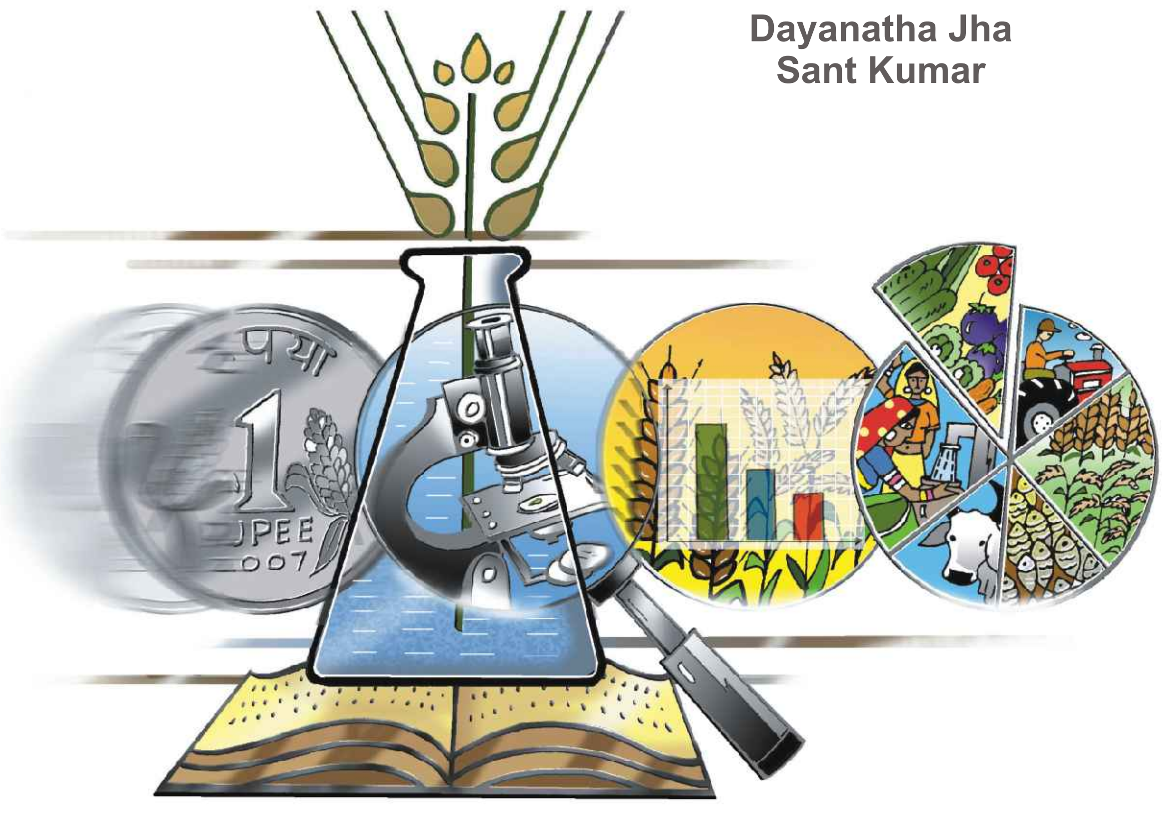
POLICY PAPER 23

Research Resource Allocation in Indian Agriculture

Dayanatha Jha
Sant Kumar



राष्ट्रीय कृषि आर्थिकी एवम् नीति अनुसंधान केन्द्र
National Centre for Agricultural Economics and Policy Research

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NCAP has been established by the Indian Council of Agricultural Research (ICAR) with a view to upgrading agricultural economics research through integration of economic input in planning, designing, and evaluation of agricultural research programs and strengthening the competence in agricultural policy analysis within the Council. The Centre is assigned a leadership role in this area not only for various ICAR Institutes but also for the State Agricultural Universities. With a view to making agricultural research a more effective instrument for agricultural and rural change and strengthening the policy making and planning machinery, the Centre undertakes and sponsors research in agricultural economics relating to the problems of regional and national importance.

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FOREWORD

Research resources in agriculture are becoming inadequate in meeting the complex challenges, at both macro-and micro-levels. The situation was different in the past when the research resources were growing at the national level, and the states followed the suit. Therefore, there was not much concern to systematically compile and document these resources at different levels across commodities and regions. The routine financial reporting used to be done for public expenditure.

In the past, allocation of research resources has been done based on the subjective judgment, which largely relied on the knowledge of research managers. This proved well in the past to meet the challenges, including food security. The scenario has completely changed now. New problems have emerged at the regional, national and global levels, these are more complex than used to be in the past. These need to be documented and supplemented adequately by additional information and detailed analysis. This could not be done due to lack of quantitative information on deployment of research resources in the national agricultural research system.

This Policy Paper contains very useful and rare information on different dimensions related to allocation of research resources in Indian agriculture. For the first time, a census of agricultural scientists has been done to assess the allocation of research resources across different agricultural disciplines, commodities and regions. The paper also contains deployment of human resources by activities and commodities, which is expected to be useful in their optimal allocation for improving research efficiency.

The Policy Paper is the part of the National Professor scheme, which was led by Professor Dayanatha Jha, and co-piloted by Dr Sant Kumar. Unfortunately, before publication of this remarkable contribution, the first author left for heavenly abode, after a brief illness. Till his last breath, Prof Jha used to discuss the outcomes of the research and its implications on future directions for allocation of research resources. I pay my heartfelt homage to him. I congratulate Dr Sant Kumar for his active participation in the study and bringing out this Policy paper.

I am sure the outputs of this unique study will go a long way in providing broad guidelines in enhancing efficiency of research resources to meet the daunting challenges in Indian agriculture.

(P.K. Joshi)
Director

PREFACE

It was remarkable that a poor society like ours was able to create a public research and education system which not only became a model for the developing world, but, in less than a generation, paid itself many times over. A grateful society lent its full support to agricultural science administrators and planners. Resources were not an issue, and the need for a serious study on research resource allocation was not felt.

The situation changed by the end of the 1980s. Public resources came under severe stress. At the same time, evidence started accumulating on faltering productivity growth in the green revolution areas. A view emerged that despite R&D investments, production in many regions and sectors was languishing. Agricultural research and technology came under sharper scrutiny and 'reforms' were called for. A number of external and internal reviews were undertaken to address these issues.

In this environment, the Indian Council of Agricultural Research (ICAR) approved a study entitled *'Resource Allocation for Agricultural Research'* as part of the National Professor Project assigned to the first author in July 2000. Scientific manpower in agriculture was chosen as the indicator of research resource and a massive inventorization of scientific manpower in agriculture was the starting point of this exercise. This report presents the results on quantitative and qualitative aspects of scientific manpower, and analyses the current pattern of allocation of these resources from different perspectives. This is the first study of its kind in the country.

Dr H K Jain, Dr Mruthyunjaya, Dr P K Joshi and Dr Suresh Pal, have reviewed the manuscript critically and offered valuable suggestions. We are very grateful to them. Remaining errors and omissions are our responsibility.

The list of our supporters and cooperators is very large and it is not possible to acknowledge them individually. We must, however, mention a few individuals and institutions whose help was invaluable. We are very grateful to ICAR which provided the research grant and other logistic support.

Dr R S Paroda, Dr Panjab Singh and Dr Mangla Rai, Director Generals of the Council over the past few years, provided all encouragement. Dr S L Mehta and Dr J C Katyal, Deputy Director Generals (Education), ICAR and their staff, particularly Dr B S Bisht, administrated this project and their help was inspiring. All administrators–Vice-Chancellors, Directors and Senior Officers of agricultural research establishments in the country helped in conducting the census of agricultural scientists. Without their help, and participation of more than 22 thousands scientists, the study could not have taken off. They deserve credit for whatever worthwhile has emerged.

The National Centre for Agricultural Economics and Policy Research (NCAP), New Delhi, has been our home, and its Directors, Dr Mruthyunjaya and Dr Ramesh Chand have been specially attentive to the needs of the project. Dr Sant Kumar, Scientist at the Centre was seconded to the project specifically. All other faculty and staff of NCAP have been a part of our team and we are grateful to them all.

Finally, our core team over this period comprised Dr Surabhi Mittal, Dr Parveen Gulia, Dr Laxmi Joshi, Dr Sanjeev Garg, Sharad Natha Jha, Anil Kumar and Rita Chopra. Their unstinted efforts can never be adequately acknowledged. There was high turnover of professional project staff during the past couple of years and this caused a time overrun during final analysis and report writing. But these individuals voluntarily lent their time even after formal closure of the project. We remain grateful to them.

Dayanatha Jha
Sant Kumar

ACRONYMS

AICRP	All India Coordinated Research Project
AEZs	Agro Ecological Zones
ag GDP	Agricultural Gross Domestic Product
ASC	Agricultural Scientists Census
ATIC	Agricultural Technology Information Centre
ATMA	Agricultural Technology Management Agency
CAGR	Compound Annual Growth Rate
CI	Congruity Index
CSIR	Council of Scientific and Industrial Research
CV	Coefficient of Variation
FBL	Final Base Line
FTE	Full Time Equivalent
GoI	Government of India
HRD	Human Resource Development
IARCs	International Agricultural Research Centres
IASRI	Indian Agricultural Statistics Research Institute
ICAR	Indian Council of Agricultural Research
IVLP	Institute Village Linkage Programme
KVKs	Krishi Vigyan Kendras
NAAS	National Academy of Agricultural Sciences
NARP	National Agricultural Research Project
NARS	National Agricultural Research System
NATP	National Agricultural Technology Project
NGOs	Non-Governmental Organizations
NSSO	National Sample Survey Organization
O&M	Organizational and Management
PME	Prioritization, Monitoring and Evaluation
R&D	Research and Development
R&E	Research and Education
SAUs	State Agricultural Universities
SREP	Strategic Research Extension Programme
TAR	Technology Assessment and Refinement
T&V	Training and Visit
TE	Triennium Ending
VOP	Value of Product

EXECUTIVE SUMMARY

- This study has been undertaken to (a) provide an inventory of agricultural research resources in the country, (b) study the allocation profile of these resources, and (c) examine the scope for readjustments to improve resource-use efficiency. Public resources dominate the agricultural research scenario overwhelmingly. There has been increasing concern regarding efficiency in recent years and reforms figure prominently in the future agenda of the NARS. This study is a quantitative contribution in this area focusing on the status and deployment of research resources. This is the first assessment of its kind in the country and was funded and supported by the ICAR.

- Scientific manpower was used as the indicator of research resource in the study. Suitable data on financial resources were not available. For this purpose, a census of agricultural scientists in all agricultural research establishments in the country – public, private and non-governmental establishments, was conducted during 2001-02.

- The census covered 21,869 scientists working in 564 establishments. The public system accounted for 96 per cent of all scientists, the SAUs alone employed 63 per cent, followed by 20 per cent in ICAR. More than 78 per cent of the institutions are in the 'other' public and private categories, but these (mostly) small entities claim only 17 per cent of total scientists. A large number of grassroot level NGOs and KVKs support adaptive research efforts which are less scientist-intensive. The infant private sector appears to have concentrated on building research-base and infrastructure. It employed 4.3 per cent of total scientists, but accounted for more than 10-12 per cent of total research investment at the turn of the century. It is poised to grow rapidly now.

- The census revealed high skill levels, particularly in the ICAR- SAU component of the system; 70-76 per cent of the scientists hold Ph.D. degrees and have 17-18 years of research experience. In all, 116 disciplines are represented in the scientific cadre, and the disciplinary diversity has increased over time. 'Other' public and private institutions have lower quality indicators. There are some worrisome points on the quality front. The first relates to relatively high average age of scientists, particularly in the SAUs and ICAR where one-third of the scientists are in their fifties. The other point to note is that the ICAR-SAU system has become top-heavy. Only 43-45 per cent of the scientists are in the bottom rung. Both these factors arise from restrictive recruitment policies in public institutions and have adverse productivity impacts.

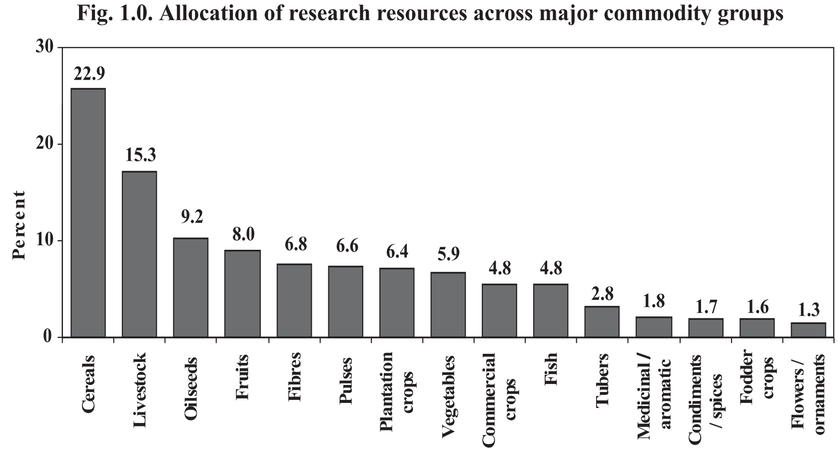
- The scientist numbers reduced to 10,350 full-time equivalent (FTE) scientists in the country. Even in these terms, the Indian agricultural research system compares with the largest in the world. These numbers convey the impression of adequacy at the turn of the century. However, two points need to be noted. First, the expected rate of attrition in the SAU-ICAR system over the next decade is high and the numbers are likely to erode rapidly. Secondly, these systems have experienced stagnation or decline in the past decade. Both these factors also arise from restricted recruitment of scientists in pursuance of government directives. This policy does not auger well for the future.

- The census focused on agricultural scientists and naturally the data on participation and time allocation to different activities showed a research bias. Teaching/training and extension ranked second and third, respectively. The average time-allocation percentages were 47 for research, 27 for teaching/training, and 15 for extension. In teaching-oriented institutions like SAUs and the deemed universities under ICAR, as well as at grassroot level units, the time allocated to research is relatively lower. Scientists in ICAR research institutes and private research units spend most of their time on research. The data revealed that 9.5 per cent to 15.1 per cent of scientists' time in various institutions was allocated to administrative functions.

- The commodity profile of research resources showed that crops, livestock, and fisheries research claimed 80 per cent, 15 per cent and 5 per cent of the total commodity research in the country, respectively. At the decentralized levels (SAUs and 'other' public) and also in private institutions, the crops dominated even more. The SAUs are the major suppliers of crop and livestock research and ICAR plays this role in fisheries. As the national arm of public R&D, the latter is expected to bridge the gaps. It has played an important role in strengthening fisheries and livestock research. With meagre resources, the other institutions — 'other' public and private — did not figure prominently.

- Detailed analysis of 15 major commodity groups revealed that research on foodgrains ranked first (30 per cent), followed by horticulture (28 per cent), livestock (15 per cent), as shown in Figure 1. Together with oilseeds, fibres, commercial crops and fisheries, these claimed 98 per cent of national research resources. Among participants, foodgrains receive greater attention in SAUs as do fruits and vegetables and oilseeds. ICAR has focused more on fisheries, livestock and tuber crops. The private sector has a narrower commodity focus and has little fisheries and livestock research. 'Other public' institutions which are mostly downstream institutions, focus more on cereals, plantation crops, fibres, livestock and medicinal/ aromatic plants. The report has also provided data on individual commodity shares in cereals, pulses, vegetables, fruits, oilseeds, fibres, livestock, and fish groups.

Fig. 1.0. Allocation of research resources across major commodity groups



- Results on resource-orientation revealed that nearly 35 per cent of research resources were focused on germplasm. This was followed by agro-chemicals (26 per cent) and soil/water research (21 per cent). More than 55 per cent of the resources were devoted to raising the productivity of natural resources. Material resources (agro-chemicals, power/machinery) altogether claimed about one-third of the resources. The rest was spread over socio-economic and other resources. There are differences among institutions within this broad pattern. ICAR, for example, gives more emphasis to soil/water and power/machinery research, and SAUs emphasize more on agro-chemical. 'Other' public and private institutions lean heavily on germplasm resource. The latter also prioritize power/machinery research.

- Regional pattern of research resource allocation was also studied in terms of 15 major agro-climatic zones of the Planning Commission. Though the main rationale of agricultural regional planning was to tailor research and other investments to optimize their potential, this exercise showed that research resources were not related to physical or even the economic size of the zones. The Gangetic Plains and the coastal zones which have been leading the country in terms of agricultural performance, claimed 40 per cent of research resources. Rainfed, semi-arid, arid, and hill zones lagged behind. Fifty per cent of the national research resources are presently targeted here to address this problem. The other important finding was the balancing role of ICAR investments in zonal research, even though state institutions are the major determinants of zonal research capacity.

- The priorities of the four major R&D players were revealed by the importance (ranking) assigned to different alternatives. Non-parametric tests were used to assess differences between institutions in this regard. Commodity priorities of ICAR and SAUs were in tandem, but those between central and decentralized units ('other public' and private) were different. SAUs bridged the two — one focusing on national and the other dealing with local problems and markets. Resource-orientation of all public institutions was found to be similar, but that of private research institutions was different. These findings differentiate and validate the roles of central, state, local and private R&D institutions. The ICAR sets the trend; the SAUs participate in the national agenda as well as integrate with grassroot level public and private institutions.

- Finally, analysis of resource-use efficiency indicated the need for some adjustments in allocation of resources to different commodities and agro-climatic zones. It was shown that resources need to be added to cereals, vegetables, fibres, livestock, and condiments/spices, drawing resources from other commodity groups. Similarly, the Lower-Upper- and Trans-Gangetic Plains, Eastern and Southern Plateau and Hills, East Coast, Gujarat Plains and Hill zones needed greater attention. This analysis was static and it was cautioned that the results should be interpreted as indicative and more appropriate for guiding incremental (plan) resources.

- Some important policy messages have been drawn from this study. First, the need to jack up research investment has been emphasized. Low capital intensity constrains research productivity and it is premature to hope that private capital will and can fill this void. Second, induction of younger scientists and rationalization of the time allocation profile are the hidden avenues for raising the scientific manpower input for research. Third, the basic concept of a network of central, state and other local institutions has been validated in terms of the roles they play. Fourth, the time is now opportune for shifting investment attention to state and grassroot-level institutions. The disparity in support between central and states institutions must be overcome. Finally, the dialogue on public-private roles in agricultural R&D has now to move beyond partnership. Clear domains of comparative advantage are beginning to emerge, and the public system must respond to it.

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Policy Paper 23

National Centre for Agricultural Economics and Policy Research
New Delhi, India

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Published by
Dr P. K. Joshi
Director, NCAP

Printed at
Chandu Press
D-97, Shakarpur
Delhi-110 092
Ph: 22526936

Dr Dayanatha Jha was the ICAR National Professor (July 2000 to March 2005) at the National Centre for Agricultural Economics and Policy Research, New Delhi-110 012, India. He passed away during the publication of this volume.

Dr Sant Kumar is a Senior Scientist at the National Centre for Agricultural Economics and Policy Research, New Delhi-110 012, India; Email: santkumar@ncap.res.in

Chapter 1

INTRODUCTION

Background

A major shift occurred in the agricultural development ideology during the early 1960s. Improved production technology, supported by a package of complementary policies and programmes, became its pivotal component. This brought agricultural research to the centre stage. Institutional changes were affected and public investment in agricultural research was jacked up significantly to augment research capacity across the board. Successive Five-Year Plans as well as external assistance provided the resources for this up-scaling and transformation. Private R&D investment has also grown in agriculture in recent years, thanks to more conducive policies and economic environment. As a consequence, investment in agricultural R&E exceeded Rs 25 billion in the beginning of the new millennium (Pal and Byerlee 2003). More than 22 thousand agricultural scientists spread over a vast network of institutions in the public (central and state) and private sectors were employed in the national agricultural research system (NARS) in the year 2001.

Investment intensity rose from 0.2 per cent of agGDP during the early-1960s to about 0.5 per cent in the 1990s (Jha and Pal 2003, Pal and Byerlee 2003). This, however, remains a way below the globally acceptable investment norms and even lower than the average for all developing countries. In recent years, investment growth has been hampered by the poor state of public finances. Even though policy pronouncements accord high priority to this investment, it is not reflected in financial allocations. This has been a major concern of agricultural research administrators in the public research system.

On the other hand, research needs are escalating. The green revolution technologies are running out of steam, renewing our anxieties on the food-security front. Non-sustainability of intensive systems threatens the future prospects further. There are concerns that despite R&D investments in agriculture, productivity growth is languishing in several food commodities and regions. Economic liberalization poses new opportunities and challenges and so do the new developments in frontier sciences. Nutritional security, changing cost-price relationships, niche situations, etc. generate more and varied demand for agricultural research. All these are overshadowed by the imperative of achieving unprecedented agricultural growth in the near-term to meet overall economic growth targets. Fulfilling these growing and diverse needs from the increasingly constrained natural resource-base and research budgets is the challenge. Added to these has been the growing concern regarding organizational and management deficiencies in the public agricultural R&D system (NAAS 2002). Most of the agricultural R&D is in the public domain and it is necessary that each research-rupee is spent efficiently. These circumstances provide the rationale for a study on research resource allocation.

In classical economics tradition, a reallocation of research resources to high priority themes raises overall research productivity from the existing bundle of resources. Implicitly, such effort has been going on in the national agricultural research system*. The main focus has been on prioritizing research themes and programmes in view of the current and emerging problems of the sector. The NARS has unparalleled knowledge in technical dimensions of Indian agriculture and is uniquely placed to articulate its research needs. Availability of adequate incremental (Plan) resources in the past enabled expansion of research capacity in line with priorities. In recent years, these funds have become tighter. This, as well as slackening tempo of productivity growth has drawn attention towards rigorous prioritization, reallocation of research resources, and O&M reforms to ensure efficient use of resources (ICAR 1998, Pal and Byerlee 2003).

Leaders of the national research system have responded in several ways. There is now a thrust on internal resource-generation through

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* Over the last decade, ICAR has undertaken reviews of the All-India Coordinated Research Programmes (ICAR 1997a), Regional Research Stations (ICAR 1999), and scientific strength of various research units (ICAR 2000). Messages have also gone down the system to review the on-going programmes and redefine priority themes (ICAR 1998). Individual research units of the ICAR have undertaken in-depth planning exercises. Several state agricultural universities have also undertaken such reviews (PAU 1998, GBPU 2001).

commercialization of research output and services. Second, improving the efficiency of the system is now receiving a greater emphasis. New HRD initiatives, operational cost support, straightening bureaucratic and procedural impediments, etc. are amongst the examples. Third, serious attempts are being made to exploit complementarities through inter-disciplinary and inter-institutional collaborations. Fourth, proactive steps have been taken to encourage the private sector investment in agricultural research and this sector is expanding rapidly. Finally, some redundancy has crept into the system and research resources have remained locked into pursuits and themes which have ceased to be relevant or important (Chandrashekhara and Ganeshaiah 2003). It is believed that there is scope for raising efficiency through redeployment of research resources. This study has attempted a quantitative and analytical contribution in this area, focusing on the status and deployment of research resources.

Objectives

This study is on deployment of research resources. Scientific manpower, material inputs, and institutions are the critical research resources in India; in this study, the focus is on scientific manpower resource because it is the most important resource. The ingenuity of human mind has, time and again, overcome other constraints. It is also most amenable to being tracked in detail.

In keeping with the unfortunate tradition of public departments in the country, manpower data are reported only for administrative purposes at the departmental/unit level. There is little information regarding their deployment by activities (programme, commodity, resource, region, etc.) below this level. Without such information, resource-allocation decisions often suffer from subjectivity and unwarranted continuity over time. The state of affairs is best illustrated by the fact that there are no firm estimates of even the number of scientists in the public agricultural R&D system! No national or even regional manpower planning exercise has ever been conducted.

Such database is the first requirement for any analytical study on research resource allocation. Only then can issues like needs, gaps, duplication, redundancy, etc. be examined. The ***first*** objective of this study was to generate this information. An inventory of scientific manpower engaged in agricultural research was the starting point. These data were collected during 2001-2002. An attempt was made to cover all the central, state, private, and NGO institutions engaged in agricultural research. Apart from quantitative indicators, qualitative attributes are also important determinants of scientists' productivity. Such an assessment was also attempted. This database, which provides a snapshot of research resources at the beginning of the new millennium, will serve as a benchmark for the future.

Data collected from individual scientists included information on time-allocation profile and their research thrust. The current allocation profile of research resources could be derived from these. This was the ***second*** major objective of this study. Estimates were generated for allocation by commodities, major resource groups and agro-climatic zones of the country. Individual researchers (Evenson and Kislev 1975, Ranjitha 1996**,** Traxler and Byerlee 2001) have used research output indicators to apportion expenditure data among commodities. This study has used a direct research input indicator which has not been tried earlier on this scale.

Redeployment implicitly assumes that there is a normative pattern of allocation, which will maximize the impact of scarce research-resources. In other words, prioritization is a pre-requisite and the basis for efficient resource allocation. This is a complex task because research has multiple goals and these could be in conflict. Uncertainties in research, time lags, spill-over effects, data inadequacies, etc. further complicate the issues. Such decisions are always made, but making the trade-offs explicit makes the process transparent. Formal analytical approaches help in this regard. The ***third*** objective of the study was to undertake such a prioritization exercise. Earlier attempts in deriving normative allocation patterns (Jha *et al.* 1995, Kelly and Rayan 1995, Birthal *et al.* 2002, Mruthyunjaya *et al.* 2003) have been partial, and none has taken the next step of relating these with the existing research resource allocation. This study is the first such attempt at the national level and proposes readjustments. This analysis will help future research-resource allocation decisions.

The major objectives of this study are summarized as follows:

- To develop a database on the current status of scientific manpower in agricultural research in the country and its major quantitative attributes.
- To generate information on deployment of scientific manpower resources in terms of major R&D activities, and specifically, its allocation amongst commodities, resources and agro-climatic zones.
- To examine the congruence between the current research resource allocation and a normative pattern based on sectoral objectives, and to examine readjustment possibilities.

This report is organized as follows. Chapter 2 provides an overview of the national agricultural research system and sets the stage for presenting the findings of this study. Details of data and analytical approaches are provided in the next chapter. The next three chapters present results based on analysis of scientific manpower data — Chapter 4 describes the scientific manpower data in quantitative and qualitative terms; resource-allocation issues are presented and analysed in Chapter 5, and Chapter 6 assesses the rationality of the present allocation profile and broad readjustment opportunities. The major findings and conclusions from this study are highlighted in the last chapter.

Chapter 2

OVERVIEW

Review of issues

The dawn of the twentieth century witnessed initiation of agricultural research and education in India under the colonial government. By mid-1920s, the provincial departments of agriculture had assumed responsibility for local research and agricultural education. The Imperial (later Indian) Council of Agricultural Research (ICAR) was established in 1929 as a national body to co-ordinate, guide, and support this effort and other initiatives of the central government. This pattern persisted through World War II. Accelerated efforts took place in the later years, as several research institutions and various commodity committees/boards were created under the central department of agriculture with proactive support from ICAR.

Agricultural extension emerged as the dominant R&D strategy in the early-Independence phase. The underlying assumption was that improved technologies were available on the shelf, and that the main task was to extend these to farmers. The national extension service and later, intensive agricultural district/area programmes sought technological upgradation of Indian agriculture. However, the agricultural crisis persisted through the 1950s and early 1960s. A consensus developed regarding the need to strengthen technical and human resource backstopping for education, research and extension at the state level through the state agricultural university (SAU) system. A massive set-up was created over the next decade. This was a part of the 'new agricultural strategy' enunciated in the early 1960s, which assigned central role to the generation and adaptation of new seed-fertilizer technology for cereal production and backed it with the needed incentives, institutions and investments. The ICAR was reorganized and assumed a direct role in agricultural research and education. It initiated, funded, guided, and managed a new phase of central initiatives embracing research, education, and frontline extension. Table 2.1 shows the evolution of public institutions at the central and state levels since Independence. Some of these were embodied in institutes, laboratories, and universities; others were in the form of multi-disciplinary, inter-institutional coordinated research programmes called All-India Coordinated Research Projects. This table also illustrates the increasing

Table 2.1. Evolution of public agricultural R&D institutions in India

Time Period	ICAR-Commodity-oriented Institutions	ICAR-Resource/ Region-oriented Institutions	State Agricultural Universities/ Units
Pre-1950s	IARI, Rice, Sugarcane Breeding, Cotton, Lac, Tobacco, Research institutes under commodity committees, Veterinary science, Inland fishery, Marine fishery		Agricultural Research Stations in States, Agricultural Colleges at Pune, Nagpur, Kanpur, Coimbatore, Sabour, Delhi
1950s	Sugarcane, Jute & allied fibres, Potato, Dairy, Fishery technology **Maize*	Arid agriculture, Soil survey & land use planning, Agricultural statistics	Uttar Pradesh-1
1960s	Tuber crops, Horticulture, Jute technology, Sheep & wool, Fishery education	Grass & fodder, Soil salinity	Assam, Karnataka-1, Madhya Pradesh-1, Maharashtra-1&2, Orissa, Punjab
	**Millet, Sorghum, Rice, Wheat, Pulses, Oilseeds (castor and soybean), Tuber crops (other than potato), Sugarbeet, Sugarcane, Cotton, Jute and allied fibres, Forage crops, Buffaloes, Poultry (breeding)*	*Dryland agriculture, Tillage requirements for different cropping systems, Soil test for crop response, Micro and secondary nutrients, Microbial decomposition and organic wastes, Long-term fertilizer experiments, Water management, Groundwater utilization through wells and tubewells, Biological control of insect-pests*	

Contd.

Table 2.1. Evolution of public agricultural R&D institutions in India - Contd.

Time Period	ICAR-Commodity-oriented Institutions	ICAR-Resource/ Region-oriented Institutions	State Agricultural Universities/ Units
1970s	Wheat, Oilseeds, Groundnut, Cotton, Sub-tropical horticulture, Plantation crops, Avian, Goats, Freshwater aquaculture	Plant genetic resources, Soil & water, Agricultural engineering, Agricultural research management, Hill agriculture (Almora), RC for Goa, RC for Andaman & Nicobar Islands, NER hills	Andhra Pradesh, Bihar-1, Gujarat 2&3, Haryana, Himachal Pradesh-1, Kerala, Maharashtra-3 &4, Tamil Nadu-1, Uttar Pradesh-2 & 3, West Bengal-1, NARP-Zonal Research Stations
	**Tobacco, Potato, Spices, Subtropical fruits, Tropical fruits, Arid zone fruits, Cashewnut, Coconut and arecanut, Vegetables, Floriculture, Oilseeds (safflower, palm, sunflower), Honeybee, Composite fish culture and exotic fish, Freshwater fishery, Marine fishery, Brackishwater fishery, Fish culture (air breathing), Cattle, Pig, Sheep (mutton and wool), Dressed poultry and piggery products*	*Stocking of fish seed, Ecology of freshwater fishery, Riverine carp collection technique, Transportation of fresh fish, Managing reservoir fishery, Riverine fish seeding, Evolving methodology for utilizing surplus milk, Costing of chilling and transportation of milk to city dairies, Epidemiological studies on foot & mouth diseases, Blood groups and bio-chemical polymorphism, Canary coloration of wool, Biological control of weed parasitic nematodes,*	

Contd.

Table 2.1. Evolution of public agricultural R&D institutions in India - Contd.

Time Period	ICAR-Commodity-oriented Institutions	ICAR-Resource/ Region-oriented Institutions	State Agricultural Universities/ Units
		Rodent control, Biological nitrogen fixation, Solar energy utilization, White grub, Salt-affected soils and saline water, PHT of horticultural crops, Seeds (crop)	
1980s	Sorghum, Maize, Rice, Pulses, Soybean, Vegetables, Mushroom, Citrus, Spices, Cashew, Cattle, Buffalo, Yak, Mithun, Camel, Equines, Brackishwater aquaculture, Coldwater fishery	Cropping systems research, Soils, Post-harvest technology, IPM, Plant Biotechnology, Agro-forestry, Weeds, Fish genetic resources, Animal genetic resources, Dryland agriculture, RC for Eastern Region	Bihar-2, Jammu & Kashmir-1& 2, Himachal Pradesh-2, Karnataka-2, Madhya Pradesh-2, Rajasthan-1, Tamil Nadu-2
	**Pearl millet, Small millet, Underutilized crops, Arid legumes, Rapeseed & mustard, Mushroom, Cashew, Ornithology, Betelwine*	*Agro Meteorology, Diaraland, Herbicide residues in horticultural crops, Management of apple scab, Weed management (Brahmputra Valley, Sorghum, Fodder crops), Agroforestry, Animal energy and system efficiency, Monitoring, surveillance and forecasting of animal diseases, Processing and storage of khandsari and jaggery, Plastics in agriculture*	

Contd.

Table 2.1. Evolution of public agricultural R&D institutions in India

Time Period	ICAR-Commodity-oriented Institutions	ICAR-Resource/ Region-oriented Institutions	State Agricultural Universities/ Units
1990s	Rapeseed & mustard, Oilpalm, Temperate horticulture, Arid horticulture, Grapes, Banana, Medicinal and aromatic plants, Orchids, Onion & garlic, Meat and meat products, Poultry	D.N.A. finger printing, Seed spices, Water management, Biological control, Animal nutrition & physiology, Women in agriculture, Agricultural economics & policy	Maharashtra-5, Manipur, Rajashtan-2, Uttar Pradesh-4 & 5, West Bengal-2 & 3
	**Groundnut, Chickpea, Pigeonpea, Goat*	*Animal genetics, Drainage under actual farming conditions, Farm implements and machinery*	
2000s	Makhana, Litchi	Micro-organisms	Gujarat-4, Karnataka-3,

** All India Coordinated Research Projects. In several cases, AICRPs were upgraded as centres/directorates/institutes*

Note: Numbers in last column indicate number of universities in a state. Central Agricultural University, Manipur was established by the ICAR.

Source: ICAR various publications

diversification in commodity research and the focus on natural resources and regional capacity creation. It also demonstrates that the system has been proactive and has initiated lead action to minimize research lags. For example, horticulture, livestock, and fisheries research received a boost during the 1970s and 1980s, even before the growth in these sectors accelerated. Research on natural resources and regional gaps also gained ground in the 1970s. The International Agricultural Research Centres (IARCs) have been active partners in the national endeavour all through.

The culmination of all this is shown in Table 2.2. It presents the current status of public R&D efforts in the country under central and state aegis as well as publicly supported grassroot level voluntary bodies. In addition, there are institutions in central departments of agriculture, CSIR, biotechnology, fertilizer and chemicals, commerce, etc. which also contribute to the national effort through dedicated research institutes or research programmes.

The private sector has been a late starter. Its entry began with liberalization of the seed sector in mid-1980s and picked momentum

Table 2.2. Status of public agricultural research system in India, 2004-05

Institutions	Number
Central	
National Institutes (Deemed Universities)	4
Central /Other Institutes	43
National Bureaux	5
Project Directorates	12
National Research Centres	31
All-India Coordinated Research Projects	91
Central Agricultural University	1
Krishi Vigyan Kendras	491
Zonal Coordination Units	8
State	
State Agricultural Universities	38
Agricultural /Zonal Research Stations	343*

* Includes 126 zonal research stations

Source: ICAR (2005), and Ghosh (1991)

in the late 1990s as incentives for private (both domestic and foreign) investment in R&D improved. Already the number of private players has become significant and in some commodities, private research plays an important role (Pal and Byerlee 2003). This is expected to gain ground rapidly.

Resources for research

The research resource-mix comprises the human, material, and institutional components. Trained and specialized scientists, well-equipped labs and experimental farms, necessary technical and other support services — all are woven together in institutional and organizational structures around targeted research programmes and projects. From Independence till about mid-1990s, agricultural R&D was on expansion path and it was not difficult to raise resources. The 'green revolution' generated support at the national as well as international levels. Investment and scientific manpower grew substantially and research institutions and programmes proliferated at the central as well as state levels (Table 2.1). We began talking about one of the largest national agricultural research systems in the world.

The fiscal crisis of the 1990s changed the investment scenario. Evidence on faltering productivity and stagnating production potential prompted a more critical stance on the part of policymakers and managers of public funds. Ideas like prioritization, resource generation, resource-sharing, privatization, economizing, and efficiency, gained ground in policy discussions. In the wake of worsening finances, the state system became critically dependent on ICAR and external grants. The former has resorted to reallocation (ICAR 1997b), economizing (ICAR 1997a, and ICAR 1999), inter-institutional collaboration, external assistance, and restraints on recruitment.

Over most of the last 40 years, there was not much concern for resources. Consequently, there has been no official attempt to systematically compile, analyze and document research resources at either the central or state level, except as part of routine financial reporting for public expenditures.

Even these are not easily accessible for states*. During each Plan preparation phase, there is focus on incremental resources for fresh starts to be initiated during the plan period. The massive non-plan component is rarely scrutinized. Several special projects for research monitoring were initiated during this period but these did not yield the desired information on resources or their deployment.

The credit for compilation of research investment data goes to individual researchers (Mohan *et al.* 1973, Evenson and Kislev 1975, Ranjitha 1996, Pal and Singh 1997, Pal and Byerlee 2003). It has been estimated that R&E expenditures grew in real terms (at 1999 prices) from Rs 2.7 billion in early-1960s to Rs 25 billion by the end of 1990s (Pal and Byerlee 2003). Table 2.3 gives the triennium average data and growth rates.

Table 2.3. Public investment in agricultural R&E (at 1999 prices)

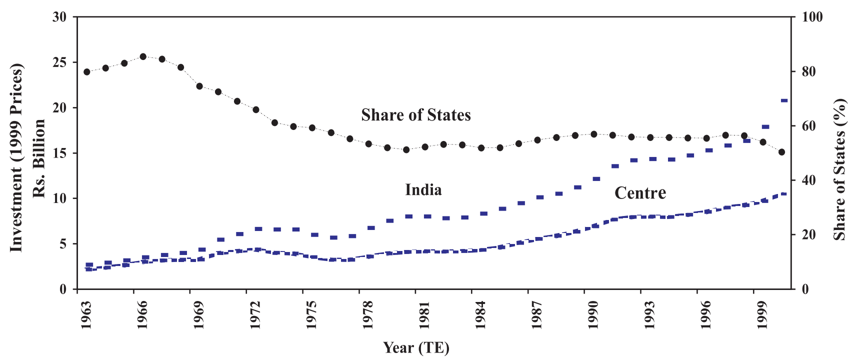
Year (TE)	Total R & E expenditure (Rs million)	Share of states (per cent)	Expenditure as per cent of agGDP
1971	6073 (8.6)*	69.2	0.32 (4.7)*
1981	8007 (1.9)	52.5	0.40 (1.3)
1991	13528 (5.2)*	56.6	0.45 (1.7)*
2000	20773 (4.0)*	50.5	0.50 (0.6)
CAGR (1971-00)	4.4*	-	1.4*

Figures within the parentheses are growth rates for the preceding decade.
* Growth rates are statistically significant.
Source: Jha and Pal (2003)

Research intensity also increased significantly. Contrary to the expectation that state (local) institutions would gain more importance over time, Table 2.3 and Fig. 2.1 depict increasing centralization — the share of states in the total R&E investment has fallen from 69 percent in 1971 to 50.5 percent in 2000. Local institutions have failed to emerge as major players and supporters of agricultural R&D. This has been a major weakness

* The ICAR reports aggregate expenditures and human resources in its annual reports. IASRI has started reporting SAUs expenditures since early-1990s (IASRI 2004).

Fig. 2.1. Public expenditure on agricultural research and education



Source: Pal (2004), personal communication

which has not been well appreciated. The central system continues to press for and obtain incremental resources. States either do not bother or lack capacity to argue their case. This dynamics can only be understood in a political economy framework. Such a study is urgently needed.

Table 2.3 also supports the point made earlier regarding stressed resource-environment in recent years. There has been a deceleration of growth in both absolute investments and research intensity which have remained practically stagnant. Table 2.4 shows that while central investments have stayed more or less on course, the deceleration has been very sharp for the states and the decadal growth rates have been very unstable.

Table 2.4. Growth in R&E investments (at 1999 prices)

Time period	CAGR (Per cent)	
	Centre	States
1961 - 1970	10.6*	7.9*
1971 - 1980	6.8*	-1.3
1981 - 1990	3.9*	6.2*
1991 - 2000	4.9*	3.3*
1971 - 2000	4.9*	4.0*

* Statistically significant at 1 per cent level
Source: Pal and Byerlee (2003)

A significant development over the past decade has been the growing importance of private sector. It now accounts for nearly 13 per cent of all agricultural R&D expenditure (Pal and Byerlee 2003). This is expected to grow rapidly. The implications of this have so far been discussed in terms of complimentarity and partnership (Pal et al. 2000). The more substantive issues of comparative advantage and selective domains remain to be tackled. These will emerge sooner than later.

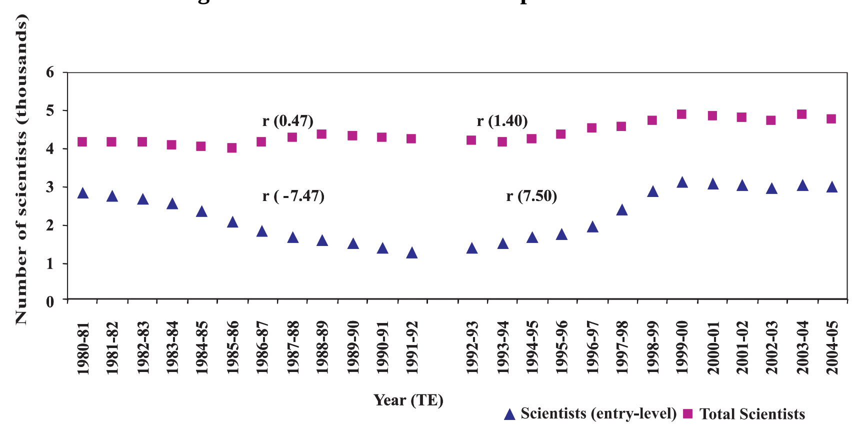
Human resources

With respect to scientific manpower resources, the data situation is worse. Sectoral reviews of the research system undertaken periodically (ICAR 1988, GoI 2005) have treated this casually and selectively. The assumption of adequacy and abundance has been so pervasive that any scrutiny has not been considered worthwhile. In fact, as part of the national drive to reduce the size of the government, there is practically a ban on fresh recruitment of agricultural scientists. Ironically, neither ICAR nor SAUs have presented a factual and analytical case contesting this position.

Though authoritative data on scientific manpower resources are not available, official pronouncements (Randhawa *et al.* 1992, ICAR 2000) and early studies (Pardey and Roseboom 1989) do convey the impression of adequacy. By late-1980s, more than 19 thousand agricultural scientists were estimated to be engaged in the public R&E system (Pal and Byerlee 2003). There are no numbers, but recent assessments consistently reveal a decline in scientific manpower in the state system (NAAS 2002.). Even the ICAR was barely able to maintain the numbers through early-1990s, essentially because of the declining level of entry-level scientists (Fig. 2.2). This has happened despite escalation in the research and education agenda and is a cause of concern.

Deficiencies have cropped up on the qualitative front also. These create inefficiencies. Functional allocation and management of financial resources; level, mix, quality, and management of human resources; bureaucratic rigidities; lack of transparency and several other areas have been identified in various reviews of ICAR and SAUs (ICAR 1988, Randhawa *et al.*

Fig. 2.2. Growth in scientific manpower in ICAR



Note: r is the annual compound growth rate in percent. All r's are statistically significant.
Source: DARE/ICAR Annual Reports

1992, ICAR 1998, NAAS 2002). There is consensus that these are holding back research productivity (Jha *et al*. 2004).

Allocations

Since the beginning of organized public research, research resources have been created and allocated on the basis of perceptions regarding its value to the society. The research system began with a focus on improving crop and livestock productivity. This initiative of the central government expanded through provincial departments of agriculture, and persisted as an important component in the ICAR (Jha 2001). Colonial trading interests were identified early on and research on export and commercial crops became the focus of attention at the federal level (Evenson and Kislev 1975, Jha 2001). Since Independence, research on foodgrains production occupied the centre stage, a thrust which persisted through the 1980s. Even today, food security and its qualitative dimension is a core concern.

Extension was the main R&D strategy during the 1950s. The assumption was that improved technologies were available with the central and state research establishments, what was needed was its dissemination to farmers. The national extension service was built and intensified. This did not make the expected impact and priority shifted again to research and education in the mid-1960s. The high-yielding varieties programme, all-India coordinated crop improvement projects, and state agricultural universities constituted the core R&D initiatives under the 'new strategy for agricultural development'. This paid high dividends and ushered in the green revolution. Over time, neglected crops and regions were emphasized in the research agenda. A revamped extension programme (T&V) also followed. In research, natural resource management and high-income sectors (livestock and horticulture) gained importance. These are the thrust areas now. Attention has also shifted to a more science-intensive transfer of technology and 'development' component (e.g. KVK, IVLP, ATIC, ATMA, TAR, and SREP), and greater role for non-governmental voluntary organizations in execution of such grassroot-level initiatives. Resources have broadly followed these policy trends.

As part of the planning exercise, resource allocation decisions are made every five years. This has been a consultative process which uses judgement of knowledgeable scientists regarding current and emerging problems, prospects and opportunities in science. Such a subjective allocation of research resources served the system well in the past; the overarching research goal of increased productivity contributed effectively to several national objectives. A number of evaluations show high rates of return to research investments and also significant contribution to poverty reduction (Alston *et al*. 2000, Fan *et al.* 1999). The scenario has become complex now and the process of resource allocation needs to be supplemented by more information and analysis.

This has been hampered by lack of quantitative data on deployment of research resources, at both ICAR and SAU levels. There has been no institutional effort and individual researchers have resorted to using scientific publications data as indirect indicators of research resource allocation (Mohan *et al*. 1973, Evenson and Kislev 1975, and Ranjitha 1996). Ranjitha's work showed that over the period 1965-92, there were changes in the commodity-wise allocation profile of agricultural research in states as well as nationally. She noted a shift from traditional cereal crops towards horticultural crops, pulses, oilseeds, spices and medicinal plants. The regional distribution of research efforts for major commodity-groups was also shown. Ad-hoc attempts have been made (Jha *et al.* 1995, Birthal *et al*. 2002 and Mruthyunjaya *et al.* 2003) at the national level to establish normative allocation profiles, but no institutional initiative to integrate these in the planning process has emerged. An attempt was made under NATP (ICAR 1998), but this did not explicitly figure in the allocation plans for national resources. The Tenth Five-Year Plan exercise for agricultural research (ICAR 2001) remained traditional in its approach, focusing on research gaps and incremental investment needs, based on scientists' judgement regarding these parameters as well as institutional strengths and weaknesses. There is criticism that the resource-allocation profile shows persistent biases in terms of commodities and regions, neglect of evolving market opportunities, and other critical weaknesses. On the other hand, it has been argued (Jha 2001) that in institutional and historical terms, the public research system has been responsive to the emerging needs and stresses in both commodities and resource sectors.

Research resource allocation based on more analytical articulation of priorities is the need of the day. The recent initiative on establishment of PME cells at research institutions is intended to improve the situation (Pal and Joshi 1999). Ideas like constraints analysis do help in deciding the research agenda and its prioritization (De Dutta 1981, Widawsky and O' Toole 1996, Ramasamy *et al.* 1997, Joshi *et al.* 2003), participatory research to improve relevance and adoption (Hall *et al.* 2002, Meer 2002). IVLP, SREP, ATMA and other initiatives contribute to this and are expected to drive R&D efforts, particularly at the decentralized levels. *This study on current deployment of research resources is expected to contribute to decisions aimed at improving allocation and research efficiency at the macro level.*

Chapter 3

DATA AND METHODOLOGY

Scientific manpower data

Data on scientific manpower in agricultural research are not available systematically. Aggregate numbers are reported for the ICAR; for SAUs, other government institutions, or the private sector, only sporadic and partial data are available from occasional studies. Even the CSIR directory on scientific manpower (GoI 1997) has incomplete coverage. With regard to attributes of scientists and their deployment, data are practically non-existent.

Compiling scientific manpower data in agriculture was the primary task of this study. A census of all agricultural scientists in the country was conducted for this purpose. An exhaustive list of establishments engaged in agricultural research was prepared. This covered government, private, and non-governmental organizations. A compact questionnaire for individual scientists was developed, covering institutional affiliation, important personal and professional particulars, time allocation by major activities, and their research foci in terms of commodity, resource, and agro-climatic region or zone (Annexure 3.1). It was pre-tested and finalized. Responses were solicited from all institutions by the Director General of ICAR, who wrote to all the heads of institutions explaining the importance of the study and seeking input from all scientists (Annexure 3.2). A nodal scientist was also identified from each large unit to ensure and certify full coverage of scientists. March 2001 was the reference time for reporting and the survey continued through 2001 - 02.

A scientist was defined as an employee on roll on April 1, 2001, who was engaged in R&D activities and had at least a Master's degree. Scientists in research management positions were included in the census but those in technical and support positions were not. Research associates/ research fellows were also not included. The assistant professor/scientist level was the starting point in the public sector, and the private-sector scientists were adjusted accordingly.

Efforts to cover all the units persisted through 2002. Scientists responded in batches and often after repeated follow-ups. Data received from all the scientists were certified by local nodal functionaries for completeness and then verified, cleaned, coded, categorized, and computerized by the project staff under constant supervision. This constituted the core of the scientific manpower data used in this study*. Table 3.1 summarizes this effort in terms of institutional coverage.

Table 3.1. Agricultural institutions and scientists in the census

(Number)

Particulars	**Units approached**	**Units responded**	**Scientists responded**
Public sector	743	447	20921
a) ICAR	98	98	4539
b) SAUs	32	32	13633
c) Other public	613	317	2749
Private sector	494	117	948
All units	1237	564	21869

Source: ASC (2001-02)

Among public institutions, the census coverage was complete for the ICAR-SAUs, the dominating agricultural research institutions. 'Other' public institution was a diverse category which included research units in other government departments, KVKs, and other non-governmental organizations (NGOs). As Table 3.1 shows, only about half of the units approached in this category responded inspite of persistent efforts. The proportion was even smaller for the private institutions. It was presumed that non-responding units were either extension or marketing units and did not have a research role.

Other data

Secondary sources were extensively used. Annual Reports and other publications of ICAR were the valuable source for providing background

∗ These data along with necessary documentation are available with Dr Sant Kumar, Scientist, NCAP, New Delhi-110 012.

and other information. Publications of the Directorate of Economics and Statistics, Union Ministry of Agriculture, Planning Commission, Central Statistical Organization, and other institutions were frequently used. Several other researchers also shared their data liberally. These have been acknowledged wherever appropriate.

Analysis

Classification

Groupings and data transformation were needed to make the large data set presentable. The 564 institutions were categorized into four groups — ICAR, SAUs, 'other' public, and private sector. The scientists represented more than hundred disciplines. Similarly, the commodity spread covered 157 items and 26 resources were reported by the scientists. These were grouped further for the purposes of analysis and presentation. Table 3.2 shows these aggregate groupings. Annexures 3.3.1, 3.3.2 and 3.3.3 provide detailed listing of individual items. All the results and analyses presented subsequently follow these classifications.

Time allocation

Scientists don't devote all their time to research. They also participate in teaching/training, extension, and sometimes in management/administrative functions. These are perceived as integrated components of the R&D system and draw strength from each other. When measuring a scientist unit, it is customary to use a full-time equivalent (FTE) unit, which reduces the individual scientist unit in pure research equivalent (Pardey and Roseboom 1989). This is obtained as:

FTE = One scientist unit X Time allocated to research

Data on time allocation were directly obtained from each scientist and these were used for the required transformation*. Table 3.3 depicts the

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* For 82 scientists (about 0.37 percent of the total) time allocation data were not reported. Most of these were from the SAUs.

Table 3.2. Classification of disciplines, commodities, resources, and agro-climatic zones

Particulars	Groups	Particulars	Groups
1. Disciplines	Crop Sciences, Horticulture, Natural Resource Management, Engineering Sciences, Animal Sciences, Fisheries, Social Sciences, Others	2. Commodities	Cereals, Pulses, Vegetables, Fruits, Tubers, Plantation Crops, Flowers and Ornamentals, Medicinal and Aromatic Plants, Condiments/ Spices, Oilseeds, Fibres, Commercial crops, Fodder, Trees/plants, Livestock, Fish
3. Resources	Germplasm, Soil/ water, Agro-chemicals, Power/ Machinery, Feed/ fodder, Human/	4. Agro-climatic regions*	Western Himalayas, Eastern Himalayas, Lower-Gangetic Plains, Middle-Gangetic Plains, Upper-Gangetic Plains, Trans-Gangetic Plains, Eastern Plateau/Hills, Central Plateau/Hills, Western Plateau/Hills, Southern Plateau/Hills, East-coast plains/hills, West-coast plains/hills, Gujarat coast plains/hills, Western dry, Islands

* Ghosh (1991)

Table 3.3. Distribution of agricultural scientists and full-time equivalent (FTE) units

Particulars	Total Scientists		FTE scientists	
	Number	Per cent	Number	Per cent
Public sector	20921	95.6	9794	94.6
a) ICAR	4539	20.7	3069	29.7
b) SAUs	13633	62.3	5810	56.1
c) Other public	2749	12.6	915	8.8
Private sector	948	4.3	556	5.4
All units	21869	100.0	10350	100.0

Source: ASC (2001-02)

number of scientists and the computed FTE researcher units. A comparison of scientists and FTE numbers in different categories reveals that ICAR and private research institutions gain importance as research entities. This follows from differences in time-allocation profiles (see Chapter 5).

Allocation over commodities, resources, and major agro-climatic regions has been examined in this study. These three dimensions are usually integrated in a research project and it is not possible to isolate them. Therefore, each researcher's time cannot be exclusively attributed to any one dimension. A wheat breeder, for example, works simultaneously on a commodity (wheat), a resource (genetic material), and usually for a specific agro-climate. These dimensions have therefore, been treated independently for analytical purposes and results are reported separately. Table 3.4 shows this distribution in terms of FTEs.

Table 3.4. Distribution of FTE scientists by commodity, resource, and regional research focus

Particulars	Commodity	Resource	Region
Public sector	7921	9402	9794
a) ICAR	2630	2808	3069
b) SAUs	4560	5736	5810
c) Other public	731	858	915
Private sector	291	556	556
All units	8212	9958	10350
	(79.3)	(96.2)	(100.0)

Figures within the parentheses are percent to total FTE (Table 3.3)

Source: ASC (2001-02)

The point made above is borne out by the results. More than 79 per cent of the scientists have a clear commodity focus, 96 per cent are able to specify a resource focus and all identify the regional-orientation of their work. Private sector researchers reveal lower commodity-orientation (about 53 per cent of total FTE), but this arises from the classification structure adopted in this study. Commodity grouping is confined to crops, livestock and fisheries only. Agro-chemicals, drugs and vaccines, and machinery are included in the resource group and a large part of private research relates to these.

Allocation

The above exercise generated data on FTE units allocated to specific commodity, resource, or region. For scientists who indicated multiple targets (commodities, resources, or regions), it was not possible to precisely allocate their research time. Equal apportionment of time was used as an approximation. Summarized results on the existing pattern of research resource allocation are presented in Chapter 5.

Underlying these allocation results are the decisions of knowledgeable researchers, research managers, and policymakers. This is a complex process which uses a subjective and highly interactive process taking into account multiple objectives, opportunities, availability of research resources, and other constraints. More quantitative and analytical tools are also available now for assisting this process. Economists have come up with various approaches (Norton and Davis 1981, Jha *et al.* 1995, Kelly and Ryan 1995). In this study, a simple congruence analysis was used which links research resources with output growth objective at the national level. The congruity index (CI) was measured as:

$$CI = 1 - \sum_{i=1}^{n} \left(R_i - V_i\right)^2$$

where, V_i is the share of the ith commodity in total value of output (VOP) and R_i is its corresponding share in total research investment measured in terms of scientific manpower resources (FTE). An index value of unity implies perfect match between the two. Under some simplifying assumptions, research resource allocation in congruence with VOP maximizes returns to research investments. This has been attempted to examine the rationality of allocation over commodities and agro-climatic regions. Other non-parametric tests of congruence (Spearman rank-order correlation, Kendall's coefficient of concordance) were also employed to compare allocation profile of different organizations (ICAR, SAUs, 'other' public and private). Data on VOP of commodities were obtained from the National Accounts Statistics and records of Central Statistical Organization of Government of India (GoI 2004). This study was based on 80 commodities and studied both congruity and optimum allocation profile. Early studies by Jha *et al.* (1995) and Mruthyunjaya *et al.* (2003)

attempted only optimum allocation and were based on 68 and 80 commodities, respectively.

Research also contributes to other national objectives like sustainability, equity, trade, nutrition, etc. These also figure in resource allocation decisions. In this study, a simple scoring model was used following Jha *et al.* (1995) which tries to factor in these variables. The factors considered were growth, equity, sustainability, and value-addition/exports; these were assigned weightages of 0.40, 0.10, 0.25, and 0.25, respectively. The contribution of each commodity to each of these goals was scored on a 1 to 5 scale and a composite score was then computed for each commodity. This was used to adjust the VOP shares to generate the final baseline (FBL). The steps followed in quantifying impact while constructing the FBL are summarized below:

(i) Modified baseline

$$B_i^{'} = \left[1 + \{M_{ij} / Max(M_{ij})\} \times W_j\right] B_i$$

(ii) Final baseline

$$B_{ij}^{''} = (B_i^{'} / \sum_{i=1}^{n} B_i^{'}) \times 100$$

where,

$B_i^{'}$ = Modified baseline for the *i*th commodity
M_{ij} = Data for *j*th modifier for the *i*th commodity
W_j = Weightage for *j*th modifier
B_i = Initial baseline for the *i*th commodity
$B_{ij}^{''}$ = Final baseline for *i*th commodity based on *j*th modifier with positive direction
i = 1,…………. , n commodities
j = 1,…………….. , m modifiers

The FBL-share thus represents an optimum profile based on multiple objectives. Comparing these with the FTE-shares indicated needed adjustments in the current resource allocation.

Other analysis

Summarization and presentation of data also called for additional analyses. For example, regression analysis was used to explain inter-institute variation in number of scientists in ICAR, and factors explaining variations in time allocated to research. The models and variables used have presented along with the results.

Data limitations

The study suffers from several data and analytical limitations. Some of these are indicated below:

* Conceptually, R&D involves all processes from generation to final adoption of the technology by end-users. Accordingly, all institutions including extension services should be studied. This study had a research bias and included only those institutions which had this role, though we have often used the term R&D. A large number of research-qualified professionals are in extension, marketing, credit and other fields. The study excluded them also.

* Research resource allocation is a dynamic process. Continuous adjustments take place to factor in emerging research needs. Time-series data and analysis are needed to capture this dimension. This study has provided a one-point snapshot and has ignored the dynamic adjustment processes.

* This is the first study of its kind for the NARS and time and resources available necessitated a selective approach to data collection. Emphasis has been given to comprehensive coverage of scientific manpower rather than in-depth investigation of causal variables.

* Assessment of research resources has been derived from this perception of individual scientists. This is subjective and imprecise. This is aggravated by indirect method of data collection, apportionment, imprecise classification, missing institutions/scientists, etc.

*The congruence or scoring models employed provide only broad indications. Optimization implies not only multiple objectives but also other attributes of research like gestation, uncertainties, cost of research, spill-over effects, etc. An in-depth analysis of resource allocation should cover these aspects.

Chapter 4

INVENTORY OF SCIENTIFIC MANPOWER RESOURCES

Compiling an inventory of current scientific manpower resources in agricultural research was the core objective of this study. This chapter presents the results of this effort. The following sections provide estimates of scientific manpower and its major attributes.

1. Magnitude

The census sought to cover all agricultural scientists in the country in 2001-02. As such, it provides a baseline at the start of the millennium. Table 4.1 presents the total number of institutions and scientists covered in the study.

Table 4.1. Agricultural research units and scientists in NARS

Particulars	Number		Scientists/ Institution	FTE scientists/ institution
	Institutions	Scientists		
Total public sector	439	20825	47	20
a) ICAR	90	4443*	49	34
b) SAU	32	13633	426	182
c) Other public	317	2749	9	3
Private sector	117	948	8	5
All units	556	21773	39	19

*Excludes scientists in 8 Zonal coordination units & ICAR headquarters
Source: ASC (2001-02)

Table 4.1 puts the total number of scientists in the country at about 22 thousand in 2001-02, of which nearly 96 per cent are in the public sector. The ICAR-SAU system accounts for only 22 per cent of institutions, but employs 83 per cent of scientists; the SAUs alone account for more than 63 per cent. There is a large number (78 per cent) of small institutions belonging to 'other' public and private categories. The 'other' public category is prolific. Private agricultural colleges, KVKs, research-oriented NGOs and agricultural research institutions supported by other ministries are included here. Because these are narrowly mandated, the average number of scientists per institution is very small in FTE terms. In the private sector too, the number of institutions is large but their share in human resources is only 4.3 per cent and the average number of scientists is only eight. In FTE terms, the share exceeds 5 per cent, and the number per unit is five only. It should be noted that private R&D institutions accounted for about 13 per cent of total financial investment by the late-1990s (Pal and Byerlee 2003). After building organizational and physical infrastructure in the early phase of their growth, these are expected to expand through human capital. Their share and importance will grow rapidly.

It has been shown earlier (Chapter 2) that states contribute nearly half of the total public expenditure on R&E. Their share in total publicly-employed manpower exceeds 65 per cent. This implies high disparity in support per scientist between the state and central sectors, even if ICAR grants to states are factored out. This is an important policy issue. The other point noted was that the SAUs have lost significantly since the 1990s (Pal and Byerlee 2003). Rao and Muralidhar (1994) studied the human resources in 18 SAUs in early-1990s. A comparison of the current census data for these institutions with the Rao-Muralidhar results shows that the number of scientists declined by 24 per cent between 1992 and 2002. This is paradoxical. The number of scientists in agricultural universities seems to have declined but the number of agricultural (and allied) universities has grown from 28 in 1990 to 34 in 2001. The new units have largely been created out of the existing universities and are being manned through redeployment. This has often undermined the critical mass needed for the effective undergraduate and post-graduate teaching as well as research.

The skewed distribution of scientists among institutions is revealed by the fact that more than 82 per cent of institutions account for only 14.3 per cent of the scientific manpower (Table 4.2). In fact, one-fifth of the institutions average only one scientist per institute. These have obviously yet to establish their viability. The table also shows that while the institutional structure is overwhelmed by small units, most of the scientists are concentrated in a few large units. Only 15 institutions account for 47 per cent of the scientific manpower. Table 4.3 shows the break-up by type of institutions.

As expected, Tables 4.2 and 4.3 indicate that nearly 65 per cent of the scientists in the country are placed in 29 institutions – 26 of these are state universities. ICAR institutes have modest and viable numbers in most cases. A few non-viable ICAR-SAU units do exist, perhaps because of infancy. 'Other' public and private categories are significantly smaller. Nearly 95 per cent of the miniscule units belong to these two categories.

Table 4.2. Distribution of institutions by size-class of scientists

Scientists (size-class)	Institutions		Scientists		Scientists/ Institution
	Number	Per cent	Number	Per cent	
< 3	110	(19.8)	158	(0.7)	1
3 – 30	347	(62.4)	2947	(13.5)	8
31 – 100	56	(10.1)	2927	(13.4)	52
101 – 170	14	(2.5)	1692	(7.8)	121
171 – 240	4	(0.7)	830	(3.8)	208
241 – 310	7	(1.3)	1866	(8.6)	267
311 – 380	2	(0.4)	688	(3.2)	344
381 – 450	1	(0.2)	404	(1.9)	404
451 – 520	5	(0.9)	2444	(11.2)	489
> 520	10	(1.8)	7817	(35.9)	782
All classes	556	(100.0)	21773*	(100.0)	39

*Excludes scientists of ICAR Headquarters & Zonal Coordination Units
Source: ASC (2001-02)

Table 4.3. Distribution of institutions and scientists by categories and size-classes

(Number)

Scientists	ICAR		SAUs		Other Public		Private	
(size-class)	Units	Scientists	Units	Scientists	Units	Scientists	Units	Scientists
< 3	3 (3.3)	4 (0.1)	-	-	63 (19.9)	96 (3.5)	44 (37.6)	58 (6.1)
3 – 30	42 (46.7)	737 (16.6)	1 (3.1)	29 (0.2)	237 (74.8)	1627 (59.2)	67 (57.3)	554 (58.4)
31–100	34 (37.8)	1791 (40.3)	2 (6.3)	145 (1.1)	15 (4.7)	770 (28.1)	5 (4.3)	221 (23.3)
101–170	8 (8.9)	929 (20.9)	3 (9.4)	392 (2.9)	2 (0.6)	256 (9.3)	1 (0.9)	115 (12.1)
171–240	1 (1.1)	194 (4.4)	3 (9.4)	636 (4.7)	-	-	-	-
241–310	1 (1.1)	287 (6.5)	6 (18.6)	1579 (11.6)	-	-	-	-
311–380	-	-	2 (6.3)	688 (5.1)	-	-	-	-
381– 450	-	-	1 (3.1)	404 (3.0)	-	-	-	-
451–520	1 (1.1)	501 (11.3)	4 (12.5)	1943 (14.3)	-	-	-	-
> 521	-	-	10 (31.3)	7817 (57.3)	-	-	-	-
All classes	90 (100.0)	4443* (100.0)	32 (100.0)	13633 (100.0)	317 (100.0)	2749 (100.0)	117 (100.0)	948 (100.0)

* Excludes scientists of ICAR Headquarters and Zonal Coordination Units

Note: Figures within the parentheses are percentages of column total
Source: ASC (2001-02)

These numbers raise the issue of viability of institutions. It is believed that an independent research unit must have a minimum size. ICAR implicitly recognizes this and has planned for a *minimum* number of 10 scientists per free-standing research unit (ICAR 1997b). Scrutiny of the census data reveals the following distribution of units below this size in each institutional category (Table 4.4).

Table 4.4. Distribution of non-viable agricultural R&D units

Institutions	Institutions		Scientists	
	Number	Per cent*	Number	Per cent*
ICAR	8	8.9	56	1.3
SAUs	Nil	-	Nil	-
Other public	264	84.2	1140	41.5
Private	91	77.8	328	34.6
All units	36.3	65.3	1524	7.0

* Per cent of total number of institutions/ scientists in the category
Source: ASC (2001-02)

About two-thirds (65.3 per cent) of the units in our data set were non-viable on this reckoning. Separately, the percentages were 9 per cent, 84 per cent, and 78 per cent for institutions in ICAR, ‘other’ public and private categories, respectively. Together, these employed 7.0 per cent of the scientific manpower. In fact, 264 units (about 47 per cent) employing 5.2 per cent scientists had less than 5 scientists each (data not reported here). It should be noted that in the ‘other’ public category the proportion is very large because KVKs and NGOs are included and these are not primarily research-focused institutions, though some on-farm and adaptive research is invariably included in their activities. These (KVKs and NGOs) constitute 78 per cent of the units in this category. In the private sector too, the problem looms in the census because the survey year caught most private sector units in the establishment phase. The non-viable units in ICAR are temporarily in this category because of infancy and vacancies. A few SAUs may have non-viable academic programmes but this has not been investigated in this study. In the research system, therefore, the problem of viability does not appear to be as acute as previously alluded to, though even a few non-viable units are a drain on scarce resources.

The census shows a wide variation in size. What determines the size of a research unit**?** Importance of the problem, mandate, coverage, range of activities assigned to the unit, etc. are some obvious considerations. Then there are some not so-obvious factors like vintage, location, nature of research, etc. An exploratory analysis was attempted with the help of the census and ancillary data to decipher some of these influences. This was done with respect to ICAR institutions only, other institutions were not included because of lack of data on explanatory variables. A regression framework was employed which used the total number of scientists (SCI) and number of women scientists (WSCI) in an institute as dependent variables in two separate equations. The following model was hypothesized:

SCI or WSCI = f (AGE, IMP, LOCATION, UNIV, STATUS, REGCOORD, APPLIED, DIVCROP, DIVHORT, DIVNRM, DIVANI, DIVFISH, DIVENG, DIVEXT)

where, AGE is institute's age in years; IMP is the importance score of the institute (1= high, 2= medium, 3= low); LOCATION is a dummy variable (1 for better location of the institute, 0 otherwise); UNIV is a dummy variable (1 if institute has university status, 0 otherwise); STATUS is a dummy (1 if institute is a national or central institute, 0 otherwise); REGCOORD is a dummy (1 if the institute has a regional station and/or a coordinated project, 0 otherwise); APPLIED is a dummy (1 if applied research receives emphasis in the institute, 0 otherwise); DIV variables are dummies for divisions, CROP= crop science, HORT= horticulture, NRM= natural resource management, ANI= animal sciences, FISH= fisheries, ENG= engineering, and EXT= extension.

The model includes variables which depict the demand side (IMP, STATUS), institute's attributes (AGE, LOCATION, DIV dummies), and others indicating the coverage of institute's activity (UNIV, REGCOORD). The multiple regression framework permits sorting out the net effect of different variables. The estimated regressions are presented in Table 4.5. The statistical results are not very robust in terms of significance of individual coefficients but the adjusted R-square values are quite high for the first equation. This is not very surprising since most of the variables are qualitative and have not been precisely measured. Nevertheless, the results substantiate the point that institutes which are considered to be more important, those which have academic programmes, and have been long established, are larger in terms of scientific manpower. Apart from these, women-scientist numbers are significantly higher in institutes which have a

Table 4.5. Determinants of number of total scientists and women scientists in ICAR institutions

Particulars	Mean	Total scientists (SCI)		Women scientists (WSCI)	
		Coefficient	t - value	Coefficient	t - value
Constant	-	35.855	1.484	5.892	1.189
AGE	27.76	1.015	3.660*	0.106	1.866@
IMP	1.96	-17.305	-1.986@	-3.310	- 1.853@
LOCATION	0.60	11.705	1.120	2.349	1.097
UNIVERSITY	0.04	141.792	5.691*	17.025	3.333*
STATUS	0.53	17.061	1.596	1.807	0.824
APPLIED	0.51	-13.272	-1.394	-3.878	- 1.987@
REG/ COORD	0.79	- 0.749	-0.053	-1.222	- 0.419
DIV CROP	0.26	10.585	0.675	5.683	1.767@
DIV HORT	0.21	7.325	0.491	4.934	1.611
DIV NRM	0.16	8.469	0.492	2.234	0.633
DIV ANI	0.17	-	-	-	-
DIV FISH	0.09	-12.794	-0.687	3.408	0.893
DIV ENG	0.07	-17.508	-0.796	0.773	0.172
DIV EXT	0.04	- 0.536	0.021	2.831	0.549
Adj. R^2		0.628		0.387	
F		12.571		5.329	
N		90		90	

*, #, @ indicate statistical significance at 1, 5, and 10 percent levels, respectively

stronger basic/strategic research-orientation, and are in crops (and horticulture) division.

Equally interesting are the non-significant variables because these negate some popular perceptions. For example, it is believed that institutes at a better location are preferred and so are the national and central institutes. It is also believed that there may be some divisional bias in allocating scientists to institutes. The results of this study do not support these perceptions with respect to total number of scientists. With respect to number of women scientists, however, there is some evidence of clustering in crop (and horticulture) division and in basic research-oriented institutes. On the whole, there is indication of rationality in allocation of scientists to institutions. This is an area where more rigorous research is needed.

2. Attributes of scientists

In addition to the size of scientific manpower, qualitative attributes like age, experience, qualification, placement level, and disciplinary-mix of the scientific staff are also important determinants of research productivity. Conventional wisdom as well as empirical evidence, for example, suggests that scientific productivity is positively influenced by the educational level and research experience, is generally higher for younger scientists, and in systems, which are multi-disciplinary. This section summarizes the salient findings on these parameters based on the census data.

Table 4.6 shows that the average age of scientists in the agricultural research system is 44 years. Scientists in the core components of NARS - SAUs and ICAR are around 44 - 46 years of age and this pushes up the average age. Conventional wisdom suggests a target of around 40 years. Census results show that only the private system meets this norm. This aging phenomenon holds at all levels and nearly 31 per cent of the scientists are above 50 years of age (Table 4.7). The ICAR-SAU system has significantly higher percentages of

Table 4.6. Age, gender and skill level of scientists

Particulars	ICAR	SAUs	Other public	Private	All units
Average age (years)	43.8	45.7	42.2	37.5	44.0
Ph.D. holders (per cent)	75.7	69.6	55.9	36.6	67.7
Research experience (years)	17	18	14	11	17
Women scientists (per cent)					
2001-02	11.9	11.3	13.8	7.8	11.6
1975-76*	5.3	4.9	6.1	2.1	4.9

*Estimated from age-partitioning of current data
Source: ASC (2001-02)

scientists above 50 years. With this age structure, the average rate of attrition through 2010 works out to be 3.5 per cent per annum for the system as a whole, and a full one-percentage point higher for ICAR scientists. High average age and high attrition rate in the public research system have been attributed to faltering recruitment over the past decade or so (Pal and Byerlee 2003).

Table 4.7. Interaction of age with other attributes

Particulars	ICAR	SAUs	Other public	Private	All units
1. Average age (years)					
Male scientists	44.5	46.3	42.8	37.8	45.0
Women scientists	38.7	41.4	38.4	33.6	40.0
Assistant professors	35.6	40.7	38.3	33.9	38.8
Associate professors	48.9	48.1	48.4	46.7	48.3
Professors	53.0	53.2	50.8	52.4	52.9
2. Scientists above 50 years (per cent)					
All scientists	33.8	32.7	21.4	14.6	30.7
Male scientists	32.2	31.1	20.4	14.2	29.2
Women scientists	1.7	1.6	1.0	0.4	1.5
3. Attrition rate through 2010 (per cent)					
All scientists	4.4	3.6	2.6	1.7	3.5
Male scientists	4.7	3.9	2.9	1.8	3.8
Women scientists	2.9	1.6	1.2	0.5	1.5

*Estimated from age partitioning of current data
Source: ASC (2001-02)

Table 4.6 also shows that skill level of the system is high. A Master's degree is the entry-level qualification in the public system and more than two-thirds of the scientists are Ph.D. degree holders. In the ICAR-SAU system, it varies from 70 to 76 per cent. The average research experience is also high. These parameters compare favourably with the best globally.

The data do reveal a gender bias — only about 12 per cent of the agricultural scientists are women. Though their average age is significantly lower (Table 4.7), the skill indicators are lower as compared to those of the male scientists (Table 4.8). Gender sensitivity and affirmative action have become important in recent times.

Table 4.8. Interaction of gender with other attributes

Particulars	ICAR	SAUs	Other public	Private	All units
Ph.D. holders (per cent)					
Male scientists	76.8	70.2	57.9	36.0	68.6
Women scientists	67.8	64.4	43.0	42.9	61.3
Average research experience (years)					
Male scientists	18	18	14	11	17
Women scientists	12	14	10	8	13

Source: ASC (2001-02)

Lest the above findings are interpreted as regressive, Table 4.6 also shows that the proportion of women scientists has more than doubled over the last 25 years. The trend is discernible in the private sector as well. Besides, these data should be interpreted in context of the generic gender bias in higher education in general and agricultural education in particular.

These data indicate that the public system has invested heavily in human resource development by simultaneously promoting academic upgradation and experience as well as gender representation. The private sector, which is relatively young, lags behind. It has taken a more flexible approach in its formative years. 'Other' public institutions also show relatively lower indicators, primarily because these include a large number of grassroot level institutions (KVKs, NGOs) which do not deal with hardcore and long-term research.

The cadre structure and placement of scientists are the important determinants of performance. Table 4.9 presents the distribution of scientists in three broad categories — assistant professor, associate professor and professor (and higher), which generally constitute the academic hierarchy; conventionally, a ratio of 5 : 2 : 1 is considered desirable.

Table 4.9. Hierarchical distribution of scientists

Particulars	ICAR	SAUs	Other public	Private	All units
Per cent of scientists					
Assistant professors	43.3	45.3	65.4	69.1	48.5
Associate professors	39.4	34.9	20.4	20.7	33.4
Professors	17.4	19.7	14.2	10.2	18.1
Number of faculty per scientist of professor or higher rank	4.8	4.1	6.0	8.8	4.5

Source: ASC (2001-02)

Table 4.9 shows that the present cadre structure for the ICAR-SAU system has become relatively top-heavy and this dominates the national profile. The number of scientists by designation in SAUs and ICAR institutes are given in Annexures 4.1 and 4.2, respectively 'Other' public and private institutions show a preference for fledging scientists. It has been noted earlier (Chapter 2) that recruitment of young scientists in the public system has been practically on hold since early-1990s. On the other hand, career advancement policies have continued to upscale the existing staff. This has generated the observed distortion. It has been argued that if this is not responded to, the overall productivity of public systems will decline (Jha *et al.* 2004)*. The private system, which does not suffer from such institutional rigidities, shows a better cadre profile.

Finally, Tables 4.10 and 4.11 give an idea about the disciplinary-mix of scientists in the agricultural research system. In all, 116 disciplines are represented in the system (Annexure 3.3.1). In the above tables, these

* A point of caution is in order here. Apart from restrictions on employment, the financial stringency also disrupted the career advancement plans in the public system and this caused stagnation. The process was resumed in 2001-02. During the survey year, therefore, the cadre structure was in a flux. Data presented in Table 4.9 reflect this distortion.

have been grouped in eight categories. Crop sciences, resource management, and animal sciences related disciplines are dominant, and account for nearly 70 percent of the agricultural scientists in the country. Their share is two-thirds or more in all public institutions. In the private sector, the distribution is narrower: crop sciences account for more than 54 percent and, together with resource management, it accounts for nearly 83 percent of the total scientists in the sector. Animal science and fishery disciplines are not favoured in this sector. Engineering and social sciences are also emphasized less.

Table 4.10. Disciplinary-mix of scientists

(per cent)

Discipline group*	**ICAR**	**SAUs**	**Other public**	**Private**	**All units**
Crop sciences	31.7	31.4	30.2	54.4	32.3
Horticulture	5.6	8.2	9.8	4.3	7.7
Natural resources	18.6	21.9	23.0	28.2	21.7
Animal sciences	17.8	16.5	11.9	6.9	15.8
Fishery sciences	6.8	1.5	1.0	0.2	2.5
Engineering	6.5	6.5	5.8	2.0	6.2
Social sciences	7.6	11.7	17.2	3.7	11.2
Others	5.5	2.2	1.1	0.1	2.7

*For details of specific disciplines, see Annexure 3.3.1.
Source: ASC (2001-02)

Based on the disciplinary profile of ICAR - SAU scientists in the above 50 age group, an attempt was made to estimate the disciplinary profile 25 years ago and Table 4.11 presents the proportionate change between the current and past disciplinary-mix. As expected, there has been an increase in diversity over time — 108 disciplines figured in the workforce in the mid-1970s as compared to 116 currently. There have been marginal adjustments in favour of horticulture, animal sciences and social sciences at the cost of crop sciences and resource management, the core conventional disciplines. ICAR has been relatively more aggressive in pursuing these trends.

Table 4.11. Estimated changes in disciplinary-mix* in ICAR and SAUs

Discipline group	Change in proportion between 2001 and 1976 (per cent)		
	ICAR	SAUs	ICAR - SAU
Crop sciences	3.7	2.0	1.4
Horticulture	+ 2.2	+ 0.8	+ 1.3
Natural resources	2.5	4.7	4.0
Animal sciences	+ 4.2	+ 2.5	+ 2.4
Fishery sciences	2.3	+ 0.6	0.4
Engineering	+ 1.1	+ 0.9	+ 0.7
Social sciences	+ 2.0	+ 2.1	+ 2.2
Others	0.8	0.3	0.5

*Estimated from age-partitioning of ASC data

Several important trends emerge from this. Firstly, the NARS will get smaller, if recruitment rates in SAUs and ICAR are not jacked up. Technological challenges and opportunities are increasing and even with rapid growth in the private sector efforts, manpower needs will continue to rise. The existing policy on restricted recruitments will hurt the public research system. Secondly, induction of younger scientists will be necessary to maintain and raise research productivity. The average age is approaching the level at which productivity as well as enthusiasm starts declining. This will also rationalize the cadre structure. Thirdly, though the ICAR-SAU system appears to be pro-gender, more needs to be done in this area. The record of private system on this is poor. These factors have long-term implications and need positive policy response.

Chapter 5

RESEARCH RESOURCE ALLOCATION

Another fact-finding objective of the study was to quantify the resource allocation profile of the national agricultural research system. This is crucial for research policy and planning. Quantitative information has not been available in the past and research planners have used knowledge and experience-based subjective judgements for resource-allocation decisions. It has been argued earlier that such decisions can be improved by supplementing them with quantitative data and analysis. This chapter begins by showing the broad activity profile of scientists, and then provides information on allocation by commodities, resources and regions. These have been derived from the specific responses of individual scientists obtained in the census.

1. Activity-wise allocation of resources

Research, teaching (training) and extension are integrated in the job description of scientists in the ICAR-SAU system. Other institutions also incorporate outreach functions in the agenda and allocate scientific-manpower resources to such activities. There are no norms regarding the proportions, but the three roles are mutually reinforcing. Individual scientists allocate their time between these activities depending on their job profile, preferences, as well as perceptions regarding relative career rewards. This is the first allocation dimension considered. This chapter begins by trying to quantify this multi-functionality. Table 5.1 shows the average participation rate of scientists belonging to different categories of institutions in these activities.

Table 5.1 clearly depicts that scientists in all kinds of institutions participate significantly in all the three major activities. Though research is the dominant activity across the board, teaching and extension also involve 70-72 per cent of the scientists, on an average. As expected, a relatively larger proportion of SAU and deemed university scientists are involved in teaching. Extension appears more important in local-level institutions. ICAR has an upstream research role and this is reflected in the time-allocation profile. In private institutions, research and extension are the major R&D activities in terms of participation. Administration has been considered as a trivial activity, but the data show that more than 60 per cent of the respondents participate in this activity.

Table 5.1. Participation rate of scientists in different activities

(Per cent)

Institutions	Research	Teaching/ Training	Extension	Adminis- tration
ICAR	97.2	48.3	57.8	68.8
Deemed universities	99.0	89.0	56.7	66.9
Other institutes	94.8	36.6	58.1	69.3
SAUs	91.8	79.6	76.6	56.7
Other public	78.6	64.3	78.4	62.3
Total public	87.3	67.7	69.6	57.4
Private	91.0	51.2	69.5	70.8
All units	91.2	70.0	72.6	60.5

Source: ASC (2001-02)

Data on average time allocation to these activities provide a more precise indication of scientists, preferences and priorities. Table 5.2 reveals that while scientists in all institutions accord the highest priority to research, those in ICAR and private institutions spend relatively more time. Teaching is next in importance in the SAUs and deemed universities. In ICAR (other than deemed universities) and private institutions, it is not a minor claimant of scientists' time. Public institutions, particularly ICAR and SAUs, emphasize on extension and percentage involvement of scientists is high, but it is relatively undervalued by scientists in terms of time allocation. These institutions are mainly in 'frontline' extension; the state department of agriculture has the mainstream extension role. Private institutions pay relatively more attention to extension, which is more akin to sales promotion effort in their case. The 'other' public category is dominated by grassroot level units (KVKs, NGOs) and this results in high average time allocation to extension in these institutions.

Interestingly, a significant amount of scientists' time (11 per cent) is allocated to 'administration'. In ICAR as a whole, it claims more time than training or extension. This has attracted the attention of research administrators,

Table 5.2. Time allocation by scientists to different activities

(Per cent)

Institutions	Research	Teaching/ Training	Extension	Adminis- tration
ICAR	67.6	9.3	8.8	14.3
Deemed universities	57.5	23.6	7.5	11.4
Other institutes	70.5	5.1	9.2	15.2
SAUs	42.8	34.5	13.2	9.5
Other public	33.3	22.7	32.3	11.7
Total public	46.9	27.5	14.8	10.8
Private	60.4	7.5	17.1	15.1
All units	47.5	26.6	14.8	11.0

Source: ASC (2001-02)

particularly in context of the perception that there is excess of administrative and supporting staff in public institutions. The high cost this entails becomes apparent when it is realized that more than 180 scientists can be effectively added to the ICAR-SAU scientific workforce if there is a one-percent reduction in time allocated to administration! Three factors need to be kept in view in this regard. First, scientists include R&D-related administration in this category — arranging meetings, seminars, conferences, administering collaborative research activities, ensuring proper technical specifications and quality in research-related supplies, and a number of similar activities engage their time. This is related to the second factor. Administrative and support staff in research institutions are largely recruited and carried over on the basis of government norms for generalists. It is not yet recognized that research administration is a distinct professional activity. Saddled with such support, the scientists feel more confident when they assume the responsibility themselves. Thirdly, some experience and hands-on training in this area are desirable. Nevertheless, this load can and should be brought down significantly by professionalization of administrative and support staff in research institutions.

There are no established norms in this regard and the observed time allocation profile is attributed to individual scientist's perceptions regarding relative importance of different activities in career advancement opportunities. The evaluation and reward systems in major public research institutions remain biased in favour of research. Is this right? This needs more research.

This time-sharing means that the effective research workforce is less than the 21,869 scientists enumerated in the census. The above data allow a more realistic assessment of manpower resources for research and other activities in terms of full-time equivalents (FTEs). These numbers are presented in Table 5.3.

In real terms, the number of full-time scientists in the country comes to 10,350. The estimated number is significantly higher than that estimated for late-1980s (Pardey and Roseboom 1989), but about 7 per cent lower than the estimate for late-1990s (Pal and Byerlee 2003).

Table 5.3. Distribution of FTE scientists by institutions and activities

(Number)

Institutions	Research	Teaching/ Training	Extension	Adminis- tration
ICAR	3069	420	400	650
SAUs	5810	4688	1790	1290
Other public	915	624	889	322
Total public	9794	5732	3079	2262
Private	556	69	156	139
All units	10350	5801	3235	2401

Source: ASC (2001-02)

Factors like stagnation in recruitment and high rate of attrition in the ICAR-SAU institutions (which account for nearly 86 per cent of FTE researchers) have already been pointed out. Despite all this, the Indian agricultural research system is comparable to the largest in the world. Table 5.3 shows that in FTE terms also, the public sector accounts for about 95 per cent of research manpower. Because of higher time-allocation coefficient, ICAR's share rises to about 30 per cent as compared to 22 per cent in terms of absolute numbers. The shares of SAUs and 'other' public institutions go down while that of private institutions rises.

These tables show that research and teaching occupy more than three-fourths of scientists' time in the ICAR-SAU system; ICAR scientists assign much more importance to research on an average, but those in the deemed universities, have a pattern similar to that of the scientists in SAUs (Table 5.2). Professionalization of administrative and supporting staff will permit more research and outreach activities in the public institutions with the same workforce. This is relatively more important for the ICAR-SAU set-up.

A more rigorous analysis was attempted to understand the effect of these and other factors on inter-scientist variations in time allocated for research. A regression framework was employed for this analysis which was conducted separately for the ICAR and SAU scientists. The percent time allocated to research (RESTIME) by individual scientists was used as the dependent variable. The independent variables included personal attributes as well as some institutional characteristics. The following regression equation was estimated:

RESTIME = f (STATUS, MANDATE or TIME, AGE, GENDER, PHD, SCI, SRSCI, PRSCI, RMPSCI, DISANI, DISCROP, DISNRM, DISENG, DISFISH, DISHORT, DISSOC, DISOTHR)

where, STATUS dummy = 1 for national/central institutes, 0 otherwise; MANDATE dummy = 1 if mandate focuses on research, 0 otherwise; TIME = percent time devoted to teaching; AGE = scientist's age in years; GENDER dummy = 0 for women scientists, 1 otherwise; PHD dummy = 1 if scientist holds Ph.D. degree, 0 otherwise; SCI dummy = 1 for scientist/asstt professor, 0 otherwise; SRSCI dummy =1 for senior scientist/assoc. professor, 0 otherwise; PRSCI dummy = 1 for principal scientist/professor, 0 otherwise; RMPSCI dummy = 1 for research managers, 0 otherwise; DISANI dummy = 1 for animal science discipline, 0 otherwise; DISCROP dummy =1 for crop science discipline. 0 otherwise; DISNRM dummy =1 for NRM disciplines, 0 otherwise; DISENG dummy = 1 for engineering disciplines, 0 otherwise; DISFISH dummy =1 for fishery disciplines, 0 otherwise; DISHORT dummy = 1 for horticulture disciplines, 0 otherwise; DISSOC dummy =1 for social science disciplines, 0 otherwise; DISOTHR dummy =1 for other disciplines, 0 otherwise.

It should be borne in mind that the choice of independent variables was restricted by availability of data and most of these were measured qualitatively. The regression coefficients capture the net effect of individual variables. This cannot be shown by simple tabulations. The results presented in Table 5.4 are reasonably robust. The adjusted R-square values, F-statistic, and several regression coefficients are statistically significant.

Table 5.4. Determinants of per cent time allocated to research (RESTIME)

Particulars	ICAR scientists			SAU scientists		
	Mean	Coefficient	t - value	Mean	Coefficient	t - value
Constant	-	65.410	25.320*	-	60.610	43.726*
STATUS	0.80	- 2.111	- 2.927*	-	-	-
MANDATE	0.74	-12.841	18.251*	-	-	-
TIME	-			34.48	- 0.673	115.987*
AGE	43.71	- 0.060	- 1.319	45.85	0.060	2.337#
GENDER	0.88	- 0.474	- 0.551	0.89	- 1.879	3.504*
PHD	0.76	- 1.822	- 2.587*	0.70	2.494	6.303*
SCI	0.44	3.910	4.523*	0.45	1.627	3.761*
SRSCI	0.39	-	-	0.35	-	-
PRSCI	0.13	-12.094	- 13.654*	0.17	- 6.333	- 12.630*
RMP SCI	0.04	- 40.341	- 26.820*	0.03	- 32.988	- 33.710*
DISANI	0.17	-	-	0.16	-	-
DISCROP	0.32	7.119	8.366*	0.31	8.719	17.159*
DISNRM	0.19	1.742	1.866@	0.22	6.211	11.486*
DISENG	0.07	- 3.686	- 2.876*	0.07	2.571	3.408*
DISFISH	0.07	1.110	0.857	0.02	- 2.466	- 1.794@
DISHORT	0.06	2.646	1.996#	0.08	- 2.915	4.181*
DISSOC	0.07	- 13.986	- 11.657*	0.12	- 6.224	- 9.823*
DISOTHR	0.05	- 1.355	0.999	0.02	4.046	3.506*
Adj. R^2		0.336			0.571	
F		150.708			1295.621	
N		4439			13594	

*, # and @ indicate statistical significance at 1, 5 and 10 per cent levels, respectively

The ICAR regression shows that scientists in larger (national and central) institutes spend relatively less time on research. They presumably have a more diversified activity profile. Others (directorates, bureaus, centres) are primarily research-oriented and scientists concentrate on research. Teaching competes with research time, an obvious result borne out by both ICAR and SAU regressions. Interesting results were obtained with respect to variables depicting personal attributes of scientists. Age and gender effects were discernible only in the SAU regression. For age, the result was unexpected — older scientists spent more time on research. Women scientists were found concentrating more on research. The net effects are small but statistically significant. Conflicting results were obtained with respect to educational status. In SAUs, scientists with higher degree spent more time on research, obviously those with Master's degree were assigned more teaching and other responsibilities. In ICAR institutions, the opposite seems to hold. The regressions suggest that there are some institutional differences between ICAR and SAUs, perhaps driven by varying mandate, culture, and motivation.

Both the regressions show that with advancement in career, scientists have to spend more time on non-research activities. Research time goes down. It is, therefore, important to maintain a pyramid-like career structure. The base has shrunk over the past decade. The regressions imply that this has affected research time adversely. Manpower planning has to factor in this consideration. Finally, some disciplinary bias was captured by the regressions. Crop science and natural resource management scientists spend more time on research relative to disciplines like engineering, fisheries and social sciences. Are these due to more time-intensive research processes for some disciplines? This needs to be probed further.

This section indicates that scientists, particularly in the public system appreciate the integrated concept of agricultural R&D and participate in all the activities, but their time allocation profile shows a clear bias in favour of research. Institutional and personal attributes affect their time-allocation decisions and manpower planning to maximize research input should factor in these variables.

2. Commodity-wise allocation of resources

Indian agriculture is large and diverse. Varying production possibilities, long-term adaptations, ethnic and cultural preferences and other factors have added an array of primary commodities in different production systems. Most of these have been part of traditional, low-productivity agriculture. In today's context, raising productivity across the board has become a compulsion. Accordingly, the agricultural research portfolio has become large in terms of commodities. It has been shown earlier (Table 3.4) that the commodity-focus of research could be clearly identified for nearly 80 per cent of FTE scientists. The 157 commodities identified in the census were grouped into 16 categories (Table 3.2). The broad research resource allocation profile is provided at this level. Subsequently, more details have been provided for important groups.

To begin with, Fig. 5.1 shows that the crop sector dominates the agricultural research scenario overwhelmingly. Nearly four-fifths of all scientific-manpower resources are dedicated to this sector as well. Livestock research claims 15 per cent and fisheries account for the rest. This crop bias pervades across institutions, public and more distinctly, in the private sector as well. ICAR plays a very important role in supporting fisheries and livestock research in the country. Other public institutions donot accord importance to the fisheries research particularly.

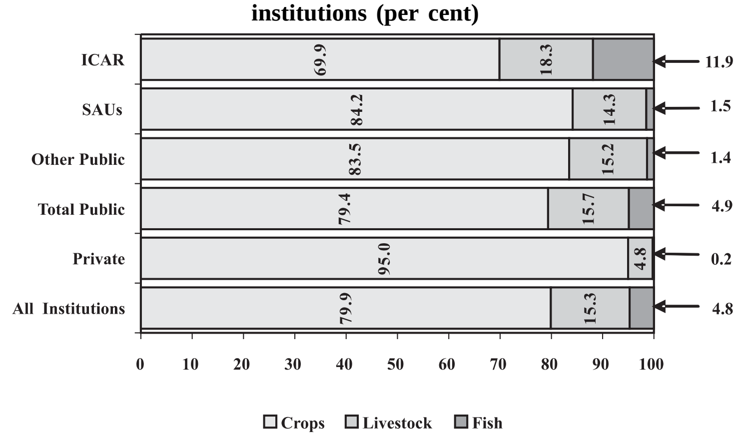


Fig. 5.1. Relative importance of major commodity sectors by institutions (per cent)

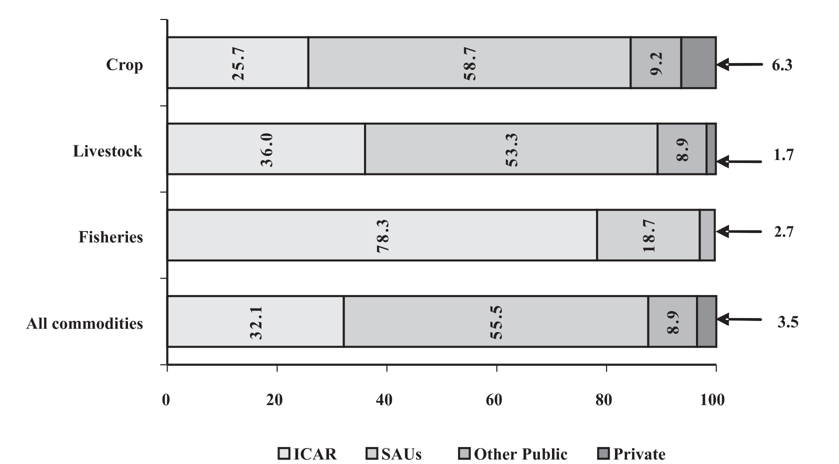
Source: ASC (2001- 02)

Private research did not accord any importance to the livestock and fisheries sectors at the turn of the century. This was surprising because these have been the high-growth sectors since 1990s. It should be noted that policy impediments to private investments in R&D were still formidable. This is changing rapidly.

Another reason could be that the classification scheme adopted in this study included drugs, vaccines, hormones, etc. in the resources category and not under commodities.

How do various institutions contribute to research in different sectors? Figure 5.2 illustrates the dominance of SAUs in crop and livestock research. 'Other' public institutions also contribute about 9 per cent. ICAR puts in 70 per cent of its resources on crops research, contributing more than a quarter (26 per cent) to the national crop research effort.

Fig. 5.2. Contribution of institutions to sectoral research (per cent)



* Negligble
Source: ASC (2001-02)

With most of the downstream research located in SAUs, ICAR is mandated to focus on basic and strategic research. Its clout is stronger in livestock and, particularly, fisheries research in the country. Livestock research in SAUs had many gaps and ICAR had to step in. In fisheries research, its contribution is overwhelming. Figure 5.2 also shows the infancy of private research in terms of the national research effort; even in crops research, its share is only 6 per cent.

Three important points emerge. First, considering the strategic importance of crops in food, employment and livelihoods, the crop-bias in research is well merited. Commercialization and demand-led development are relatively recent phenomena and the allocation profile reported here still reflects the traditional biases. Secondly, the figures show that ICAR which has the mandate to guide public research, has given more emphasis to livestock and fisheries research. This bears out the dynamic nature of resources allocation process in the ICAR. It has played an important role in identifying and bridging research gaps. Finally, even though the private sector is contributing significantly in the high-growth sectors, it still is a minor player in the agricultural R&D scenario and its portfolio remains locked to selected commodities. The investment environment is changing and a rapid growth in private agricultural research and broadening of the agenda are projected.

Detailed information on commodity-wise allocation is provided below. This was a core objective of this study. To begin with, Table 5.5 summarizes the census data in terms of shares of major commodity groups for each institutions category. At the turn of the century, foodgrains (cereals and pulses) constituted the most important group, claiming about 30 per cent of the commodity-focused research resources in the country. Cereal research dominated this group. Self-reliance in foodgrains continues to be a very strong undercurrent, despite attainment of self-sufficiency since mid-1980s. Horticultural research comes a close second with 28 per cent. This is a diverse group–fruits and vegetables account for half of total horticultural research. Diversification and high-value agriculture has been the major thrust since the 1990s and horticulture figures importantly in this scheme. Livestock research ranks third, followed by oilseeds, fibres, fisheries, and commercial crops. These groups account for more than 98 per cent of commodity-focused agricultural research in the country. In several cases, only 1-2 per cent of resources are allocated (fodder crops, condiments and spices, medicinal/aromatic plants, flowers/ornamentals). It should be noted that more than 8200 FTE scientists are engaged in commodity research (Table 3.4), even 1-2 per cent of this would imply 80-160 full-time scientists!

This current profile has evolved over time. Food crops and commercial crops attracted more attention till the mid-1980s. Food self-sufficiency and foreign exchange (exports and import substitution) were the overriding goals of the agricultural sector. The growth strategy began emphasizing diversification and high-value output mix since the 1990s. Horticulture, livestock, and fisheries research have gained importance. Table 2.1 shows how the central (ICAR) system has anticipated and responded to the emerging trends and Table 5.5 also illustrates this point.

Table 5.5. Allocation of research resources across major commodity groups by institutions

(Per cent)

Commodity groups	**ICAR**	**SAUs**	**Other public**	**Total public**	**Private**	**All units**
1. Cereals	16.5	26.8	20.4	22.8	27.0	22.9
Foodgrains	**21.1**	**35.6**	**24.1**	**29.7**	**27.4**	**29.6**
3. Vegetables	3.7	7.3	2.5	5.7	13.0	5.9
4. Fruits	7.1	9.4	4.8	8.2	2.8	8.0
5. Tubers	5.7	1.4	2.1	2.9	0.8	2.8
6. Plantation crops*	4.5	3.8	21.1	5.6	26.9	6.4
7. Flowers/ Ornamentals	1.3	1.2	2.1	1.3	1.5	1.3
8. Medicinal/ Aromatic	1.0	1.3	8.4	1.9	0.7	1.8
9. Condiments/ Spices	1.6	1.7	2.1	1.7	1.6	1.7
Horticulture	**24.8**	**26.1**	**43.1**	**27.3**	**47.3**	**27.9**
10. Oilseeds	7.4	11.2	4.4	9.3	4.9	9.2
11. Fibres	7.1	5.8	9.1	6.5	13.2	6.8
12. Commercial crops	7.2	3.9	2.4	4.9	2.3	4.8
13. Fodder crops	2.4	1.5	0.4	1.7	0.0	1.6
Total crops	**69.9**	**84.2**	**83.5**	**79.4**	**95.0**	**79.9**
14. Livestock	18.3	14.3	15.2	15.7	4.8	15.3
15. Fish	11.9	1.5	1.4	4.9	0.2	4.8
All commodity groups	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

* includes trees and plants group

Source: ASC (2001-02)

Table 5.5 also shows the allocation pattern at the central, state and private levels. All institutions attach importance to foodgrains but these receive higher priority at the decentralized levels. Nearly 36 per cent of SAU-resources are allocated to this category. Political economy considerations warrant this. ICAR has moderated its thrust on foodgrains focusing on basic/strategic research, and has switched resources to the fisheries and livestock sectors where major research gaps existed. It has been able to show greater resilience and make relatively rapid adjustments, essentially because of availability of incremental (plan) funds. The 'other' public category is dominated by small grassroot level institutions. These emphasize cereals and other commodities with high visibility and impact potential (cereals, plantation crops, livestock, fibres, medicinal/aromatic plants). It has been shown later (Table 5.19) that these institutions are concentrated in a few regions and local production patterns influence their portfolios significantly. Cereals also receive greater attention in the private sector research. Hybrids of maize and millets provided the entry point for the private sector in Indian agricultural research, and these along with rice hybrids, continue to be important. Plantation crops, fibres and vegetables are the other important foci for the private sector.

Table 5.6 shows the relative importance of different players in R&D efforts on various commodity groups in the country. The public sector overwhelms the scene and, as expected, SAUs have the leading role in most cases. Research on plantation crops, fish, and tubers is an exception to this. The ICAR accounts for about one-third of all commodity-based research; in fisheries and tuber crops research, it has a dominating share. In a few other commodities (livestock, commercial crops, fodder crops), it has strong presence. 'Other' public institutions play important role in medicinal/aromatic plants, plantation crops, flowers/ornamentals, and fibres. Private research, as argued above, has not yet assumed a comparable importance in any major group. Inter-group allocation is most balanced in SAUs and ICAR, as indicated by low CV values. 'Other' public and private R&D institutions have large variations between groups. Small size and the need to respond to specific local and market demands perhaps necessitate this.

Table 5.6. Share of institutions in research by commodity groups

(Per cent)

Commodity groups	ICAR	SAUs	Other public	Total public	Private-units	All units
1. Cereals	23.1	64.8	7.9	95.8	4.2	100.0
2. Pulses	22.0	72.9	5.0	99.8	0.2	100.0
Foodgrains	**22.8**	**66.7**	**7.3**	**96.7**	**3.3**	**100.0**
3. Vegetables	19.9	68.5	3.8	92.2	7.8	100.0
4. Fruits	28.3	65.1	5.4	98.8	1.2	100.0
5. Tubers	64.5	27.9	6.7	99.0	1.0	100.0
6. Plantation crops*	22.7	33.0	29.4	85.1	14.9	100.0
7. Flowers/Ornamentals	30.6	51.8	13.6	96.1	3.9	100.0
8. Medicinal/ Aromatic	17.5	40.2	40.9	98.5	1.5	100.0
9. Condiments/ Spices	29.9	55.5	11.2	96.6	3.4	100.0
Horticulture	**28.4**	**51.9**	**13.7**	**94.0**	**6.0**	**100.0**
10. Oilseeds	25.7	68.1	4.3	98.1	1.9	100.0
11. Fibres	33.6	47.6	11.9	93.1	6.9	100.0
12. Commercial crops	48.2	45.6	4.5	98.3	1.7	100.0
13. Fodder crops	47.6	50.3	2.1	100.0	0.0	100.0
Total crops	**28.0**	**58.5**	**9.3**	**95.8**	**4.2**	**100.0**
14. Livestock	38.1	51.9	8.8	98.9	1.1	100.0
15. Fish	79.9	17.4	2.5	99.8	0.2	100.0
All commodity groups	**32.0**	**55.5**	**8.9**	**96.5**	**3.5**	**100.0**
Coefficient of variation	50.0	31.8	102.3		120.2	

* includes trees and plants group

Source: ASC (2001-02)

Are different R&D institutions in accord in terms of the priority they assign to research on different commodity groups? In Table 5.5, some differences were noted. Non-parametric statistical tests like Kendall's test of concordance and Spearman rank-order correlations were employed to add rigour to these comparisons. This analysis was done in two steps: first, the null hypothesis that the rankings (priority) assigned to the 15 commodity groups by the four major participants — ICAR, SAUs, 'other' public, and private, were unrelated (independent) was tested by working out Kendall coefficient of concordance (W). Second, pair-wise Spearman rank-order correlations were worked out between the priority rankings observed in these institutions.

The values of W (0.669) and statistically significant Chi-square (37.46) led to the rejection of null hypothesis, implying that there was a fair agreement in the rankings assigned to various commodity groups by different institutions. One could conclude from this that all institutions are guided by the same research objectives and have similar priorities. This appears counterintuitive. Public and private R&D are segmented. Central and decentralized institutions are also expected to pursue different agenda. The concordance coefficient (W) does not seem to capture these.

Table 5.7 presents the full range of Spearman rank correlations between pairs of institutions. These are more revealing. The priorities of the major public players — ICAR and SAUs – are similar. ICAR's priorities appear to be independent of those of 'other' public, and private R&D institutions. This is consistent. National compulsions drive ICAR research, and these are mediated through SAUs which are the major partners. Within the same priority framework, the two institutions focus on different parts of the research spectrum — the ICAR focusing on basic/strategic research, and SAUs emphasizing on applied research. The other two institutions have different motivations. The state and locally-oriented institutions have greater similarity as all the correlations are statistically significant[#] . The rank correlations are more discriminating. These clearly show that the central and state components, which claim 83 per cent of national research resources, share common goals. Then, there is another cluster of institutions which have locally-driven priorities. As one would expect, the SAUs act as a bridge between the two.

[#] The correlation between state and 'other' public institutions is also statistically significant at 5 per cent level

Table 5.7. Spearman rank correlations between ranking of different commodity groups by institutions

Institutions	ICAR	SAUs	Other public	Private
ICAR	1.00	0.691*	0.332	0.382
SAUs	1.00	0.588	0.617*	
Other public			1.00	0.761*
Private				1.00

* indicates significance at 1 per cent level

These numbers clearly reveal as follows : (1) The crop sector accounts for nearly four-fifths of all the commodity – oriented research; in private sector, the share is even higher. (2) The cereals, livestock, fruits and vegetables, oilseeds, and fibre crops account for more than two-thirds of the national R&D efforts. Their share is close to three-fourths in the state system. ICAR has a more diversified portfolio. Cereals (hybrids), plantation crops, fibre crops and vegetables claim more than four-fifths of private R&D efforts. Its commitment to non-crop R&D is as yet insignificant. (3) Overall priorities of ICAR and SAUs are in agreement, though specific shares of individual commodity groups differ. SAUs, 'other' public and private institutions are driven more by local needs and markets, and have broadly similar priorities. There are pointers suggesting a differentiation of public-private domains. This will grow as private R&D grows and matures. (4) Public institutions have been responsive to the growing opportunities by allocating relatively higher share of research resources to livestock and fisheries research as compared to the budding private R&D sector. ICAR stands out clearly in this regard as compared to the SAUs and 'other' public institutions. (5) Foodgrains research has gradually lost relative ground across the board, thanks to higher level of food production and security. This has enabled diversification to other commodities. (6) Finally, the state system's dominance in most commodity research is amply brought out by the results, as is its mediating role between the central and local institutions. These have to be borne in mind as strengthening and revamping of public agricultural research system is contemplated.

Meaningful intra-group analysis is possible only with respect to major groups–cereals, pulses, vegetables, fruits, oilseeds, fibres, livestock, and fisheries. As shown earlier (Table 5.5), together, these eight groups employ nearly four-fifths of the total scientific-manpower resources. Figure 5.3 presents the profile for the country as a whole, and Tables 5.8 through 5.15 show institution-wise picture with respect to each of these groups.

Figure 5.3 shows that rice and wheat account for nearly 68 per cent of all the cereal research in the country. Maize ranks next, followed by major millets. Rice research dominates all public research on cereals (Table 5.8). Together with wheat, it accounts for more than 76 per cent in ICAR, 66 per cent in SAUs, and 74 per cent in 'other' public institutions. Maize and major millets follow next. The private sector emphasizes on maize, rice comes next.

Pulses research is more diversified and nationally, gram, pigeon pea, green gram, cowpea and lentil are emphasized (Fig. 5.3). ICAR's pulse research

Fig. 5.3. Allocation of research resources by major commodity groups

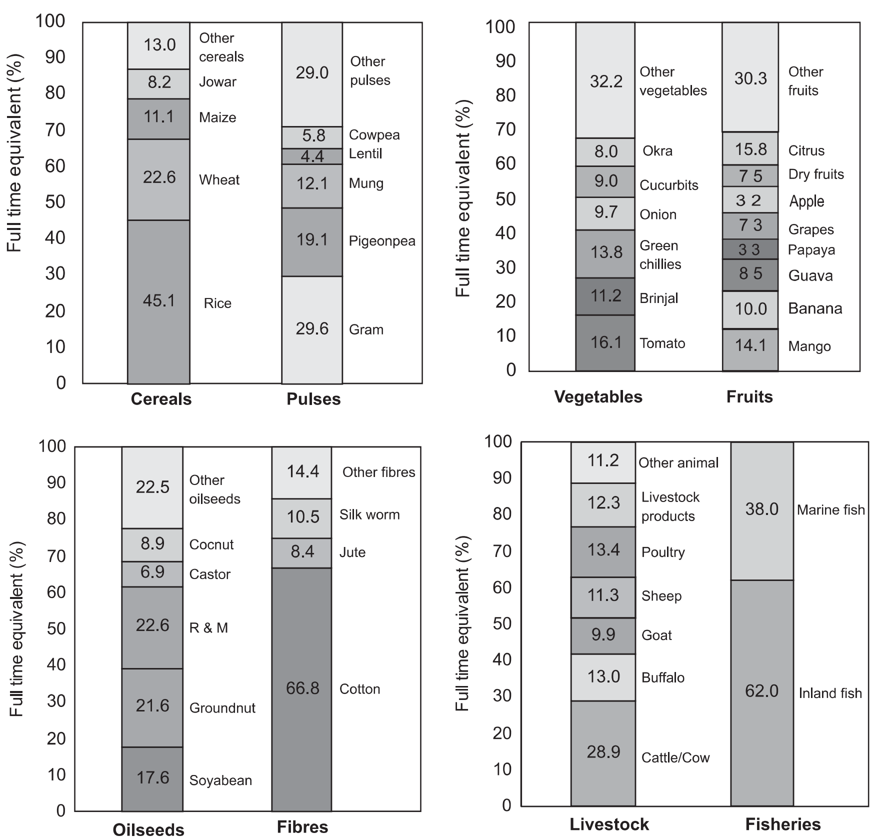


Table 5.8. Commodity-wise allocation to cereals group

(Per cent)

Commodities	ICAR	SAUs	Other public	Private
Rice	51.6	43.8	46.8	26.5
Wheat	24.7	22.4	27.7	4.6
Jowar	6.9	8.9	5.1	10.1
Bajra	0.6	2.7	1.7	1.5
Maize	8.9	10.1	8.3	43.0
Barley	1.5	1.7	1.4	-
Other cereals*	5.8	10.4	9.0	14.3

* Coarse cereals, triticale, nagli, ragi, and food product
Source: ASC (2001-02)

has a sharper commodity focus as compared to that of other public institutions (Table 5.9). Private sector has insignificant presence in pulses research, confined only to gram.

Table 5.9. Commodity-wise allocation to pulses group

(Per cent)

Commodities	ICAR	SAUs	Other public	Private
Gram	25.0	30.7	32.1	100.0
Pigeonpea	23.6	18.5	7.6	-
Mung	23.1	9.0	8.6	-
Lentil	10.6	2.7	3.8	-
Cowpea	1.4	5.7	26.7	-
Other pulses*	16.3	33.4	21.2	-

* Rajmah, dry pea, khesari, other pulses, legumes, moth, and guarseed
Source: ASC (2001-02)

Horticulture has the most diverse research portfolio; it includes not only fruits, vegetables and flowers, but also other groups (tubers, aromatic/ medicinal, condiments/spices, etc.). Detailed break-up has been provided only for vegetables and fruits. Nationally, Fig. 5.3 shows that tomatoes, chillies, brinjal, onion, cucurbits, and okra among vegetables, and citrus, mango, banana, guava, grapes, papaya, and apples among fruits, receive significant research attention. As expected, Tables 5.10 and 5.11 suggest higher diversification in the state and 'other' public institutions.

Table 5.10. Commodity-wise allocation to vegetables group

(Per cent)

Commodities	ICAR	SAUs	Other public	Private
Onion	16.4	7.6	20.5	6.3
Brinjal	2.7	13.0	9.0	18.3
Cabbage	7.2	4.3	-	3.2
Cauliflower	-	1.3	9.4	7.1
Okra	4.5	9.2	-	10.1
Green pea	-	0.2	4.4	-
Tomato	15.6	16.6	6.8	18.1
Green chillies	7.7	16.2	14.0	8.5
Carrot	4.0	0.9	-	-
Mushroom	-	1.0	27.6	-
Garlic	-	1.2	4.3	-
Cucurbits*	9.4	7.7	-	24.6
Other vegetables#	32.7	20.7	4.0	3.8

* Pumpkin, watermelon, melon, bitter gourd, bottle gourd, cucumber and other gourds
# Radish, capsicum, beans and other vegetables
Source: ASC (2001-02)

Table 5.11. Commodity-wise allocation to fruits group

(Per cent)

Commodities	ICAR	SAUs	Other public	Private
Apple	-	4.4	6.2	-
Grapes	13.2	5.4	-	-
Guava	4.7	10.3	6.6	-
Litchi	-	0.3	7.6	-
Mango	12.1	15.2	14.3	-
Papaya	3.1	2.9	2.9	28.9
Banana	6.8	10.7	13.0	33.0
Other arid fruits*	-	3.7	5.8	-
Dry fruits#	7.0	8.5	0.6	-
Citrus fruits@	17.4	15.3	16.2	4.7
Other fruits**	35.7	23.6	26.8	33.4

* Ber, custard apple, amla, other arid fruits
# Almond, cashewnut, apricot, walnut, date palm, other dry fruits
@ Mausambi, lemon, orange, kinnu, other citrus fruits
** Plum, jamun, jackfruit, tropical fruits, sub-tropical fruits, other fruits, chikoo, pomegranate, pear, peach, strawberry, sapota, pineapple
Source: ASC (2001-02)

Private research institutions focus more on cucurbits, brinjal, tomato, okra, chillies, cauliflower, and onion. We note that potato is not included in this group. Among fruits, citrus, mango, grapes, arid / dry fruits and banana are more prominent in ICAR (Table 5.11). Downstream institutions emphasize on guava, apple, and litchi, in addition. Papaya and banana are important in the private sector.

Oilseeds and fibres are the other important groups for which institute-specific details are provided in Tables 5.12 and 5.13. At the national level, Fig. 5.3 identifies rapeseed/mustard, groundnut, soybean, coconut, and castor as the prioritized oilseeds, though a number of other crops also receive attention. Relative to the SAUs, ICAR pays more attention to soybean, rapeseed/mustard, coconut and oilpalm (Table 5.12).

Table 5.12. Commodity-wise allocation to oilseeds group

(Per cent)

Commodities	ICAR	SAUs	Other public	Private
Soybean	25.2	14.6	17.1	21.5
Groundnut	12.1	24.9	32.4	9.1
Rapeseed/mustard/toria	26.8	20.7	29.9	15.3
Linseed	-	1.1	3.0	5.0
Sunflower	-	2.6	4.0	29.8
Castor	4.5	7.8	-	19.4
Nigerseed	-	0.1	4.7	-
Coconut	13.7	7.5	7.3	-
Oilpalm	6.4	0.3	-	-
Other oilseeds*	11.5	20.3	1.6	-

* Sesamum, safflower

Source: ASC (2001-02)

Table 5.13. Commodity-wise allocation to fibres group

(Per cent)

Commodities	ICAR	SAUs	Other public	Private
Cotton	75.5	72.1	4.5	95.0
Jute	9.3	10.5	1.9	0.3
Sisal	1.4	0.9	-	-
Mesta & sunhemp	-	0.3	0.7	-
Other fibres*	13.9	16.1	93.0	4.7

*Fibres, silk, clothing & textile

Source: ASC (2001-02)

In livestock, cattle, buffalo, poultry, goat and sheep account for nearly four-fifths of all research resources (Fig. 5.3). Livestock products are also important. The remainder is allocated to a number of other animals and birds. Institution-wise profile (Table 5.14) shows that ICAR is the lead player in camel, equines, yak/mithun, where other institutions have insignificant research and the private sector has no research at all. In terms of livestock commodities, ICAR and SAUs appear to have the same priorities. In other institutional categories ('other' public and private), the FTE numbers are too small for constructing a meaningful profile. In fisheries research as well, only a marine-inland break-up is possible. Figure 5.3 shows that 62 per cent of research resources are devoted to the inland fisheries sector. In Table 5.6, we see that almost all fisheries research is in the public sector and about four-fifths of this is in ICAR. The current profile, shown in Table 5.15, clearly indicates that the inland fisheries bias is driven mainly by ICAR, perhaps in response to the rising domestic demand and historical neglect of this sector in fisheries research in the state. What is surprising is the response of the small private R&D sector which also accords relatively high priority to the inland fisheries.

Table 5.14. Commodity-wise allocation to livestock group

(Per cent)

Commodities	ICAR	SAUs	Other public	Private
Cattle / Cow	21.5	35.2	19.3	62.0
Buffalo	16.9	11.0	9.0	-
Goat	16.3	6.9	1.6	-
Sheep	16.7	9.4	0.9	-
Camel	2.7	0.2	-	-
Poultry	12.3	15.6	3.3	30.5
Rabbit	-	0.9	1.9	-
Yak / Mithun	0.7	0.2	-	-
Donkey / Mule / Equine / Horse	1.9	0.3	-	-
Livestock products*	8.0	8.1	56.6	-
Other animals#	2.9	12.2	7.3	7.5

* Other livestock products, milk, meat, honey, wool

Dog, rodents, wild animals, deer, lab animals, invertebrates, rat, canine, duck/ other birds, pig

Source: ASC (2001-02)

Table 5.15. Commodity-wise allocation to fishery group

(Per cent)

Commodity	**ICAR**	**SAUs**	**Other public**	**Private**
Marine Fish	34.8	53.1	31.9	53.6
Inland Fish	65.2	46.9	68.1	46.4

Source: ASC (2001-02)

3. Resource focus of agricultural research

Agricultural research is mostly mediated through production resources– genetic material, land, energy, water, agro-chemicals, and so on. This is well-recognized and more than 96 per cent of the respondent scientists identified the resource focus of their research (Table 3.4). Figure 5.4 summarizes the census results in terms of major resource groups, and Table 5.1 shows the institution-wise position. It was not always possible to segregate individual resources from scientists' data. Many researchers, for example, combined soil and water, or power and machinery in their responses. Data presented in this section are at the aggregate level only.

Fig. 5.4. Allocation of research resources by major resource groups (per cent)

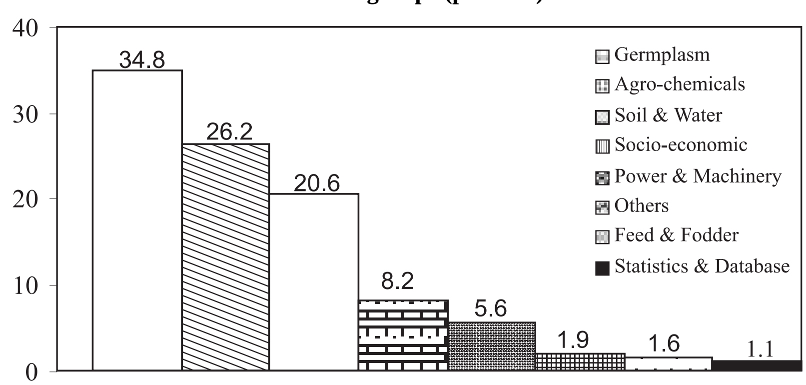


Figure 5.4 shows that nearly 35 per cent of research is focused on germplasm resources, seeking to raise the potential, resilience, and quality of the existing cultivars/breeds. The bias in favour of germplasm resources is a global phenomenon and arises from enormous opportunities which have opened-up in this area. More than 55 per cent of research manpower

is engaged in trying to raise the productivity of natural resources (germplasm, land and water). There is enormous heterogeneity in these endowments across the country which must be investigated and exploited through research. This is reflected in the data.

Material resources agro — chemicals and power/machinery — have contributed significantly to agricultural intensification in the country and together, these claim about one-third of all resource-focused research. Agro-chemicals have been the dominant component of this with more than 26 per cent of research resources. The socio-economic environment encompassing human, institutional, infrastructural, and information resources, is an important determinant of agricultural performance and more than 9 per cent of resources are focused on it. As a caution, it should be noted that a fair amount of socio-economic research in agriculture is conducted in institutions outside the agricultural research system and the census did not cover these. Feed and fodder resources, which are important for the livestock sector, appear to be neglected even if the effort in commodity-oriented research (fodder crops in Table 5.5) is factored in.

Table 5.16 shows that this broad pattern holds across all the public institutions. Significant deviations include a relatively large emphasis on

Table 5.16. Resource-focused research by institutions

(Per cent)

Resource group	ICAR	SAU	Other public	Total public	Private
Germplasm	32.3	32.9	45.5	33.8	52.2
Soil / Water	25.9	20.3	16.6	21.6	3.1
Agro-chemicals	21.6	30.2	20.1	26.8	16.9
Power/Machinery	7.0	3.4	6.8	4.8	19.4
Feed / Fodder	1.5	1.8	1.6	1.7	0.1
Socio-economic	6.4	10.1	5.8	8.7	1.7
Statistics/Database	2.7	0.5	0.3	1.1	0.9
Others*	2.6	0.8	3.3	1.5	5.7
Total	100.0	100.0	100.0	100.0	100.0

* Includes fungi /algae/ bacteria, insect/ pest/ parasite, weed /sea weed, gases

Source : ASC (2001-02)

soil/water and power/ machinery research in ICAR, agro-chemicals in SAUs, and germplasm resources in 'other' public institutions (because of greater emphasis on varietal assessment work in grassroot level institutions). These are consistent. Private sector research is sharply biased towards germplasm and power/machinery and, with agro-chemicals, these account for 88 per cent of private resource-based research. It has hardly any soil-water research.

Agro-chemicals (fertilizers, pesticides, weedicides, fungicides, drugs/ vaccines, other chemicals) rank second overall. The spill-over potential in this category is believed to be high and a few good institutions nationally could meet the requirement. Yet, state-level institutions seem to accord disproportionately high priority to this sector. This is necessitated by large variations in the local agro-climatic conditions. Considerable downstream research is needed before optimal input-use strategies are finalized. Most of the SAU-research in agro-chemicals is perhaps of this genre. Private sector is the major player in this research globally; Table 5.16 does not show this pattern. Energy (power and machinery) resources account for 5.6 per cent of resource-focused research nationally (Fig. 5.4), less than 5 per cent in the public institutions, and only 3.4 per cent in the SAUs. As expected, private R&D pays significantly more attention as compared to other institutions.

Non-material resources (socioeconomics and statistics) account for a little more than 10 per cent of research resources, most of it relates to socio-economic factors. The ICAR-SAUs system, particularly the latter, pays more attention and the private sector does not accord any priority to this area. It has been mentioned earlier that human, social, economic, and institutional resources have not traditionally been the part of agricultural research till a few decades ago. This analysis underestimates the national socioeconomics research by excluding non-agricultural research institutions.

Table 5.17 shows quite clearly the dominance of public institutions, particularly the SAUs, in all resource-based research. With respect to natural and other non-tradable resources, this is expected; for tradable resources like agro-chemicals and power and machinery, the private sector is expected to play a greater role in the future. Table 5.16 shows that even though their size is small, the private research is focusing in these areas.

Table 5.17. Share of institutions in resource-focused research

(Per cent)

Resource group	ICAR	SAUs	Other public	Total public	Private	All units
Germplasm	26.1	54.4	11.2	91.6	8.4	100.0
Soil / Water	35.5	56.7	6.9	99.2	0.8	100.0
Agro-chemicals	23.2	66.3	6.9	96.4	3.6	100.0
Power/Machinery	35.4	34.6	10.6	80.6	19.4	100.0
Feed / Fodder	26.6	64.6	8.9	99.6	0.3	100.0
Socio-economic	22.2	71.1	5.6	98.9	1.2	100.0
Statistics/Database	68.5	24.5	2.4	95.3	4.7	100.0
Others*	39.5	29.4	14.4	82.9	17.1	100.0
All resources	28.2	57.6	8.6	94.4	5.6	100.0

* Fungi /algae/ bacteria, insect/ pest/ parasite, weed /sea weed, gases
Source: ASC (2001-02)

With improvement in investment environment, this pattern is likely to evolve further.

The Kendall coefficient of concordance indicated similarities in priorities assigned to different resources by institutions. The coefficient value (0.876) had a highly significant Chi-square value (24.53), leading to rejection of independence hypothesis. The rank correlations were worked out to provide sharper details (Table 5.18). The value indicates that there are similarities in rankings amongst all the public institutions. The private sector has a completely different orientation.

Table 5.18. Spearman rank correlations between resource group by institutions

Institutions	ICAR	SAUs	Other public	Private
ICAR	1.00	0.857*	0.904*	0.714
SAUs		1.00	0.952*	0.619
Other public			1.00	0.809
Private				1.00

* indicates significance at 1 per cent level

4. Regional focus of agricultural research

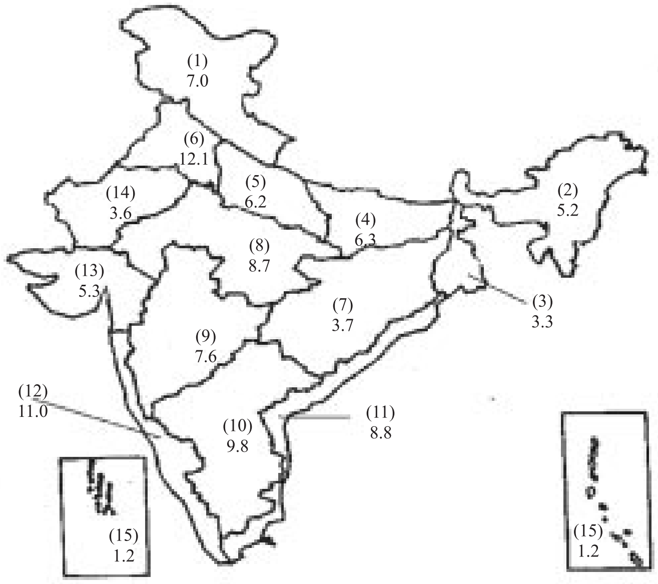
Indian agriculture is highly diverse. Agro-climatic, social, cultural and economic differentiations have given rise to a myriad of farming and production systems. Everyone agrees that agricultural development strategies must factor in this diversity. This is even more crucial for R&D planning because technology interacts strongly with agro-ecological and socio-economic variables. Regionalization is, therefore, important. All public research institutions have identified relevant regions-based on their mandate. The Planning Commission and subsequently, the ICAR demarcated 15 major zones and 126 agro-climatic zones in the country, respectively. In this study, the classification of Planning Commission has been adopted. As indicated in Chapter 3, ICAR's (NARP) zones were integrated with these to accommodate individual scientists' responses.

Figure 5.5 shows the distribution of national research resources over the 15 Planning Commission Zones. Overall, 58 per cent of all scientific-manpower resources are deployed over six zones – 6, 8, 9, 10, 11, and 12. Zones 3, 7, and 14, which are relatively important from poverty point of view, claim a relatively small (10.6 per cent) share.

The green revolution focused on the Gangetic Plains and these (Zones 6, 5, 4, 3) still claim 28 per cent of national research resources. These are areas where intensification has been and continues to be pursued. The western and eastern coast regions (Zones 12 and 11) are also high potential areas and 20 per cent of research resources are allocated there. Rainfed, semi-arid and arid agriculture dominates in Zones 7, 8, 9, 10, 13, and 14. Nearly 39 per cent of research resources are currently deployed in these regions. Together with the hill areas (Zones 1 and 2), these lagging regions claim 50 per cent share of national research.

Table 5.19 presents the estimates of zonal distribution of resources for each institutional category. It shows that the aggregate pattern shown in Fig. 5.5 is influenced by the variation in the research-resource situation in states. Zones which have strong SAUs (6, 8, 9, 10, 11 and 12) have larger shares. More than 56 per cent of ICAR resources are in six zones (Zones 4, 5, 8, 10, 11, and 12), the last four have strong state-support

Fig. 5.5. Allocation of research resources by agro-climatic zones



Figures within parentheses indicate Planning Commission Zones (1. Western Himalayas; 2. Eastern Himalayas; 3. Lower-Gangetic Plains; 4. Middle-Gangetic Plains; 5. Upper-Gangetic Plains; 6. Trans-Gangetic Plains; 7. Eastern Plateau & Hills; 8. Central Plateau & Hills; 9. Western Plateau & Hills; 10. Southern Plateau & Hills; 11. East Coast Plains and Hills; 12. West Coast Plains and Hills; 13. Gujarat Plains & Hills; 14. Western Dry; 15. The Islands)

also. 'Other' public institutions are concentrated in the Himalayan region (Zones 1 and 2), Middle-Gangetic Plains (Zone 4) and the east and west coast (Zones 11 and 12) regions. More than 58 per cent of their resources are in these regions. Private sector investments are small, and at this time these appear to be spread everywhere.

The CV value across zones is the lowest for the private R&D. ICAR has a balancing role, as indicated by its lower CV (41 percent) as compared to that of SAUs (53 per cent). 'Other' public institutions show more uneven distribution over zones (64 per cent).

One presumes that the zonal allocation profile is related to the relative size of the zones. We have used the relative share of zones in the gross area of

Table 5.19. Regional focus of research resources by institutions

(Per cent)

Region*	ICAR	SAUs	Other public	Total public	Private	All units
1. Western Himalayas	6.4	7.5	8.4	7.2	4.2	7.0
2. Eastern Himalayas	6.5	3.9	9.9	5.3	4.0	5.2
3. Lower-Gangetic Plains	4.4	2.7	3.0	3.3	4.2	3.3
4. Middle-Gangetic Plains	7.4	4.3	13.8	6.2	9.3	6.3
5. Upper-Gangetic Plains	9.3	4.4	6.0	6.1	9.3	6.2
6. Trans-Gangetic Plains	6.8	16.4	6.7	12.3	6.0	12.1
7. Eastern Plateau & Hills	4.7	3.1	4.1	3.7	4.6	3.8
8. Central Plateau & Hills	10.3	8.7	4.6	8.8	6.8	8.7
9. Western Plateau & Hills	6.1	8.9	4.4	7.6	8.6	7.7
10. Southern Plateau & Hills	9.6	10.1	7.2	9.7	11.5	9.8
11. East Coast Plains & Hills	10.5	7.7	9.8	8.8	8.8	8.8
12. West Coast Plains & Hills	9.4	11.4	15.9	11.2	7.8	11.0
13. Gujarat Plains & Hills	3.2	6.8	2.9	5.3	6.3	5.3
14. Western Dry	2.6	4.3	1.7	3.5	4.6	3.6
15. The Islands	2.9	0.0	1.5	1.1	3.9	1.2
All regions	100.0	100.0	100.0	100.0	100.0	100.0
Coefficient of variation	40.8	53.2	63.8	47.3	36.5	45.8

*Planning Commission zones

the country as a proxy. The correlation between the two is positive (0.38) but not statistically significant. This implies that mere area of the zone is not an adequate determinant of relative priority. Value of production (VOP) is another indicator of the size in economic terms. These data are not available. As an approximation, value of crop and livestock production was used (Rao 2004, personal communication). The correlation between research and VOP shares of zones worked out to be 0.19 and was not statistically significant. It implies that size of the zone does not affect research share. It has been indicated earlier that regions pushing yield frontiers and sustainability are high on the current priority scheme, as are low productivity regions (rainfed, semi-arid and hills).The latter are also important from poverty point of view. Table 5.20 substantiates these findings. State

Table 5.20. Share of institutions in regional research

(Per cent)

Regions	ICAR	SAU	Other public	Total public	Private	All units
Western Himalayas	26.8	59.4	10.6	96.8	3.2	100.0
Eastern Himalayas	37.1	41.9	16.9	95.8	4.2	100.0
Lower-Gangetic Plains	39.6	45.4	8.1	93.1	6.8	100.0
Middle-Gangetic Plains	34.6	38.3	19.3	92.1	7.9	100.0
Upper-Gangetic Plains	44.2	39.2	8.5	92.0	8.0	100.0
Trans-Gangetic Plains	16.6	75.9	4.8	97.3	2.7	100.0
Eastern Plateau & Hills	37.0	46.8	9.6	93.4	6.6	100.0
Central Plateau & Hills	35.1	56.0	4.7	95.8	4.2	100.0
Western Plateau & Hills	23.5	65.4	5.1	94.0	6.0	100.0
Southern Plateau & Hills	29.3	57.9	6.5	93.7	6.3	100.0
East Coast Plains & Hills	35.6	49.2	9.8	94.6	5.4	100.0
West Coast Plains & Hills	25.4	58.1	12.7	96.2	3.8	100.0
Gujarat Plains & Hills	17.7	71.1	4.8	93.7	6.4	100.0
Western Dry region	21.6	67.4	4.2	93.2	6.8	100.0
The Islands	71.6	0.0	11.3	82.5	17.5	100.0
All regions	29.7	56.1	8.8	94.6	5.4	100.0

*Planning Commission zones

institutions contribute more than 56 per cent to zonal research on an average, and nearly 30 per cent is contributed by ICAR. The SAUs share exceeds the national average in five zones (1, 6, 8, 9, 14), in all but one of these, ICAR's share is below the national average. The correlation between the two works out to be (-) 0.94. This clearly indicates that ICAR explicitly takes local research capacity into account while allocating its resources to regions. It is expected to do so.

Once again the difference in ranking accorded to zones by institutions was tested using the coefficient of concordance (W) and Spearman rank correlations. The vales of W (0.523) and Chi-square (29.28) were not able to discern differences in ranking by institutions.

The correlations reported in Table 5.21 reveal that all institutions broadly follow ICAR's lead in regional resource allocation. This is expected because only ICAR has a national vision. There is no logical reason to

Table 5.21. Spearman rank correlations between regions by institutions

Institutions	ICAR	SAUs	Other public	Private
ICAR	1.00	0.606*	0.743*	0.671*
SAUs		1.00	0.454	0.567
Other public			1.00	0.413
Private				1.00

* indicates significance at 1 per cent level

expect association in priority of different institutions because those are more region-specific. The correlations in Table 5.21 are not statistically significant.

Chapter 6

RESOURCE USE EFFICIENCY

Assessing efficiency of research resource use and allocation is a tentative task at most of times. R&D is a long-term and highly uncertain process. Nevertheless, research managers and institutions are compelled to model this as they allocate limited research-resources to the competing goals and programmes. Historically, their experience and knowledge of agriculture, its critical constraints, and opportunities offered by science have stood them in good stead. Ex-post evaluations showing high rates of returns to investments in agricultural research bear testimony to the efficacy of this subjective decision process.

It has been argued that research goals have become more complex now and it has become necessary to inject quantitative and diverse information and analysis in the research resource allocation decision process. Attempts have been made to develop normative research resource allocation scenarios at the national level based on multiple criteria (Jha *et al*. 1995, Birthal *et al*. 2002, Mruthyunjaya *et al*. 2003). Such studies have pointed out that to be really able to contribute to decision-making, these must be compared with the existing resource allocation profiles. This could not be attempted because data were not available. The census data enabled some analysis along these lines in this study. This is the first such attempt at the national level.

The simplest assessment of rationality involves comparing research resource allocation with the relative economic importance of different commodities measured in terms of value of output (VOP). Estimates of such congruity, measured as congruity index, are presented in Table 6.1 for all commodities and within individual commodity groups.

A very high level of congruence is indicated for all commodity-oriented research. An index value of 0.96 implies that, on the whole, research managers have been responsive to the criteria of economic importance of the commodity, the primary determinant of research productivity from institutional point of view. Within groups also, allocation of resources to individual commodities appears to be in line with the relative economic importance. Condiments and spices and, to some extent, plantation crops are exceptions. The former appears under-researched and the latter receives disproportionately high attention.

Table 6.1. Congruity index for major commodity groups

Commodity groups	Per cent share		Congruity index
	VOP	FTE scientists	
Cereals (8)	25.8	23.65	0.965
Pulses (7)	3.8	6.79	0.987
Fruits (12)	8.8	8.28	0.926
Vegetables (10)	8.8	6.11	0.969
Condiments/spices (13)	2.9	1.72	0.367
Plantations (4)	2.3	6.58	0.817
Oilseeds (10)	4.7	9.45	0.920
Fibres (5)	3.4	6.98	0.909
Livestock (3)	26.7	15.8	0.938
All commodities (80)	100.0	100.0	0.958

Notes : 1. Figures within the parentheses indicate the number of commodities within each group

2. Congruity index for commodity groups having two commodities or less were not measured. However, commodity groups having single commodity too have been included in all commodities in estimation of congruity index. The FTE shares do not match those in Table 5.5 because this table relates to 80 commodities only for which VOP data were available

Accord between value-based priority and that revealed by relative distribution of scientists was also assessed by working out rank correlations. These have been shown in Table 6.2 for each institutional category. Except for the 'other' public and private categories, the null hypothesis of independence has been rejected at 1 percent probability level. This implies similarity in priority ranking; in other words, the existing research resource allocation in the ICAR-SAU system which accounts for 83 per cent of national research resources, is in line with the economic importance of commodities. In the 'other' public and private categories, research is either locally focused or targeted to few specific commodities and not to VOP rankings.

Table 6.2. Estimated rank correlation coefficients: VOP and FTE shares

Particulars	Spearman rank coefficients (r s)
ICAR	0.737*
SAUs	0.786*
Other public	0.317
Total public	0.754*
Private	0.453
All units	0.725*

* Significant at 1 per cent level (one-tailed test)

Though the above analysis indicates overall efficiency in resource allocation, it is a naïve approach with limited discriminatory power. A number of other objectives like sustainability, equity, trade and value-addition, diversification, etc. have also become important. In the next step, a simple scoring model was adopted to generate a normative allocation profile. Growth, equity, sustainability, and value-addition/trade were the goals considered in this exercise; these were assigned weightages of 0.40, 0.10, 0.25, and 0.25, respectively. The available database would easily permit evaluation of alternative weighting schemes. The final base-line (FBL) figures obtained from this exercise indicate the normative shares of important commodity-groups based on multiple criteria. These are presented in Table 6.3. In most cases, the difference between VOP share (Table 6.1) and modified values (FBL) are marginal. A comparison of results of this study with earlier studies (Jha *et al*. 1995 and Mruthyunjaya *et al*. 2003) showed a similar pattern in allocation of resources. But, this study emphasizes for more importance to be given to the horticulture and livestock sector.

The last two columns of Table 6.3 are relevant for rationality assessment. A ratio (FBL/FTE) greater than unity implies the need for flow-in of resources at the cost of those where the ratio is smaller. The last column shows the needed shifts in the existing level of research resources. These shifts are on the margin. The following adjustments are indicated by this analysis.

Table 6.3. Optimal allocation profile and adjustment coefficients

Commodity groups	Optimum shares (FBL)*	FBL/FTE	Shift in existing resources (%)
Cereals	0.2440	1.031	+ 3.19
Pulses	0.0401	0.591	- 40.92
Fruits	0.0923	1.115	+ 11.48
Vegetables	0.0893	1.461	+ 46.13
Tubers	0.0119	0.408	- 59.22
Condiments/ spices	0.0282	1.644	+ 64.49
Medicinal/ aromatic	0.0065	0.350	- 65.01
Plantations	0.0197	0.299	- 70.02
Commercial crops	0.0461	0.938	- 6.19
Oilseeds	0.0512	0.541	- 45.84
Fibres	0.0292	0.418	- 58.14
Livestock	0.2914	1.843	+ 84.31
Fish	0.0499	1.016	+ 1.66
All commodities	1.0000		0.00

* FBL stands for final base-line. These figures have been derived by factoring in the criteria of growth, equity, sustainability, value-addition and trade. The scores given to broad commodity groups and composite scores obtained are shown in Annexure 6.1

Note: Medicinal/aromatic plants include flowers and ornamental group. Commodity groups like 'trees and plants' and 'fodder crops' could not be included because of inadequate data.

Source: ASC (2001-02)

Particulars	Commodities
Augmentation of resources	Cereals, Vegetables, Condiments/ spices, Fibres, Livestock
At the cost of	Pulses, Tubers, Medicinal/aromatic, Plantation crops, Oilseeds, Commercial crops

Some of these adjustments imply small percentage changes (cereals, fish), but in other cases, relatively large shifts are indicated. Some of these appear to be counter-intuitive–the suggestion to withdraw resources from oilseeds, commercial crops, pulses, for example. There are other factors like foreign-exchange compulsions, nutrition, projected scenarios, etc. which this analysis has not considered but decision-makers must reckon these. Even more important is the limitation that this static exercise does not factor in past adjustments, which go on constantly. The intention of this exercise was to make the direction of trade-off explicit. In deciding the magnitudes, policy planners have to consider these aspects also.

A similar framework was employed to look at the rationality of regional allocations. This exercise was confined to VOP comparisons only because other data to construct FBL could not be collected at the regional level. Table 6.4 shows the VOP and the existing as well as readjusted FTE shares for 14 agro-climatic zones.

Table 6.4. Reallocation of research resources by regions

Regions*	Percent VOP# (crop and livestock)	FTE scientists (per cent)	Shift in existing resources (per cent)
1. Western Himalayas	3.7	7.1	- 47.80
2. Eastern Himalayas	3.4	5.3	- 35.04
3. Lower-Gangetic Plains	7.5	3.4	+ 124.94
4. Middle-Gangetic Plains	4.6	6.4	- 28.86
5. Upper-Gangetic Plains	16.3	6.3	+ 157.98
6. Trans-Gangetic Plains	15.4	12.2	+ 26.07
7. Eastern Plateau and Hills	9.9	3.8	+ 159.67
8. Central Plateau and Hills	0.3	8.8	- 96.43
9. Western Plateau and Hills	0.4	7.7	- 94.87
10. Southern Plateau and Hills	13.4	9.9	+ 35.64
11. East Coast Plains and Hills	10.3	8.9	+ 15.81
12. West Coast Plains and Ghat	4.5	11.1	- 60.06
13. Gujarat Plains and Hills	8.0	5.4	+ 47.28
14. Western Dry Region	2.4	3.7	- 35.54

* Planning Commission Zones/ Regions
\# Rao (2004), personal communication, these data were not available for the Island zone
Source: ASC (2001-02)

In this case too, high congruity between VOP and FTE shares (index = 0.962) was indicated. However, the Spearman rank-order correlation was very low (0.20) and the null hypothesis of independence could not be rejected. The VOP/FTE ratios suggest that Zones 3, 5, 6, 7, 10, 11, and 13 need greater attention in terms of allocation of resources in order to create a more rational resource-allocation profile.

The rationalization exercise is simplistic and three things need to be noted. First, a major weakness of this analysis is that it is static, it compares the actual and optimum shares in 2001-02. This has introduced bias because resource-allocation decisions factor in past decisions as well as future needs and opportunities, neither of which have been explicitly considered in this exercise. Nevertheless, in today's constrained environment such pointers would be helpful to the decision-makers. These will also assist in planning of incremental (plan) resources. Second, in both commodity and regional allocations, adjustments in the existing allocation of research resources have been indicated. It is emphasized that the direction of these adjustments are more important than the absolute magnitudes. Finally, further research in this area is urgently needed. More elaborate and sophisticated approaches have been proposed and these should be employed.

Chapter 7

SUMMARY AND CONCLUSIONS

This study has been undertaken (a) to provide a quantitative and qualitative inventory of agricultural research resources in the country. There have been some sporadic and partial efforts by individual researchers, but comprehensive information is lacking. As a result, conflicting views have been expressed regarding the level of public commitment to agricultural R&D. Managers of public systems, particularly at the state level, find it difficult to meet the existing and emerging research challenges, others talk about slacks and inefficiencies in the system; (b) to develop a profile of agricultural research resource allocation at the national level. In times of rapidly changing research needs and new institutional modes, such data and analysis are crucial. Here too, past efforts have been partial or normative (Jha *et al*. 1995, Kelly and Rayan 1995, Birthal *et al*. 2002, Mruthyunjaya *et al*. 2003), and a national profile has been lacking; (c) to address the question: Is the existing allocation of research resources consistent with priorities? There have been sporadic attempts in the past confined to specific commodity or region. Some simple quantitative indicators have been used in this analysis to provide a national perspective on this aspect. This is the first effort of its kind in the country. It is hoped that the three issues investigated here will aid agricultural research planning and policy decisions.

This study, sponsored by the Indian Council of Agricultural Research, has used scientific manpower as the indicator of research-resource. A census of all agricultural scientists in the country was conducted during 2001-02 for this purpose, covering all public, private, and non-governmental agricultural R&D institutions. Time allocation and research focus data provided by individual scientists have been used to quantify and designate research resources.

Scientific manpower in agriculture

Inventory

The census of agricultural scientists has covered 556 R&D institutions and 21,869 agricultural scientists in the country. Nearly 96 per cent of them were in the public system, the nascent private system has accounted for only 4.3 per cent of the scientific manpower resources in 2001-02. The SAU system dominates and accounts for 63 per cent. The central research establishment (ICAR) has a little over one-fifth of the scientific manpower. There are a large number of small, non-governmental entities with some research activities. These, and other government departments employ 12.5 per cent scientists.

Time allocation data have been used to quantify the effective scientific manpower. This generated a number of 10,350 full-time equivalent (FTE) agricultural scientists in the country – a figure comparable to that of the USA and second only to China. The manpower shares of ICAR and private sector are higher in FTE terms (at 29.6 and 5.4 per cent, respectively) because of higher time allocation for research in these institutions.

The institutional structure for agricultural R&D is dominated by a few large institutions. More than 85 per cent of scientists are located in 18 per cent of the institutions. 'Other' public and private institutions account for 78 per cent of the institutions in the census: 84 and 78 per cent of these, respectively, were non-viable when assessed against the criterion of minimum critical size of 10 researchers.

It is noted that there has been an erosion of scientific strength at the decentralized (state) level in recent years. Other assessments have pointed out that the financial situation of state agricultural universities has been deteriorating (NAAS 2002). Yet the number of SAUs continues to grow. This implies less per unit financial and manpower support for research and often sub-critical staff strength for effective teaching. The central (ICAR) and private R&D systems enjoy much better financial support per scientist than the state system. Declining support at this level, which accounts for 63 per cent of all scientists in the country, will have serious long-term impact. Already there is concern about productivity of the public research system. Revamping the state system must figure prominently in any scheme of strengthening it.

Attributes

The public agricultural research system compares with the best globally in terms of skill and experience. More than two-thirds of the scientists hold doctorate degrees and their average experience span exceeded 17 years. The disciplinary-mix is also highly diverse. However, there are some worrisome aspects as well. The average age of scientists in the ICAR-SAU system was around 45 years in 2001 and, given the fact that fresh appointments have petered out over the past one decade, it must be significantly higher now. The cadre structure has become top-heavy, partly because of this. In the ICAR-SAU system, only 43-45 per cent of scientists were at the entry level in 2001-02. These numbers would have gone down further since large-scale promotions almost followed the census. Both these aspects — aging and top-heavy hierarchical structure — have adverse productivity impacts which undermine the advantages of high skill and experience levels in the system. Ignoring of these trends will affect the long-run productivity of the R&D system as well as curtail its capacity to tackle emerging problems.

Resource allocation profile

Census results on participation of scientists in various activities have validated the concept of integration of education, research and outreach in the core public system. More than 91 per cent scientists were engaged in research, participation in teaching/training and extension was 70 per cent and 73 per cent, respectively. In terms of time allocation also, a clear bias existed in favour of research. The time allocated for research was significantly higher in the ICAR and private systems than SAUs and 'other' public institutions where teaching and extension activities, respectively, were also important. Over 60 per cent of scientists reported involvement in administration and this claimed 11 per cent of their time. Further analysis on determinants of research time has shown that scientists in smaller research units spend more time on research. Research time has been found to decrease with rise in research hierarchy, and, by association, with age. It has been shown (Jha *et al*. 2004) that both these factors influence research productivity also. These findings make the case against large research institutions and for recruitments at the entry level.

Commodity allocation profile

Analysis of the commodity allocation profile has revealed that the crop sector dominates the agricultural research scenario overwhelmingly. Nearly 80 percent of national research resources are allocated to crops; livestock and fisheries research accounts for 15 per cent and 5 per cent, respectively. The ranking is similar across institutions, but the levels vary. For example, the crop sector receives 95 per cent of the private sector's research resources, ICAR allocates only 70 per cent. 'Other' public and private institutions do not have meaningful fisheries research, the latter give little emphasis to livestock research. The role of ICAR-SAU system in maintaining a diversified research capacity in the country has been clearly brought out. The analysis has further revealed that more than two-thirds of all commodity-based research is focused on food (foodgrains, vegetables, fruits, tubers, livestock, and fish). Food security and hunger continue to be important. Very clearly, the core domains and core concerns of Indian agriculture continue to drive research resource allocation in the public R&D system.

Among major commodity groups, cereals and pulses, livestock, fruits and vegetables, oilseeds, and fibre crops have major research programmes and these accounted for about three-fourths of national research resources. Their share was about 84 per cent in SAUs, 65 per cent in the ICAR, and 52 per cent in the private sector. Private research was most narrowly focused — more than 80 per cent of its resources were allocated to cereals (hybrids), plantation crops, fibres, and vegetables. For several commodity groups (fodder crops, flowers/ ornamentals, medicinal and aromatic plants, condiments and spices), the resource shares at the national level were only 1-2 per cent. This may appear trivial but it should be noted that this amounts to 80-150 FTE researchers! Institutional shares in research has shown the dominant contribution of states (more than 55 per cent) and the balancing role of ICAR in bridging research gaps among commodities.

Analysis based on ranking of different commodity groups in various institutions has revealed an agreement in priorities between ICAR and

SAUs. These are the core constituents of NARS and account for 83 per cent of all research resources. The national research agenda articulated by ICAR is essentially executed by these institutions. The rank correlations substantiate this. The other two institutions — 'other' public and private — have different motivations. Local, regional and market considerations are more important in their case. Accordingly, their priorities are more in sync with SAUs and not with the central institution (ICAR). Absolute emphasis varies between institutions. For example, research on fibres, commercial crops, livestock and fish has received relatively more emphasis in the ICAR while foodgrains, fruits and vegetables and oilseed crops have dominated the SAUs research-mix. 'Other' public institutions have assigned more importance to plantation crops, medicinal/aromatic plants, fibres, and condiments and spices. Private research has emphasized on cereals, vegetables, plantation crops and fibres. The last two categories of institutions have accounted for barely 17 per cent of the total number of scientists and the small numbers have necessitated focus on fewer commodities.

Two important trends have emerged from this analysis. First, ICAR plays an important role in identifying and addressing commodity research gaps in collaboration with SAUs. It is expected to do so as the national institution. Second, SAUs play a crucial bridging role between the national and local/ private institutions. These contribute to national goals by participating in national (ICAR) programmes, and also appear to shape the priorities of other institutions which operate at the state and local levels. These findings are consistent with the idealized vision of the role of different partners in the national system. This differentiation will get sharper.

Detailed information on commodity-wise allocation within each important commodity group — cereals, pulses, vegetables, fruits, oilseeds, fibres, livestock, and fish has been shown for the country as a whole as well as for each institutional category. Differences among institutional categories in this regard have been pointed out. The SAUs dominate the system in terms of research resources. This is also reflected in its share in commodity research in the country.

Resource thrust

The census has revealed that more than 96 per cent of researchers could identify the resource thrust of their work, substantiating the point that almost all agricultural research is mediated through resources — germplasm, soil and water, agro-chemicals, power and machinery, etc. Scientist level data have revealed that nearly 35 per cent of researchers in the country focus on germplasm resources. This is the dominant thrust. Agro-chemicals ranked second with 26 per cent share; nearly 21 per cent is devoted to soil and water research. In fact, nearly 56 per cent of all research is focused on the natural resources (germplasm, soil and water). A wide diversity in agro-ecological environment in the country and the need to study it in depth necessitates this priority. Material resources (agro-chemicals, power and machinery) have claimed 32 per cent. Power and machinery research has accounted for only one-fifth of this, a trend which has to be interpreted in the light of prevalence of low wages till recently. Research on human, institutional, and infrastructural resources has accounted for the rest.

Analysis based on ranks has revealed that all public R&D institutions follow this broad pattern. Private institutions had a different resource-orientation. As per the finding with respect to commodities, ICAR plays an important balancing role. For example, it allocates more resources to soil and water and power and machinery as compared to other public institutions. The SAUs are local-level institutions and need to guide extension services. A sharper focus on agro-chemicals is noted here. Private research is almost totally involved with tradable resources. Germplasm, agro-chemicals and power and machinery account for 88.5 per cent of their research. This is the pattern observed globally and even the infant private R&D sector works exclusively for the market. As expected, the resource-orientations of public and private research institutions have been different. This is expected to become sharper.

It follows from the above that there is no alternative for public R&D for research on public goods. Natural resources, human and institutional resources are areas where private research has very selective interest-domain, driven entirely by the product-specific interests. The contours of public-private partnership in research are being debated and this issue of comparative advantage must figure prominently in these discussions.

Regional orientation

Regional resource-allocation analysis has revealed that six agro-climatic zones — Trans-Gangetic, Central Plateau and Hills, Western Plateau and Hills, Southern Plateau and Hills, East-coast Plains and Hills, and West - coast Plains and Hills — account for more than 58 per cent of all research resources. Lower-Gangetic Plains, Eastern Plateau and Hills, and Western Dry Region are relatively under-emphasized.

It has also emerged that physical size of the zones or its economic importance is not a major determinant of research investment. It is the strength of the state research system within the zone which contributes to the regional capacity. As the main arm of central assistance to state R&D, ICAR has taken into account the local research-capacity and sought to bridge the gaps. A high negative correlation between central and state shares indicates this. ICAR is the only institution which has the analytical capacity to translate national goals in regional terms. Correlations between regional rankings of different institutions have suggested that all of these follow ICAR's lead in allocating resources regionally.

The current regional profile suggests that while public R&D resources are spread everywhere, there is a focus on low productivity (rainfed and hills) zones and on regions which are facing sustainability threat. These priorities are well-merited. A forward looking policy would perhaps call for a change. An open economy perspective calls for production patterns based on specialization and comparative advantage. Public R&D efforts should be attuned to these, as against the present pattern which is built around a common agenda.

Efficiency of resource-use

Simple congruence analysis has revealed that at the national level, research resources are broadly allocated in accordance with relative economic importance of commodities. Institution-wise assessment has revealed that the priorities of ICAR and SAUs research are in accord with the economic criterion, but for 'other' public and private R&D institutions, the two are not. This is what one expects. Mature public system (like ICAR and SAUs) having knowledgeable scientists and consultative processes may lead to this. Further analysis incorporating additional criterion like equity, sustainability, and trade has suggested the need for adjustments in resource allocated to different commodities. It is indicated that research resources need to be augmented for cereals, vegetables, commercial crops, condiments/spices, and livestock, drawing resources from pulses, tubers, medicinal/aromatic, plantation crops, oilseeds, and fibre. Within zones, Lower–Upper, and Trans-Gangetic Plains, Eastern and Southern Plateau and Hills, East Coast, Gujarat Plains and Hills need relatively greater attention.

Such readjustment proposals should be interpreted as indicative. Research resource allocation decisions are complex. In addition to the above, research planners implicitly take into account factors like past investments, severity of constraints, projected supply-demand scenario, probability of success, existing research capacity, etc. These variables have not been modelled in this analysis. As such, it has only provided pointers which would help in improving the information base for decision-making, particularly relating to incremental (plan) resources. More comprehensive analysis must follow the present study.

Research policy issues

- The Indian agricultural research system is one of the largest in the world in terms of scientific manpower. The skill and experience levels are also comparable with the best world over. Is it as productive? The evidence is not reassuring. There are a number of constraints. It operates at low capital intensity and is not able to provide adequate operational back-up to scientists, particularly at the state level. More than 95 per cent of the scientists are in the public institutions and their track record in efficient use of resources has been far from impressive. Raising investment in agricultural research specially at the state level, and ensuring its efficient deployment is the most critical need of the system. Low capital intensity constraints and the numerically dominant state system suffer most.

- The roles of the centre and states need to be re-examined. Centralization of the system has grown over the past few decades. Bridging research gaps in the NARS and responding to the emerging needs and opportunities have necessitated strengthening of ICAR. This study has clearly shown the role played by the ICAR in balancing the research portfolio in terms of commodities, resources and regions. In this process, the numerically dominant system has got neglected. It now plays a secondary role with significantly lower operational support. Unlike ICAR where reforms are always on the agenda, the state system has become passive. This must change. A larger share of enhanced R&D spending should move to the states to overcome the disparity. States focus mainly on applied and adaptive end of the research spectrum but there is no reason to assume that this research is less expensive. The SAUs act as the bridge between central and local R&D and are far more important in technology adoption and use. These cannot be ignored anymore. Policymakers bemoan poor off take of technologies but ignore the primary institution responsible for this.

- The public system suffers from other infirmities. It is aging and has become top-heavy, thanks to unimaginative directives from public finance managers regarding replacement and recruitments. Research productivity cannot be sustained, let alone improved in this environment. Even the current renewal of interest in public R&D sidesteps this issue.

- The overall research resource allocation profile has been found consistent with priorities, but adjustments have been indicated with respect to individual commodity groups and regions. This implies that the efficiency of the existing research-resource bundle can be enhanced by shifting resources among commodity groups and regions. Rationalization of the time allocation profile of scientists and induction of younger scientists have been identified as other avenues for raising effective research input. These are important in times of stressed public funds, because these imply internal resource generation. This study has provided pointers. More in-depth analysis is needed to proceed further along these directions. The model used in this exercise was static and simplistic, and did not factor in many relevant variables. Nevertheless, the information and analysis provided would help in making the process more objective and transparent.

- Rapid growth in private R&D is visualized in the short-to-medium term. The public system will need to respond to this in terms of adjustments in their research and investment portfolios. There are domains of comparative advantage which need to be taken into account. This calls for a public research agenda which makes space for the private research without losing core capacity anywhere. This also provides opportunities for shuffling resources in the long-run. The public-private dialogue in the country has matured enough to embark on this path now.

- Resource allocation is the core theme of this study. The other side of the coin is the efficiency with which research resources are utilized. Imbalances in functional allocation, poor monitoring and evaluation, duplication, bureaucratic rigidities, etc. have been identified as the weaknesses of the public agricultural research system in several reviews of the system. There are other science bodies in the public domain where not much is heard about these. What prevents the public agricultural research system from learning from our own examples? Agricultural research is the largest, most varied and dispersed. Every farmer is a client. These factors call for a far more rigorous decision-making apparatus in agricultural research. This is not appreciated; indeed, in recent years, there have been calls for trimming this capacity. This is not to make a case for more bureaucracy, but for more information and analytical capacity at the institutional level. Unfortunately, this has escaped the attention of various committees which have looked at the needed reforms in public research system.

- Finally, this study has clearly brought out that the core constituents of the public system ICAR and SAUs, allocate their resources broadly in tandem with their mandates. The SAUs are effective partners in executing national research programmes. They also link national and local priorities by influencing the activities of local institutions, public as well as private. There are deficiencies which undermine the potential productivity of the system, but the basic concept of a network of central and state research institutions has been broadly validated by this study and this needs to be strengthened further.

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Annexure 3.1: Census of Scientific Manpower in Agriculture-2001

Please read the instructions carefully

Individual Scientist Proforma

Name of the Institution …………………… Division/Section/Sub-Unit …………………………..

(a) Personal Details

Name of the Scientist	Sex (M/F)	Date of Birth (D/M/Yr)	Last Degree (M.Sc /Ph.D.) and Year	Discipline	Designation	Experience as Scientist (No. of years)
(1)	(2)	(3)	(4)	(5)	(6)	(7)

(b) Focus of Present Research Work (as on March 2001)

Percent time allocated for				Focus of current research work		
Research	Education	Extension	Administration and Others	Commodity (ies)	Resource (s)	Agro-climatic Zone (s)
(8)	(9)	(10)	(11)	(12)	(13)	(14)

Explanatory Note (Instructions)

Section (a) is self-explanatory.

Section (b) seeks to specify in detail the focus of your current work. In columns 8-11, provide in detail the percentage time allocated by you during the current year for different activities. In Col 12, indicate the commodity (crop or animal), and in Col 13, specify the resource on which you are working (fertilizer, soil, water, genetic resource, power, etc.). Please note that crop and resource focus are usually linked. Whenever we work on a crop (or animal) we also focus on a resource (seed, fertilizer, water, etc.) and vice versa. Therefore, normally, both these columns will need to be filled. In Col 14, the geographical zone in which you are working is to be indicated. Most applied research relates to a specific zone or region. Some may have relevance for more than one zone. Others, which are basic in nature, may have even national relevance. Specific NARP, NBSSLUP, Planning Commission or other zonation may be used.

Annexure 3.2.1: Letters from the Director Generals of ICAR

DR. R. S. PARODA
SECRETARY
&
DIRECTOR-GENERAL

भारत सरकार
कृषि अनुसंधान और शिक्षा विभाग एवं
भारतीय कृषि अनुसंधान परिषद
कृषि मंत्रालय, कृषि भवन, नई दिल्ली 110 001

GOVERNMENT OF INDIA
DEPARTMENT OF AGRICULTURAL RESEARCH & EDUCATION
AND
INDIAN COUNCIL OF AGRICULTURAL RESEARCH
MINISTRY OF AGRICULTURE, KRISHI BHAVAN, NEW DELHI 110 001
Tel. 3382629; Fax 91-11-3387293; E-Mail: rsp@icar.delhi.nic.in

D.O. No. Secy. (DARE)/DG, ICAR/2001
February 27, 2001

Dear Dr.

As you are aware, preparations have started for the Tenth Five Year Plan. This is a very important event for us. While there is an awareness that support for R&D needs to be increased, there is equal emphasis on more rigorous analysis of research resource deployment and needs. Stricter financial discipline and accountability is being demanded.

A critical component of such analysis is a study on current deployment of research resources. Only if we have a clear picture of how our resources are presently being used, can we justify future demands. This requires a census of all agricultural scientists in the country and we have decided to undertake this activity. This can be done only with your cooperation and active support and I am writing this letter to solicit the same. We attach very high priority to this activity and I am sure you will find this inventory extremely valuable for your own planning.

Dr. Dayanatha Jha, ICAR National Professor at NCAP and Dr. J.L. Tickoo, ADG (Planning) at the Council are entrusted with this task. They have designed a small questionnaire, which has to filled in by all scientists in your organization, at headquarters and other (regional and zonal) research stations. I enclose a copy of the same. I shall appreciate if you could get the material duplicated on complete enumeration and it will be necessary to provide information even in respect of scientists who may be on leave or training. This task has to be completed by the end of May, 2001.

It will be helpful to identify a senior officer as nodal person who can keep track of progress and be the contact person for Drs Jha and Tickoo. The name of the nodal officer may be communicated by return post to the following address. The questionnaires need to be assembled, checked for total coverage, and then sent to Dr. Jha.

Dr. Dayanatha Jha
ICAR National Professor,
NCAP,
P.O. Box 11305,
New Delhi – 110 012.

I look forward to your cooperation and personal interest in this important task for its timely completion.

With kind regards.

Yours sincerely,

(R.S. PARODA)

Encl: as above.

Annexure 3.2.2: Letters from the Director Generals of ICAR

DR PANJAB SINGH
SECRETARY
&
DIRECTOR-GENERAL

भारत सरकार
कृषि अनुसंधान और शिक्षा विभाग एवं
भारतीय कृषि अनुसंधान परिषद्
कृषि मंत्रालय, कृषि भवन, नई दिल्ली 110 001

GOVERNMENT OF INDIA
DEPARTMENT OF AGRICULTURAL RESEARCH & EDUCATION
AND
INDIAN COUNCIL OF AGRICULTURAL RESEARCH
MINISTRY OF AGRICULTURE, KRISHI BHAVAN, NEW DELHI 110 001
Tel. 3382629; Fax: 91-11-3387293; E-mail: psingh@icar.delhi.nic.in

D.O. No.Secy.(DARE)/DG, ICAR/2001
Dated the 29th November, 2001

Subject: ***Census of Scientific Manpower in Agriculture – 2001***

Dear Dr.

I am writing to you regarding the subject cited above. As you are aware, we have crossed the deadline for receiving the information from scientists of your institution, despite a couple of reminders from my predecessor, Dr.R.S. Paroda. This Census was initiated early this year under the sponsorship of the Council with a view to strengthen our planning process and 10th Plan preparations. I would like to emphasize that the Census has already covered more than four-fifth of the public research system and lack of information from a few institutions is holding up further analysis.

We are very keen that this enquiry, which will be immensely useful for your own planning activities as well, is completed expeditiously. I, therefore, request you to kindly take personal interest in the matter and help us in completing the task. I also enclose earlier communications from the Council in this regard and also a copy of the proforma, which has to be filled in by all scientists (at main campus as well as sub stations). I shall be grateful if you could kindly arrange to have the information completed with the help of the nodal officers at your institution and send it to Dr. Dayanatha Jha, ICAR National Professor at NCAP for further analysis. I have asked Dr. Jha to follow this up with you personally to expedite matters. This may be treated as **MOST URGENT.**

Soliciting your cooperation and with kind regards,

Yours sincerely,

(PANJAB SINGH)

Annexure 3.3.1: Grouping of Disciplines

Code	Disciplines group	Disciplines included
1	Crop Sciences	Biochemistry (Plant), Biotechnology (Plant), Botany, Genetics and Cytogenetics, Plant Breeding, Plant Physiology, Seed Technology, Molecular Biology, Agricultural Entomology, Nematology, Plant Pathology, Zoology, Plant Protection Science, Beekeeping, Microbiology (Plant), Microbial Genetics, Plant Taxonomy, Forest Pathology, Mycology.
2	Horticulture	Floriculture, Pomology, Olericulture, Horticulture.
3	Natural Resource Management	Agronomy, Biophysics, Agrostology, Organic/ Agricultural Chemistry, Agricultural Chemicals, Geography, Pedalogy, Physical Chemistry, Agricultural Physics, Soil Chemistry, Soil Fertility, Soil Physics, Soil Science, Industrial Microbiology, Soil Microbiology, Chemistry, Geology, Ecology, Food Science & Technology, Climatology, Textile Chemistry, Physics, Post-harvest Technology, Agricultural Meteorology, Forestry/Silviculture, Environmental Science, Textile Technology.
4	Engineering Sciences	Dairy Engineering, Fish Processing Technology, Agricultural Structure & Processing Engineering, Chemical Engineering, Electrical Engineering, Electronics & Instrumentation, Farm Machinery & Power, Mechanical Engineering, Soil Water Conservation Engineering, Environmental Engineering, Engineering Science and Technology, Post-harvest Technology /Post-harvest Engineering, Civil Engineering, Irrigation and Drainage Engineering, Food Engineering / Post-harvest Processing.
5	Animal Sciences	Animal Genetics & Breeding, Animal Nutrition, Animal Physiology, Animal Reproduction/ Dairy Production, Biochemistry (Animal), Biotechnology (Animal), Dairy Bacteriology, Diary Chemistry, Diary Technology, Livestock Production and Management, Livestock Products Technology, Microbiology (Animal), Pharmacology & Toxicology, Poultry Science, Veterinary Bacteriology & Virology &

Contd.

Annexure 3.3.1: Grouping of Disciplines - Contd.

Code	Disciplines group	Disciplines included
		Microbiology/Epidemiology, Veterinary Medicines, Veterinary Parasitology, Veterinary Pathology/Animal Virology, Veterinary Public Health, Veterinary Surgery & Radiology and Anaesthesiology, Veterinary Science, Veterinary Helminthology, Veterinary Immunology, Veterinary Gynaecology & Obstetrician, Veterinary Anatomy, Animal Husbandry, Animal Feed Technology/ Feed & Fodder Technology, Ornithology (Birds), Dairy Science.
6	Fishery	Fish and Fisheries Sciences, Fish Breeding, Fish Processing Technology, Marine Biology, Marine Chemistry.
7	Social Sciences	Agricultural Economics, Agricultural Extension, Home Science, Home Science Extension, Human Nutrition, Sociology/Psychology, Food & Nutrition, Business Management, Family Resource Management/Home Management, Anthropology, Child Development, Clothing and Textiles, Political Science, Agricultural Research Management.
8	Others	Statistics & Maths, Computer Sciences, Bio-Informatics.

Annexure 3.3.2: Grouping of Commodities

Code	Commodity groups	Commodity included*
1	Cereals	Rice, Wheat, Jowar, Bajra, Maize, Barley, Food products, Coarse cereals, Triticale, Nagli, Ragi.
2	Pulses	Gram, Pigeonpea, Mung, Lentil, Guarseed, Moth, Cowpea, Rajmah, Dry pea, Khesari, Legumes.
3	Vegetables	Onion, Brinjal, Cabbage, Cauliflower, Okra, Pea green, Tomato, Green chillies, Carrot, Mushroom, Capsicum, Garlic, Beans, Cucurbits, Pumpkin, Watermelon, Melon, Bitter gourd, Bottle gourd, Cucumber, Other gourd, Radish.
4	Fruits	Apple, Chikoo, Pomegranate, Pear, Grapes, Guava, Litchi, Mango, Papaya, Strawberry, Banana, Peach, Sapota, Pineapple, Ber, Custard apple, Amla, Other arid fruits, Almond, Cashew nut, Apricot, Walnut, Date palm, Other dry fruits, Mausambi, Lemon, Orange, Kinnu, Other citrus, Plum, Jamun, Jackfruit.
5	Tubers	Potato, Sweet potato, Other tuber, Yams, Tapioca.
6	Plantation Crops	Tea, Coffee, Rubber, Other plantation crops, Betel vine.
7	Flowers/ Ornamentals	Flowers and Ornamental crops.
8	Medicinal/ Aromatic	Medicinal & Aromatic crops.
9	Condiments/ Spices	Tamarind, Dry chillies, Ginger, Turmeric, Pepper, Areca nut, Coriander, Cardamom, Cumin seed, Nutmeg, Clove, Olive.
10	Oilseeds	Soybean, Groundnut, Rapeseed & Mustard (including Toria), Sesamum, Linseed, Sunflower, Castor, Safflower, Nigerseed, Coconut, Oilpalm.
11	Fibres	Cotton, Jute, Mesta & Sanhemp, Silk, Sisal, Mulberry, Clothing & Textile.
12	Commercial crops	Sugarcane and Tobacco.
13	Fodder Crops	Barseem, Fodder grasses, Forage crops, Oat.
14	Trees and Plants	Bamboo, Teak, Eucalyptus, Neem.
15	Livestock	Cattle / Cow, Buffalo, Goat, Sheep, Camel, Poultry, Duck / Other birds, Rabbit, Pig, Yak / Mithun, Donkey/Mule/Equine/Horse, Milk & milk products, Meat & meat products, Honey, Wool, Dog, Rodents, Wild animals, Deer, Lab animals, Invertebrates, Rat, Canine.
16	Fish	Marine fish, Inland fish, Prawn & Shrimp, Pearl & Mussel, Shell fish, Molluscs, Fresh water fish.

* In all groups, an omnibus category 'Others' have been included

Annexure 3.3.3: Grouping of Resources

Code	Resource group	Resources included
1	Germplasm	Plant germplasm, Animal germplasm, Fishery germplasm
2	Soil-water	Soil, Water
3	Agro-chemicals	Fertilizer, Bio-fertilizer, Pesticides, Agricultural chemicals, Drugs & vaccine, Diagnostics
4	Power and machinery	Power, Computer, Agricultural equipments, Gases, Biogas
5	Feed and fodder	Feed and fodder
6	Human and institutional resources	Statistics and database, Human and institutional resources
7	Socio-economic	Socio-economic factors, Farmers, Human subjects, HRD
8	Others	Fungi/Algae/Bacteria, Insect/Pest/Parasite, Weed/ Sea weed

Annexure 4.1: Number of Scientists by Designation in State Agricultural Universities, 2001

State Agricultural Universities	Assistant Professors	Associate Professors	Professors & above
Assam Agricultural University, Jorhat	98	314	163
Acharya NG Ranga Agricultural University, Hyderabad	554	320	152
Birsa Agricultural University, Ranchi	22	50	20
Bidhan Chandra Krishi Vishwavidyalya, Nadia	79	84	81
Central Agricultural University, Imphal, Manipur	19	10	-
Chaudhary Charan Singh Haryana Agricultural University, Hisar	213	358	301
Chandra Shekar Azad University of Agriculture & Technology, Kanpur	102	77	77
Govind Ballabh Pant University of Agriculture & Technology, Pantnagar	191	83	183
Gujarat Agricultural University, Ananad, Gujarat	388	345	69
CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur	172	101	63
Indira Gandhi Krishi Vishwavidyalaya, Raipur	47	63	12
Jawaharlal Nehru Krishi Vishwavidyalaya, Jabalpur	266	430	23
Kerala Agricultural University, Trichur	201	267	49
Dr Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli	150	65	31
Maharana Pratap University of Agriculture & Technology, Udaipur	163	95	39
Mahatma Phule Krishi Vidyapeeth, Rahuri	354	157	77
Marathwada Agricultural University, Parbhani	109	72	23
Narendra Deva University of Agriculture & Technology, Faizabad	113	57	50
Orissa University of Agriculture & Technology, Bhubaneshwar	127	114	25
Punjab Agricultural University, Ludhiana	498	193	451
Dr Panjabrao Deshmukh Krishi Vidyapeeth, Akola	299	163	54
Rajasthan Agricultural University, Bikaner	264	144	45
Rajendra Agricultural University, Pusa, Samastipur	147	191	14
Sher-e-Kashmir University of Agricultural Sciences & Technology, Srinagar	136	52	24
Sher-e-Kashmir University of Agricultural Sciences& Technology, Jammu	107	47	13
Tamil Nadu Agricultural University, Coimbatore	352	172	206
Tamil Nadu Veterinary & Animal Sciences University, Chennai	225	72	107
University of Agricultural Sciences, Bangalore	210	369	155
University of Agricultural Sciences, Dharwad	337	202	90
Uttar Bangla Krishi Vishwavidyalaya, Coach Behar	34	11	8
West Bengal University of Animal & Fishrery Sciences, Kolkata	44	18	41
Dr Yashwant Singh Parmar University of Horticulture & Forestry, Solan	161	67	42
All units	6182	4763	2688

Annexure 4.2: Number of Scientists by Designation in ICAR Institutes, 2001

ICAR Institutes	Scientists	Senior Scientists	Principal Scientists & above
Deemed universities	359	465	189
Central institutes	1173	960	403
National bureaux	102	111	28
Project directorates	110	102	44
National research centres	208	119	70
All units	1952	1757	734

Annexure 6.1: Scores Assigned to Different Criteria for Resource Allocation

Commodity groups	Scores (scale 1-5)				
	Growth	Equity	Sustain-ability	Value-addition & export	Composite score
Cereals	3	5	4	3	0.7275
Pulses	4	5	5	4	0.9200
Fruits	5	3	4	4	0.9100
Vegetables	4	4	4	4	0.8500
Tubers	1	5	2	1	0.3425
Condiments/ Spices	3	3	4	5	0.8125
Medicinal/ Aromatic	2	2	4	2	0.5250
Plantations	3	1	1	4	0.5600
Commercial	4	1	2	2	0.5650
Oilseeds	5	4	4	5	0.9925
Fibres	3	2	1	4	0.5800
Livestock	5	5	5	4	1.0000
Fishery	3	4	4	5	0.8325

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POLICY PAPER 23

राष्ट्रीय कृषि आर्थिकी एवम् नीति अनुसंधान केन्द्र
National Centre for Agricultural Economics and Policy Research
(Indian Council of Agricultural Research)
Post Box No. 11305, Library Avenue, Pusa, New Delhi - 110012
Phone: +91-11-2584 7628, 2584 8731, Fax : +91-11-2584 2684, E-mail : director@ncap.res.in
http://www.ncap.res.in