animal Health : In the area of Animal Health, the analysis of the subgroup have revealed that after 1970, it has not been possible for the system to come up with a new vaccine or a commercialy viable diagnostic kit. In fact for national Rinderpest control and eradication programme the diagnostic kits had to be imported and are even imported today. It is, therefore, necessary that the Animal Health establishment be revamped so

that it can gain the same eminence as a world leader of thirties and forties. For this it is absolutely necessary that the emphasis be on converting IVRI into an institute of biotechnology so that the dividends required to be ploughed into the livestock sector are quickly obtained. The details of how it can be done are given in the body of the report.

15. Animal production - Animal Genetics and Breeding : The greatest failure in the area of Animal breeding has been that we have not been able to establish a field performance recording system for progeny testing of cattle and buffalo bulls nor have we able to develop a multiple ovulation and embryo transfer driven programme of sire proving at two of our premier institutes, IVRI and NDRI. It is, therefore, recommended that a (MOET) programme for selection of sires be developed at IVRI and NDRI crossbred herds in order to produce proven crossbred bulls of the index greater than 5,000 kg of milk in 305 days (Rs. 500 million).

16. It is also recommended that a new institute be established on Animal cloning so that by the endof the Xth plan if we do not succeed in implementing recommendation No. 15, we can have technology of genetic improvement through cloning and bypassing the traditional genetic improvement pathway using progeny testing as a base. The NRC on animal biotechnology could be convertd into Institute of Animal Cloning. Estimated cost Rs. 2,300 million).

Animal Feeding

17. The animal production in the Indian sub-continent cansurvive only if the Indian Scientists provide the mechanism for using plant cell wall in the crop residues as a source of energy for animal feeding. it isa paradox that India produces 500 million mt of crop residues and this has not been converted into energy to feed 400 milion livestock. An effort was made to create an institution for this specific purpose to use biotechnology in breaking lingo-cellulosic ring in the plant cell wall to produce lignin and cellulose through a solid-state fermentation process. Some partial success at the bench has been obtained but we need toinvest both in technologyas well as in production so that the end product is available from the crop residues. This should be the priority of Animal Science Research in the country; all the other researches can wait (Rs. 500 million).

18. India produces 35 million tons of oil meals,oil cakes a year. About 5 to 10% of this can be used in the livestock sector as source of protein. The major problem with these cakes is that besides containing proteins, it contains large numberof incriminating factors like toxins, anti-growth factors and many oxidants, which bind the protein and makie it

unavailable for the animal. A number of efforts using chemicals to neutralize these have been made but minor break throughs apart nothing substantial has come up. It is therefore, necessary that we concentrate on these cakes and oil meals and first find out the kind of factors, which make its use unsuitable and develop methods toeither break these down or remove them from the meals such that this protein can be vailable for animal feed. If these are taken into account and can be solved during the Xth plan, India will become a colossus and an economic giant in the livestock sector and agriculture as a whole (Rs. 500 million).

19. Socio-Economic Research - The subgroup was informed that it is not known as to what is fed to a cow or a buffalow in an Indian village around the year. There is a growing group of animal scientists who believe that milk and meat is produced by the Indian Animals from the water they drink and the air they breath and this special genotype performs its physiological function without the need of energy and protein. It is, therefore recommended that a project to study the basic inputs by various species under the various production systems be quantified on a yearly cycle basis so that this matter is resolved. While it cannot be denied that the animals produced products, which are utilized by the society, but the economists have not done any real time study on input/output ratios and the economic impact of livestock industry for sustainable livelihood of the rural people. It would be necessary that a major research effort be made on the economic value of livestock, their products and their interactions within the system.

20. Livestock based land use, pattern and integrated farming systems : The farmers of Indian sub-continent have been the embodiment of integrated farming system practioners based on wholist framework of animal, crop, fish and horticulture. Unfortunately, we have not loked at the terms of socio-economic asset based systems.

    It is recommended that livestock based cropping system which is basic livelihood option in watershed management of low rainfall areas - dry lands of India be given the highest priority in research particularly in dry land states like Rajasthan, Gujarat, parts of Maharashtra and Karnataka and Himalayan states of north-east and Uttranchal.

21. Species wise/institute-wise and commodity wise priorities have been identified and are available within the body of the report.

22. Restructuring of the institutes and coordinated projects : It is recommended that the coordinated projects be merged with the institutes which are currently servicing them. It is also recommended that the

project directorate on foot and mouth be shifted from its present location at Mukteshwar, Kumaun Hills to IVRI Regional Station at Bangalore where a P3 containment facility is available at Yahalanka and the vaccine production of FMD vaccine be stopped at that center. Entire FMD work of IVRI be located at Bangalore as a part of the Project Directorate. Efforts be made that this directorate is recognized by OIE as the World Reference Laboratory for Southern and South Eastern Asia. it is also recommended that the division of Virology be shifted to IVRI Iztnagar from its present location.

Thrust Areas and New Institutes

23. The subgroup has recommended the establishment of new institutes/centers.

1. Establishment of A Repository of Pathogenic Microbes of Indian origin.
2. Establishment of a central Institute of Toxicology
3. An institute of Veterinary Parasitology
4. National Centre on Pet Animals
5. A National Centre on Ethno medicines
6. Establishment of a repository of Microbes of dairy and food use.
7. An institute of Indian indigenous Dairy Products.
8. An institute for Dairy Engineering
9. Estabmlishment of Hill Animal Husbandry Institute

Structural Changes

24. The sub group was informed that in 1966 when the government decided to transfer IARI, IVRI and NDRI to the ICAR, it was stipulated that these three institutes would be treated as institutes of national importance and would be established through an act of parliament and would be governed on the pattern of Tata Institute of Fundamental Research. The subgroup wants to reiterate this recommendation of the cabinet and wants this implemented during the Xth plan.

7. Horticulture and Protected Agriculture

Horticulture

1. Collection, evaluation and documentation of germplasm using conventional and molecular techniques of fruits such as mango, citrus, guava, papaya, litchi, sapota, banana and grapes; vegetables, specially indigenous and minor vegetables; tuber crops such as sweet potato and dioscoria; mushrooms; oil palm; cashew; spices such as pepper, cardamom, ginger and turmeric; seed spices such as coriander, flannel, cumin and fenugreek; important medicinal and aromatic plants and major flower crops such as rose, carnation, tuberose, orchids, gladiolus, lilium, anthurium and gerbera including traditional flowers like merigold; jasmine, crysanthemum, desi rose, china aster, crossandra etc.

2. Utilization of modern techniques for the development of suitable plant type for mandated horticultural crops for resistance to abiotic and biotic stresses.

3. Development of packages of practices for improved varieties of all horticultural crops for different agro-climatic zones and cropping systems.

4. Identification and studies of the processes leading to ripening and senescence and clonal variation for all the horticultural crops and assessment of post harvest losses.

5. Development of rural based post harvest technologies leading to :

   (i) reduced losses during storage and transport.
   (ii) Improved shelf life of all perishable horticultural commodities, and
   (iii) Enhanced employment of rural youth.

6. Development of integrated disease and pest management strategies in horticultural crops for eco-friendly and safe produce for human consumption.

7. There must be added emphasis on entrepreneurship development and horticulture based industries in rural and tribal areas to create employment opportunities and social upliftment.

8. A strong base for technology transfer using the latest IT resources needs to be created.

9. Development of policies and standards for ensuring superior quality of horticultural produce to promote export under the present WTO regime.

10. the ICAR institutes must endeavor to impart short and medium term trainings to farmers and entrepreneurs for better horticultural production and higher employment generation.

Protected Agriculture

1. There cannot be any uniform greenhouse design suitable for the entire country. The greenhouse designs have to be situation specific to be successful. The present greenhouse designs adopted in different agro-climatic conditions need to be studied and, wherever necessary, newer designs need to be evolved. A catalogue of suitable designs needs to be prepared for convenient selection by perspective users.

2. The greenhouse market at present is small and hence not many fabricators are coming forward for venturing into this business. Efforts need to be made to create awareness among people about the usefulness of the protected cultivation technology, which would ultimately lead to a larger market.

3. The role of NCPA is appreciable in promotion of the greenhouse and other protected cultivation technologies. People are now using these technologies in places like Maharashtra, Karnataka, J&K even without subsidy. The NCPA should be given more autonomy and mandate for effective functioning. If necessary NCPA may be transformed into a National Board for Hi-tech Horticulture Development.

4. Human resource development in horticulture has got the attention of the government of India. It has already selected six supervisory training centers. There is need to have one such training center at IARI, New Delhi. The training center at IARI may develop modules to meet contemporary requirements in the area of protected horticulture.

5. Currently, cost of greenhouse is high and therefore, prohibitive for its adoption. There is a need for rationalization of greenhouse cost. Greenhouse and its accessories should be exempted from any kind of taxation.

6. Protected cultivation needs specific varieties for best results. There is a need to identify and develop suitable cultivars. Internationally available material should also be tested and made available.

7. There is a need for creation of a forum for interaction among manufacturers and users and other related professionals. An association of protected horticulture is required for technology assimilation and for creating a favourable policy environment.

8. There should be adequate standards on protected cultivation technology for healthy and sustained growth.

9. Multi-disciplinary teams of scientists in different agro-climatic zones should be organized in the form of Centers of Protected Horticulture to provide technical and training support.

10. Demonstration farms covering 5-10 ha each should be established where the protected horticulture practices are on live display. These farms must be self sustaining after meeting initial establishment costs from public funds.

11. A target of 5,00,000 ha under protected cultivation practices including greenhouse, low tunnels, plastics mulching, floating covers etc. may be set up. The potential areas of these intervention may be identified and adequate funds may be allocated.

8. Fishery

The fishery research under ICAR is being carried out under five major programmes namely (i) captive fisheries, (ii) culture fisheries, (iii) fish genetic resources, (iv) fishing and fish processing technology, and (v) fisheries education. The main areas of research under each programme are given below :

Capture Fisheries

1. Monitoring of exploited marine fish stocks.
2. Stock assessment of commercially important marine species.
3. Marine biodiversity, database, conservation and management.
4. Fisheries enhancements in inland open waters.
5. Catchment ecology in relation to fisheries.
6. Ecology and fishery potential of canals.
7. Riverine hydrodynamics and fish behaviour.
8. Hill fishery resources assessment and management.
9. Development of sport fishery in hill areas.
10. GIS based inventory of aquatic resources.
11. Development of predictive models.

Culture Fisheries

1. Breeding and culture of aquatic organisms.
2. Fish health management and immunology and disease diagnosis.
3. Fish nutrition and feed development (supplementary and balanced).
4. Aquafarm engineering.
5. Integrated fish farming.
6. Environment Impact Assessment.
7. Cage and pen culture in large water bodies and floodplain wetlands.
8. Development of pearl culture technologies.
9. Ornamental fish breeding and culture.
10. Coastal zone management.
11. Culture technologies of fish and shrimp for utilization of inland saline and water resources.
12. Breeding and culture of coldwater cultivable fishes.
13. Sewage-feed fisheries.
14. Biological control of weeds.

Fish Genetic Resources

1. Cataloguing of germplasm resources and development of database.
2. Biodiversity repository.
3. DNA Fingerprinting of prioritised species.
4. Genetic improvement and Bio-technology.
5. Exotics and quarantine.

Fishing and Fish Processing

a) Harvest

1. Fuel efficient vessels for offshore and deep sea fishing.
2. Ecofriendly and responsible fishing techniques for EEZ.
3. Craft and gear design improvement for marine and inland waters.

b) Post Harvest

4. Handling and transportation of fish.
5. Sanitation, hygiene and quality control.
6. Processing, value addition, packaging and marketing.
7. Waste utilization and by-products.
8. Bioactive substances from aquatic plants and animals.
9. Quality management and food security.

c) Engineering

10. Onbroad and onshore equipments for fishing and fish processing.

Fishery Education

1. Education and training programmes in specialised areas of fisheries.
2. Fishery informatics and database.
3. Vocational and distance education.
4. Socio-economics.
5. Extension and Transfer of Technology.
6. Information Technology and produc;tion of educational materials.

New Initiatives

a) All India Coordinated Research Projects

1. Freshwater prawn breeding and culture.
2. Integrated management of inland saline waters.

3. Mariculture and sea ranching.

b) Network Programmes

1. Exotics and new candidate cultivable species.
2. Development of quarantine system.
3. Hill fisheries development.
4. Food safety and risk assessment.

Suggestions for Increased Budget and Infrastructure Development During X Plan

1. The budgetary allocation to fisheries sector should be enhanced to 9% of total agricultural allocation in X Plan from present level of 5.6% allocation during the last plan period.

2. The infrastructure of following to be developed in X Plan :

   i) Hatchery for seed production to be established for mahsser in U.P., H.P. and Meghalaya.

   ii) Hatchery for seabass to be established in A.P., Orissa, West Bengal, Tamil Nadu, West Bengal, Orissa, Haryana and Punjab.

   iii) Hatchery for Scampy to be established in A.P., West Bengal, Orissa, Punjab, Haryana, U.P., Bihar, Maharashtra, Goa and Tamil Nadu.

   iv) Aquafarm to be established for rainbow traout in U.P., H.P., Jammu & Kashmir, Meghalaya and Tamil Nadu.

The Appropriate Budgetary Requirements for the Suggested Thrust Areas and Programmes

In view of the suggested thrust areas and programmes for X Plan in fisheries the budgetary requirement will be as follows :

A.	Non-Plan budgetary requirement	240.00 crores
B.	Plan budgetary requirement	200.00 crores
C.	Externally aided project on Indo-Frech proposal for seabass breeding and culture	4.00 crores
D.	Total Budgetary Requirement	444.00 crores

The non-plan expenditure during the IX Plan was 190.83 crores which needs to be increased to 240.00 crores in view of increased salary and related items considering 25% budgetary increase during the X Plan.

The plan actual expenditure during the IX Plan is 112.80 crores including budgetary allocations for 2001-2002. In view of the additional requirements for developing modern equipments and laboratory facilities for research, education and extension and infrastructure for hatcheries, demonstration farm and aquafarm and marine fish capture vessels and processing machinery the plan allocation to fisheries should be increased to Rs. 200.00 corres considering about 75% increase due to additional demand for infrastructure development. In addition to this externally aided project on Indo-French proposal for seabass breeding and culture is sanctioned for Rs. 447.66 of which most of the money will be utilized during X Plan. Hence the total X plan budgetary requirement for Fisheries Division will be Rs. 444.00 crores.

9. Biotechnology and Genetic Engineering

Introduction

The Planning Commission has envisaged a growth rate of 9% for which it is estimated that the growth rate in the agriculture sector has to be at 4.7% in the X plan. When this figure is viewed against the 0.7-0.9% growth rate actually achieved till now, the demand appears to be a tall order. Whatever, may be the ultimate growth rate achieved in the agriculture sector against the projected figure, it is clear that a quantum jump is needed in productivity, both in quantitative and qualitative terms. It is also apparent that to achieve a break through against a plateauing scenario in terms of agricultural productivity, additional land availability, irrigated and rain-fed, is not a major option. It is obvious that emphasis has to be laid on new technologies that can improve crop / plant yields against adverse conditions of biotic and abiotic stresses. Apart from improving yields, the physical health of a nation can only be improved through nutritius food. Since, the lower socio-economic segments cannot afford different varieties of foods to constitute a balanced diet, the main staple food itself should be able to provide adequate nutrition. Genetic Engineering and Biotechnology offers an opportunity to achieve these goals when introduced as one of the important components in the overall strategy in agriculture to achieve the projected targets.

The Present Scenario

Internationally, about 40 mn hectares are under the cultivation of transgenic cross. USA dominates the list of countries taken to commercial activation of transgenic groups. But, China, Argentina and Canada among other countries are also involved in commercial use of this technology. Soybean, Corn, Cotton, Canola and Potato are among the major transgenic crops cultivated. The emphasis on transgenics is for battling against biotic stress, pest and herbicide resistance in particular. The commercial interest of MNCs is essentially in these two areas, which are the major determining factors for the yield parameter. Efforts to improve quality traits to provide better nutrition have received only minimal attention, although the generation of golden rice reflects an initiative to improve the β-carotene status, which can eventually help to improve the vitamin A status of the population.

In India, there have been efforts to develop transgenic technology, especially for the generation of Bt cotton. There have also been efforts at the laboratory / green house level to develop Bt-rice vegetables etc. There are also efforts to improve quality traits such as ‘OO’ Brassica, transgenic potato with amaranth gene coding for a storage protein with high lysine and sulphur aminoacids. The success stories can be best be described as promising. Overall,

we are not really close to introducing any transgenic material for serious co-ordinated trials, except perhaps in one or two cases.

Priorities

Research

There is a general tendency to lump all biotechnologies together, ranging from plant tissue culture, biological control, biofertilizers to transgenics and the impact of anyone of these technologies on productivity is not clear. While, all these technologies have a place, the main concern of this subgroup is genetic engineering as applied to agriculture. But, it would be relevant to examine independently as to what extent tissue culture, biological control and biofertilizers have influenced Indian agriculture and what is their scope.

Biotic Stress

Crop losses to major pests is of primary concern to increase productivity. The reason why Bt-cotton has taken the centre stage in transgenic revolution is that it provides an ideal setting to demonstrate the efficacy of this approach. It affords protection against the lepidopteran insects and also brings down the number of pesticide sprays substantially. Considering the plight of farmers of this country against insect pest infestation and indiscriminate use of pesticides, incorporation of appropriate Bt genes, keeping the present and future in mind, into crop plants and bringing them into cultivation at the earliest is a top priority. While, research can be carried out in a wide variety crop and other plants, time targeted induction of transgenics against insect pests into Indian agriculture should concentrate on rice (cereal), chickpea and pigeon pea (pulses) and cotton (cash crop). The transformation protocols, claimed to be working, should be rigorously examined and propagated. Another major affliction is yield loss due to viral infection. Losses due to the propagation of Gemini viruses transmitted by white fly calls for a transgenic approach to develop resistance, especially in tomato, soybean, mungbean and cotton.

A major effort on steps leading to cultivation of transgenic rice should be a priority. Apart from the diseases already mentioned, a major effort to analyse for disease resistance genes in rice and isolation of genes conferring resistance to abiotic stresses from the wild relatives of the genus oryza should be undertaken. Since, India is participating in the rice genome project, micro satellite or CAPs markers should be quickly developed for marker assisted breeding to select for desirable quality traits. A number of transgenics have already been developed internationally. These should be procured and used for back-crossing into important Indian cultivars and field trials undertaken.

Heliothis armigera is a major pest on a number of crops. Gene discovery for the control of *armigera* through transgenics should be undertaken and dovetailed to IPM technologies to control this pest.

Quality Traits

In the area of post harvest technology, a transgenic approach to delay fruit ripening can be attempted in mango, banana, tomato etc.

As already stated, the major effort of MNCs is in the development and commercialization of transgenics to protect against pests and to confer herbicide resistance. India has to lay emphasis also on strategies to improve the nutritive quality of grains and vegetables and other quality traits. The specific projects could be :

1. Nutritional improvement in rice.
2. Change of fatty acid profile and meal quality in mustard.
3. Baking quality of wheat to make bread and biscuits.
4. Transgenic potato with balanced protein.

Abiotic Stresses

Crop losses are also due to a variety of abiotic stresses, which range from poor rainfall, water lodging, saline soil etc. Major stress related genes have been identified mostly in tobacco and *Arabidopsis thaliana.* Research has to be undertaken to put these genes in crop plants.

Veterinary and Fisheries Biotechnologies

A major concern with livestock and poultry is infectious diseases. Foot and mouth disease has caused serious concern even in Europe. Viral diseases destroy hatcheries wholesale. An important step would be to develop diagnostic kits to detect infectious diseases early and also develop cost effective modern vaccines such as recombinant/DNA vaccines. Embryo transfer technology does not appear to be economically viable and research is needed for cost effective production of the required hormones to induce super ovulation. A policy needs to be developed quickly on animal cloning, before serious investment on research can be made in this area.

Fish is the cheapest source of animal protein and a health food. To increase fish productivity substantially a variety of strategies are needed. Protocols should be developed for successful induction of triploidy and meiotic gynogenesis in a large number of fish species. There is need for developing new techniques for conservation of wild strains and cryopreservation of the sperm can constitute the gene banks, in addition to storage of DNA *per se.* Transgenic research is needed to introduce new traits such as enhanced growth, disease

resistance and thermal tolerance in fish. Appropriate DNA vectors are needed for expression of useful genes in fish. Diagnostic tools such as PCR should be standardized for the early detection of bacterial, viral and fungal infections.

Implementation

To achieve the goals suggested in the area of application of genetic engineering and biotechnology to agriculture the following steps are essential.

1. The actual level of competence in recombinant DNA technologies is limited to a few centers in the agriculture sector. This base can be broadened by net-working with other universities and national laboratories on a project mode, which should also include hands on training of the scientists from agricultural universities.

2. The Planning Commission needs to earmark a sum of Rs. 250 crores for the X plan period for R & D in the area of modern biotechnology related to agriculture.

3. The funding mechanisms should go beyond agricultural universities to include basic research laboratories in a net-work mode. For example, a net-work project in this area could be on rice. The kind of questions could be

(a) Transgenic-rice is available elsewhere. They can be quickly back-crossed with Indian varieties and steps taken to put them through co-ordinated trials and eventually for cultivation
(b) Massive support for indigenous research on development of transgenic rice against pest, viral and fungal resistance
(c) Study of computational genomics in rice
(d) Analysis of hardy genes from wild relatives of rice (e) Incorporation of stress-resistant genes in rice
(f) Marker-assisted breeding etc. Such major net-work projects should be formulated by expert groups with short-term, medium-term and long-term objectives.

4. The task forces for research funding should have specific experts as chairman and there could be an overall approval committee patterned after SERC (DST) or BRPC (DBT). The fact of the matter is that ICAR should assume leadership in funding and co-ordinating research projects in this area. The recent example of ICMR, attempting to assume major responsibility for biomedical research is worthy of note. Decisions on funding research projects should be taken within 6 months after submission of the projects. A mechanism for co-ordinating with the efforts of DBT in this area is essential.

5. These task forces should also be responsible for building appropriate infrastructure for research ranging from molecular biology gadgets to greenhouses with containment facilities.

6. A quicker mechanism needs to be evolved for lab to and transfer of promising transgenic crops / plants.

7. Provision should be made for undertaking joint research between public funded institutions and private companies, including MNCs. The IPR issues can be clearly spelt out in the beginning of the study and MOUs signed.

8. The procedure for obtaining permission to carry out small scale and large scale field trials of transgenic crops involving the state governments should be simplified, without compromising on the standard of evaluation.

9. Clarity does not exist on patenting / registration of transgenic varieties and useful genes *per se*. These issues should be settled at the earliest, in terms of actual execution in practice.

10. A major effort should be undertaken to strengthen research infrastructure in this area in agricultural universities. Competence building can be undertaken through net-work programmes. This interaction with basic science universities and national laboratories should also be used to improve curriculum and teaching. A bioinformatics network in the Agriculture sector is essential.

11. Serious efforts should be made to project correct and balanced views on transgenic technology to the public, especially farmers. Workshops should be conducted in villages in local languages for the purpose.

12. Technical expertise of the plant quarantine laboratory staff should be quickly built up in recombinant DNA technology.

In a nut shell the recommendations are :

Major network projects should be initiated to usher in transgenic technology to combat biotic and abiotic stresses and to improve the nutritive quality of foods. Transgenic rice should receive major attention. While, the transgenic stocks available from resource laboratories should be used to back-cross with the local cultivars, vigorous indigenous research should be pursued to develop transgenics against insect pests, viral and fungal diseases. Other crops for priority would be pigeon pea and chick pea (pulses) mustard and ground nut (oil seeds), and cotton (cash crop). Rice genome should be a major area of study,

which knowledge should be quickly harnessed for marker assisted breeding. In veterinary biotechnology, major emphasis should be to generate molecular diagnostic tools and modern vaccines to protect cattle & poultry against major infectious diseases. In fisheries, efforts should be towards sperm cryo-preservation, transgenic approach to obtain fishes with desirable traits and diagnostic tools such as PCR for detection of bacterial, viral, fungal and parasitic infections to help hatcheries choose a pathogen free brood stock.

Long term research should be devoted to application of genetic engineering to secondary crops (e.g. millets), post-harvest preservation of crops, fruits and vegetables, improvement in nutritive quality of foods, new genes for pyramiding to combat pest resistance, genes to combat abiotic stresses etc.

A sum of Rs. 250 crores should be earmarked for R & D in this area during the X plan. ICAR should emerge as the major funding and coordinating agency on genetic engineering and biotechnology research in agriculture. The funding and certification mechanism need a drastic change. Major net-work projects involving agricultural universities, basic science laboratories and research agencies should be formulated by expert groups in the areas mentioned, clearly indicating short-term medium-term and long-term objectives.

Task forces / PACs patterned after the DST / DBT evaluation procedures should be evolved to fund projects and to assess infrastructural requirements in agricultural universities and the associated institutions to execute research and carry out field trials. Mechanisms should be evolved to expedite lab to land transfer of technology. Extension activities should be directed to inform and educate the stake holders on the benefits and concerns inherent to this technology.

Important Projects in Crop Biotechnology

Major studies have been undertaken in the past ten years on molecular mapping in crop plants, development of transgenics and genome wide studies which would allow mining of alleles that would confer disease resistance and other important traits on our major crop plants. In the light of major developments in the area of Genetics and Structural and Functional Genomics, a special effort needs to be made in the next plan on initiating projects which would lead to improvement of our crop plants utilizing the latest technologies. These projects will have to be run in a network mode. Collaborations would have to be well defined and institutions within ICAR and outside will have to be involved. A major effort will have to be made in providing postdoctoral fellowships to students to improve the knowledge base in the country on genetic engineering and molecular breeding of crop plants. We suggest a few projects that would

bring major benefit to agricultural communities in the country. The following projects are suggested for funding in the next plan.

Rice genomic and transgenics

Rice crop is affected by a large number of biotic and abiotic limiting its yield potential. Indian efforts on transgenics as well as genomics and inputs from the Rockefeller Foundation have helped in developing useful components for the improvement of rice for high yield. Ongoing work for rice genome sequencing and gene discovery is likely to lay a strong foundation for future work. Keeping in view such progress and the importance of rice in national food security, research on the following aspects should be undertaken.

- Identification of genes of agronomic importance in rice, particularly for resistance to disease, pests and abiotic stresses.
- Defining the value of genetic variability in terms of SNPs among *indica* and *japonica* varieties and their wild relatives.
- Isolation and sequencing of complete cDNAs for selected genes of interest.
- Development of set of markers for precision breeding in rice.
- Characterization of tissue specific and inducible promoters.
- Participation in international effort to tag genes of utility.
- Functional validation of the utility of selected genes by transgenics and insertional mutagenesis.
- Development of F_2-derived populations with useful genes for marker assisted breeding.
- Back crossing of promising transgenic stocks into important Indian cultivars to be followed by extensive field trials.
- Alternative systems for hybrid seed production.
- Nutritional improvement of rice.

Development of transgenics resistant to viral diseases

Major studies have been conducted worldwide on developing transgenics for resistance to viral diseases. Being in the tropical/sub-tropical zone, a very large number of viral diseases, particularly caused by geminiviruses which are transmitted by white fly have become major yield constraints in tomato, soyabean, mungbean (*Vigna* species) and cotton in India. Some work has been initiated on molecular characterization of viruses in India but the attempts remain half-hearted. To develop viable technologies a major project should be launched with the following components :

- Molecular characterization of variability present within geminiviruses infecting the above mentioned four major crops.
- Development of constructs with most conserved sequences of geminiviruses and development of transgenics in cotton, mungbean, soybean and tomato.
- Field evaluation of transgenics.

Genetic transformation technologies for rainfed crops

Genetic transformation technologies should be developed for rainfed crops like sorghum, pigeonpea, chickpea, groundnut, saflower etc. so that suitable genes for disease and pest resistance could be introduced in these crops. Routine transformation technologies are not available in these crops. The crops mentioned above are frugal in resource consumption and are well adapted to dryland agriculture. These crops are also of importance for the nutritional security of millions of people. However, conventional improvement programmes have not yielded desired improvements and the productivity of rainfed crops has remained stagnant for a very long time. Development of transgenics for insect resistance and disease resistance would be a major goal of this project. Some work has been initiated in this area by funding from DBT and NATP. More intensive research is required in the next plan.

Hybrid seed production system

Hybrids offer a major way of enhancing yield. Research funded by DBT has led to development of new molecular methods for the control of pollination by developing male sterile lines. This technology has been developed in mustard and should now be taken to other major crops like cotton, pigeonpea, rice, safflower etc. With large number of breeding institutes in the ICAR system and the results obtained with coordinated programmes on Hybrids by ICAR, it should be possible to use the newly developed technologies for hybrid seed production in major crops.

Sequencing of a model legume

Legumes fix atmosphere nitrogen for use by the plant. It is conceivable that in near future a sequencing project on a model legume will be launched through a worldwide effort. India must participate in such a program. Although long term, such a project may have huge implications for genetic modification of plants. For a country like India the discoveries in the area of nitrogen fixation could be of major value in achieving food security. However, such projects could not be developed in isolation and should be carried out in collaboration with international efforts.

***Management of polyphagous insect* Heliothis armigera**

Heliothis armigera has been recognized as the major pest on a number of crops i.e. cotton, chickpea and pigeonpea. This insect pest has become resistant to a large number of pesticides and, therefore, multiple insecticide sprays have to be made to protect crops. This is increasing the input costs and at the same time leading to environmental pollution.

A major project needs to be launched to study the molecular endocrinology of this insect. Gene discovery for the control of *H. armigera* through transgenics should be explored. Management of this insect should be fortified with IMP technologies. This has to be multidisciplinary and multilab project with both short term and long term strategies.

Project on cutting post-harvest losses in fruit crops

Very large amount of fruit in India is lost due to over ripening during transport. There is dearth of expensive cold storage facilities. Genetic engineering methodologies could provide longer shelf life to fruit and, therefore, could provide cheaper alternatives to large-scale cold-storage facilities. The strategies for senescence retardation could be tested on a model crop first and subsequently deployed in other crops like mango, banana etc. Techniques for genetic transformation of major fruit crops will have to be established.

Nutritional enhancement of crops

Biotechnology for nutritional enhancement and quality enhancement can bring rich dividends. Some work is already going on in India and this should be further strengthened. The following subprojects could be undertaken :

a) Change in fatty acid profile and meal improvement of mustard.

b) Breeding of quality wheat for bread and biscuits.

c) Transgenics with nutritionally balanced proteins in crops like potato.

It would be useful if industry is involved in the projects from the beginning. As any superior materials will have to be commercialized interest of industry will be very useful. Both seed companies and fertilizer companies can be involved in the project. It would be also useful to involve Farmer's Cooperatives in research and development.

10. Plant Protection

Biotic stresses are a major constraint in achieving full yield potential of crop plants. The losses due to weeds, diseases and insects have been estimated to be around 40% in the developing or underdeveloped countries. If the post-harvest losses (15-20%) are also added, the situation becomes even more alarming. Intensive agriculture, driven by the need to produce more food from limited land and water resource has further aggravated pest and disease problem. Sanitary and Phytosanitary (SPS) Agreement of the World Trade Organization (WTO), aimed at developing measures that would ensure protection of human, animal and plant life or health and transparency in global agricultural trade adds another dimension and urgency to address plant protection related problems. There are also serious concerns related to the impact of climate change and indiscriminate use of pesticides on pest and disease problems.

Table 1. Estimated crop losses due to biotic stresses as percentage of total production.

	Diseases	**Insects**	**Weeds**
World	10	12	10
Asia	11	21	11

For sustainable agriculture, in an environment-conscious world, the growth-reducing factors like pests, pathogens and weeds have to be managed by biotechnological, biological and other eco-friendly measures, supported by judicious use of chemicals to maintain high economic returns without disturbing the ecological balance. The country will also have to strengthen its research base in this area so that the SPS measures of WTO are used to advantage in agricultural trade rather than impediment as non-tariff barriers.

Changing scenario of Biotic stresses

The intensive agriculture, specially the introduction of new high-yielding genotypes but susceptible to the pests and the pathogens already present in the country and changing cropping patterns including cultivation in non-traditional areas have resulted in a spurt of pests and diseases in various crop pathosystems, remarkably changing the scenario of biotic stresses. It is not only that new pest problems have emerged, but also the minor pests have assumed serious proportions.

Plant Diseases

Plant disease epiphytotics have been a major cause to change agricultural patterns and even food habits in many parts of the world. In India, the brown spot of rice (*Cochliobolus miyabeanus*) caused the great Bengal famine in 1943; red rot of sugarcane caused severe ephiphytotics in Uttar Pradesh and Bihar in 1938-42; wheat rust in Uttar Pradesh and Madhya Pradesh in 1946-47; Helminthosporium blight of wheat and barley in Uttar Pradesh, Bihar and Maharashtra in 1932 and 1974; grey mould (*Botrytis cinerea*) of chickpea in Bihar in 1979-81, Andhra Pradesh, Himachal and Tamil Nadu leaf curl of cotton in Punjab and Rajasthan in 1994-95; tungro disease of rice in Punjab in 1998-99; and necrosis disease of sunflower in Karnataka in 1997-2000 are just a few examples of the serious problems caused by plant diseases. Ironically most of these diseases have caused destruction in crops grown under rainfed agriculture, indicating vulnerability of such cropping systems.

In wheat, rusts were the most serious problems until the mid-seventies, but currently with the wide use of rust-resistant varieties, a minor disease of the past, namely, Karnal bunt has assumed serious proportions. The rice tungro virus and the bacterial leaf blight of rice are the most devastating diseases in the new varieties. Sheath blight has become serious on rice in the non-conventional areas. Maize and millets are now devastated by downy mildews. Blight of cotton became a major problem when the indigenous diploid cottons were replaced by exotic cotton tetraploid cottons. The new exotic cotton varieties are also highly susceptible to a new disease known as 'parawilt of cotton' of unknown etiology. During the past few years the viruses of cotton (particularly whitefly transmitted leaf curl) has become dangerous, and require special efforts to check the spread to different areas. Such examples of changing disease scenario are available for pulses, oilseeds, vegetables, fruits, etc. Certain diseases of complex or unknown etiology, e.g. parawilt of cotton, coconut root wilt, citrus dieback, mango malformation, guava wilt, crown rot of oil palms, brown bast disease of rubber, etc., need special efforts to develop management practices to minimize the losses.

Insect Pests

In India there had been serious outbreaks of insect pests like gram pod borer *Helicoverpa armigera,* tobacco caterpillar *Spodoptera litura*¸sorghum stem borer, *Chilo partellus*¸ rice stem borer *Scirpophaga incertulas,* diamond back noth *Plutella xylostella,* whitefly *Bemisia tabaci,* brown planthopper *Nilaparvata lugens*, onion thrips *Thrips tabaci,* army worm *Mythimna separata,* cutworms *Agrotis* spp., rice green leafhopper *Nephotettix* spp., white grubs *Holotrichia consanguinea,* root grubs *Anomala dorsalis,* fruit fly *Bactrocera cucurbitae, B. dorsalis,* termites *Odontotermes* spp., and red spider mite *Tetranychus telarius.* All these are fairly

widespread and cause serious damage in agricultural and horticultural agrosystems, both in terms of quantity and quality of the produce. Besides these, there are many insects which cause serious losses in storage like the rice weevil *Sitophilus oryzae,* flour beetle *Tribolium castaneum,* pulse beetles namely *Callosobruchus chinensis, C. maculatus,* resulting in huge losses to stored food , grains and seeds. There is no region in the country, which is devoid of these insects, and at any particular time, there are serous outbreaks of one or more of these pests. There had been serious outbreaks of *Helicoverpa armigera* on cotton, in 1988 in Guntur district of Andhra Pradesh, and it was followed by resurgence of whiteflies leading to several farmers committing suicide, and other social problems. Whiteflies not only cause damage as a polyphagous pest but also transmit economically important viruses. All these highlight the importance of insect pests, their role as insect vectors transmitting plant diseases, and the need for research on insects and evolving the integrated pest management strategies for major crop pests.

The magnitude of insect biodiversity amounting to more than two thirds of all known living organisms, and the 1 million species described so far indicate the need for increased emphasis, and studying them in detail. In the country losses due to insect pests amount to Rs. 60000 crores annually, of which effective insect pest management at the present level, is able to save only upto 12000 crores.

Nematodes

Plant parasitic nematodes, the unseen enemies, cause serious perpetual problems in agricultural production all over the world. Favourable weather and almost continuous availability of host crops in the tropical and subtropical regions including India favour their build-up. Being soil-borne and with wide host range nematodes are one of the toughest pests to control. India suffers heavy quantitative and qualitative losses to the tune of Rs. 24,100 crores annually, in various food, fibre and commercial crops due to nematodes. A number of new nematode problems have emerged in the intensive cropping systems. Nematodes also aggravate a number of bacterial and fungal diseases.

Root-knot nematodes: *Meloidogyne incognita* and *M. javanica* are spread all over the country and cause damage to vegetables, pulses, fruits, ornamentals, oilseeds and fibre crops. *M. arenaria* damages groundnut. Recently, a new root-knot nematode species *M. triticoryzae*, has been found, which can cause damage to rice and wheat in the north-western plains where rice-wheat cropping system is very popular. The burrowing nematode, *Radopholus similes,* causes serious problems in banana, coconut, arecanut, betelvine and other plantation crops in southern and coastal regions of Kerala, Tamil Nadu, Karnataka and Andhra

Pradesh. These have been found to be spreading fast to other areas like Maharashtra, Gujarat, Orissa, Madhya Pradesh and Assam.

The ear-cockle nematode, *Anguina tritici*, which cause the seed galls when alone and the yellow slime rot (Tundu) in combination with the bacteria, *Clavibacter michiganense,* is wide-spread in the wheat growing regions. Crop losses as high as 80% have been recorded in certain areas of Bihar and Madhya Pradesh where impact of agricultural technology is very low. Despite the easy and cheap methods developed for its management, this nematode caused havoc in Bihar in 1997-98.

There are threats of the entry of serious exotic nematode pests not so far present in the country. The stem and bulb nematode, *Ditylenchus dipsaci*; sugarbeet cyst nematode, *Heterodera schachtii*; soybean cyst nematode, *H. glycines;* coconut red-ring nematode, *Rhadinaphelenchus cocophilus*; pine-wilt nematode, *Bursaphelenchus xylophilus* etc. can cause havoc if they gain entry into India. Nematode infestations and contaminations in export commodities can be serious limitation in international trade in agricultural commodities; this aspect has gained even greater significance with globalization. Proper quarantine, denematization procedures, surveillance and pest risk analysis are necessary.

A few useful species of nematodes like entomopathogenic nematodes, *Steinernema* and *Heterorhabditis* species can also be used as bio-control agents of insect pests, while some other bacterial and fungal feeding nematodes play beneficial role in maintaining soil health.

Weeds

Weeds are an important constraints in agriculture. Weeds compete with crop plant for applied fertilizers and irrigation water, thereby decrease the crop yield to a great extent. Uncontrolled weed growth often results in yield reduction to the tune of 30-65%. Besides this direct loss they also results in depletion of large quantities of soil nutrients. Weeds also affect crop quality and health of humans and livestock.

Manual removal of weeds which is laborious, backbreaking and less efficient in slowly making way for improved weed management methods. Use of herbicides is one such method. Nevertheless, over -reliance on herbicides must be avoided, as it would create increased problem of environmental pollution, development of herbicide resistance in weeds, etc. Continued research is, therefore, very essential to monitor herbicide residues in environment and to identify and manage herbicide resistant biotypes. In view of problems associated with herbicide use, there has to be an increased emphasis on use of biological

control agents (insects, pathogens, etc.) and botanicals (microbial toxins, allelochemicals etc.). Despite extensive research, there has been limited success in this field. This area of research, therefore, should receive priority in X plan.

Vertebrate Pests

The menace of vertebrate pests, particularly the birds and rodents is increasing. There is a need to strengthen research for the management of these pests. The rodents are a serious concern as they cause direct damage to grains in storage.

Impact of Climate Change

The effect of changing global climate on diseases is largely unknown. It now appears that the Southern Asia (and India) will become warmer and much wetter. The major changes in global temperature and climate are expected to be mainly due to atmospheric CO_2, methane and chlorofluorocarbons. Initial experiments have shown that an increase in atmospheric CO_2 concentration from the current level of 330 ppm to 670 ppm, increases the susceptibility of plants to pathogens and pests.

There are practically no data on the effect of climatic variability on diseases and pests, because most of the studies have been more concerned with day-to-day weather conditions rather than with year-to-year climatic variability. Data are available mostly on the specific effect of meteorological variables on dissemination, infection, incubation period, sporulation and survival of pathogens. Climatic variability can affect any part of the life-cycle of the pathogen, insects, nematode as well as the interaction between or among these organisms. The integrated pest management (IPM) and Integrated disease management (IDM) strategies strongly rely on natural controlling factors such as weather and the pests' natural enemies. The increased interest in biological control should be accompanied by the recognition of the fact that the climatic variability may play an important role in some hyperparasitic relationship.

India is endowed with a wide range of agricultural climatic conditions at altitudes varying from sea level to the high mountains including areas with highest mean annual rainfall in the world and dry semi-desert conditions. Based on physiography, soils, climate and growing period, 21 agro-ecological regions (AERs) have been identified. Most of the major pest and disease problems in rainfed agriculture occur in subhumid and semi-arid conditions which represent 72 per cent of the total geographical area (329 m ha) of the country. These areas required greater research efforts related to plant protection. The other AERs have relatively fewer serious disease problems.

Indiscriminate Use of Pesticides

There are serious problems due to indiscriminate use of insecticides, of which insecticide resistance, pest resurgence, secondary pest outbreak, and minor pests becoming major pests are of a great concern. In many cropping systems such problems are becoming more serious, rampant and evident. There are manifold increase in the kinds of insect species recorded and the numbers of some of them have increased, creating imbalance, leading to development of serious pests. The indiscriminate use of insecticides in the cropping systems of cotton, rice, vegetables, fruits, storage etc., had resulted in resurgence of insects like whiteflies, aphids, thrips, mites in cotton, gall midges, leafhoppers and planthoppers in rice. The indiscriminate use of insecticides had also resulted in problem of insecticide residues and other safety hazards. In the state of Delhi, around 20 kg of insecticides are dumped in every hectare of vegetable cropped areas. The residue levels of insecticides monitored in the vegetables, fruit and milk samples indicate that in many cases these levels are far above the maximum permissible limits set by WHO. We need to have extensive research for the ecofriendly management of the pest and disease problems and a sound network of referral laboratories for monitoring pesticide levels which will also be very useful for meeting the SPS requirements of WTO.

Biological Control and IPM

The present and future emphasis will be on ecofriendly integrated pest and disease management for sustainable agriculture growth. This can be achieved through the use of biocontrol agents like: a) Microbial (viral, bacterial, protozoan and fungal) organisms, (b) Entomophagous nematodes, and (c) predators and parasitoids. In addition, Plant-derived pesticides (botanicals), Secondary metabolites from microorganisms (antibiotics) and insect pheromones applied for mating disruption, monitoring or lure-and-kill strategies will be important in IPM programmes. In the coming years, use of transgenic plants resistant to pests, pathogens and herbicides will help in minimizing the losses caused by the biotic stresses.

Biopesticides offer unique opportunities to countries like India to explore and develop their own natural biopesticide resources in crop protection. Such endeavours will aid in conserving foreign cash reserves, improving safety to applicators and consumers and protecting the environment. It should, therefore, be our effort to exploit such resources and recognize it as a thrust area for development.

In view of the increasing number of pests of crop plants and the effects of constitutive and induced defence, there is an urgent need for identification of plant based chemicals and volatiles attracting natural enemies of pests and

increasing the resistant potential of plants in relation and feeding behaviour of reproduction. Allelochemicals like pheromones and kairomones , are important signaling chemicals. Aggressive research is required on such compounds for their effective use in the mangement of pests.

SPS Related Issues

Sanitary and Phytosanitary (SPS) Agreement of the World Trade Organization (WTO) is aimed at development of measures which would ensure protection of human, animal and plant life and equivalence and transparency in global agricultural trade. There is a growing concern that certain SPS measures impede the export of agricultural produce due to lack of appropriate infrastructure to address various issues related to SPS Agreement. The factors that put us in disadvantageous position are:

- Lack of PRA on the pests of interest in international agricultural trade
- Lack of infrastructure for scientific research, testing, conformity assessment and equivalency.
- Lack of infrastructure and scientific support to benefit from the provision of transparency and adaptation to regional conditions.
- Lack of understanding on the SPS measures of other countries

The agreement requires the member countries to develop domestic SPS measures that (a) are technically sound and economically feasible to implement, (b) are based on geographical, climatic and epidemiological conditions prevailing in different regions of the country, (c) do not discriminate in favour of domestic producers, (d) recognize disease-free areas of other countries, and allow import of products originating from such areas, (e) permit introduction of measures providing a higher level of protection than achieved by measures based on international standards, if these are scientifically justified and are based on risk assessment, and (f) allow provisional adoption of SPS measures as a precautionary step, in case where the scientific evidence is insufficient but probable risk exists of the spread of pests or disease in the importing country. All these aspects require well researched inputs for effective implementation. We must develop the necessary infrastructure for plant protection research so that SPS measures are used to the advantage of Indian agriculture. For this, the overall infrastructure for research in plant protection will have to be reorganized and strengthened to provide basic scientific inputs for regulatory policies in the country.

Paradigm Shift

- Increase in the complexity of pest problems and pest outbreaks.

- Urgent need to harness the new technologies for reducing the losses due to pests and diseases
- Need to develop prototype IPM systems to cover all agrogeographical regions to minimize pesticides use and imporve the product quality.
- Increase in the use of biological control and host plant resistance in IPM.
- New tools of molecular biology and genetic engineering will significantly contribute to effective pest management.
- Development of forecasting and forewarning systems and corresponding network of advisory services based on computer programmes will help the farmers in taking timely decisions.

In view of the above scenario, it is imperative that a vibrant and well-knit plant protection research system is in place side by side the plant improvement and production research systems in the country.

X Plan Priorities of Plant Protection Tesearch at ICAR Institutes

- Organizing, strengthening and upgrading of basic research in the individual plant protection science disciplines will have to receive high priority.
- Major thrust will continue to be on development and promotion of Integrated Pest and Disease Management in all-major crops for sustainable agriculture.
- Strengthening of work of biosystematics of pest organisms for conservation of biodiversity and for providing identification services.
- Emphasis on survey, surveillance and monitoring programmes in order to develop medium and long term pest forecasting and forewarning systems.
- Strengthening of the national support system for developing crop varieties to major pests and plant pathogens.
- Application of biotechnology for pest and disease management.
- Acceleration of research on pesticides with particular emphasis on biopesticides and compounds of botanical origin.
- Strengthening of research in apiculture for pollination and increased honey production.
- Reorientation of research on vertebrate pests of agricultural importance.
- Establishment of model Plant Health Clinics for providing efficient plant protection services to the farmers.
- Creation of National Network on Bio-Informatics for Plant Protection.

Research Agenda

Although good progress has been made in India in the area of Plant Protection, still our knowledge about the pest organisms (Po), epidemiology (E) and management (M) is fragmentary and our database far from complete. In the coming years the research agenda will have to be based on PoEM (Box 1). The pest organisms have to be characterized at morphological, cytological and

molecular levels for identifying their races/strains/ biotypes, developing diagnostic probes and identifying genes which could be used in plant transformation for developing disease and pest-resistant genotypes.

Disease and pest epidemiology is a big issue, it encompasses all aspects of disease/pest development and requires a much broader database than any other aspect of plant protection. Epidemiological data will have to be developed on a location-specific basis for each crop and its diseases/pests for dependable pest risk analysis (PRA). This will require determined efforts by plant protection scientists and allied scientists working in different institutes and universities of the NARS. The data will have to be easily accessible through information technology innovations in electronic form to all concerned students, scientists, extension agencies and above all the farmers. It is only then that a 'dial in' management information would reach the end users.

All future disease and pest management strategies will have to be ecofriendly for sustainable agricultural growth. Search, development and use of resistant varieties will continue to have a major thrust of all crop (plant)-based institutions. However, this approach alone cannot meet the aspirations of the future. For the effective management of diverse pests and pathogens the country will have to launch, in earnest, identified research programmes (Box 1). These will require both research and developmental efforts. In the coming years many a pests and diseases will require application of biotechnological approaches for their management which will be a key area in the future, considering that in the present century almost all the crops will have genetic engineering interventions. For satisfactory progress of these research and development agenda, the country will have to provide highly trained manpower and adequate infrastructure.

Box 1 : PoEM-based research agenda for plant disease and pest management to meet the future needs

Characterization of pest organisms (Po)

- Collection and maintenance of biodiverse forms of pathogens, nematodes, insects and weeds
- Molecular characterization of plant pathogens and pests for
    - Race/strain/biotype identification
    - Identification of useful genes
    - Development of diagnostic probes
- Molecular characterization of host-pathogen/pest interactions
- Characterization of microbial toxins and their management
- Characterization and improvement of biocontrol agents including microorganisms insects and nematodes

Eepidemiology (E)

- Survey and surveillance to determine economic losses in different agroclimatic zones
- Phytosphere population in relation to diseases and pests
- Modelling disease / pest epidemics
- Forecasting of pest and diseases
- Pest risk analysis; identification pest / disease free areas

Integrated disease and pest management (M)

- Maintenance of pest-free status of the areas identified as of disease and pest free for export promotion
- Containment of new disease / pest and development of confidence measures to counter unexpected outbreaks of diseases and pests (possible biological warfare)
- Developing crop varieties with durable resistance through conventional breeding and genetic engineering
- Use of disease and pest free planting material
- Integrated ecofriendly disease and pest management
- Development of botanical pesticides
- Pesticide residue monitoring

Organization of Plant Protection Research

At present under the ARS system four broad disciplines related to plant protection viz., Agricultural Chemistry, Agricultural Entomology, Nematology, and Plant Pathology are identified, with an approved cadre strength of 459 S1 scientists (Table 2). These scientists are placed in 37 crop based ICAR institutions, six natural resource management institutions, five plant protection related institutions, two All India Coordinated Programmes and three networks. Most of the crop based institutions have only one to two scientists representing plant protection disciplines. These scientists, work, in tandem with the crop improvement and crop production scientists for developing (a) crop varieties resistant to pests and diseases, and (b) plant protection practices for the identified crop(s). Both are very important functions and have to continue indefinitely with adequate infrastructural support and need based deployment of expertise. However, changing scenario of disease and pest problems and to meet the challenges of globalization of agricultural trade much greater efforts and inputs are would be required for plant protection research in the country.

Table 2. Sanctioned strength of S-1 Scientists of ARS related to Plant Protection.

Plant Protection disciplines*	Cadre strength
Agril. Chemistry	35
Agril. Entolomology	181
Nematology	38
Plant Pathology	205
Weed Sciences	*

* There is no separate cadre of weed scientists.

Plant protection research will need to be reorganized by strengthening the existing research centers, opening of some new research centres considering specific needs by upgrading and improving some of the existing centers of excellence, and closing or merging of some other centers (Fig. 2). Plant protection research will have to be supported by well trained human resource. For providing adequate emphasis on various specialized areas of plant protection these will have to be identified as distinct disciplines in ARS.

Projects/Programmes which should be strengthened during the X plan

1. Plant Protection Programmes at the Crop Based Institutes

All these programmes should continue with adequate funding , infrastructure and peer support.

2. National Bureau of Agriculturally Important microorganisms

National Bureau of Agriculturally important microorganisms (NBAIM) has been established recently (during the 9th Plan) at New Delhi. One of the important area of work of the newly established bureau would be related to plant pathogenic fungi. The Bureau will have to organize research on the collection, identification and maintenance of viable cultures of the fungi and their races, and provide identification service at the national and international levels. Considering the vast diversity in pathogenic fungi a network on the biosystematics of pathogenic fungi should be established to support the identification service and maintenance of cultures.

Fig. 1. Plant Protection

	hemicals	**Related Economic Products**	**Biological Control/** IPM	**Other Pests**	**Entomology**	**Pathology**	**Mycology**	**Bacteriology**	**Virology**	**Nematology**	**Weeds**
Institute	NIA				NIE	NIFP					
National Bureau							NBAIM				
NRC		Mushroom	NCIPM					NRCBDP	**NRCPV**	NRCN	NRCW
		Apiculture									
Project Directorate			PDBC								
AICRP	Pesticide Residues	Apiculture	AICRPBC		Whitegrub	Seed & Beetlevines				AICRPNPC Nematology)	AICRP (Weeds
Network	**Pesticide Residue**	**Apiculture**	**NCIPM**	Ornithology	Agril. Acarology	Applescab	**Biosystematics of pathogenic fungi**		WTGs		Weeds
				Rodent Control	**Heliothis Management**	Seed borne pathogens					
					Soil Arthrpods	Phytophthora			**Topso viruses**		
						Rhizoctonia					

Existing centers to continue | Existing centres to be closed | New centres proposed | Approved in IX Plan

3. NRC Mushroom

This centre should take up work on all mushroom and related fungi. The centre needs strengthening so that research on this important group of fungi - in which country is very rich - is done in totality and not just restricted to cultivable forms.

4. *NCIPM*

NCIPM established in 1988, has made a significant beginning in achieving the goals of IPM and is making essential and pragmatic efforts to develop computer-based programmes for storage and retrieval of information on different aspects of IPM.

Programmes for developing and promoting environmentally sound IPM technologies for different crops are underway. This centre requires strengthening for work in the following areas : (i) IPM Synthesis and Validation Network, (ii). Synthesis and validation of IPM for vegetable crop, fruit crops and plantation crops., (iii) Strengthening Pest Management Database & Information System, (iv) Upgrading IPM Training Facilities and (v) Creation of National IPM Information Centre. The centre would require additional well trained scientific manpower, an appropriately furnished training hostel, a well equipped computer facility for networking and database generation at the national level.

5. NRC Weed Science

NRC Weed Sciences is one of its kind anywhere in the world. By staffing competent scientists and by providing adequate facilities, it would become a centre of international repute for research and training in weed science. This is also required to meet the ever-growing multitude of problems created by weeds in agriculture and horticulture. The research efforts during the Xth Plan should be aimed at generating data that would help in developing efficient, economical, ecologically safe and environmentally friendly methods of weed control in different crops, cropping systems and other eco-systems. As this cannot be achieved by a single method, approach should be to lay greater emphasis on integrated weed management. The main objective should be to cut cost, to increase productivity and to maintain sustainability in crop production. A stronger and more aggressive approach is required in the future to mitigate. To meet the emerging challenges it is suggested that NRC Weeds should be adequately strengthened by deploying need-based manpower trained in the required areas concerning weed management. Strengthening of NRC for Weed Science is therefore recommended. NRCWs requires a training centre, a national weed herbarium, a weed gene base, a herbicide residue laboratory, radio tracer laboratory and facilities for conducting research under controlled environment. It should also be assigned the function of developing techniques for weed identification particularly those based on seed morphology to help in preventing introduction of exotic invasive weeds.

6. Project Directorate of Biological Control

This is the only institute in the country to provide major technological inputs for IPM for the biological management of different crop pests. It is proposed to strengthen it to cater the enhanced needs of this system of pest management not only in India, but also to assist the other neighbouring countries by opening up the facilities, particularly for training.

The Directorate requires restructuring into the following Divisions: (i) Biosystematics, Introduction, Cataloguing and Quarantine; (ii) Entomophages Mass Production in vivo; (iii) Insect Pathology; (iv) Biological Suppression of Plant Diseases and Phytonematodes; (v) Biotechnology and Genetic Improvement of Biocontrol Agents; (vi) Entomophages Behaviours Study; (vii) Transfer of Technology and Human Resource Development.

7. All India Coordinated Research Project on Nematodes

This project is doing valuable service by providing countrywide information on distribution of nematode problems and crop losses; multilocation testing of technology and germplasm and demonstration. It should cover the areas of the country not studied so far and should establish a computerized National Nematology Data-Base with a computer software specialist.

8. All India Network Project on Ornithology

All India Network on Agricultural Orinthology has the mandate to: (i) undertake multi-located and coordinated research on survey of bird species affecting agricultural crops, their distribution, population dynamics, food and feeding habits and migration patterns; (ii) evaluate economic status of birds in relation to crops in different agro-ecosystem including their beneficial role, and (iii) assess crop loss and investigate economic method for their management. It is an important area. The project should continue to develop practical management practices.

9. Network Project on Rodent Control

Rodents are a major menace in agriculture. The All India Network Project with its 10 centres has considerable achievements to its credit in developing some management programmes for major crops. This is the only research project for rodent management in the country. Apart from conducting basic and strategic research on rodent control, the project's mandate includes multilocational programme on testing new technology inlcuding new rodenticides for integrated rodent management. An important aspect of the project is to impart training and promote control campaigns at community level. This project should have greater impact than at present.

10. All India Network Project on Agricultural Acarology

This project has the mandate to conduct basic and strategic research on biology and ecology of major mite pests specially factors effecting their resurgence and management, to identify and develop technology for utilization of predatory mites for biological control and to provide identification services for agriculturally important Acarina. This is a very important group of pests affecting a number of field crops, fruits, vegetables and ornamentals. Recently, the coconut Eriophyid mite has completely devastated coconuts plantations in Southern states of Kerala, Karnataka, Tamil Nadu and Andhra Pradesh. At present the AINP on Agricultural Acaralogy has 8 centres. These centres are mainly involved in location specific research for survey and control of mite pests. These centres need to be strengthened to take up basic and strategic work.

Projects that are recommended to be modified

1. All India Coordinated Project on Pesticide Residue

It is recommended to change this as an All India Network Project with the Director of the newly proposed institute of pesticides to coordinate the activities of the network.

2. All India Coordinated Project on Weeds

This project is recommended to be changed to network with the Director, NRCWS to coordinate the activities of the network.

3. All India Coordinated Project on Apiculture

This project is recommended to be changed to network with Director NRC Apiculture to coordinate the activities of the network.

Projects recommended to be transferred to SAUs

1. All India Coordinated Project on Applescab

This project is recommended to be transferred to the SAUs.

Projects recommended to be dropped

1. All India Coordinated Project on Whitegrlub

The project is recommended to be dropped.

2. All India Coordinated Project on Beetlevine

This project is recommended to be dropped.

Establishment of New Institutes/Centres/Networks

The new institutions proposed here can be established by redeploying the existing manpower and infrastructure available so that the objectives are achieved without much financial burden. This will also help in the effective

utilization of the limited resources for cutting edge research in highly specialized and advanced disciplines related to plant protection.

1. National Institute on Agrochemicals

Pesticides, whether of synthetic or natural origin, constitute one of the basic inputs in plant protection. As on today, there is hardly any product worth the name that has been indigenously developed, even though big strides have been made in generating alternative technologies for various imported products. With the introduction of Intellectual Property regime, development of alternate technologies of making known chemicals will henceforth not be possible. To overcome these constraints, it is essential that the country creates a strong base in agrochemical research and development. Presently, sporadic efforts have been made at the Indian Institute of Chemical Technology (IICT), Hyderabad, and National Chemical Laboratory, Pune to develop indigenous technologies of some of the imported pesticides. Institute of Pesticide Formulation Technology (IPFT), Gurgaon attends to the pesticide formulation needs of the industry. The Central Insecticide Laboratory (CIL), Faridabad, attends to the quality control requirements of the pesticides and verifications of the data required for registration of pesticides. However, there is no centre devoting exclusive attention to the multifarious aspects of research (such as chemistry and development of synthetic and natural pesticides, product scale up, quantitative structure activity relationship, formulation, packaging and delivery system, toxicology, biochemical mode of action, environmental chemodynamics including persistence degradation and interaction with the ecosystem, safety evaluation studies, effect on non-target organisms, bioefficacy, decontamination, disposal, analysis and quality control), education and training on the subject. It is, therefore, proposed to create a National Institute on Agrochemicals under the Indian council of Agricultural Research to devote exclusive attending to the various aspects of research and development in the field.

The proposed Institute shall lay emphasis on the development of environmentally benign agrochemicals from synthetic and natural sources, generate chemical structure-activity leads, manipulate insect behavior through the use of semio-chemicals, standarise process development and scale-up, develop novel approaches based on molecular, biochemical and technological advances, and address to various other chemical based issues to achieve a precise pest control package. The development of usable formulations of the potential products and their delivery systems, shelf-life, safety evaluation, pesticide interaction with the agro-ecosystem, analytical methodologies and minimizing environmental hazards including detoxification, decontamination, disposal etc. of pesticides shall also be addressed.

A data base will be created on all aspects related to pesticide development and use. The institute shall specifically address the quality aspects of the agro-chemicals as well as the agricultural produce to

facilitate the export/import of products of desired quality complying with national/international sanitation and phyto-sanitation requirements. Above all, it will serve as a national referral centre for pesticide quality and residues.

The Institute may be organized in the following major Divisions/Units : (i) Botanical Pesticide Division, (ii) Synthetic Pesticide Division, (iii) Formulation Division, (iv) Environmental Safety Division (Application and Monitoring), (v) Toxicology and Standards Division and (vi) Analytical Chemistry Division and Referral Unit.

2. National Institute of Entomology

There are more than 1 million recorded species of insects, out of the 1.6 million or so of the total living organisms recorded so far. Many of these species of insects recorded so far are of significance to human beings in view of their utilitarian or economic values. Thus for every ten living species of biological organisms, there are atleast six insect species, which denotes the relative significance of insects. Due to the species which are injurious every year we are losing agricultural crops, in addition to man days lost due to insect born diseases. In India there had been serious outbreaks of insect pests like gram pod borer *Helicoverpa armigera*, tobacco caterpillar *Spodoptera litura*, sorghum stem borer Chilo partellus, rice stem borer *Scirpophaga incertulas*, diamond back moth *Plutella xylostella*, whitefly *Bemisia tabaci*, brown planthopper *Nilaparvata lugens*, onion thrips *Thrips tabaci*, army worm *Mythimna separata*, cutworms *Agrotis* spp., rice green leafhopper *Nephotettix* spp., white grubs *Holotrichia consanguinea*, root grubs *Anomala dorsalis*, fruit fly *Bactrocera cucurbitae, B. dorsalis*, termites *Odontotermes* spp., and red spider mites *Tetranychus telarius*. All these are fairly widespread and cause serious crop losses in the field. Besides these, there are many insects which cause serious losses in storage like the rice weevil *Sitophilus oryzae*, flour beetle *Tribolium castaneum*, pulse beetles namely *Callosobruchus chinensis, C. maculatus*, resulting in serious losses to stored food, grains and seeds. There is no region in the country, which is devoid of these insects, and at any one time if taken, there are serious outbreaks of any one or more of them. These cause serious losses in various agricultural and horticultural agroecosystems, both in terms of quantity and quality of the produce. There had been serious outbreaks of *Helicoverpa armigera* on cotton, and in the year 1998, serious outbreaks occurred in Guntur of Andhra Pradesh, and it was followed by resurgence of whiteflies leading to several farmers committing suicide, and other social problems. There was a serious outbreak of leaf curl virus disease in cotton and yellow vein mosaic disease on mung bean transmitted by aphids and whiteflies, especially in the north western parts of the country. All these highlight the importance of insect pests, their role as insect vectors transmitting plant diseases, as pollinators and as beneficial members silk, lac and Honey bees of the living biodiversity (Silk worms, Lac insects and Honey bees) and the need for research on insects and evolving the integrated pest management strategies for major crop pests. The magnitude of insect biodiversity

amounting to more than two thirds of all known living organisms, and the 1 million species described so far indicate the need for increased emphasis, and studying them in detail. Broad estimate indicate that we are losing 30% of the entire crop produce in the field and almost 35% in the storage.

There are serious emerging problems due to indiscriminate use of insecticides, of which insecticide resistance, pest resurgence, secondary pest outbreak, and minor pests becoming major pests are the serious ones. In many cropping systems such problems are becoming more serious, rampant and evident. There are manifold increase in the kinds of insect species recorded and the numbers of some of them have increased, creating imbalance, leading to development of serious pests. The indiscriminate use of insecticides in the cropping systems of cottton, rice, vegetables, fruits, storage etc., had resulted in resurgence of insects like whiteflies, aphids, thrips, mites in cotton, gall midges, leafhoppers and planthoppers in rice. The indiscriminate use of insecticides had also resulted in problem of insecticide residues and other safety hazards. In the state of Delhi, around 20 kg of insecticides are dumped in every hectare of vegetable cropped areas. The residue levels of insecticides monitored in the vegetables, fruit and milk samples indicate that in many cases these levels are above the maximum permissible limits.

The emergence of increasing potential for exploitation of semiochemicals in novel crop protection strategies in recent years has led to a better appreciation of their impact on insect pests and the essential role that they play as one of the important components on IPM. In today's scenario, allelochemicals and pheromones are of increased relevance to ensure a greater understanding of the communication systems in insects and plants.

Recognition of plant allelochemicals as agents influencing the behaviour of insects and their natural enemies is comparatively recent. The green leafy odours of plants comprising mixtures of fatty acid derivatives such as C6 aldehydes, alcohol and esters provided by the lipoxygenase pathway forming "aerial bouquets" enable insects to reliably detect host plants through olfaction. Many of these plant volatiles also stimulate oviposition, though oviposition deterrent substances are important aspects deserving increased consideration.

Future prospects of semiochemical research associated with insect-crop interactions appear bright. While there is no doubt that they cannot be used alone as direct replacement for pesticides, they must be integrated with other forms of pest control involving natural enemies and aspects of host plant resistance conferred by plant breeding. Today, such an approach has been called the push-pull or stimulo-deterrent diversity strategies, wherein deployment of semiochemicals will protect the crop by deflecting pests from the vicinity and at the same time attracting them into trap crops with increased natural enemy potential. The most important future opportunity lies in modifying pathways leading to

semiochemical production wherein existing pathways could be modified to produce more useful metabolites. The production of semiochemicals by plants as a bridging point in the biotechnological production of semiochemicals by molecular biological techniques is a vision for the future. Such knowledge may also lead to the development of new plant varieties with enhanced chemical defenses or to methods of inoculating plants with elicitors to increase their resistance to insect pests.

The proposed Institute should have the following Divisions/Sections for research and teaching in different mandated areas related to insect and mite pests: (i) Biosystematics and Biodiversity, (ii) Insect Ecology and Population Dynamics, (iii) Soil Arthropods, (iv) Physiology and Semiochemicals, (v) Pest-host Interactions, (vi) Insect Toxicology and Resistance Management, (vii) Vectors of Pathogens, (viii) Insect Pathology, (ix) PRA, (x) Post-harvest Entomology, and (xi) Insect Pest Management.

3. National Institute of Fungal Pathology

In the recent years, there has been increase in fungal diseases throughout the country. Many of the fungal diseases not only result in yield reduction but also adversely affect quality of agricultural produce and lead to the problem of microbial and toxin contamination. Due to the fast development of new races the diseases caused by fungi require continuous monitoring and management. It requires a concerted effort by highly trained and motivated plant pathologists to generate basic data on the fungal pathogens of our concern. In view of the economic importance of fungal diseases, a National Institute of Fungal Pathology has been proposed with the following objectives:

- To develop diagnostics for major pathogens based on immunodiagnostic techniques and nucleic acid.
- To develop molecular markers for characterisation of pathogenic variability in important plant pathogens causing diseases in cereals and pulses.
- To identify molecular markers for resistance in important crops and utilise them for marker assisted selection for breeding for resistance against important fungal pathogens.
- To exploit the use of novel techniques such as PR proteins and SAR for the management of fungal diseases.
- To strengthen researches on biological control of soil borne and foliar pathogens and to develop bioformulations and delivery systems.
- Work on crop loss assessment due to disease, epidemiological studies and forecasting.
- Pest risk analysis of pathogens for quarantine importance.
- Diseases of unknown etiology need to be investigated with special emphasis on diagnostics and management.
- Strengthen the existing Phytophthora network and initiate a Rhizoctonia network in view of their importance in fungal pathology.

The proposed Institute should have the following Divisions/Sections for conducting research and developing trained human resource in the areas related to Institute's mandate: (i) Molecular characterization of fungal pathogens, (ii) Host-fungus interactions, (iii) Epidemiology and forecasting, (iv) PRA, (v) Post harvest pathology, (vi) Disease diagnosis, (vii) Integrated disease management, and (viii) Resistance monitoring and management.

4. *National Research Centre of Plant Virology*

Virus and virus like diseases of plants cause enormous economic losses in agricultural production. These diseases are major constraint in improving crop, fruit and vegetable production, particularly in the tropics and subtropics which provide ideal conditions for the perpetuation of the viruses and their vectors.

Actual losses caused by virus and virus like diseases are difficult to estimate. However, enormity of the losses can be easily judged from the fact that mungbean yellow mosaic geminivirus alone is reported to cause an annual loss of over US$ 300 million by reducing the production of crops like black gram, mungbean and soybean. Similarly, sterility mosaic agent along with wilt disease can result in a loss of over US $ 300 million in pigeon pea. The losses are even more alarming in rice and cassava. Estimates of losses of perennial horticultural plants like banana, citrus, coconut, papaya etc. are not available. But these horticultural crops are most vulnerable to reduction in yield due to diseases caused by viruses and other submicroscopic pathogens (SMPs) like BLOs, MLOs and viroids. In these crops the yields are not only reduced, but the plants decline quickly and are predisposed to other pathogens resulting in large-scale destruction of plants. Citrus is an example in which dieback has assumed a very serious proportion in the major citrus growing parts of the country. The increase in the incidence of viral diseases in banana is also a cause of great concern.

The losses caused by virus and virus like diseases can be minimized through integrated management of the casual agents and their vectors. It requires a thorough understanding of the pathogens like viruses, viroids, other SMPs and their interactions with the plant host and vectors. It is only then that practical management practices can be developed for each virus-vector-host combination. Realising the importance of advanced research in this difficult area, establishment of a National Research Centre of plant Virology (NRCPV) was approved in the IX Five Year Plan. The need to have such a centre is urgent. It should be set up as early as possible.

NRCPV will become a nodal centre for all plant virology work in country, and develop strong linkages with other institutes/universities where virology work is being done in the country. The Centre will also help in establishment of laboratories in various institutes/universities to undertake research on plant virology in the strategic areas, and development of network projects.

NRCPV will undertake the work on characterization of important sub-microscopic pathogens like BLOs, MLOs, viroids and viruses, and the development of diagnostic probes. A major function of the Institute would be to provide national diagnostic service for the important diseases caused by viruses and allied pathogens. The Centre will also undertake ecological studies on the pathogens and their vectors. Characterization of the pathogens will help in the identification of alien genes which could be used in developing resistances in desirable genotypes of plants of agricultural and horticultural importance. The centre will develop technologies and strategies for the management of diseases caused by viruses and the production of disease free planting materials. The major emphasis will be on the management of diseases in small holdings. The Centre will provide valuable inputs for developing national policies to contain the diseases caused by viruses and allied pathogens.

Apart from the above research and development activities, NTCPV will play an important role in human resource development of trained personnel who would be able to undertake studies on these difficult pathogens at State Agricultural Universities, other National Institutes, and Government and private agencies concerned with improving production of agricultural and horticultural crops in the country.

Major objectives of the Centre would be:

- To collect, classify, characterize (at biological and molecular levels) and conserve viruses and other sub-microscopic plant pathogens (SMPs) like (BLOs, mycoplasmas, and viroids).
- To study the ecology of viruses and other SMPs and their vectors
- To characterize viral genes and their functions, and study their diversity.
- To study process of replication of viruses
- To determine mechanism of resistance in plants to viruses, other SMPs and their vectors.
- To identify alien genes which could be introduced into desirable genotypes of plants for developing resistance to economically important diseases caused by viruses and other SMPs.
- To develop virus-based system which could be used for the production of edible vaccines.
- To develop technologies for the production of virus-free (seed and planting materials)
- To develop virus management practices particularly for small holdings
- To develop trained manpower through teaching and training programmes for capacity building

NRCPV should have the following divisions: (i). Fundamental Virology, (ii) Molecular Virology and Genetics, (iii) Vector Biology, (iv) Virus ecology, (v) Phytoplasmology, and (vi) Applied virology.

5. *National Research Centre for Apiculture*

Bee keeping is an important cottage industry in India. It is an integral part of different farming systems in agriculture, horticulture and animal husbandry. Honey's immense food and medicinal values are also well known. In addition, honey has also a tremendous export potential. However, the biggest services the bees render to us are in the pollination of crops. The value of honeybees as pollinators of different crops has been estimated to be 20-30 times more than their value as honey providers.

In recognition of the importance and need for research in apiculture, ICAR had started the AICRP on Honeybee Research and Training which at present has 13 centres. These centres mainly take care of the regional research needs and are also mandated to impart training to beekeepers and development officers. The project has some significant achievements to its credit, specially in the introduction of the European bee, *Apis mellifera* to the various parts of the country, from Assam and Bihar to Karnataka, Kerala and Tamil Nadu.

The Indian apiculture, today, however faces a number of problems, perhaps the most important has been outbreak of Thai sac brood virus which had almost wiped out all the colonies of the Indian bee, *Apis cerana indica* in Southern India. The proposed National Centre for Apiculture is needed to undertake the basic research to address the problems in bee management, bee pathology, bee breeding, processing and bee-products, standardization of equipment and marketing. Greater emphasis has to given to crop pollination. It is estimated that about 150 million bee-colonies are required to cover the area of over 50 million hectares under cross-pollinated crops in the country, while the estimated number of total colonies at present in the country is only about 1 million.

6. *National Research Centre of Bacterial Diseases of Plants*

In India a large number of bacterial plant diseases are present. Good work has been done on bacterial diseases in rice, cotton, potato and pulses, and the data generated on varieties and biocontrol has been very useful in the ecofriendly management of these diseases, Some other known serious diseases need immediate attention e.g. wilt of solanaceous crops (including ginger), black rot of cole crops, soft rot of vegetables, citrus canker and mango canker. Bacterial diseases are also serious in maize, grapevine, onion, sesamum, tomato and coconut root wilt. The internationally important diseases like crown gall of stone fruits (where the genus Agrobacterium is involved) and fire blight of apple (Erwinia amylovora) have also been reported from India, but there is no further data on even the extent of disease occurrence / losses.

Work in bacteriology needs sophisticated instruments and training in molecular biology, biotechnology and genetics to generate basic data on plasmid biology, biochemical taxonomy, primary disease determinants, chemistry / ultrastructure of exopolysaccharides, HR / SR factors, toxins, enzymes, bacteriophages, avr, vir, hrp genes and their cloning and successful transfer to useful varieties, mobility of genes, molecular detection of pathogens / races / biotypes, prokaryotic inhibitors, secondary metabolites of the biocontrol agents, etc., which can be utilised in the integrated disease management.

Infrastructure has to be created and scientists have to be trained and motivated to work on plant bacteriology. It must be indicated that it takes sustained efforts to generate useful data on bacterial plant pathogens, which are prokaryotic and can not be seen by naked eyes. Their taxonomy also depends on physiological / biochemical / genetical characters.

NRCBDP will have the programmes covering the following thrust areas

- As most bacterial plant pathogens are seed borne and as use of healthy seeds / planting material is one of the most important inputs, the following programmes are suggested : Rapid molecular detection of pathogens at low levels (target 1 bacterium / seed). Currently, the methods used are ELISA (involving mono-and polyclonal Antibodies), fatty acid profile, plasmid profile, nucleic acid probes, PCR and bio-PCR (i.e. combined biological and enzymatic amplification). With improved detection levels these methods can be used in plant sanitary / phytosanitary certificates. Correlative quantitative studies between seed borne inoculum and their seed transmissibility, highlighting the minimum / critical inoculum needed for seed transmission under different climatic conditions.
- Database on phytopathogenic bacteria of major / minor quarantine significance in different agroclimatic zones.
- Generate pest-risk analysis data. The data should be available on line through agrinet in India and this electronic facility / data should also be connected to international data base system.

The proposed Centre will have the following Sections for conducting research and developing trained human resource in the areas related to its mandate: (i) Genetic characterization, (ii). Bdellovibrio, (iii). Bacteriophages, (iv).Host-bacteria interaction, (v). Epidemiology, (vi). PRA, and (vii) Management.

7. National Research Centre of Nematology

Plant parasitic nematodes, the unseen enemies of the farmer, have been recognized as one of the serious limitations in agricultural production all over the world, more so in the tropical and subtropical regions including India. About 20 species of nematodes are pests of national importance with high damage potential and wide distribution, while 10 species are of regional importance. Species of root knot, cyst, reniform, ear-cockle, root

lesion and burrowing nematodes are considered the most important. The favourable weather and almost continuous availability of host crops favour nematode pests. Since nematodes are mostly microscopic, soil borne and cause non-specific symptoms their damage potential is generally underestimated. They cause quantitative and qualitative losses in all types of food, fiber and commercial crops. They also aggravate a number of bacterial & fungal diseases. A few useful species of nematodes can also be used as bio-control agents of insect pests, while some other bacterial and fungal feeding nematodes play beneficial role in maintaining soil health.

Investigations under the All India Coordinated Research Project on Nematodes have shown potential crop losses ranging from 7 to 81% in infested fields. On the basis of the frequency of distribution and experimental data from a large number of field crops in different states, it has been estimated that nematodes are responsible for 8% loss of cereals (Rs.11920 Crores), 5% of oilseeds (Rs.1650 Crores), 6% of pulses (Rs. 1440 Crores), 12% of vegetables (Rs.3880 Crores), 10% of sugarcane (Rs. 1620 Crores) and 10% of fruits (Rs. 3700 Crores). Thus, the total crop loss in these crops comes to Rs. 24210/- at 1999 prices. Reliable estimates are not available for plantation and fiber crops. Due to their wide distribution, even very small losses of less than 1% caused by ectoparasitic nematodes, to which little attention has been paid so far, amounts to huge financial losses at the national level. If the presently available technology is implemented with adequate extension effort we are likely to save crop losses to the extent of Rs.6000/- Crores. With improvement in technology currently in the pipeline we may be able to attain a saving of Rs. 12000 Crores. There is also an urgent need to develop ecofriendly bio-control, botanical pesticides and use biotechnology for nematode management. Proper denematization procedures, surveillance and pest risk analysis are necessary to meet the needs of organic farming, globalization and international trade in agricultural commodities.

Establishment of a National Research Centre of Nematology with emphasis on the following is recommended :

- Nematode taxonomy - For identification service, characterization and registration of agriculturally beneficial and harmful nematodes.
- Molecular research on nematode - plant interaction to provide the inputs for use of biotechnology for nematode management.
- Basic research on biological control agents - survival, formulation, application technology and bio-safety of (1) nematode antagonistic fungi and bacteria and (2) entomophathogenic nematodes.
- Nematode ecology - Survival adaptations of nematodes for effective management.
- Integrated nematode management
- Pest Risk Analysis for nematodes, to meet the needs of globalization.

The proposed Centre will have the following Sections for conducting research and developing trained human resource in the areas related to Institute's mandate: (i) Biosystematics and biodiversity, (ii) Beneficial nematodes, (iii) Molecular host-nematode interaction, (iv) PRA, and (v) Management.

8. Network of Pesticide Residues and Referral Centres

The AICRP on Pesticide Residues is proposed to be changed to an All India Network Project (AINP) provided the proposal for a National Institute on Agrochemicals is accepted.

The mandate for the Network would be basically the same as for AICRP except the position of the Project Coordinator would become redundant. The mandate would be as follows:

i. To organize & promote coordinated research on pesticide residues in agricultural produce at national level.

ii. To study the dissipation of pesticides in crops and monitor the pesticide in abiotic and biotic components of environment.

iii. To maintain a data base on pesticide residues and provide input for developing sound IPM strategies.

iv. To work as referral centres

All the 16 centres of AICRP are proposed to continue. They must however be upgraded to GLP standards by providing the need based strengthening of facilities and manpower.

9. Network on Heliothis

Helicoverpa armigera (Heliothis) has become the most serious pests of Indian Agriculture. It attacks a number of valuable crops such as cotton, chickpea, pigeonpea, tomato, tobacco, sunflower, maize, sorghum and others. The proposed research Network will address the following important aspects:

- Studies on host plant resistance, migration pattern and population dynamics of the pest.
- The development of IPM packages under selective crop conditions.
- Development of sound insecticide resistance management strategy.

10. Network on Soil Arthropods

Soil arthropods like Symphyla, Collumbola, Soil Acari, Millipedes, Centipeds and insects that spend part of their life in soil are very important components of biota related to soil and plant health. Research on soil arthopods, however, has remained neglected. This gap is to be filled through the proposed network project.

11. Network on seed-Borne Pathogens

There are numerous plant diseases, caused by seed-borne plant pathogens belonging to all major groups, viz. fungi, bacteria, viruses, viroids etc. The seed is most often successful in establishing infection in the young plants followed by spread of the disease from the fea infected plants, which function as foci for multiplication of secondary inoculam for rapid spread of the disease in the whole field. It is, therefore significant to develop and promote technologies for detection and development of seed-borne plant pathogens. Paying the required attention to the seed will go a long way in producing disease free crops and their productions by preventing introduction of the seed-borne pathogens in the field. It is, therefore, proposed to establish a network of advanced centres and scientists for ensuring use of healthy seed in crop production.

12. Network on Phytophthora

Phytophthora spp. Comprise one of the most common plant pathogenic fungi, which cause serious diseases in a wide variety of field crops, vegetable crops, horticultural crops, forest trees etc. Different species are serious on both annual and perennial plants and cause foliar Blights, stem rots, fruit rots, storage & seed rots, seedling blights and root-rots etc. In view of economic importance of *Phytophthora*, it is proposed to develop and strengthen a network programme to study all aspects of the pathogen in a coordinated and focussed manner : distribution, taxonomy, pathogenic variability, genetics, physiology, epidemiology and integrated management. The required focus on fundamental and applied aspects of *Phytophthora* would make it possible to tackle it in a variety of crops and situations.

13. Network on Rhizoctonia

Like *Phytophthora*, species of *Rhizoctonia* have a very wide host-range and cause many serious and damaging diseases of both dicots and monocots, which include almost all the major field crops, vegetable crops, horticultural crops and forest trees. For example, only one species, *Rhizoctonia* solani is known to cause economically important diseases in numerous crop plants. The anastomosis groups of *R. Solani* are capable of producing new pathogenic strains, which can attack both underground and above ground plant parts and kill them fast. It would be highly useful to survey and catalogue the *Rhizoctonia* and their biocontrol agents occurring in our country, study their taxonomy, ecology, genetics, physiology, pathogenic variability, epidemiology and devise integrated management procedures. It is proposed to generate the required information and develop data basis through a networking of *Rhizoctonia* researchers in the country.

14. Network on Biosystematics of Pathogenic Fungi

In the early years of development of plant pathology, the biosystematics of fungi (mycology) provided the strong foundation. Some how in the more recent past, the emphasis on mycology got diluted in favour of field pathology for varied reasons. In this process, the science of plant pathology is being deprived of the required emphasis on identity or species and formae specialis of pathogenic fungi with unknown consequences. The SAUs have strong teams of field plant pathologists, who are many times ill equipped to handle biosystematics of the pathogenic fungi. However, mycology has survived in a few botany departments of the conventional universities. It is, therefore, proposed to develop a Network of the experts in such universities and SAUs and connect the same with the new National Bureaux of Agriculturally Important Microorganisms (NBAIM) to make it work. The NBAIM can become a repository of the pathogenic fungi and the expertise of the Network experts would be easily available to it on a regular basis. Each Centre of the Network can specialize in the selected group(s) of fungi of their interest to develop the much-needed centres of excellence on specific groups which would also help in training human resource apart from providing service for identification of fungi of that group.

15. Network on whitefly Transmitted Geminiviruses

Whitefly transmitted gemniviruses (WTGs) are one of the most damaging group of viruses. Cotton leaf curl, tomato leaf curl and yellow mosaics in legumes are just a few examples of the devastating diseases caused by WTGs. Nearly 100 WTGs naturally occur in India. These viruses mostly have a bipartite genome which form frequent recombinants resulting in increased host range and virulence. Natural variants of each of the WTGs are also common. WTGs, as the name suggests, are transmitted by whiteflies-which also become serious pests in their own right. In order to generate information on the variants of important WTGs and biotypes of the vector whiteflies a network is essential so that the basic data on these viruses and their vectors become available on the country basis which will be very useful in their management. It will also help in identifying factors for their resurgence.

16. Network on Tospoviruses

Tospoviruses are the most damaging of all viruses as these viruses unlike other viruses, kill the host plants resulting complete destruction of crops in epidemic spears. As was found on sunflower in Karnataka and groundnut in Andhra Pradesh. These viruses are transmitted by thrips which are the most difficult vectors to control. Tospoviruses have tripartite genome which results in quick development of new recombinants. Tospoviruses also have a very wide host range. Considering the quick development of new viral strains, their wide host range and efficient transmission any management strategy has to be based on large geographical regions cutting across state boundaries. A network on these viruses with the NRCPV as the nodal centre will help in their containment and development of management practices. Isolated efforts will not yield useful results.

17. Plant-Health Clinics

Each SAU must establish Plant Health Clinic for which good models exist in the country and elsewhere. These clinics should develop active linkages with the ICAR Institutes, particularly those dealing with plant protection and soil health.

Linkages

All the Institues / Centres / Networks should have strong linkages with the crop based Institutes / Centres of the ICAR, various Institutes of CSIR and DBT dealing with issues related to plant protection, various SAUs and basic science departments of general universities and the Directorate of Plant Protection, Environment of India for developing and conducting collaborative research. These linkages will play an important role in generating scientific data on problems of national and international importance, which will help taking policy decisions.

Management of Plant Protection Research

Considering the enormity of pest and disease problems and the emerging new challenges due to globalization of agricultural trade there is an urgent need to restructure and revamp plant protection research and its management. Two alternative approaches are purposed for technical management.

A. *Based on the Present Mmanagement System*

A separate Division of Plant Protection (which was proposed and agreed in the seventies) be created to be supported by one DDG and four ADGs to cover all the diverse areas of plant protection. This will be in tune with the current organizational set up.

B. *Based on Peer Group Management System*

The Peer Group management system is ideal for scientific researches. For Plant Protection Research it would requires

a) National Plant Protection Policy Committee to be headed by a renowned Plant Protection Scientist and to have four expert members from the University system, four foreign expert members, and all the Directors of the Plant Protection Institutes / Centres as members. The Committee should meet once in a year to deliberate on broad policy issues and identify areas requiring research direction.

b) Scientific Panels for each major areas of Plant Protection for identification of specific national and regional problems and considering research projects for support by the ICAR. The Panels should have internal and external members. The Panels should meet at least twice in a year.

c) Each institution to have a Research Advisory Committee (RAC) headed by an external expert, and the Director of the Institution and 3 to 5 external experts of the concerned areas as expert members. RAC

should meet quarterly (i) to consider research project proposals, (ii) to review the progress of the approved internally and externally funded projects and (iii) to help in improving research facilities and creating scientific temper.

Organization of Research Networks

Research Networks are the most productive systems for research. Under this system the existing centers, where work is being done on the area of the Network, are to be identified and provided contingency support for carrying out specific projects for generating valuable area-specific scientific data which will help in building national data bases related to serious biotic stress problems. These databases will also be very useful in sorting out SPS related issues. The activities of the network should be monitored and funded through the RAC of the concerned institute.

Human Resource Development and Utilization

The country has established excellent infrastructure for developing trained human resource in various areas of plant protection at State Agricultural Universities, Traditional Universities and Research Institutes. However, we have not been able to adequately utilize the trained manpower for plant protection research, leading to 'brain drain'. Our bright young graduates who could contribute to scientific progress in the country have taken assignments in other countries making outstanding scientific contributions. We can reverse the trend by establishing world-class research facilities, scientific temper and freedom to pursue scientific goals. As far as Plant Protection disciplines are concerned, under the ARS system we must have separate cadre for each discipline like virology, bacteriology, mycology and fungal pathology, instead of clubbing them together as Pathology. Separate cadre will help in recruiting young scientists majoring in the required discipline rather than making them to change the area of their specialization. There is also a need to have a separate cadre for 'Weed Science' which will improve research in this area. Whatever the discipline, we must provide opportunity in the field of their specialization and upgrade their capabilities for leading front-line research. This will help in confidence building and improve scientific outputs.

BUDGET

For the reorganization and strengthening of plant protection research a separate allocation of Rs. 400 crores would be required during the X Plant period, as per the following suggested distribution.

1. Strengthening of existing plant protection projects/programmes

	Rs. (Crores)
Crop based institutes	60.0
Mycology at NBAIM	2.5
NRC Mushroom	2.5
NCIPM	10.0
NRC Weed Sciences	10.0

Project Directorate Weed Control	10.0
AICRP Nematodes	5.0
Network on Ornithology	2.5
Network on Rodent Control	2.5
Network on Agricultural Acanlogy	2.5
2. Establishment of New Institutes/Centres/Networks	
National Institute of Agochemicals	50.0
National Institute of Entomology	50.0
National Institute of Fungal Pathology	50.0
NRC Plant Virology	30.0
NRC Bacterial Diseases of Plants	20.0
NRC Apiculture	10.0
NRC Nematology	15.0
Network on Pesticide Residue Referral Centres	20.0
Network of Heliothis	5.0
Network on Soil Arthropods	5.0
Network on Seed-borne Pathogens	5.0
Network on Phytophthora	5.0
Network on Rhizoctonia	5.0
Network on Biosystematics of Pathogenic Fungi	5.0
Network on Whitefly Transmitted Geminivirus	5.0
Network on Tospoviruses	5.0
3. Support to establish Plant Health Clinics at SAUs	7.5
Total	**400.00**

11. Agricultural Education

India has developed a strong agricultural education system since the independence (Table 1). The establishment of State Agriculture Universities on the pattern similar to that of the Land Grant Colleges of the United States, made a landmark in reorganizing and strengthening agricultural education system. The contributions made by these universities and other institutions accorded the status of deemed-to-be universities, as partners of the national Agricultural Research system (NARS), are well recognized. The green revolution, with its impressive social and economic impact, would have not been possible without the significant contributions made by these centers of learning in the form of development of trained scientific manpower, the generation and assessment of new technologies and their dissemination to the farming community.

Table 1. Agricultural education System

Type of University	**Number**
State Agricultural Universities	30
Central Agricultural University	1
State University of Horticulture and Forestry	1
State University of Veterinary and Animal Sciences	2
Deemed to be - Universities	5
Traditional Universities having Agricultural Faculty	3
Private / Government Colleges affiliated to General Universities	48

Emerging Concerns

The human resource developed by agricultural education system has been instrumental in agricultural transformation in the country. However the agricultural education system has not kept pace with the rapid technological development taking place globally. While we are proud of our agricultural education system, there are emerging concerns which need to be addressed to gain advantage from the globalized agriculture. The main concerns are: -

- *Lack of adequate financial resources*- The SAUs are charged with complete integration of research, teaching and extension, for the holistic societal development. Most of the SAUs have not been able to achieve integration of these functions due to the limited resources.

- *Lack of support to colleges*- The opening of new campus colleges without adequate financial resources or faculty has adversely affected the quality of HRD programmme.

- *Opening of new SAUs*- the original concept was to have one agriculture university in each State, but several States have more than one SAU resulting in thin distribution of the limited resources. Some States have also opened 'discipline' based universities. This too is against the concept of SAUs

- *Extensive inbreeding*- Inbreeding as a result of State policies for recruiting staff basically form the region and product of the university has resulted in having less competent faculty and absence of introduction of expertise in new areas of science. Such policies have deprived the universities of the opportunities for cross hybridization of ideas required for the growth and academic improvement of the universities.

- *Poor infrastructure*- Most of the SAUs have poor infrastructure, out-dated equipment, poor lecture halls, poor libraries and amenities required for frontline educational institutions, as funds are not available for maintaining and upgrading the infrastructure.

- *Faculty competence*- This is one area which has been neglected. Most of the institutions have no career development plans. The kind of opportunities for training of faculty which existed during the early part of their establishment, are no more available. Faculty competence is critical since faculty is the key resource for academic excellence. Unless the faculty keeps abreast with the new developments, it is hardly possible to impart the necessary skills to the students.

- *Neglect of the holistic societal developments*- The SAUs at the time of their establishment were considered as the engine for societal development particularly in the rural areas. This role, however, has been neglected.

- *Neglect of basic sciences*- Development in the basic science is the backbone of applied sciences. The SAUs, by and large, have ignored this concept.

Some reforms initiated by the ICAR

To overcome the above concerns, in assuming the role as UGC for agricultural universities, ICAR has initiated a number of reforms for the improvement of quality of education. These include:

— Course curriculum revision
— Accreditation
— Capacity building for human resource development
— Faculty competence improvement

— Reducing inbreeding
— Access to scientific information
— Capacity building for skill development
— Development of Centres of Excellence

Need for reorientation and Strengthening

It is essential to introduce necessary structural changes to reflect modern realities, challenges and opportunities. The institutional system must be relevant towards the emerging issues and concerns. During the early part of the establishment of SAUs the academic programmes were structured to produce graduates who became primarily technology agents. In the present era of specialization and development in modern science it is necessary that we restructure our agricultural education in a manner that the graduates coming out are analytical, technology oriented, sensitive to social and economic issues of farming in India, and able to meet the challenges of the new millennium with determination, zeal and commitment. For this to happen, universities will have to develop and strengthen both formal and nonformal degree programmes, bring academic excellence and education relevant to future needs. This requires some new initiatives and strengthening of the programmes which, have shown promise, with greater support from the ICAR.

Linkages among institutions

The Agricultural Universities in the country should assume the responsibility of holistic development in their geographical areas by developing teaching and training programmes in all the relevant science discipline to meet the aspirations of the people of the region. There should also be greater interaction with the traditional universities and with scientific research in all the major disciplines of science.

Development of competitive manpower

Admissions to the Universities should be open to all streams on the sole criteria of competence - without any restrictions. The Science education in general has to be secular if we want to develop highly competitive manpower to meet the challenges of the new century and compete in the open world.

Faculty competence

The teaching should shift from simple provider of information to the development of knowledge and wisdom. This will require a highly competent faculty. We must develop mechanism(s) to attract the best talent to teaching and for ensuring that they keep growing in stature. This will require, (a) debureaucratization of the education, (b) greater freedom to the faculty for developing intra-institutional collaboration and participation in international meetings, (c) appropriate career development plan for improving competence, (d) a greater fund allocation and (e) efficient infrastructure.

Basic and emerging sciences

Education in the neglected areas like basic sciences, biodiversity, environment, fisheries, forestry, veterinary sciences etc. and the new areas like biotechnology, information technology requiring cutting edge science should be strengthened to meet the growing demand of trained human resource in such important areas.

Accreditation

There is a need for consolidation during the 10th Plan through accreditation human resource planning, merger of universities where possible and closer of inefficient units. Similarly the private colleges should either be strengthened to improve their educational standards or closed. The Accreditation Board, set up recently, must be strengthened and provided with enough capacity for enforcing norms and standards of education.

Entrepreneurial orientation

There has to be a clear understanding of the purpose of agricultural education. The aspiration of the stakeholders must be met. Some farm graduates may go for post-graduate education and others may be more interested in entrepreneurship. The courses should be accordingly tailored.

Vocationalization

The SAUs should start non-degree vocational training programmes particularly in the emerging areas, for upgrading the skills of in-service candidates.

Distance education

Reaching the unreached: there is a large number of dropouts in schools who will remain a burden unless empowered with new skills. The SAUs should develop programmes for training of rural youths and active farmers for imparting newer skills to improve farming practices. Similar programmes should be developed for the rural women particularly for covering home science. If it is implemented the country would not only improve agricultural production but would also address problem of population through general education and empowerment of women.

Education Media Development Centres should be established for dissemination of knowledge in agriculture and allied sciences through television and use of multimedia as a part of distance learning.

Centres of Advanced Studies

The Centres of Advanced Studies established during Eighth Plan need to be continued and further strengthened. These centers are playing a very important role in improving the competence of the faculty in frontier areas of science. The SAUs and DUs should be encouraged to identify the areas in which they could be the lead centers in the country and appropriate support should be provided to develop such centers

Centres of excellence

The ICAR Scheme for developing centres of excellence by identifying outstanding scientists as National Professors and National Fellows has been very successful for advanced scientific research and in motivating agricultural scientists. The scheme needs to be further strengthened and efforts made to identify persons who are able to contribute a National Professors / National Fellows for at least 10 to 15 years.

International agriculture

There is an urgent need to reorient academic programmes to meet the emerging global market forces. New courses need to be started to address various issues related to world trade, IPR etc. to help in improving agriculture based industry.

The country should also aggressively market agricultural education in the developing countries to generate additional resources and at the same time open new opportunities for agricultural trade.

Adequate Financial support

Agricultural education should be given greater financial support than at present. The ICAR, which functions like UGC for State Agricultural Universities, provides supplementary grant for achieving improvement in educational standards in SAUs. There is a need to allocate at least one per cent of the GDP, both at the Central and State levels for agricultural research and education. This could be achieved by introducing a cess for agricultural education. In the long run it will be useful to have a separate Agricultural Education Council.

For improving agricultural education and achieving the above objectives, a separate allocation of Rs. 1250 crores should be made for agricultural education in the 10th Five Year Plan.

12. Agricultural Extension

Thrust Areas

New Initiatives

a) Promotion of agribusiness through establishment of agribusiness centres

b) Strengthening extension system through establishment of a national research centre for agricultural extension

c) Use of distance education in dissemination of farm technologies.

d) Promotion of computer aided extension

Continuation of Existing Areas

e) Consolidation and strengthening of existing KVKs and TTCs

f) Removal of imbalances and meeting the demand of front-line extension in less developed and backward areas through opening new KVKs.

g) Technological empowerment of women in agriculture

h) Facilitating accessibility of farm information.

i) Facilitating a programme approach for appropriate combination of technology under different agro-ecological situation through IVLP

j) Promoting utilization of non-conventional energy

k) Demonstration of improved practices for enhancing the productivity along with sustainability for cotton

l) Providing information support for location specific weather forecast

Programmes under Thrust Areas Including Infrastructure Requirements

Programme under new initiatives

Promotion of Agribusiness through development of agri-business centres

1. Development of Agribusiness Centres : Though agribusiness is not a new concept it started gaining momentum since the beginning of 1990's due to liberalized policies in Indian agriculture. In fact during early nineties taking advantages of new policies in seed development some private enterprises and multinationals made entry in agri-business dealing with seed farm, horticulture, floriculture and meat processing to cater to both domestic and foreign markets. The opening of Indian economy since 1991 couples with demand for quality product and processed items have increased the pace of commercialization. Thus, today our agriculture is increasing transformed into a specialized agri-business activities related to production of seeds, crops, medicinal and aromatic plants, propagation of - planting materials through tissue culture techniques,

aqua-culture, floriculture, production of fruits and vegetables for domestic and export purposes.

Agribusiness promotion has to undertaken at farm level through farm entrepreneurship programmes. The existing entrepreneurship development programme of selected universities and KVKs are mainly concerned with establishment of cottage level or small business activities related to poultry, bee-keeping, mushroom cultivation, and other crop production activities. While we have to continue to support the development of rural entrepreneurship, there is a strong need due to changing economic scenario to promote specialized agribusiness activities for domestic and export purposes. This will also involve encouragement of public private collaboration such as ITC tobacco programme in Andhra Pradesh, which has been complemented by the varietal developmental efforts of Central Tobacco Research Institute, Rajamundry. Another example of public support for agri-business is provided by PAU, which supplied hybrid varieties for Pepsi Contract Farming business. Since the Government extension machinery is likely to face more financial crunches in the coming years, encouragement of agribusiness through joint-venture will strengthen extension at field level through the involvement of NGOs, young entrepreneurs etc. Hence, establishment of agribusiness centres in ten SAUs/ICAR Institutes on pilot basis with the following mandates is proposed :

a) To provide Consultancy on agribusiness activities and prepare project proposal on demand. The specialized enterprises will be related to seed farming, crop and animal production, medicinal and aromatic plants, farm machinery, fruits and vegetables, food processing, green house activities, ornamental horticulture etc.

b) To provide market intelligence to the farmers on agribusiness for domestic and export purposes.

c) To establish effective linkage and promote joint ventures with Farmer Organisations, NGOs/private agencies for agribusiness training and Consultancy

d) To train farm graduates to undertake agribusiness enterprises who in turn to set-up Agro-clinics at Block and village level.

Each agribusiness centre will be headed by a Director and assisted by a team of six subject matter specialists drawn from areas like agronomy, horticulture, agricultural engineering, agricultural extension, animal husbandry and management.

2. Establishment Agro-clinics : The demand for farm information and other services has increased in rural areas as a result of increased commercialization of farming and market orientation. At present farmers mainly depend upon a government agencies for supply of farm information which is often inadequate and in effective. There exist a vast scope for providing agro-based services for the farmers in irrigated and or developed areas where farmers are in position to pay for the extension services. The unemployed agricultural graduates can be trained and encouraged to open

agro-clinics which will also act as "information shop" to provide all developmental information using computer and internet technologies. The agro-clinics should have the following objectives.

1. To provide advisory services to the farmers on crop and animal production with emphasis on commercial or orientation.

2. To act like a single window for location specific farm information, product and services including farm inputs.

3. To offer services related to plant protection.

4. To provide development oriented information including weather, travel, etc.

The farm graduates will be trained by the Agri-business Centres for establishing agro-clinics and financial assistance should be given to set up these units by state Governments and banks. The above schemes may be opened in ten SAUs/ICAR institutes.

Thrust area : Strengthening agricultural extension system through establishment of a National Research Centre for Agricultural Extension

3. National Research Centre for Agricultural Extension : It is a well-known fact that India has developed an effective research system, which is one of largest in the world. However, the agricultural extension system of our country is weak. The prospect of improving the production and productivity in agriculture in the coming years depends upon strengthening agricultural extension. The present extension system originated as the result of the Community Development Programme of 1952 with a major emphasis on raising food production. The National Extension Service under the leadership of Mr. S.K. Day was started in 1953. It covered about 5000 community development blocks. The need for training manpower in agriculture extension in areas such as extension methods, communication aids and undertaking research in adoption and diffusion of innovation was felt in mid fifties. This has led to the establishment of four extension education institutes by the Ministry of Agriculture at Nilokheri, Anand, Hyderabad and Jorhat during 1959. Extension as an academic subject was introduced in selected agricultural colleges during fifties. During 1960s post graduate programme in extension was introduced in many agricultural universities and at present almost all agricultural universities have well established departments of agriculture extension which not only offers teaching programme but also involved in research in the whole process of extension education.

A brief review of extension science will reveal that it started as a specialization within rural sociology with a focus on change. In the beginning the extensionists were pre-occupied with finding out the factors related to diffusion of innovations. Later on extension became decision or activist oriented and deviated itself from rural sociology and became more concerned with utilizing communication methodology for effecting change. Extension did not need theories of change but rather, of changing. The focus of extension during eighties was on extension methods, strategies and interpersonal communication.

Since mid eighties there have been major changes with emphasis on participatory technology development and the need for developing appropriate technologies for resource poor farmers. Thus the focus of extension during nineties have shifted to technology assessment and refinement. Presently, extension has to solve not only existing problems such as production of food for increasing population, reduction of poverty and inequality, rural unemployment etc. but also a variety of complex problems. These issues are related to sustainable development, environment protection, energy efficiency and rapid changing technological and economic scenario. The recent advances in the field of communication and information technology, behavioural sciences including management are well known. The changes in the present context of extension calls reorienting the focus of extension research as well as the curriculum of post graduate education in extension. Keeping this in mind, the post graduate curriculum in extension has been recently revised at national level and new courses have been added in areas like management development, agri-business development, information technology, participatory extension methodology including agro-ecosystem analysis. The present context of extension calls for research and training at national level to solve the problem arising out of emerging challenges as described above. This necessitates an establishment of a National Research Centre for Agricultural Extension which will provide leadership at National level in undertaking relevant research, training and providing direction to solve the emerging challenges related to agricultural extension. The mandate of the Institute will be to gain insight into the whole process of agricultural extension and to develop appropriate methods and strategies suited to different agro-ecological and socio-economic situations. The Institute will organise training for extension functionaries of ICAR/SAUs on latest developments in the field such as modern communication and information technology, participatory training methodology, extension management tools and techniques and agribusiness development. The major function of the proposed centre will be as follows :

a) To undertake and test different extension models and strategies for different agro-climatic zones and socio-economic conditions.

b) To help in upgrading the professional skills of extension professionals of state agricultural universities and ICAR research institutes in the fields like agri-business development, management skills, organizational behaviour, modern training technologies, participatory extension methodology, application of computer and internet in extension.

c) To formulate methodology for diagnostic planning, prioritization and developing extension teaching programmes for different agricultural universities and ICAR institutes.

d) To develop methodology at micro and macro level for environmental scanning and study of opportunities and threats related to sustainable development.

e) To collect, process and disseminate information related to farmers, agro-industries, socio-economic conditions of rural areas within and among

agricultural institutes, agricultural universities, NGOs and farmers organizations utilizing the developments in information technology.

f) Providing information support on inter-institution mode for strengthening Agricultural Technology Information Centers.

g) Facilitate exchange of talents, expertise and networking of facilities related to training, modern information and communication technologies.

h) To develop capacity for global scanning, collection, retrieval, processing and dissemination of information related to agricultural extension at national and international level.

i) To provide consultancy to undertake process analysis to solve specific field based problems related to transfer of technology.

j) To work as a repository of information on extension methods, tools, techniques, cases and extension packages after appropriately adjusted having regard to temporal and spacial specifications.

The proposed Centre will be headed by a Director along with a team of six principal scientists and twelve senior scientists apart from twenty technical and administrative officers.

Thrust area : Use of distance education technologies in dissemination of farm information

4. Establishment of Distance Education Centres : Distance education, which is also called distance learning, has existed for centuries. Essentially it is a form of education where there is physical separation between teacher and learner and this physical gap is bridged through technology medium such as print, telephone, radio TV, computer etc. The distance learning is far from new and in recent years we have witnessed an explosion of modern tools and techniques for its effective implementation. New Communication and information technologies have also made the distance education cost and time effective. The expansion and availability of communication technology in India offers a great promise for using distance education to disseminate farm information to a vast number of farmers, farm youth and extension workers. As mentioned earlier the use of distance education methods in transfer of farm technologies is not new. Agricultural universities and state agricultural departments have effectively used the mass media such as radio and television. Some of the universities have also successfully implemented programmes such as “farm school on the AIR” and correspondence courses for the farmers. Further, management of pest like *Heliothis*, which migrate from place to place, will be effective if it is done through distance education mode. In the coming years distance education will play a major role in transfer of farm technologies for the following reasons :

a) The rapid technological development specially based on computer and Internet technology has made distance education more interesting and effective.

b) Distance education is cost effective and will be highly appropriate in the context of decreasing level of public fund for extension activity.

c) It is impossible to reach the millions of farmers and farm youth through face to face means and we have to rely up on distance education.

The above scenario undoubtedly show the need for establishing distance education centres. It will be a good idea to make use of distance education methods to solve specific problem faced by farmers and extension workers. In this context, we can establish distance education centers specifically for the following purposes:

a) Dissemination of crop production technologies including IPM and IPNS.

b) Dissemination of diary or animal husbandry technologies

c) Dissemination of fishery technologies

There it is proposed to establish three distance education centres on pilot basis, at appropriate SAUs/ICAR Institutes, so as to disseminate the farm technologies mentioned above. Fund will have to provided for establishment of centres at concerned universities. The existing staff will be utilized to run the programme.

Thrust area : Promotion of computer aided extension

Modern information technology provides opportunities for reaching the unreached in terms of information and technological empowerment. Many institutions have developed multi-media training packages for extension functionaries and farmers. The staff of KVKs, which are provided with computer facilities, will be trained in developing technology database relevant to the farming system of a district. Further computer softwares, which will facilitate access of information directly by the farmers through pictorial mode, will be developed.

Programmes under Continuation of Existing Activities

Thrust area : Consolidation and strengthening of existing KVKs, TTCs

5. Continuation of existing Krishi Vigyan Kendras (KVK) and Trainers Training Centres (TTC) and its strengthening

5.1 Based on the recommendations of the Education Commission (1964-66) and further discussions at various levels including the detail recommendations by Dr. Mohan Singh Mehta Commission (1973). The Indian Council of Agricultural Research (ICAR) initiated for the establishment of Farm Science Centres, which are commonly called as Krishi Vigyan Kendras (KVKs). The KVKs is an innovative science-based institutions designed to impart (a) the latest knowledge to the farmers through work experience by employing the principles of “Teaching by doing” and “Learning by doing” as per the needs and requirement in agriculture and allied aspects and also in other income-generating activities; (b) training for the extension personnel to update their

knowledge in the frontier areas of agricultural technology; (c) frontline demonstration to establish production potential on the farmers' fields; and (d) on-farm testing for identifying the location specificity of technologies in various farming systems.

5.2 The first KVK was established in 1974 in Pondicherry. Subsequently, 19 KVKs were established during the Fifth Plan (1974-79), 70 during Sixth Plan (1980-85), 20 during Seventh Plan (1985-90), 74 during 1991-92 and 78 during Eighth Plan (1992-97). The total number of KVKs at present is 261, which includes 141 under State Agricultural Universities (SAUs), 28 under ICAR Institutes, 71 under NGOs and the remaining 21 under other educational institutions/state government and public sector undertakings.

5.3 The Trainers Training Centres (TTCs) are specialized institutions for planning and organising training courses for refreshing the knowledge and upgrading the skills of the scientists/technical personnel working in the KVKs and the field functionaries of the line departments which are working directly or indirectly for the development of agriculture. At present there are eight TTC on Dryland Agriculture, Horticulture, Hill Agriculture, Dairying, Home Science, Freshwater Acquaculture, Marine Fisheries and Agricultural Engineering.

5.4 Apart from continuation of the existing 261 KVKs, 8 TTCs and 8 Zonal Coordinating Units, the Council has a proposal for opening of 66 new KVKs and 2 TTCs. These 66 KVKs include 35 under State Agricultural Universities, 11 under NGOs, 17 under State Governments, 1 under Public Sector Undertaking and 2 under ICAR Institutes. Two TTCs one for Citrus and another for Vegetables, will be based in ICAR institutes. For the first time, 12 new KVKs have been proposed to function on participatory mode and 25 new KVKs are exclusively meant for the North Eastern Region. The participatory mode includes utilization of the existing manpower and infrastructural facilities already available with the host institutions.

5.5 The exiting 261 KVKs together with the proposed 66 KVKs will be 327. Similarly, the number of TTC will be 10 including 8 existing and 2 proposed during 2001-2002.

5.6 In view of constraints of funds for establishment of new KVKs, the Council took up an alternative proposal for strengthening the existing Zonal Agricultural Research station (ZARS) to take up the additional functions of KVK in 53 districts of the country, where there were no KVK, under the National Agricultural Technology Project (NATP). Thus the total number of KVKs by the end of IXth Plan will be 380.

Thrust Area : Removal of imbalances and meeting the demand of front-line extension in less developed and backward areas through opening new KVKs.

6. Need for opening new KVKs/TTC

6.1 The National Commission on Agriculture (1976) in its report on 'Research, Education and Extension' recommended that with a view to meeting the needs of development in agriculture and related activities, we should plan for each district ultimately one centre (KVK) to provide for regular short

duration training in agriculture and agro-industries. The Commission recommended that by 1985 each district should have at least one KVK and by 2000, atleast three for each district. The Commission further emphasized that if this institution of the KVKs has to serve any useful purpose in modernizing agriculture in the country and in creating an effective impact in the field of agriculture, the number of KVKs recommended by them was essential.

6.2 The Parliamentary Committee on Agriculture in its Second Report (1991-92) had recommended to establish one KVK in each district of the country on top priority to be funded on 100 per cent basis by the Centre.

6.3 The Standing Committee on Agriculture (1995-96) in its Thirty-Sixth Report was extremely distressed over the slow pace of establishment of KVKs. The Committee, therefore, recommended that the government should evolve suitable methods of monitoring and provide sufficient funds to ensure that each district in the country was provided with atleast one fully functional during the 9th Plan. Considering that one district may have one or more agro-eco-climatic zones, the Committee further recommended that besides having one KVK in each district of the country additional KVKs should be sanctioned to each different agro-climatic zone in a particular district. The Committee strongly recommended that 100% funding by ICAR must continue to meet the social objective and sustenance of healthy KVKs.

6.4 In view of the facts stated above it is proposed to establish 182 KVKs with the emphasis on participatory mode except for those districts where no such infrastructural facilities / manpower is available.

7. Frontline transfer of technology programme for farmers in tribal and hill areas

Inspite of over fifty years of development efforts, the tribal and hill areas continue to be neglected. Though the modern farm technologies are available to these areas, the extent of adoption is very less due to poor extension efforts. There is a need to pay special attention in transfer of technology for farmers in hill and tribal areas. It is proposed to have special frontline extension programmes for the above areas, to be undertaken by ICAR institutes and SAU with the objective of demonstration of appropriate farm technologies. This activity will be undertaken with the help of existing staff and fund will be made available for planning and execution of the programme.

8. Developing Coordination and monitoring mechanism of KVKs and its strengthening

8.1 In view of the size and other complexities of the project, a number of mechanisms have been built into its design to ensure effective coordination and decentralized management. The project is implemented and monitored at the central level by the Division of Agricultural Extension of ICAR, headed by a Deputy Director General and supported by three Assistant Directors General, besides Principal Scientists and Senior Scientists. At the zonal level, the Project is monitored through 8 Zonal Coordinating Units, located at Ludhiana (Zone I) for the states of Delhi, Haryana, Punjab, Himachal Pradesh, and Jammu and

Kashmir; Calcutta (Zone II) for the states of West Bengal, Bihar and Andaman and Nicobar Islands; Barapani, Shillong (Zone III) for Assam and North Eastern Region including Sikkim; Kanpur (Zone IV) for Uttar Pradesh and Uttaranchal; Hyderabad (Zone V) Andhra Pradesh and Maharashtra; Jodhpur (Zone VI) Rajasthan and Gujarat; Jabalpur (Zone VII) Madhya Pradesh and Orissa; and Bangalore (Zone VIII) for Karnataka, Kerala, Tamil Nadu, Pondichery and Lakshdeep. The Zonal Units monitor the programmes by organizing Zonal and State level workshops, besides frequent visits to the KVKs.

8.2 For effective planning and management, each KVK has a Scientific Advisory Committee (SAC) consisting of the Head of the host institution as the Chairman, Training Organizer as the Member-Secretary and representatives from farmers, farm women, Heads of the district development departments and the representative of the ICAR Headquarters as members. One SAC meeting is held every six months for reviewing the progress as well as approval of the future action plan.

8.3 Besides, 380 KVKs including strengthening of 53 ZARSs to take up the additional functions of KVKs, 147 projects funded under NATP are also monitored by the Zonal Units; the details of which are indicated below

Zone	**No. of KVKs**	**No. of strength-ened to take up KVKs activities**	**New KVKs**	**Total**	**NATP**				**Grand Total**
					IVLP	**Strength-ening of DES/ZCUs**	**ATIC**	**Total**	
I	35	5	12	52	12	6	8	26	78
II	31	4	6	41	9	5	3	17	58
III	13	6	25	44	2	3	2	7	51
IV	30	9	5	43	11	4	4	19	62
V	30	7	4	41	9	6	6	21	62
VI	41	4	1	46	6	3	3	12	58
VII	342	6	11	49	7	4	4	15	64
VIII	49	13	2	64	14	6	10	30	94
Total	261	53	66	380	70	37	40	147	527

8.4.1 In the pattern of Scientific Advisory Committee (SAC) of the KVKs it is proposed to have Zonal Advisory Committee (ZAC) for each of the Zonal Units to facilitate the flow of technology to the projects implemented by the Zonal Units. The members of the ZAC can also serve as Roving Team for monitoring and advising the KVKs.

8.4.2 In addition the mission mode projects on ITK and IPM under NATP are also implemented by the Zonal Coordinators of Zone VII and Zone VI respectively. With the large number of KVKs already existing and further increased due to proposed establishment during the Xth Plan, the Directors of extension of the SAUs, which have already been strengthened under NATP, should play important role in monitoring the activities of all the KVKs under its jurisdiction including NGO KVKs.

During 1979 while implementing Lab to Land Programme, some of the Directors Extension Education of the State Agricultural Universities were appointed as Zonal Coordinators as additional responsibilities to monitor the programme for which honorarium was being paid to them. Each SAU has Director Extension Education who is charged with the responsibility of implementation of the Extension Education Programmes of the University including the programmes of the ICAR and the State Government. These Directors of Extension Education may also be drawn and assigned again responsibilities to monitor the frontline extension education programmes of the ICAR. Some budgetary support as being extended in case of Lab to Land Programme may also be provided to them for monitoring all the Frontline Extension Programmes in their area of operation irrespective of the fact that whether they belong to SAZU or ICAR Institutes or NGOs.

9. Strengthening of Division of Extension of ICAR

As per the TATA Consultancy Report, each ADG has to service and monitor 100 KVKs in the country. Since there will be around 400 KVKs in the beginning of the Xth Plan, an additional post of ADG will be necessary to be created to make it four ADGs in the Division. For all other projects, another post of ADG will be required as per the recommendation of the TATA Consultancy Report. Hence there will be five ADGs in the Division during the Xth Plan. The Division has at present only two sections, there is a need to have three additional sections so that each ADG will have one Section. A post of Finance and Accounts Officer in the Division will facilitate in terms of examining the proposals of KVKs for concurrence and thereby reducing the time lag in processing the case in the Division. There is also a need to have a post of Deputy Secretary/Under Secretary in the Division of Agricultural Extension to deal with the administrative matters of the project centres.

10. Continuation of the pattern of funding staffing pattern

The KVKs are funded on 100% basis from the ICAR. The funds are released by the Zonal Coordination Units to the host institutions based on the Audit Utilization Certificate and commensurate performance in implementation of programmes of the KVKs/TTCs. The pattern of funding may be continued for Xth Plan also.

10.2 The staffing pattern of each KVK has been revised to 16 during 1997, with the approval of Planning Commission and the competent authority of ICAR. Each KVK has a multi-disciplinary team consisting of a Training Organizer, six subject matter specialists depending upon the important thrust areas of the district, three technicians, two administrative staff, two drivers and two supporting staff. This staffing pattern is proposed to continue during the Xth Plan also.

11. Continuation of the present infrastructural norms : The building infrastructure for each KVK is restricted to a main building (500 sqm), a trainees hostel (305 sqm), residential apartments for 6 staff (400 sqm), and two demonstration units (160 sqm). The infrastructure of the TTC is restricted to a main building with a plinth area of 300 sqm, trainees hostel with a plinth areas

of 305 sqm., and residential quarter for Chief Training Organizer with a plinth area of 150 sqm. This infrastructure is developed in a phased manner.

Each KVK and TTC is provided with a jeep, modest farm machinery/tools including tractor and accessories for cultivation of the instructional farm, office equipments and audio visual aids for conducting training programmes.

12. Provision of funds for North-Eastern region

Provision of funds (Rs. 12.01 crores) for infrastructural development of 25 new KVKs, proposed to be established in the North Eastern Region out of Non-Lapsable Central Resource Pool for North East and Sikkim during 2001,2002. The similar support should continue during the Xth Plan.

13. Budget of Zonal Units, KVKs and TTC under non-plan

At present the pay and allowances and TA for 8 Zonal Units, 9 TTCs (7 out of existing 8 TTCs and two to be established during 2001-2002) and 28 KVKs under ICAR are proposed to be met out of Non-Plan budget. However, the contingency for taking up the activities and additional support for infrastructure development will be met from Plan budget. The total amount during 2000-2001 has been worked out to be 7.87 crores.

Thrust Area : Technological empowerment of women in agriculture

14. National Research Centre for Women in Agriculture

The Council has established a National Research Centre for Women in Agriculture (NRCWA) for taking up research programmes to develop technologies appropriate to farm women for different productions systems, creating a database for women specific research information, development of appropriate extension models for farm women, training of scientists to sensitize them on gender implementations in various production systems and to develop National and International linkages with such organizations engaged in research activities related to Women in Agriculture. These programmes will continue to be implemented and entire essential infrastructural development for the Institute will be completed during the Xth Plan.

14.1 Establishing Centres of Excellence on Women in Agriculture under National Centre for Women in Agriculture : In order to meet the developmental and training needs to establish Centre of Excellence one each for East, West, North and South regions. A provision of one Principal Scientist (home science extension), two Senior Scientists, two scientists apart from two administrative assistants have to be made for each Centre of Excellence.

Thrust Area : Facilitating accessibility of farm information

15. Establishment of Agricultural Technology Information Centre (ATIC)

15.1 The Division has been implementing the programme of establishment of 40 Agricultural Technology Information Centres (ATIC) with the State

Agricultural Universities and ICAR Institutes to provide a single window support system for the availability of technology products, diagnostic services, and technology information to the farmers and other end users. The programme will continue to be supported under NATP till the first year of Xth Plan.

15.2 The Division has been implementing the strengthening of the Directorate of Extension of 29 State Agricultural Universities (SAU) and 8 Zonal Coordinating Units (ZCU) under NATP, which will continue to be supported till the first year of Xth Plan, besides the support proposed to be provided as indicated in para 3.4.2 for monitoring the Frontline Extension Programmes of ICAR.

Thrust Area : Facilitating a programme approach for appropriate combination of technologies under different agro-ecological situation through IVLP

16. The ICAR has launched an innovative Technology Assessment and Refinement Programme called "Institution-Village Linkage Programme" (IVLP). The concept is based on participatory mode ensuring greater scientists-farmers linkages in bottom of approach. It ensures access to agricultural technologies generated by the entire institute or for that matter by the entire agricultural research system in the country to the entire farming community in a village a cluster of villages. Two important paradigms have been considered, (i) technologies have to be assessed and refined before their transfer; and (ii) a programme approach involving various technology components relevant to the farmers in varying agro-ecological conditions will be required for a perceptable change. The programme is implemented in a village or a cluster of villages covering about 10,000 farm families in 70 centres of ICAR Institutes and SAUs with a total financial outlay of Rs. 23.86 crores for a period of four years from 99-2000 and upto to the first year of 10th Plan.

16.1 In addition to it is proposed to implement this programme by all the KVKs. The proposal for implementation of the programme initially by 50 KVKs during 2001-2002 has already been approved by SFC in its meeting held on 2.5.2001. This will help in expansion of the project and implementation of the concept on larger scale. Since each KVK has already been provided with a multi-disciplinary term of scientists, mobility facilities and other infrastructural facilities; there is no additional support required for implementation of the programme except contingency and T.A.

Thrust Area : Promoting utilization of non-conventional energy

17. Setting-up of Energy parks

The Ministry of Non-Conventional Energy Sources (Special Area Demonstration Programme) provides assistance for setting up of Energy Parks under Special Area Demonstration Programme. These Energy Parks are having a number of Renewable Energy Systems which may be set up for demonstration purposes in Krishi Vigyan Kendras (KVK) where large number of farmers, farm women and rural youths come and participate in different training programmes. The cost for each Energy Park is to be borne by the Ministry of Non

Conventional Energy Sources. Ten Krishi Vigyan Kendras (KVK) have been selected. The duration of this Project will be 5 years, however, the system and devices will be installed in the first years during the current year.

Thrust area : Demonstration of improved practices for enhancing the productivity along with sustainability for Cotton

18. Frontline demonstration under cotton development programme

The Frontline Demonstrations under Centrally sponsored Scheme of Intensive Cotton Development Programme (ICDP-Cotton) under Mini-Mission-II and Technology Mission on Cotton will be organized jointly by the selected KVKs in cotton growing areas and Directorate of Cotton Development, Mumbai. The main emphasis of the demonstration will be to enhance productivity of cotton in low productivity areas / problematic areas, where improved technology practices be demonstrated. If required, demonstration on specific problems will also be conducted. A total of 730 hectares in 54 Krishi Vigyan Kendras will be taken up to conduct frontline demonstrations.

Thrust Area : Providing information support for location specific weather forecast

19. Linkage between Agro-Meterological Advisory Units (AAS) at Krishi Vigyan Kendras

A networking of Agro-Meterological Advisory Service Units of National Centre for Medium Range Weather Forecasting in selected Krishi Vigyan Kendras will be taken up. These KVKs will develop an Agro-Meterological Advisory Unit (AMAU) to further improve the quality of bulletin at the place where AMAU and KVK exist. The KVKs will play an active role in dissemination of advisory bulletins. The National Centre for Medium Range Weather Forecasting will prepare a video film and furnish material for Krishi Vigyan Kendras for dissemination and use in different training programmes in the KVK.

20. Technology Evaluation and Impact Assessment Project

20.1 The All India Coordinated Crop Improvement Project organize multi-locational trials across various crop production technologies in different parts of the country to identify superior yielding varieties. However, the number of testing locations available with these projects are not sufficient to represent all the variables of any production ecology. This is particularly so in the advanced / final stages of testing the promising varieties / technologies where a large number of trial sites are required.

20.2 The Division of Crop Sciences and Agricultural Extension took up a collaborative project to enhance interaction amongst the research workers and the KVK scientists. Sixty KVKs have been implemented the programme covering 17 important crops. The project is funded at present from AP cess fund. It is proposed that the funding may be continued from the regular budget of the concerned Project Directorate / Institute / Project Coordinating Unit.

13. Agro-Economics and Rural Development

I. Introduction

The agricultural economics component in the National Agricultural Research System (NARS) serves four sets of users. First, farmers who are the ultimate target of all research in the NARS. Second, policy makers at the national and state levels who require advice on matters concerning the formulation of policies related to the agricultural sector. Third, the NARS itself, to evaluate costs and benefits of the research it undertakes and to set new research priorities. And, fourth, NARS students who are the next generation of agricultural economists and require to be equipped with the necessary skills.

In the present context of Indian agriculture there is concern about degradation of the resource base, even as farmers and agricultural scientists have to prepare for the challenges thrown up by changing patterns of domestic demand and from greater exposure to international competition. This poses new problems for each of the users of the agricultural economics component in the NARS:

(i) In addition to the traditional problems of low yields and absence of cost-effective technology, many farmers are now confronted with consequences of inadequate environmental support, causing cost increases, deteriorating product quality, and susceptibility to pests and diseases. On top of this, market uncertainties have increased. This is in part a result of surpluses which are difficult to dispose and in part because of greater exposure to international competition. The NARS will be failing its ultimate users if it is unable to apprise accurately the long-run economic costs of unsustainable practices or provide reliable economic assessments of the risks involved, both technological and market-induced, in the crop varieties and practices that it recommends itself.

(ii) Policy makers, both at the National and State level, are required to evolve appropriate and timely responses to various contingencies, particularly the distress of farmers and pressures on agriculture from developments elsewhere. In the recent past, WTO concerns and the suicide of farmers in many states have heightened the importance that policy makers place on advice from the NARS. Such advice has been sought increasingly, both in workshops and seminars convened to address these issues and in consultations at the highest levels. Unfortunately, the agricultural economics component of the NARS has sometimes proved less than capable to respond adequately to the questions posed, so that governments have relied more on agricultural economists from outside the NARS. This is a loss not only to the NARS, whose credibility is thereby reduced, but also to policy makers, who often receive economic advice not fully informed of the agronomic issues involved. It is urgently necessary that the NARS take immediate steps to augment its in-house economics capability, and also develop closer liaison with agricultural economists outside the NARS, at least as an interim measure, so that it retains its ability to effectively inform economic decision-making.

(iii) Economic evaluation of research and extension of the NARS is part of the existing mandate of agricultural economic research. But, besides the economic assessment of sustainability issues and of market risks referred to above, there are certain other developments which need to be addressed urgently. This includes the entry of large private sector seed producers, the increasing trend of public sector institutions to do contract work for the private sector, and initiatives

such as Agri-clinics which seek to privatise extension effort. The ICAR system needs to develop the capability to monitor such private efforts, carry out their economic evaluation, and benchmark NARS performance against these. For this, existing methodologies will need to be re-examined and new systems developed.

(iv) The above requirements will create the need for agricultural economists to develop new skills and capabilities. Since the NARS is itself the training ground for new entrants, the agricultural economics syllabi will require constant review and revision to ensure that students are given the necessary training.

Thus, the relevance of agricultural economics for the NARS in the present context extends beyond the role it has played hitherto. In particular, the developments during the last few years have brought out (1) the importance of an extended system of economic evaluation of research within the NARS, (2) the requirements of evaluating the impact of resource degradation and (3) the imperatives flowing from the exposure of Indian agriculture to international trade. It is necessary for the system to adapt itself to these changed priorities.

II. Achievements and gaps during IX five Year Plan

Some of these priorities were already recognised in the IXth Plan. In this, seven areas of research had been identified.

(i) **Technology Evaluation:** Continuous prioritisation, monitoring and evaluation of existing and prospective technologies for generating and promoting technically feasible, socially acceptable, economically viable and environmentally sustainable agricultural technologies.

(ii) **Efficiency Issues:** Economic liberalisation and market globalisation processes underline the need for competitiveness in agriculture sector management which brings efficiency to the forefront.

(iii) **Sustainable Development of Irrigated Agriculture:** Production base for intensive agriculture in 85 million ha of irrigation potential created until now has to be managed carefully to promote productivity, diversity, equity and sustainability.

(iv) **Sustainable Development of Handicapped Regions:** Agricultural development in marginal production environments like rainfed areas, hilly areas, tribal areas, coastal regions etc., is crucial both for achieving sustainable higher production and equity in income distribution.

(v) **Equity Aspects:** With increasing emphasis on all around development in the welfare of the people, inter-and intra-generational equity considerations tend to gain prominence.

(vi) **Technology Policy:** Given the quantitative and qualitative changes in the agricultural research scenario, economic assessment of agricultural research priorities is imperative to gear up the agricultural technology management.

(vii) **Marketing and Trade:** Increasing expansion in the share of agriculture exports to total exports as well as country's share in the world trade in agricultural commodities is essential to exploit global market opportunities. Marketing and trade, both at national and global level, would need research thrust.

Also, at the Council level, the cadre strength in agricultural economics was almost doubled to 211 during the IXth Plan. Greater emphasis on agricultural conomics research was provided by funding agricultural economic research projects under AP Cess fund. A better focus was provided in these projects in relation to the issues of topical interest. A team of excellence in 'Natural Resource Economics' was also established at University of Agricultural Sciences (UAS), Bangalore. The Council gave emphasis to research prioritisation, monitoring and evaluation (PME) of agricultural research. The Council also ran an externally aided project on sustainable rainfed agriculture which has provided research agenda for sustainable development of rainfed agriculture. Further, in the World Bank funded National Agricultural Technology Project, social science and policy is one of the main themes receiving priority attention. Besides significant socio-economic components under production system research projects in each one of the 5 agro-economic regions, 14 agro-economic research projects, 7 under production system research, one under O&M component, one under team of excellence and five under competitive grant mode have been sanctioned amounting to about Rs.12 Crore. These are in operation in various institutions under NARS. Suitable changes in the syllabus/curriculum for teaching in UG and PG courses to address issues relating to environment, equity, WTO, IPR etc. have also been made. In fact, on account of all these initiatives and also owing to emerging complex challenges, there is a perceptible change in research administration in NARS to obtain inputs from agricultural economists.

During the IXth Plan, agricultural economics in the ICAR system became more credible with NCAP emerging as an academic policy research institute of national importance. This not only provided policy advice to ICAR but also support to other related institutions, such as the SAUs in the NARS. Other initiatives include social science networking, social science information repository and the launching of an independent web site.

Although, by and large, these IXth Plan initiatives did make a qualitative change in the decision making environment in the NARS in general and the Council in particular, certain gaps are still evident. For example, although emphasis was given on involving agricultural economists in major agro-biological research, the success has been less than adequate. Similarly, the efforts made towards institutionalising PME mechanisms in the NARS remain incomplete. Several research questions relating to sustainability of agricultural systems, profitability of farming under WTO regime, future research agenda etc. are yet to be answered. Moreover, the lack of adequate and reliable data bases and analytical protocols is proving to be a serious constraint to good agricultural economic research. The interface with institutions outside NARS remains weak. All this hampers capacity building both for advanced research work and in the teaching of agricultural economics.

These gaps and grey areas must engage the priority attention of agricultural economists during the Xth Plan. But for this a major organisational lacuna needs to be addressed. This is that the Council does not at present have, at its headquarters, any umbrella under which the cross cutting activities like policy and planning, socio-economic research, Centre-State co-ordination, technical co-ordination etc. can be properly guided and directed.

III. Some concerns

Until recently, India has depended mainly on the seed-fertiliser-chemical approach to productivity growth in agriculture, with emphasis put most on wheat and rice. The research effort has progressively been extended to other crops and to non-crop

agriculture. Although this has led to considerable modernisation of India's overwhelmingly small farm agrarian economy, there are certain signs that this effort needs to be intensified and also extended to cover new concerns. Thus, total factor productivity growth has decelerated during the 1990s, mainly because yield growth has slowed down in the case of almost every major crop and some of the major production systems appear fatigued.

There are many reasons for this. Public investment and capital formation in agriculture has been declining since the 1980s, and this trend has accelerated during the 1990s, limiting the spread of necessary infrastructure. Also the seed-fertiliser-chemical approach to productivity growth gave inadequate emphasis on sustainability issues, and there was inadequate environmental support for a sound farming system. Farmers have themselves given up some of the time-tested and wise traditional practices which had earlier supported sustainable agricultural development. This has led to cases to rapid depletion of soil fertility and increase in the pest-disease complex. Related to this is the removal of vegetative cover resulting in disturbance of the biological equilibrium. All these have led to an increase in unit costs of production and decrease in product quality, making Indian agriculture less competitive in the international market.

With GATT agreement and WTO in operation, Indian agriculture with all its structural weaknesses has to compete with highly commercial agricultural systems of the developed countries. The country is thus facing an uncertain period not only in the technology area but also the economic scenario confronting agriculture. These uncertainties have created a dis-equilibrium and has led to "development restlessness" among Indian farmers, scientists, planners and policy makers.

This has increased the importance of advice from economists regarding agricultural policy and assessment of which investments in agriculture are most appropriate. Economists need to advise government on policy and on the best means to provide support to farmers, advise farmers about the profitability of technologies recommended through KVKs, and also advise the research system itself on whether what they are doing is right and relevant. However, the system as it currently exists needs to be strengthened for it to cope with these requirements.

During the X Plan a major effort will be required for this. In view of the enormity of the challenge and the limitations of the existing economics components within the NARS this can be only be accomplished if NARS works jointly with other institutions. In this, the Ministry of Agriculture has a special responsibility to co-ordinate with NARS the functioning of agencies under it. In addition to this there would be need to strengthen the cadre strength of agricultural economists within the NARS and upgrade the skills of the existing cadre.

IV. New Thrust Areas of the X Plan

In addition to the IX Plan initiatives identified above, certain new directions and needed strategies have been identified for the X Plan. A few are elaborated below. A detailed list of themes for agricultural economic research during X Plan is provided in Annexure I.

We need to recognise the specific R&D support required for the three major farming situations viz., rainfed agriculture, well (private) irrigated agriculture and canal (public) irrigated agriculture. In case of rainfed agriculture, adequate attention must be directed towards use of hybrid varieties, proper soil and water conservation measures on watershed basis, use of adequate amount of organic manure, adoption of improved agronomic practices farm mechanisation, and mixed farming and mixed cropping

practices with tree crops as necessary components. Under well irrigated farming situation, with water use efficiency as the central point, profitability of crops along with economic use of water, avoidance of water - intensive and mono cropping systems and application of organic manure should be kept in view, among others. In case of canal irrigated farming, water supply discipline, management of drainage system, proper crop planning and rotation and balanced use of fertiliser with organic manure should be emphasised.

A wider purview of technologies impacting on all components of the farming system and judicious use of technologies must be given adequate attention. A combination of best of modern and traditional practices, crop rotation, mixed cropping, mixed farming, use of organic manure, tree crops as options particularly in dry farming areas are some of the examples in this direction.

The Indian livestock and fishery sector holds considerable potential both in the domestic and international markets. These sectors, along with horticulture will bring about next food revolution in India. The high income elasticity of demand for livestock and fishery products and the growing health consciousness among consumers are sure signs that the demand for these products will grow in the coming years. Competition from foreign products is expected under liberalised trade regime. This would call for production and marketing efficiency at both farm and processing levels, improvement in quality products and their keeping quality, improvement in nutritive value of these products and innovative product development.

Indian agriculture is undergoing substantial change, with fruits/ vegetables, flowers, spices, medicinal and animals plants and speciality crops, having grown much more rapidly than forecast crops over the last decade. This is clearly an area where agricultural economists must put in greater research, both on farm level economics and on the required backward and forward linkages.

At the micro level, there are many farm level studies on the economics of fruit/vegetable and livestock/poultry production. But these need to be consolidated and linked to other studies which relate to linkages, both in input supply and in processing and other post-harvest issues. For this an all-India effort is required. This is necessary because the potential for diversification and of mixed farming requires a specific systems approach.

In particular, development of processing and agro-export zones will require both state governments and industry to identify compact regions which have the greatest future potential and banks will need reliable cost estimates for credit plans. Policy makers will thus require projections of future supply-demand balances and an idea of which agro-economic regions are likely to diversify most and from which crops. Since much of the technology in these crops are being diffused through private sector seed companies, it will be necessary to evaluate the economics of these technologies, benchmark these against technology available from public sources, examine the incidence of unethical practices such as in the distribution of spurious seeds and pesticides, and identify the post-harvest constraints.

Research will have to play a major role in our search for sources of productivity growth and efficiency in agriculture, and go beyond this. It has to focus not only on yield growth, but also on yield stability, unit cost reduction and quality augmentation. In addition, price and other market uncertainties will need to be quantified, the effect of these on farmers' decisions analysed, and advice given to both policy makers and farmers on how to handle such risks. Only by bringing such new issues into focus can

the agricultural economists in the NARS provide the cutting edge for Indian agriculture to be competitive.

Rebuilding the natural resource base to provide a sound environment to support farming is a critical part of this new direction. The need to develop sustainability indicators has assumed critical significance. This should be piloted both at farm level and community level. Unless this is done, it will not be possible to achieve sustainable agricultural growth while meeting the challenges of competition in both the domestic and international markets. Restoration of soil health and fertility through appropriate technology package including vegetative cover would be crucial. At the community level, vegetative cover around the village, on main roads leading to farms, on tank / canal bund, and on common land will have to be promoted to provide sound environmental support to agriculture.

'Farmers' Group' as a development unit is needed in future. Farmers as individuals cannot enjoy competitive edge to reap the benefits of scale economies. We need to define farmers' group as a development unit for certain activities like developing land and water resources, restoration of natural resource base of the community, strengthening bargaining powers of the farmers in marketing and technology transfer. Promotion of Agricultural/Horticultural/fish processing centres for a cluster of villages by providing policy support to private entrepreneurs and tie up with farmers through contract production could sharpen the role of farmer's group in development process. This could be the basis for ventilating the concept of decentralised production, but organised processing and marketing.

New Provisions for Agreement on Agriculture have become critical for survival of profitable farming in India. Tariffs and exchange rate adjustments are necessary but may only be short run palliatives. The real solution to meet the competitive challenges is to promote efficiency in agriculture. Efficiency gains through domestic market reforms are also substantial. The issue of price volatility and its influence on our agricultural prospects also needs careful analysis. Detailed market intelligence and quick government response to threats and opportunities of WTO are a must to be benefited from WTO. Added to this is the need for articulating the inclusion of new provisions (like Development or Livelihood Security Box) as instruments in AOA. This would be crucial to allow sufficient period to prepare Indian farmers to compete in the international market, to develop on farm facilities and to develop off-farm infrastructure support.

In this context it might be noted that that there is sufficient expertise within the Agricultural Universities and ICAR institutes to do competent cost of production and farm business analysis which must form a critical component of any SWOT analysis for Indian agriculture. However, for this to lead to a proper system, **there must be closer interaction of research within the ICAR proper with that of other institutions, including economics in the UGC system, which have more experience with issues such as international trade, risk management, and environmental impact analysis.**

V. Agro-Economic Database, Information and Networking

Sound empirical research in social science in general and frontier areas of concern as outlined above requires sound statistics. India is uniquely placed in having rich data base on various aspects of agriculture. The NARS itself has an excellent database on technical parameters derived from trials on farmers fields and from All India co-ordinated research projects etc. In addition, Agricultural Universities are continuously collecting farm-level data under the Comprehensive Schemes on Cost of Cultivation of important crops. These data can provide the essential input for analysis of strength and weaknesses of Indian agriculture.

Unfortunately, much of these data are not easily available for research purposes and even where available cannot be utilised adequately because of the dissemination format. As a result, although considerable expenditure is being incurred on data collection, agricultural economists remain severely constrained by lack of reliable, consistent and comparable data to answer several research questions, particularly relating to structural changes taking place in Indian agriculture over the years, analysis of farming systems, complex technical aspects relating to perennial crops, biodiversity, on-farm trials etc. Similarly, agricultural economists do not have comprehensive data on international price and cost trends.

Since a strong socio-economic database on a continuous basis is essential to objectively monitor and evaluate the process of agricultural growth and development, and since the secondary database support currently generated by various organisations in India do not facilitate multi-dimensional impact analysis of technological and other changes occurring at farm level, a beginning was made in the IXth Plan, involving the existing network of the ICAR Institutes/SAUs, towards a comprehensive farm household based data generating mechanism for each one of the 120 agro-climatic zones. The social science networking initiated for the above purpose during IX Plan should be further strengthened during X Plan to fulfil the mandate of generating data in respect of technologies traditionally practiced, currently recommended/adopted. Besides this, the socio-economic unit at each SAU/ICAR institution should be enabled to continuously monitor and analyse these data to guide the agricultural technology management process. The proposed data-generating mechanism should also supplement the existing institutions in strengthening and widening the coverage in the areas of agricultural prices and market-related statistics which are currently weak and inadequate.

However, although essential for research evaluation, this effort of the NARS cannot be a substitute for the existing system of national agricultural data collection and dissemination. Strengthening this system, particularly in the areas of livestock/poultry and fruits/vegetables where data is currently weak, is an urgent priority which must be addressed jointly by the IASRI and the Ministry of Agriculture.

In this, the Ministry of Agriculture must play a pivotal role by ensuring closer interaction of the NARS with units such as the Agro-economic Research Centres and the Cost of Production Units collecting data for the Comprehensive Scheme. In particular, an immediate effort is necessary to make more easily accessible the detailed data already collected over the years in programmes such as the NARS' own co-ordinated programmes and farmers field trials, and the farm-level data from the Ministry of Agriculture's Comprehensive Scheme on Cost of Cultivation. **To make such data available easily and on-time, by removing procedural obstacles and making adequate investment in a suitable repository and dissemination system will be far more economical than duplication of this by new surveys.**

VI. Institutional Strengthening, Interfaces and Human Resource Development

The research and policy analysis agenda suggested above would call for trans-disciplinary research efforts, apart from independent research efforts by economists in their domain. Economists should work with not only biological and physical scientists, but also with sociologists, anthropologists, political scientists who can provide objective assessment of social setting and experts in management, especially in areas where evaluation of institutional arrangement is involved. Further, it also suggests the need for involvement of socio-economists in evaluation of not merely varieties of crops and

animals, but also other technologies like natural resource management and even socio-economic research itself for their cost effectiveness.

The emphasis during Xth plan should be on strengthening institutions with adequate manpower and infrastructure to accelerate research in Agro-Economics, on developing interfaces with other institutions including institutions which fall within the purview of UGC, ICCSR etc. and on developing interfaces with other social science disciplines. Capacity building in SAU's and ICAR institutions through relevant HRD Programmes is also critical. To mention a few :

Human resource development through post-graduate training at SAUs and DUs, is in a disarray both quantitatively and qualitatively. Due to the sad state of state finances and low priority assigned to agricultural economics by concerned institutions, there has been a drastic erosion of faculty strength. Poor monitoring and massive inbreeding coupled with inefficient internal evaluation procedures, have undermined quality. The Education Division of the Council has recently undertaken substantial revision of syllabi to make it more relevant and up to date, but there is a shortage of competent faculty to implement these. Nor can this be addressed internally in the ICAR-SAU system. Addition of young faculty and effective training must be ICAR's priority in X Plan. Further, there should be proper planning, co-ordination and support to programmes in agri-business management, risk analysis, and trade in SAUs. A detailed course on international agriculture should be included in such a programme, and inputs may have to be sought from institutions outside the NARS.

The economics component is currently extremely weak, and often entirely absent, at the KVK level. Also, although policy analysis at the national level has been initiated by NCAP, there is no corresponding body to convey NARS analysis to policy makers at the state level. Since demands from farmers and state governments is likely to increase, there is a need for NARS to formulate a regional level arrangement to co-ordinate research and provide policy advice and training. For this, 5 regional advanced research centres (SAUs) may be identified and adequate provision made for them to develop the necessary network and capabilities.

VII. Recommendations

1. In view of the enormity of the challenge and the limitations of the existing agricultural economics and policy component within the NARS, there is an urgent need for better co-ordination among agro-economists within the NARS, and for encouraging joint work with other institutions in and outside Ministry of Agriculture. For this, existing norms and procedures may require modification.

2. Policy and planning have become critical for co-ordinated, long range planning, monitoring and impact assessment. There is, therefore, a need to establish a full pledged Division of Policy and Planning at ICAR (Head Quarter). Such a Division is necessary to provide an umbrella framework for guided changes in cross cutting areas like policy and planning, economics, statistics, and marketing, IPR etc.

3. The Council should organise time bound network research programmes in a mission mode, as is done in other areas of agricultural research. Some ideas for such projects include: comparative efficiency and risk studies in different regions for important agricultural activities (crops, horticulture, fisheries, etc.); marketing of high value perishables; environmental stress and its economic impact; etc. The idea is to have national perspective on such critical issues. The NARS is the only system with presence in all eco-regions of the country and a

stake in their development. However, since capacity is weak, at least some of these studies should involve economists from outside the NARS.

4. NCAP should be strengthened and developed as a nodal and coordinating Centre for agricultural economics and policy research, training and networking of agricultural economists working in the NARS and other institutions. Further, 5 regional advanced research centres (SAUs) should be identified to co-ordinate agro-economic and policy research at the regional level and impart training to agricultural economists in the NARS.

5. There are a number of institutes in the Council, where there is not even one economist. This situation has to be redeemed particularly in critical sectors like horticulture, animal science, fisheries, natural resource management etc. More particularly, economics input is totally lacking in programmes like KVKs/ZRS which are closer to farmers and from where economically feasible technologies have to be transferred to farmers. For KVKs, ZRRs ICAR should see that the economists are provided. There are about 210 sanctioned positions of agricultural economists, representing 3.4 percent of total scientific manpower in the Council. This may need to be raised to 4 to 5 percent during X Plan (Annexure II).

6. Concerted efforts must be made for involvement of agricultural economists in all the major agro-biological research programmes. In such programmes, economists should work with not only agro-biological scientists, but also with sociologists, anthropologists, political scientists and experts in management science.

7. Absence of local and micro-level information on socio-economic profile of farming system and changes occurring therein, has been a critical bottleneck in agricultural development planning, including planning for agricultural R & D. This is one reason why decentralised planning has been so difficult. The Council should support the idea of socio-economic information repository initiated by NCAP during IX Plan.

8. Market intelligence, cost and price data assume greater significance in the present context. Access to such data collected by public agencies should be ensured and procedural impediments should be removed. An inter departmental initiative in this respect is necessary, particularly in the case of the Comprehensive Scheme for Cost of Cultivation of Principal Crops. This is collected by units situated within NARS and can provide detailed on-time data, but is currently subject to restraints on dissemination set by the Ministry of Agriculture. It must be pointed out that the value of timely assessment of strengths and weaknesses of farming systems possible with this data far outweigh any consideration of confidentiality in, say, the formulation of price policy.

9. A program should be initiated at the Indian Agricultural Statistics Research Institute (IASRI) to examine existing agricultural statistics for their consistency, reliability, comparability and adequacy. Further, IASRI should have strong research programmes to address methodological/ statistical problems relating to temporal changes, farming system and other complex technical aspects like on-farm trials, perennial crops etc.

10. The teaching and HRD programmes in NARS require immediate strengthening to develop new skills and capabilities. There should be continuous review of agricultural economics syllabi for its relevance, both by economists from outside NARS and by biological and physical scientists within NARS. The system of

summer schools and workshops should be streamlined and made more focussed, with greater input from outside NARS in areas where the system's capability is weak. A documentation unit should be set up within NARS to maintain easily accessible lists of resource persons and research abstracts. There is also a need to consider international training to agricultural economists in policy research relating to certain cutting edge areas, such as evaluation of agro-biodiversity, IPR and SPS issues, WTO issues etc,

11. Finally, it should be recognised by NARS that the requirements of agricultural economists to conduct their research is often quite different from those of agro-biological scientists, Therefore, it may be necessary to provide economists with greater support in the areas of computer facilities, field investigators, and travel etc. than the norms laid down for agro-biological scientists. Further, program directors of agro-economic projects within NARS should have greater flexibility to draw upon talent from outside the system.

VIII. Budgetary Requirements

To implement these recommendations, it is estimated that about Rs. 150 crores will be required during X Five Year Plan.

Annex II : Themes and Programmes for Agricultural Economics Research during X Five Year Plan.

I. **Technology Policy**

- Technology, institutional structure and policy frame to support farmers.
- Techno-economic feasibility for research-farm-industry tie up and establishment of Agro-Hort processing centres in and around rural areas.
- Evaluation of livestock/fishery technology generation, transfer and adoption.
- Diffusion of farm level livestock technologies in different farming systems.
- Economics of diversification in farming.
- Assessment of feeds and fodder for accelerated livestock development.
- Need and scope for hi-tech agriculture/horticulture.
- Needed changes in technology and policy for R-W system in India.
- A feasibility study on establishment of agri-clinics by agricultural graduates for Self -Employment.
- National agricultural policy vis-à-vis State Agricultural policies.
- *Ex-ante* and *Ex-post* impact of agricultural technologies, new varieties, with environmental cost examined in each case.
- Integrated production and marketing system- Role of co-operatives.
- Technology forecasting, methodology improvement for priority setting at different levels as for NRM research, quantification of spill over effects of

technology, emerging areas like IPR, biotechnology private sector participation in agricultural research.

II. Efficiency

- Rural energy for farm and household use: Technological and Economic Designs.

- Models of public - private sector partnership in R & D and technology transfer.

- Capacity building in rural community for a transition from protected agriculture to competitive commercial agriculture.

- Restructuring extension systems of SAUs and ICAR Institutes: Organisational frame, extension focus and extension education methodologies - Farmer driven and controlled extension system

- Economics of water harvesting technologies.

- Cutting edge technology- biotechnology, biodiversity, GM technology.

- Post-harvest losses, post-harvest management and value addition.

- Institutions for greater technology and policy impact in rural development - A relook at the relevance of the present institutions.

- Information and communication technology for accelerated rural development.

III. Sustainability

- Building Natural Resource Base for Agriculture: Technology, Institutions and Policies.

- Economic evaluation of natural resource degradation including mapping of sustainability status of natural resources for sound policy making.

- Develop indices of environmental degradation based on economic return particularly in intensively cultivated states.

- Socio-economic and ecological impact of watershed management.

- Role of farmer groups in natural resource management, particularly common property resources.

- Economics of organic farming and its scope and limitations in India.

- Analysis of global climate change, environmental stress and economic impact.

- Land-use-planning and peri-urban agriculture.

- Rural-urban interface-social forestry.

- Conflicts, interactions and scenario analysis in NRM.

- Methodology for quantifying the externalities and internalizing them into the policy analysis.

IV. Equity

- Development of laggards: Regions (eg: Dryland, Eastern India), crops (pulses, horticulture livestock, fishery, agro-forestry, plantation crops) and farm groups (small and marginal, tribal, backward, women).

- Food and nutrition security: National, Regional and Household.

- Participatory model for watershed management.

- Partnership mode for agriculture - rural development: Role of farmers, cooperatives, NGOs and Government agencies.

- Problem and prospects of land reforms.

V. Market and Trade

- Globalisation and shifts in costs and comparative advantage of different farming systems (crops, horticulture, livestock, fishery etc.) in different agro-climatic regions of the country.

- Surplus management of farm produce including decentralized system.

- Liberalisation and shifts in cropping pattern, technology adoption and credit and marketing propensities of farmers.

- Export of agricultural goods and national food security, potential of domestic market and how to strengthen it and serve it better.

- Cost effectiveness of technological options for storage structures.

- Mechanisms to cope with violent price fluctuations: Role of Centre and State Governments.

- Reduction of subsidies to agriculture: Implications to technology adoption, input use and productivity.

- Evaluation of development support services and subsidies for livestock

- Development of market strategies for segmented domestic and international market for livestock products.

- Supply and demand for farm products and inputs

- Identification of Models for Small Farmers Agri-Business Consortium.

- Techno-economic justification for subsidies to agricultural implements and machinery, particularly to promote mechanization in the wake of labour shortages.

- Weaknesses in the credit and marketing structure and functioning.

- Identifying niche markets, establishing international market intelligence mechanism.
- Need and approaches for food quality, safety, SPS etc.

Annexure II **Current and proposed cadre strength of agricultural economists in ICAR during X Five Year Plan**

Sectors	Current Strength				Proposed (X Five Year Plan)			
	Scientists	Senior Scientists	Principal Scientists	Total	Scientists	Senior Scientists	Principal Scientists	Total
Crops	30 (2.35)	15 (2.65)	3 (1.24)	48 (2.30)	27 (2.12)	19 (3.35)	4 (1.66)	50 (2.40)
Animals	26 (4.04)	14 (5.07)	6 (4.84)	46 (4.41)	30 (4.66)	20 (7.25)	12 (9.68)	62 (5.94)
NRM	27 (4.62)	18 (6.79)	5 (4.0)	50 (5.13)	30 (5.13)	18 (6.79)	7 (5.60)	55 (5.64)
Horticulture	12 (2.14)	2 (1.01)	1 (1.28)	15 (1.79)	23 (4.09)	12 (6.03)	3 (3.85)	38 (4.53)
Fishery	17 (3.5)	4 (3.01)	1 (1.59)	22 (3.23)	15 (3.09)	7 (5.26)	4 (6.35)	26 (3.81)
Agricultural Engineering	15 (5.60)	6 (5.31)	1 (1.54)	22 (4.93)	10 (3.73)	7 (6.19)	3 (4.62)	20 (4.48)
Agricultural Education	-	2 (9.09)	1 (5.56)	3 (7.50)	-	4 (18.18)	2 (11.11)	6 (15.0)
Agricultural* Extension	5 (25)	-	-	5 (10.20)	5 (25)	5 (21.74)	-	10 (20.41)
Overall (ICAR)	133 (3.46)	60 (3.75)	18 (2.5)	211 (3.43)	140 (3.65)	92 (5.26)	35 (4.86)	267 (4.34)

Figures in parentheses indicate percentage of agricultural economists in total scientists

* It is also proposed to involve an agricultural economist in each one of the KVKs.

14. Organization, Finance and Management — Restructuring for Revitalization

Introduction

ICAR is a strategic organization of national importance entrusted with the vital mission of providing technological backstopping to accelerated and

sustainable agricultural development. By all counts, the organization has done well in fulfilling this mandate besides winning international recognition. However, Indian agriculture is presently in crisis - crisis of confidence, ability and preparedness to face complex challenges not only relating to household food and nutritional security, sustainability of natural resources and equity but also more importantly protect and promote the longrun interest of profitability and livelihood of Indian farmers in the wake of globalization and WTO regime. The organizational structure, finance and management of ICAR, the flagship of National Agricultural Research System, for coping with these challenges will have to be well planned and ably executed during the X Plan so that the strategic mandate can be performed in a cost effective, creative and socially responsive manner. To serve the emerging knowledge based society, it should become a knowledge organization by strengthening the learning system, particularly strategic learning. ICAR should have a vision of making R&D as a vehicle of rural development.

Challenges and the Need for O&M Reforms

Nobody can deny either the critical role of agriculture in economic development or the role of technological change for agricultural development. Thus, the need for continued investment in agricultural research and education becomes obvious. The food surpluses of today are the outputs from agricultural research investments made a few years earlier. Whether India will be able to feed its burgeoning population depends critically on our present investments in agricultural research. Though public sector research will still remain dominant, but there is a paradigm shift towards broadening it with participation of NGOs, FOs, private sector etc. to ensure breadth, pluralism and competition and thus challenge the monopoly of public sector. In this changed context, questions are often raised how much to be spent, how should it be spent, who should spend it, who should pay, what is the role of private sector, how can the resources be used more effectively, what is the scope for convergence, phasing out etc. Thus, organization, finance and management should be concerned about these issues.

Rates of return to agricultural research investment are higher relative to other (public or private) investment opportunities. A minimum target of 1 per cent of the value of the agricultural output for public research is recommended to be appropriate and socially optimal with a long term target of 2 per cent. In India, only 0.46 per cent of agricultural output value (AgGDP) is spent on agricultural research. This is grossly inadequate. The Standing Parliamentary Committees successively expressed their concerns and recommended repeatedly to raise it to a level of atleast 1 per cent of agricultural GDP. Thus, ICAR is faced with the severe problem of dwindling resources on the one hand and increasing pressure to respond to emerging complex R&D challenges. It has also to address issues relating to needed changes in research resource allocation across regions, sectors commodities etc.

The profile of future Indian scientific organization emphasises excellence, flexibility in rules and procedures, open to questions, rewards by clients, access to resources without harassment and delay, satisfy curiosity, work closer to client, entrepreneurship spirit, look at global market for technology, have

compassion for regional, gender and class inequities. O&M system should respond to this profile. For R&D system, scientists is the internal customer and farmer is the outside customer. The organization can satisfy the outside customer only by satisfying the internal customer. X Plan should monitor outputs and outcomes not inputs. For this, knowledge networking navigation and knowledge intensification at scientists, team, institute, and headquarter level are essential.

Since, most of the upcoming problems in different regions or sectors require interdisciplinary research, the team spirit at the ICAR headquarter is most necessary. ICAR (HQ) should be concerned with long term as well as short term thinking about emerging technological frontiers. It should also be more concerned with monitoring and evaluation. Through this, the culture of implementation is sought to be modified.

The response time and feedback loops will have to become shorter. The wisdom of creative and innovative farmers and their institutions will have to be drawn upon more systematically than has been the case in past. To assume new functions and new roles within and outside the country, the R and D system will have to dispense with some of the old roles and functions. Unless space is created by folding back some of the historical functions (which were very important when state agricultural universities had not come of age), space for new entrepreneurial functions to be performed by ICAR as well as by private and NGO sector will not be available, much less expand. For example, the research and development system will have to focus more on research and recognize that in a federal system, the task of development has to devolve to state and sub state institutions. While research on extension must be done to find new ways of blending the experience of private sector and civil society organizations, the extension proper will have to be done by state and private institutions as well as farmers' organizations.

The ability of administrative and management systems to be in sync with the needs of future will depend to a great extent on the adoption of modern management methods and approaches. The government rules and regulations are not expected to help achieve this transition. And yet, all these years, agricultural system has suffered from excessive reliance on these procedures designed to maintain a status quo and not bring about change. The tragedy is that while several government agencies are, in fact, modernizing very fast, the ICAR system has become more and more centralized over time and has got trapped into a complicated labyrinth bureaucratic of systems which are sapping the energy of the research and development potential of our society. The time has come for Indian agricultural research system to prepare itself for new roles globally and domestically by reinventing itself. How will it happen will depend upon the realization at the top level that despite continuous good monsoon since 1989, if we have not been able to maintain even a reasonable rate of agricultural growth, it is so also to some extent because our approaches to solving problems have not kept pace with the need of time.

Accomplishments and Concerns

As regards sectors, rationalization was attempted during IX Plan by giving needed impetus to the fast emerging growth sectors. For instance, increased outlays (in terms of per cent) were suggested for researches in animal science, horticulture fishery, agricultural education etc. It is felt that such an emphasis is necessary to be continued in X Plan as well.

More than 80 O&M initiatives were taken during IX Plan. Notwithstanding these, many of which have not yet been implemented, O&M and finance problems relating to shortages of operating expenses, inadequate incentives for performance, bureaucratic rules and procedures, out-dated laboratory equipments, pilot plants, farm / field facilities, classroom and audio-visual facilities and manpower training specially in frontier areas persist. The idea of onetime catchup grant to modernize these facilities being carried forward from VIII Plan, has not been supported sufficiently.

It is also stated in IX Plan document that IX Five Year Plan should be a period of consolidation and selective strengthening. Towards this, ICAR did take decisions on the Jain Committee recommendations on merger, phasing out etc. of AICRPs. The regional / sub-stations of ICAR institutes were also got reviewed by MV Rao Committee. Some decisions on merger, phasing out etc. have been taken up. However, the Council has not been able to stop expansion of KVKs, which has hardly any research function. It has also not been possible to balance the proportion of scientists to technical to administrative staff. It remains at 1:1.61:1.15. The ideal ratio thought of was 1:1.5:0.75. These unfinished tasks should be completed in X Plan.

By the end of 9th plan most of the senior staff in ICAR institutions will superannuate and there would be real dearth of qualified senior staff to man middle and higher level positions. This would create a big void which should be avoided by proper manpower planning and recruitment policy. This should be an urgent thrust in the 10th Plan. The functioning of ASRB was reviewed by a high power committee during the IX Plan. Its recommendations need to be implemented soon.

As far as resource generation is concerned, many hurdles are encountered while implementing the Johl Committee recommendations. Besides, overcoming these, the Council should also look forward for the report of the consultancy hired for this purpose recently.

The transition of ICAR (Headquarters) structure from the maintenance functions to primarily policy, planning, and futuristic mission oriented functions will call for a cultural change. Lots of decentralization, differentiation and O&M reforms introduced in the Council should be logically carried forword to the grass root level so that the much talked cultural change, mindset change etc. becomes a reality.

Thrusts Areas for Tenth Plan

Some of the thrust areas during X Plan under O&M include the following :

1. Completing the unfinished tasks of IX Plan relating to project based budgeting, zero-based budgeting, decentralization, research prioritization, monitoring and impact assessment, establishment of Division of Policy and Planning, modernization of office and management process, revise AAR proforma, purchase manual, incentives and rewards, implementation of recommendations of several consultancies relating to institute management, financial management, personnel policies, commercialization of agricultural technologies, strategic Plan for translating Vision 2020 of ICAR planning for extensions of NATP, AHRD projects etc.

2. Developing own rules and procedures for ICAR.

3. Consolidation, convergence and functional integration of subject/commodity sectors within ICAR to address eco-regional concerns. Shedding field extension programmes like KVKs to Department of Agriculture (MOA).

4. Extending functional autonomy to all the field units and projects replacing target and control.

5. Developing strong capabilities and facilities for IPR and SPS issues.

6. Developing ICAR as a learning system.

7. Promoting strong HRD programme for faculty/ staff upgradation by international training.

8. Forging linkages for strong inter-institutional research within ICAR institutions as well as institutions under CSIR, ICAR, ICSSR etc.

9. Indexing AP Cess rates as well extending its coverage to other commodities.

10. Sorting out stress points between ICAR-DARE in relation to financial control and foreign travel.

A few of the above thrust areas are elaborated below. The presentation is organised under five heads.

Research policy, structure and organization

Bureaucracy stifles creativity. The ICAR system now is too large and diverse to be managed efficiently by rigid centralized processes characteristic of Government. The ICAR society must evolve its own financial, administrative, and personnel policies. Eventually, such autonomy may be extended to national institutes like, IARI, IVRI, NDRI etc. In the meantime, all GOI circulars before being made applicable to ICAR, to be critically examined in relation to their relevance and efficiency to ICAR and adopted after appropriate changes. Adhoc responses attempted in the past need to be replaced by a systemwide overhaul.

The council has little analytical capacity for prioritization, planning, monitoring and evaluation. Independent subject matter divisions have become

obsessed with routine administrative chores which should best be left to Institutes. With the identified function mechanism, the five DDGs relating to crops, horticulture, animal, fishery, and agricultural engineering will be responsible for multi-disciplinary eco-regional research, DDG (Planning and policy), a new position suggested by us will look after planning, PME co-ordination, etc.

There should be functional mechanisms to be made mandatory to integrate disciplinary mode to matrix mode as articulated above at the DDG level in the Council.

Most of the activities in the Division of Extension (particularly KVKs) should be handed over to the Department of Agriculture as field extension programme. The role of extension activities in ICAR needs to be dispassionately thought through. The model of KVKs can now be taken up by DAC or Department of Rural Development or state governments etc. In the districts, where there are no KVKs, the FTCs and ZRS scan be graduated into KVKs on the model of KVKs. The funding mechanism and the nature of support has to be reviewed and built into the system. The ICAR may provide technical/ training backstopping. ICAR's mandate is research and innovative programmes in extension fall legitimately under the domain, but there is little justification for carrying on tested programmes under ICAR. It is different for SAUs because extension is their mandate. Extension in ICAr should be a part of research process where each scientist after developing the technology will assess its worth in farmers fields and refine it before handing it over to public extension system. In other words, technology assessment and refinement (TAR) which is presently perceived as an extension function must be internalized as part of research process. Insistence on this will ensure accountability.

The DARE-ICAR Interface has several stress points which need to be straightened. Two particular areas which need special attention are financial control and foreign travel. In fact, DARE ought to have two major concerns - budgetary and achievement audit to ensure that public funds generate commensurate benefits. As regards foreign travel, powers need to be suitably delegated to Director-General and Directors to eliminate avoidable harassment and tension.

Research management

Modern management processes must replace target and control oriented ones. Project-based budgeting, flexibility, decentralization, effective monitoring and evaluation, efficiency-oriented personnel, management, incentives and rewards, revised AAR proforma, purchase manual; etc. are ideas which have been either approved or under discussion. These must be implemented during the X Plan period.

The importance of data base and computerization and information networking is important. There is need for increased use of IT in the Council. Substantial investment is made already. But the system should become functional. The Council must seek advice from IT professionals on this because in-house capacity is inadequate.

ICAR should be unburdened of routine administrative and management tasks through greater delegation. Decentralization has to be real and not just cosmetic, if resources are to be utilized in the time to maintain the momentum of work. This is of essence in research and this is often not realized by those who want to wield power and authority.

The scientists at the institute level should be given full freedom to use resources, if they raise such resources while working for the mandate of the institutions. At present this is beset with hassles and bureaucratic controls. This will create a new user oriented culture with increased self-confidence and greater responsibility.

The Council has wisely established an IPR cell at the Headquarter. But that is all. Not much progress is made to institutionalise the concept and spread IPR literacy among scientists in the Council. It is strongly felt the issue of patenting can be dealt at the institute level itself by appointing panel of lawyers. Similarly, a major initiative is necessary to address SPS measures. CSIR's lead on this needs to be emulated. Regional referral laboratories may have to be identified and supported well.

Linkages and partnerships

Though there has been some improvement in inter-institutional research collaboration, but it should be further strengthened. Collaboration with CSIR, ICCSR, ICMR, CFTRI etc. may be helpful.

Funding agricultural research

Normally there may not be any need for opening up of new institutes, regional and zonal research centres/ stations. After review, some of them may be merged with the SAUs. The ones which will be retained should be supported well and be really made Centres of excellence. For instance, the biotechnology laboratory should be well established at only major institutes and all other institutes should take advantage of them. The regional stations of the IOAR institutes may be closed, if found non-viable. The recommendations of MV Rao Committee have to be implemented faithfully.

Despite efforts during the last plan, the issue of duplication of research remains a matter of concern. Institutes vs co-ordinated projects has been examined. At more fundamental level, the question is : ICAR initiated research programmes in many areas because there was no capacity in states. Now, there are state institutions. ICAr should concentrate on problems or issues of national importance. One could argue that ICAR's main role should be to strengthen such institutions, rather than create a competitive environment. Strength of land grant institutions in the US has been the main source of strength for its agriculture, the USDAs role has been essentially supportive.

Similarly, there may not be any need for creating additional and new scientific positions in Five-year Plan. Additional requirements may be met mostly though redployment. While doing so, the ratio of 1:1, 5:0.75 (scientist to technical and administrative staff) may be thought of. In the overall interest of the Council, hiring research associates/ fellows may be preferred in place of

technical staff. The existing proportion of 1:1.61"1.15 needs correction, particularly in respect of administrative staff over the next 2 plan periods. The cadre strength by disciplines have to be fixed keeping in mind the existing staff strength and the incremental staff required.

Establishment cost of the institutes will have to be brought down to a level of 50-60% eventually. This should enable a corresponding rise in the working capital, contingency etc.

The Johl Committee (1995) has made several suggestions for resources mobilization through internal resource management and external funding agencies. These suggestions need to be implemented through concerted efforts. It must be ensured that no other rules (GFR etc.) should be superimposed on these and throttle incentives associated with this reform. There should also be provision, for contracting out activities by the Directors institutes, if that is found to be economical and advantageous.

Cess fund grant to the ICAR is quite important and necessary. There should be an indexation of cess rates. The cess fund collected from sugarcane, cotton, spices, cashew etc. like other commodities should also be made available to the ICAR for further strengthening research on these commodities.

There should be serious effort to get more external funding in critical areas. Critical gaps in research will have to be bridged through externally aided projects. The Council may have to seriously plan for next phases of AHRD, NATP etc.

Reaching an ideal investment level of 2 to 3 per cent as against the present level of 0.46 per cent of agricultural GDP is necessary if agriculture has to achieve a growth target of 4.5 per cent per annum as envisioned in the New Agricultural Policy document. In view of the absorptive capacity, a target of 1% for the 10th Plan is suggested.

For modernization of the NARS, a onetime catchup grant of Rs. 500 crore is also considered critical for improving the efficiency and compe;tititveness of the system.

Human resource development

The Council must learn strategies through interface with market, clients, international collaboration etc. The useful recommendations and suggestions from monitoring and advisory mechanisms take QRT, RAC, IMC, SRC should be implemented faithfully.

There has been consistent decline in the quality of our education system over the last two decades. This has originated from qualitative decline in faculty and teaching and research at SAUs and DUs. Consequently, the knowledge gaps has widened. The council has been trying to upgrade the faculty and teaching programmes through NATP, AHRD etc. but these are symptomatic responses. Even countries like Japan and China resort to foreign training as a strategy to catch up. So did India in the late fifties and early sixties. But since that time, the supply of foreign trained scientists has dried up. Consequently,

programmes in frontier areas are manned by ill-trained scientists. Therefore, there should be strong HRD programme for faculty upgradation similar to the one existed during 1960s. The Council needs to allocate a major part of its education grant to train degree level scientists in premier institutions and laboratories abroad. The biggest threat to our system is degeneration because of quality.

Strengthening HRD activities would enable NARS to be vibrant and itnernationally compe;titive. In fact, Council should evolve a long term training policy covering all categories of staff for training in India as well as abroad. NAARM should be involved in research management issues by developing case studies etc.

Recommendations

1. Raise the level of funding for agricultural research to at least per cent of agricultural GDP in the 10th Plan. Further, one time catchup grant of Rs. 500 crore is also recommended.
2. Develop own financial administrative rules and procedures.
3. Integrate subject/ commodity sectors within ICAR to address eco-regional concerns.
4. Promote strong HRD programmes for faculty/ staff upgradation by international training.
5. Council should become a knowledge organization. The useful recommendations of advisory mechanisms like QRT, RAC, IMC should be implemented faithfully.
6. Normally these may not be any need for opening up of new institutes, regional and zonal research centres stations during X Plan.
7. Implement project based budgeting, zero based budgeting, research prioritization, monitoring and impact assessment modernization of office and management process, revised AAR proforma, and other O&M initiatives taken during IX Five Year Plan.
8. Shed field extension programmes like KVKs to Department of Agriculture, MOA.
9. Extend functional autonomy to all the institutes under ICAR replacing targets and control.
10. Develop strong capabilities for IPR & SPS issues throughout the system.
11. There should be an indexation of AP cess rates. The cess fund collected from sugarcane, cotton, spices, cashew nut should also be made available to ICAR.
12. Strong collaboration with CSIR, ICSSR, CFTRI etc. is recommended.
13. The Council must promote growth of professional bodies like societies, National Academy of Agricultural Sciences, etc. which make immense contributions to the overall goals of the NARS.

15. NATP

Approach and Thrust Areas for the Xth Plan

The purpose of the NATP has been to improve the relevance of agricultural technologies being generated, their refinement, assessment and transfer to meet the changing needs of farmers, processors and consumers, thereby, meeting the national goals of food security, economic growth, equity, alleviation of rural poverty and conservation of natural resources. This warrants changes in the research and extension paradigms and associated planning processes. Towards this need, the NATP is providing a model that will enable assessment of progress on several interlinked research and extension activities under the various agro climatic zones / agro-eco-systems.

The main objectives for continuation of the NATP in the X Plan are as follows:

1. Consolidating and sustaining existing gains. Agricultural research has contributed enormously to agricultural development and thus to poverty alleviation and employment generation in the rural sector. The continued emphasis would be on consolidating these gains.

2. Promoting new gains through applications of advances in science and technology.

Keeping in view the goals set in the Agricultural Policy and the ICAR's Vision documents, the agricultural research should emphasize elevation of productivity and profitability of agriculture together with addressing the problems related to management of natural resources, input efficiencies and inbuilt agri-related complementarities like horticulture, animal, aquatic, agro-forestry activities.

Thrusts and Priorities

The basic thrust of the Xth Five Year Plan under the NATP will be three fold:

(i) Firstly, some of the projects already approved and implemented during the Ninth Five Year Plan will have to continue by the very nature of research work proposed under them. Several Mission Mode projects are of long term nature and work must continue in response to new needs and advances in science. For example, the development of hybrid varieties in different crop plants including cereals, oil seeds, pulses, fruits and vegetables is a continuous process. The old hybrids have often to be replaced with new ones as they become susceptible to diseases and pests, which almost invariably happens as new races or biotypes take over. This is the recognized practice all over the world. The work on the development of transgenic varieties of crop plants continues to be at a very early stage in India and it will take some years before the country

becomes one of the world leaders in this field, as it has become in the field of classical plant breeding.

(ii) Secondly, as we analyze the present stage of evolution of Indian agriculture, we find that there are major opportunities which remain to be exploited and there are several critical gaps in technology which need to be filled. For instance, with all the past work the problem of increased production and productivity in the drought prone areas has not yet been solved. Also, the yields in 100 million ha of India's non-irrigated lands continues to be low. NATP will address these issues with greater emphasis during the Xth Five Year Plan by identifying opportunities and gaps in technology. The technology gaps are particularly evident in the area of biotechnology.

(iii) Thirdly, there is the question of taking full advantage of the technologies and concepts developed in the Ninth Five Year Plan. The research programme under NATP in the Ninth Five Year Plan took the form of a large number of research projects spread over many sites under various agro-ecological situations. It obviously makes sense that during the Xth Five Year Plan, we develop and implement integrated R&D operational models on large area based in the various agro-ecological zones / sub-zones. Keeping in view the results obtained during the Ninth Plan Period, many of these integrated R&D projects will have a strong component of on-farm research. These will bring together the research staff under the various NATP components including ZARS and ATMA. The district level research and extension personnel could all become participants in this integrated operational research model. A base line, quantitative benchmark survey to be followed by periodical and planned assessments would provide for the measurements of progress at the district level. This would be a unique model for on-farm operational R&D activity with inter-disciplinary and in-built inter-institutional linkages to demonstrate measurable progress to meet the Plan objectives. The NATP would then have demonstrated a different model and a process that would elevate agriculture to practical and attainable heights.

On the basis of the these basic thrusts some of the major issues that need to be addressed on priority are as follows:

(i) Emerging concerns in crop and animal production and productivity through application of *New Science.* All over the world, science is breaking new paths that specifically address issues directly relevant to human development. Agriculture should avail of this new science opportunities like gene-cloning, gene-transfer, improvements in material sciences for machinery and engineering development etc.

(ii) Ensuring e*co-friendliness* in new technology development.

(iii) Use of Information Technology and other modern developments in science and technology in agriculture.

(iv) Application of *New Economics* to social and socio-economic problems and ensuring e*quity* - social, economic and gender.

(v) Social concerns including decentralization of responsibilities and decision-making at the local level, and ensuring appropriate *empowerment* of institutions and individuals for this purpose.

(vi) Natural resources management, including decentralized inventorization, management technologies for conservation and enhancement of resource base, water management at micro / meso / macro level, monitoring the state of soil resources, research focused on regional issues such as drought management, management of flooded areas and improving agriculture in ravine infested areas.

(vii) Improving input-use efficiency by promoting crop improvement and ensuring plant diversity through protection of biodiversity, improving fertilizer-use efficiency and effectiveness of agricultural chemicals including hormones and growth regulators, pesticides and related products with an emphasis on natural and non-polluting products and cultivation under controlled conditions.

(viii) Reduction of drudgery in work through selective mechanization and ensuring that the approach does not displace labour adversely and promote unemployment.

(ix) Providing a socio-, ethno-, economic and cultural thrust to development, specially taking into account local needs and requirements and respecting tradition where it is demanded. This will include developing appropriate indicators of development and blending indigenous technical knowledge with new technologies.

(x) Value addition to agricultural commodities, specially primary value addition at the rural level. This would include promotion of small farmers group enterprises.

(xi) Development of educational programmes and curricula to meet the above needs.

Human Resource Development (HRD)

The Ninth Five Year Plan as explained earlier has made major investment in HRD. Some of these projects will be continued specially those in the area of bio-technology. However, new initiatives will be needed both for training within the country and abroad. Exposure of research scientists to advanced laboratories to learn new techniques is essential to keep pace with the rapid developments taking place in the frontier areas of science. Our scientists should also have greater opportunities for attending international events like workshops, seminar and symposia in their respective fields. Similar exposure

will also be useful for policy makers, administrative and financial staff as part of the continuing O&M reforms.

A major problem in the development of modern bio-technology in the research system has been the non-availability of M.Sc and Ph.D. graduates with intensive training in DNA technology. These graduates do have a strong background in classical biological sciences but they have never been exposed to practical work, in modern biotechnology. The best solution to this problem would be to organize M. Phil programmes in selected research centers within the country, like IARI. The major focus of these programmes will be to provide intensive training in the techniques of modern bio-technology. In this way, within a short period a large number of highly qualified bio-technologists could be produced with minimum of expenditure.

Other Infrastructure / Development Issues

(i) *Centralized Analytical Facilities in Each of the Agricultural Universities:* Assist setting up of centralized analytical facilities in each of the Agricultural Universities to enable scientists access these facilities on charge basis and to avoid the need of each scientist/laboratory purchasing their own. These labs must be 'service' oriented, ensure up keep and replacement of facilities when required and be somewhat self-sustaining and costs to be shared with State Govt.

(ii) *Set-up Soil-Plant-Fertilizer-Pesticide Testing Laboratory at Each of the Zonal Research Station of the SAUs:* Zonal Research Stations of the SAU's are the primary organ of the research system where teams of scientists interact with farmers, generate and promote technologies and provide a feedback to the system. To address sustainability issues increasing emphasis is called for on monitoring of resource base quality to develop appropriate management strategies and to assist farmers' groups in taking appropriate decisions. This will require that service facilities for soil, plant, water, feed etc. analysis/testing are considerably improved. NATP funds should be used to strengthen these features at the Zonal Research Stations.

(iii) *Strengthen Social Science and Policy research at ZRS and ICAR institutes:* Developing and promoting technological solutions which are sound considering the prevailing socio-economic conditions will be the key to success in the future. At present social science and policy research base within the national agricultural research system is weak. We need to strengthen both manpower and research base. ZRS will be the starting point.

(iv) *Improved Institutional Linkages to Enhance Quality of Research:* There is urgent need to develop linkage with advanced research institutions to improve the quality of manpower and research. This should be done by developing collaborative research and build up relations over a period of time.

Epilogue

In the course of the Ninth Five Year Plan, the NATP had addressed the problems of improving production systems in five agro-ecological zones (Rainfed, Irrigated, Dryland and Hill & Mountain). The projects sanctioned in these zones and production systems are often multi-disciplinary and multi-locational. A good example of this approach is provided from the coastal area integrated research programme. In this shrimps and fish health management, their brood-stock development, mariculture, culturing of pearl oysters, enhanced productivity of ducks, pigs, mussal culture and production of value added products are all linked to poverty alleviation of small farmers. Such programmes will have to be continued in the Xth Plan. Similarly, in the rainfed lands, restoration of soil fertility and harvesting rain water will involve on-farm research in close association with the farmers, if an impact is to be made. The important point as we enter the Xth Five Year Plan is that some of the relatively simple technologies such as those based on improved seeds, chemical fertilizers, pesticides and mechanization have already been extended to farmers in large parts of the country and have already made an impact. However, the more complex techniques relating to natural resource management including land, soil, water and bio-diversity require a different kind of approach. The scientists to be successful with these technologies have to work in close collaboration with the farmers and the extension workers. It is in this context that on-farm research will receive major attention in the course of the Xth Five Year Plan by NATP.

Similarly, the more recent advances in science giving rise to technologies like integrated pest management, use of bio-fertilizers, application of tissue culture techniques on a large scale, will call for closer collaboration with the farmers, NGOs, extension workers and industries. Also, as India no longer remains deeply pre-occupied with food self-sufficiency, the focus will shift to export oriented technologies with emphasis on quality of the produce and not just productivity. It will be advisable to identify those regions in the country where agro-ecological conditions are particularly favourable for improved quality of the produce for export purpose. A good example of this is provided by wheat in Madhya Pradesh, where the best grain development takes place and export quality rice in Chattisgarh and other zones. Value addition and food processing will call for closer collaboration with industry. In order to take full advantage of modern biotechnologies. NATP must lead in developing closer links of scientists of the ICAR institutes and SAUs with those in universities under the UGC system, where some of the most advanced work is being done in the field of biotechnology. In addition, there are other advanced laboratories like the Indian Institute of Sciences, Bangalore, and the Tata Energy Research Institute, New Delhi with which fruitful collaboration should be developed.

Budgetary Requirements

A total of Rs. 1500.00 crores is the projected requirement of funds for NATP for the Xth Five Year Plan (Table1)

Table 1. NATP: Projected Budget for Xth Five Year Plan

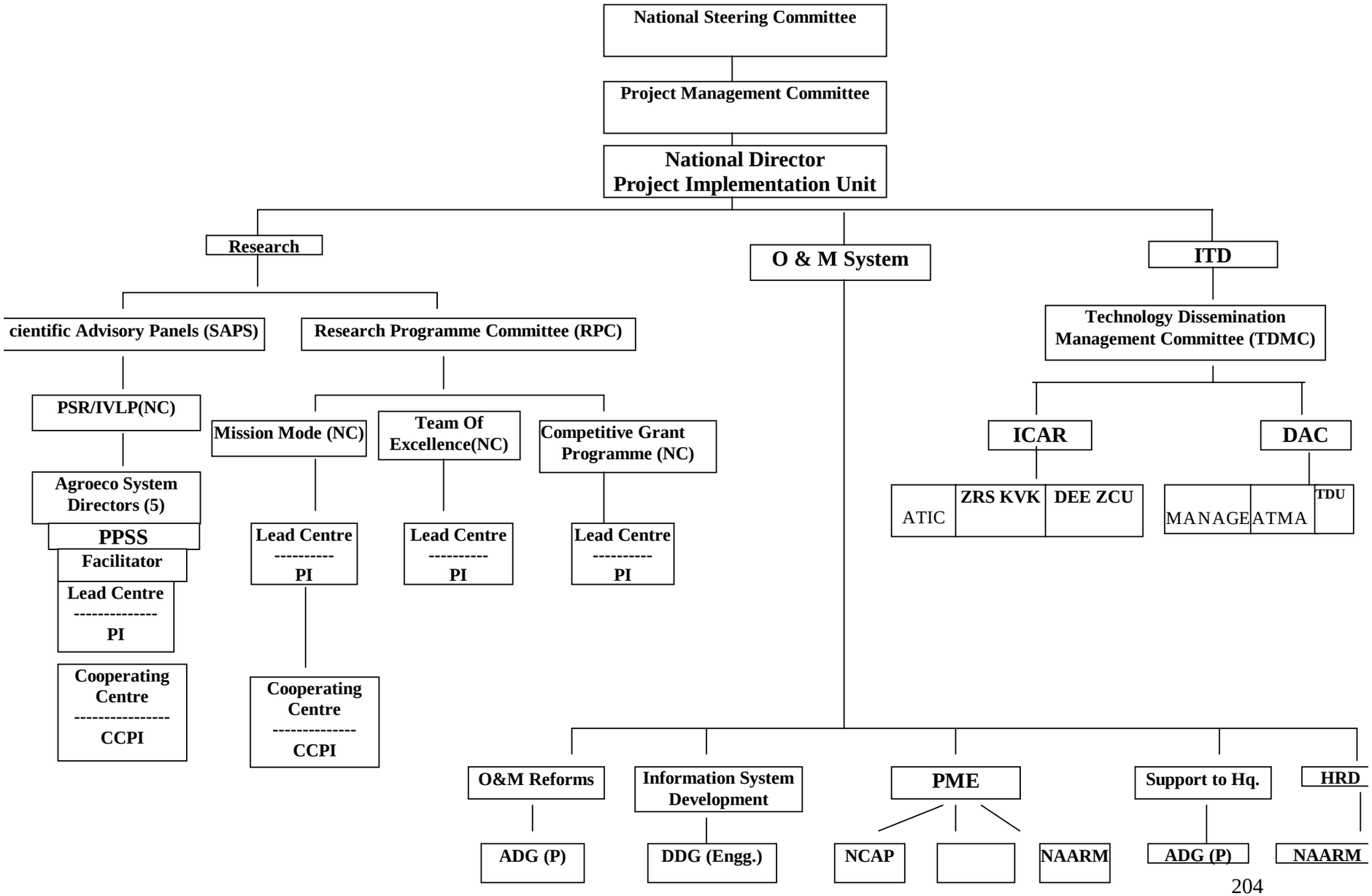
(Rs .in Crores)

Components		IX Plan Outlay	X Plan Projection*
A. Research			
(i)	Production System Research	260.00	175.00
(ii)	IVLP / TAR	23.00	75.00
(iii)	Mission Mode / TOE	201.00	200.00
(iv)	CGP	60.00	100.00
(v)	Infrastructure development	—	300.00
	Sub Total (A)	**544.00**	**850.00**
B. ITD			
(i)	ICAR Component (KVKs / ATICs / ZARs / NGOs)	55.00	150.00
(ii)	DAC Component (ATMA / SAMETI / MANAGE etc.)	135.00	250.00
	Sub Total (B)	**190.00**	**400.00**
C. O & M System			
(i)	PIU	20.00	50.00
(ii)	ISD	85.00	100.00
(iii)	O & M Reforms (including HRD)	53.00	100.00
	Sub Total (C)	**158.00**	**250.00**
	Total	**950.00**	**1500.00**

* Includes the committed outlay from April 1 - December 31, 2003 for NATP during X Plan period.

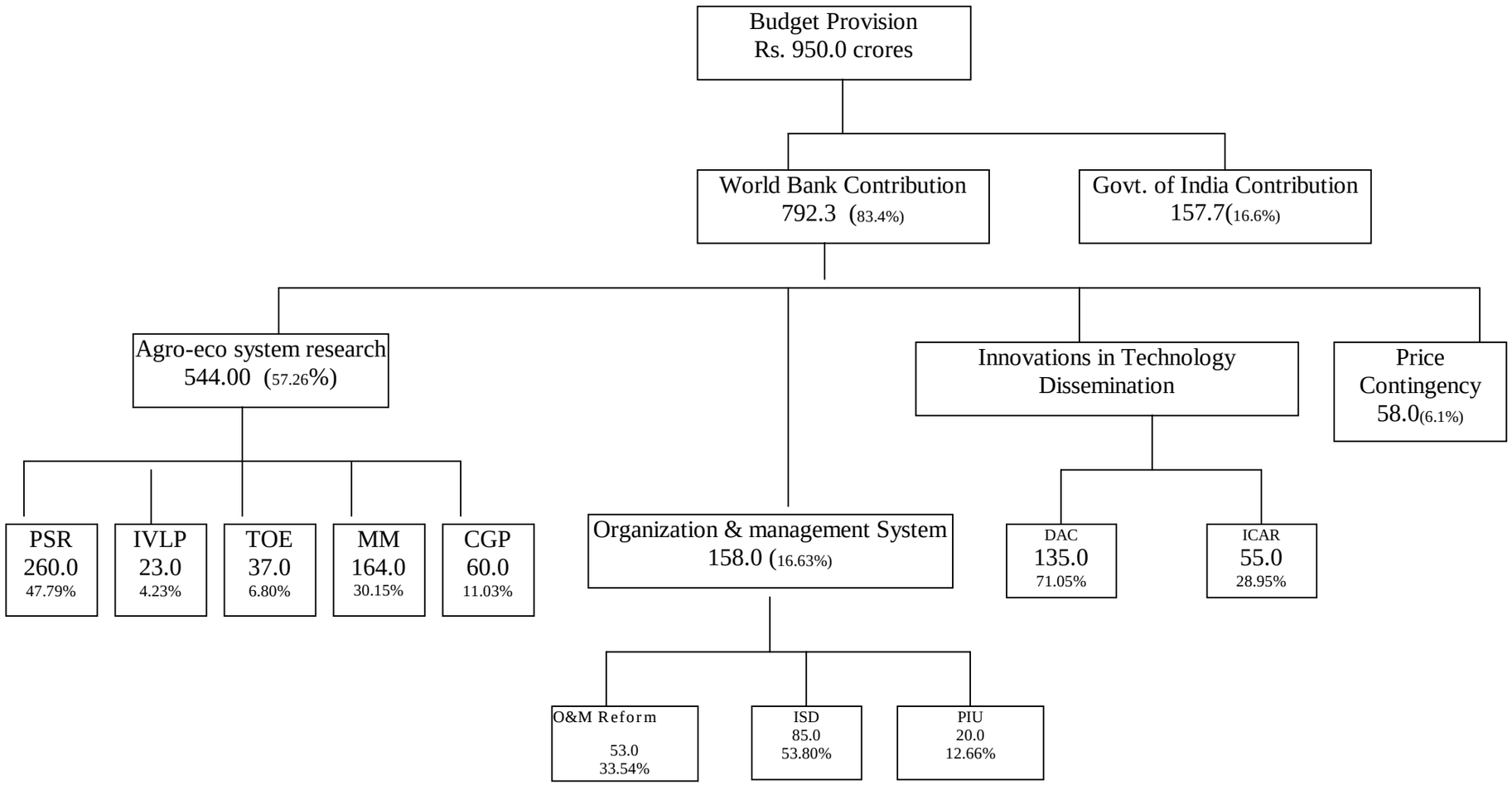
Organizational Chart

Annexure-I



Annexure II

Component Wise Revised Cost of NATP



Annexure III

Summary of the projects sanctioned under different modes as on (11/05/01)

Programme	Total Out lay	Revised Outlay	No. Sanctioned	No. Approved	(Rs. In Amount Croress)	
					Amount sanctioned	Amount Released**
A. Research						
Team of Excellence (TOE)	**40.00**	**37.00**	**27**	**27**	**35.76**	**14.52**
Mission Mode (MM)	**80.00**	**164.00**	**38**	**38**	**167.03**	**59.76**
CGP	**52.00**	**60.00**	**123**	**264**	**36.72**	**13.84**
Agro-Ecosystem Research (PSR)						
Rainfed	105.00	103.00	103	103	103.76	30.13
Irrigated	80.00	74.00	65	65	75.38	24.11
Coastal	45.00	35.00	31	31	30.24	10.10
Arid Agro-Ecosystem	32.50	28.00	24	24	25.86	9.54
Hill & Mountain Agro-Ecosystem	32.50	20.00	24	24	21.73	4.13
Sub-Total (PSR)	**295.00**	**260.00**	**247**	**247**	**256.97**	**78.01**
IVLP/TAR	**25.00**	**23.00**	**70**	**70**	**23.86**	**14.20**
Grand Total Research (A)	**492.00**	**544.00**	**505**	**673**	**520.34**	**180.33**
B. Development of ICAR O&M System						
1. Support to ICAR O & M Reforms						
a. Support for ongoing ICAR Reforms	7.22	4.00	1	1		0.41
b. ICAR HQs Strengthening including NASC	17.80	37.58	1	1		3.10
c. Division of Policy and Planning	0.25	0.05	1	1		-
d. Dir of Information and Publication of Agriculture	3.15	1.50	1	1		0.13
e. Priority Setting – NAARM	5.09	4.36	1	1		0.42
f. Priority Setting – NCAP	5.55	2.75	1	1		0.40
g. Priority Setting - IASRI	1.89	2.76	1	1		0.40
Sub-Total Support to ICAR O & M Reforms	**37.95**	**53.00**	**7**	**7**		**4.88**
2. Information Systems Development						
a. Electronic Connectivity	94.03	55.00	1	1		43.61
b. Library and Information Services	31.86	30.00	1	1		6.77
Sub-Total Information Systems Development	**125.89**	**85.00**	**2**	**2**		**50.38**
3. Project Management Unit						
a. NATP- PIU	28.80	20.00	1	1		5.05
b. AEDs						
Rainfed						0.99
Irrigated						0.41
Coastal						0.44
Arid						0.79
Sub-Total Project Management Unit						**8.47**
Grand Total O&M (B= 1+2+3)	**192.84**	**158.00**	**10**	**10**		**63.73**
C. Innovations in Technology Dissemination						
1. ITD-DAC Component						
a. SAMETI	Not specified in EFC Report	15.00	6	6	6.85*	3.43
b. ATMA		86.00	24	24	49.83*	14.29
c. MANAGE		15.00	1	1	9.38*	9.45
d. Strengthening of Directorate of Extension		14.00	1	1	10.30*	1.31
e. State Headquarters in the 6 states		5.00	6	6	1.00*	0.59
Sub-Total ITD DAC Component	**124.37**	**135.00**	**38**	**38**	**77.36***	**29.07**
2. ITD-ICAR Component						
a. Strengthening of SAU Directorate of Extension Education (29)	Not specified in EFC Report	3.23	29	29	3.20	
b. Strengthen of ICAR ZCU Units (8)		1.33	8	8	1.31	7.91
c. ATIC (40)		17.00	40	40	17.19	14.85
d. ZARS for Technology Dissemination (53)		33.44	53	53	32.76	4.07
Sub-Total ITD- ICAR Component	**23.77**	**55.00**	**130**	**130**	**54.46**	**26.83**
Grand Total ITD (C= 1+2)	**148.14**	**190.00**	**168**	**168**	**131.82**	**54.90**
TOTAL BASE LINE COSTS	**780.79**	**892.00**	**-**	**-**		
Physical Contingencies	**-**	**-**	**-**	**-**		
Price Contingencies	80.10	58.00	**-**	**-**		
TOTAL PROJECT COSTS	**860.89**	**950.00**	**683**	**851**		**299.96**

* Amount sanctioned up to March 31, 2001

** Total release up to April 30, 2001

Annexure IV

Mid Term Review of the Project

The project has been reviewed twice by the World Bank Review Missions. The first review was from May 8, 2000 to June 6, 2000. The second review mission visited from October. The overall progress of the project has been rated as satisfactory by the World Bank.

The salient points of the Aide Memoire are as follows:-

Key Project Data

Effectiveness Data	November 19, 1998
Closing Date	December 31, 2003
Project age	2.0 years
% Disbursed	10% of the Credit*

Ratings & Flags

Development Objectives	Satisfactory
Implementation Progress	Satisfactory
Problem Flats	Legal Covenants

Progress

§ Good progress has been made in implementing the project since the visit of last mission in June, 2000.

§ Distinct improvement in overall management, disbursements, procurement and implementation of research and extension activities.

§ Assessment shows that new business process for preparation, review and sanctioning of technology development adopted under the project are having a positive impact on the system.

§ **Project Management** : PIU is beginning to function effectively. However, it needs additional resources to deal with the increasing administrative load.

§ **Financial Management** : The project has made substantial progress in improving financial management system. Key staff including Director (F), are in place.

§ **Procurement :** Project has made good progress in addressing many of the constraint to effective procurement identified by the June, 2000 mission.

§ **Project Cost :** Total project cost is now estimated at Rs. 950/-crores, up from Rs. 860/- crores. This reflects saving of US$30.00 million of bank loan.

Annexure V

NATP: Landmarks

Concept Paper	February 1995
Preparatory document	January 1997
First Appraisal by WB	April 1997
Final Appraisal	August 1997
Negotiations	January 1998
Approval by WB	March 1998
Signing of Loan Agreement	June 1998
Date of effectiveness	November 1998
Supervision Mission	July 1999
MTR Mission 1	May-July 2000
MTR Mission 2	October 2000
MTR Mission 3	April 2001

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Prof. Deepak Pental
Director

Prof. S.K. Sinha
Former Director
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Dear Prof. Sinha,

I am writing to you about my general impressions after the meeting that was held on March 17, 2001 under your chairmanship to decide on the priorities for the Xth Five Year Plan (2002-2007). I must say that it was a very rewarding experience to hear all the experts and officials of the Indian Council of Agricultural Research. I have following general observations, which may be of some use to the Committee :

1. Funds should be only provided for the up-keep and maintenance of the buildings and no more funding should be provided to either create new institutions or new buildings.

2. Due to erratic electric supply in many parts of the country, equipments are lying waste. All the institutions should make sure that the existing infrastructural facilities are up-graded, labs are provided proper electric connections, voltage stabilizers and other ancillary gadgets to stop wanton destruction of expensive pieces of equipment bought for research purposes.

3. Fingerprinting of key germplasms should be completed in a time bound manner and should not be allowed to drag on. But much more important than fingerprinting is collection and acquisition of germplasm from outside and large scale trials on germplasm for unearthing sources for resistance to biotic stresses in the germplasm. I believe, we are not working efficiently in this area.

4. I feel that our psyche in plant breeding basically has been conditioned by our success with dwarf wheat and rice. Without taking any credit from the major achievement of spread of high yielding dwarfs in India, I would propose that with other major crops i.e. legumes and oilseeds the progress is going to be incremental and breakthrough like dwarfs are not possible. In many cases breeding is being done from a very narrow genetic base and hopes for transgressive segregants may never materialize. New breeding plants should involve precision breeding methodologies and use of molecular makers to achieve this so that a large number of

traints contribute to yield could be diversified into different varieties through marker aided selection.

5. Overall, in breeding, the most important goal should be heterosis breeding and precision breeding for disease and insect resistance.

6. In the preliminary documents conservation tillage has been given lot of importance. However, this will have to be in consonance with use of herbicide resistance crops. It would not be possible to do conservation tillage only on the strength of some farm machinery.

7. Emphasis will have to be placed on horticulture crops. Although a lot has been said about this area in the past, productivity of our fruit crops is stagnating, disease pressures are increasing and in comparison to some of the developed countries the productivity is woefully low.

8. Characterization of genomic variability in pathogens should be given major emphasis. A major project should be launched on geminiviruses, both for study of variability and for the development of virus resistant transgenics.

9. For genomic work the major emphasis should be on characterization and isolation of genes conferring resistance to diseases and pests from the wild relatives of crop plants.

10. Major effect needs to be put on reducing post harvest loss particularly in fruit and vegetable. Transgenic technologies hold great promise in this area. Effective methodologies are available, but nobody seems to be serious about this area.

11. Mechanism should be evolved, without adding to the numbers in officialdom, for rapid testing of transgenics.

12. A major thrust should be put on breeding of rice for the development of high yield but much lower requirements of irrigation as compared to present day varieties. Some very clever research strategies are required to achieve this.

In general, our success in increasing agricultural production will depend on proper utilization of land and water resources. Here I cannot make many suggestions but the emphasis should be to switch to crops that are frugal in their water requirement.

With best wishes,

Yours sincerely,
Sd/- xxx
Deepak Pental

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