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ACRONYMS AND ABBREVIATIONS

AgGDP	Agricultural gross domestic product
AICRP	All India Coordinated Research Project
ARIS	Agricultural research information system
CAG	Comptroller and Auditor General
CGIAR	Consultative Group of International Agricultural Research
CIFE	Central Institute of Fisheries Education
CIMMYT	International Maize and Wheat Improvement Centre
CMIE	Centre for Monitoring Indian Economy
CSIR	Council of Scientific and Industrial Research
CSO	Central Statistical Organisation
DAC	Department of Agriculture and Cooperation
DARE	Department of Agricultural Research and Education
DBT	Department of Biotechnology
DES	Directorate of Economics and Statistics
DRDO	Defence Research and Development Organisation
DST	Department of Science and Technology
DVM	Dummy variable model
ECM	Error components model
FTC	Farmers Training Centre
FTE	Full-time equivalent
GCA	Gross cropped area
GDP	Gross domestic product
GLS	Generalised least squares
GOI	Government of India
IARI	Indian Agricultural Research Institute
IASRI	Indian Agricultural Statistical Research Institute
ICAR	Indian Council of Agricultural Research
IPR	Intellectual property rights
IVRI	Indian Veterinary Research Institute
KVK	Krishi Vigyan Kendra
LLP	Lab-to-Land Programme

MANAGE	National Institute for Agricultural Extension Management
MOA	Ministry of Agriculture
MOF	Ministry of Finance
NAARM	National Academy of Agricultural Research Management
NARES	National agricultural research and extension systems
NARP	National Agricultural Research Project
NAEPV	National Agricultural Extension Project
NARS	National agricultural research system
NATP	National Agricultural Technology Project
NB	National Bureau
NCAP	National Centre for Agricultural Economics and Policy Research
ND	National Demonstration
NDRI	National Dairy Research Institute
NGO	Non-governmental organisation
NRC	National Research Centre
OLS	Ordinary least squares
ORP	Operation Research Project
PD	Project Directorate
PME	Priority setting, monitoring and evaluation
RBI	Reserve Bank of India
R&D	Research and development
SAU	State Agricultural University
TTC	Trainers' Training Centre
T&V	Training and visit (system of extension)
USAID	United States Agency for International Development
WTO	World Trade Organisation
ZARS	Zonal Agricultural Research Station
2SLS	Two stage least squares

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FOREWORD

Analytical work on agricultural research investments has been constrained by lack of reliable data. This report seeks to fill this void by providing detailed time-series data on research and extension investments. This takes our work in NCAP Policy Paper 3 'Research Priorities in Indian Agriculture' further. Analyses of growth in and determinants of research and extension investments would be useful for policy makers and researchers. The authors have also attempted to review and highlight ongoing reforms in the national agricultural research and extension systems, which are intended to improve the efficiency of these investments.

We hope the intended audience will find this work useful. We solicit your comments.

December, 1997 | Dayanatha Jha

New Delhi | Director

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December 1997 Authors

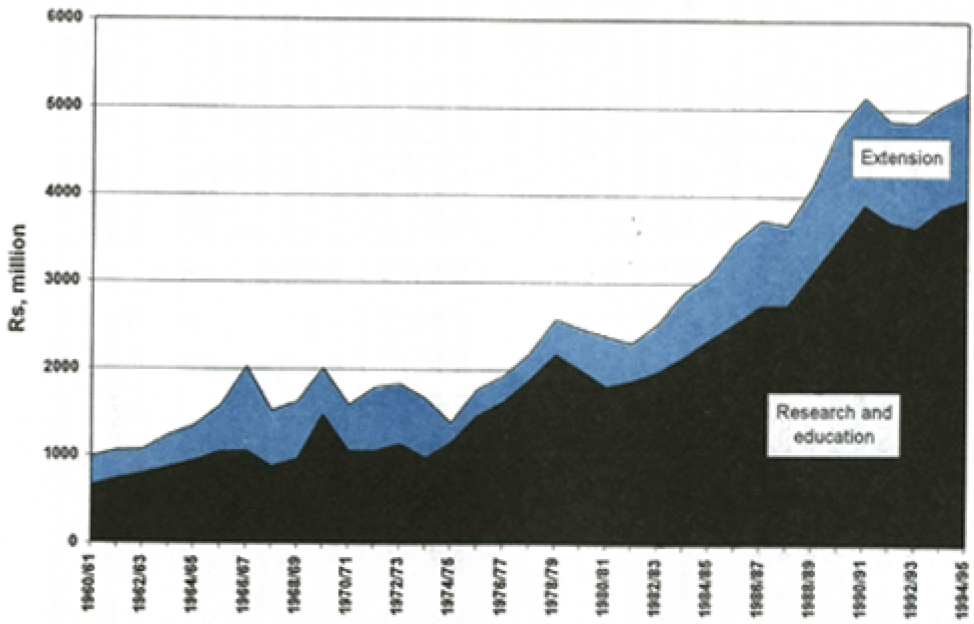
EXECUTIVE SUMMARY

Agricultural research and education system is a three-tier system in India. At the centre, there is Indian Council of Agricultural Research (ICAR) with its 89 institutions to plan, promote, coordinate and execute research in the country. At the state level, there are 28 state agricultural universities (SAUs) and one central agricultural university to impart education and conduct research for the respective states. Affiliated to the SAUs are 120 zonal research stations to conduct adaptive research for the zone. Responsibility of extension lies with the state Department of Agriculture. The ICAR/SAU system undertakes only front-line extension activities. Funding to the ICAR is from the Union Government, while SAUs and extension system are mainly funded by the State governments. Some ICAR funds are also transferred to SAUs in the form of regular grants and research schemes. Participation of corporate sector (both public and private) in funding or execution of agricultural research is nascent, confined to embodied technologies like machinery, fertilizers, pesticides, hybrids and food processing.

The national research agenda is growing rapidly in size and complexity. Acceleration in the growth of food products is still required to feed the growing population. Superimposed to this are the issues of sustainable use of natural resources, diversification towards high value crops, better product quality, bringing fragile areas into main stream of development, export-led growth, etc. These call for much higher degree of research and extension efforts in an efficient institutional and funding framework. The concern is - whether current investment levels are adequate to address new, complex research needs of the country? What best can be done to make research and extension systems more efficient? We present estimates of current investments in research, extension and education, and argue for enhanced funding support, diversified institutional structure and improved management decision support system to increase technical (cost) and allocative efficiency of research and extension systems.

Aggregate public investment in research and education, at 1981/82 prices, has shown consistently high growth (5.4 per cent) since 1960s (Figure 1). The major impetus came in the 1970s when the investment grew at the rate of 9.5 per cent, mainly because of manifold increase in the central funds. The investment, in terms of percentage of AgGDP (excluding forestry) increased from 0.21 per cent in the early 1960s to 0.39 per cent in the early 1980s, which further rose to 0.49 per cent in the early 1990s. The central and state funds contributed almost equally to the national investment. 'Research' intensity (net of education) is 0.42 per cent and the contribution of private sector is only 15 per cent. This level of 'research' intensity is much lower in India compared to 2.4 per cent in the developed countries.

Figure 1
Trends in government real investment in research, extension and education in India (at 1981/82 prices)



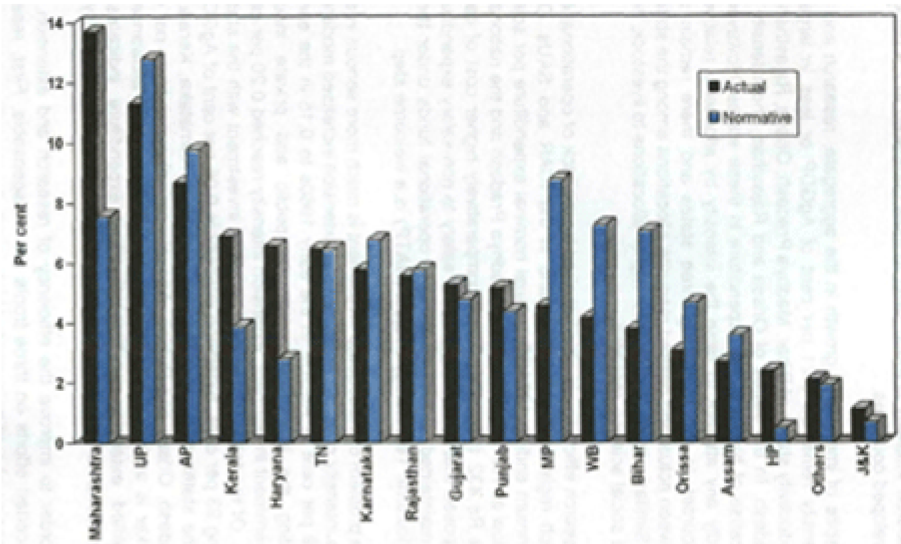
In spite of impressive growth in the aggregate, research and education intensity remained 0.21 per cent of AgGDP or less in large and low productivity states of Bihar, Madhya Pradesh, Orissa, Rajasthan and Uttar Pradesh. In the states of Orissa and Rajasthan, the intensity improved because of higher ICAR expenditure in these states. However, there is hardly any attempt to raise the intensity by allocating relatively higher resources to the remaining three states and there remain deviations between actual and desired resource allocations among the states (Figure 2). Similarly, there is a need for higher allocations to livestock, horticulture and social science research.

Research efficiency is also impaired by the lack of operational expenses, which registered a sharp decline in the ICAR and SAUs. During the triennium ending 1994/95, annual nominal expenditure per scientist was as low as Rs 145 thousand in Madhya Pradesh and the national average was Rs 432 thousand. Given comparatively higher cost of capital, it is proposed that a ratio of 60:40 for salary to non-salary expenditure should be maintained. Efforts to increase operational funds under the National Agricultural Technology Project (NATP) is a welcome step.

The problem of inadequate investment is much more serious in extension. The intensity of public investment in extension increased moderately from 0.09 per cent of AgGDP in the early 1960s to 0.15 in the early 1990s. Adding the investment made by public and private industries to government investment, extension intensity reached 0.20 per cent (1992-94). Of the total, 92 per cent is public investment with the states' share being 93 per cent. Extension intensity is 0.06 per cent of AgGDP or less in the states of Andhra Pradesh, Haryana, Karnataka, Kerala, Madhya Pradesh, Orissa and Punjab. Annual nominal expenditure per extension worker is as low as Rs 25 thousand. Even making allowances for low qualified extension workers, the low expenditure indicates lack of operational funds, questioning the effectiveness of extension system.

In order to improve the efficiency of research and extension systems, concerted efforts on three fronts are indispensable. First, research and extension should be accorded high priority for government investment and the level of intensity should be doubled to correct imbalances in the factor shares and to rationalise allocation of resources across states and research programmes/commodities. Impressive rates of return to the past investments support the case for enhanced investments. Secondly, efforts should be made to diversify the institutional structure. The principles of institutional economics and experience of developed countries suggest that myriad forms of institutions like public, private, voluntary and farmers organisations and some combination thereof, may be more efficient for the provision of research and extension services because the degree of subtractability and excludability differs at different stages of research and extension spectrum. Public research institutions may be more efficient in the provision of upstream or basic and strategic research. The ICAR and SAUs should, therefore, concentrate on upstream and crop and resource management research, besides education. Within the ICAR/SAU system, location specific research on crop and resource management should be concentrated in SAUs. Accumulating body of evidence indicates increasing trend of private investment in applied research, i.e., development and dissemination of embodied technologies. This trend should be encouraged by liberal industrial and regulatory policies, placement and effective enforcement of intellectual property rights, besides providing basic research support. As the private sector become competitive, public research programme should withdraw from applied research activities like mechanical and chemical technologies and hybrids. This would also imply reduction in the public sector's involvement in transfer of embodied technologies. Adaptive research can be provided by private sector, and non-governmental and producers' organisations.

Figure 2
Actual and normative allocation of national research investment



Research coordination by the ICAR will be a difficult task in a multi-institutional set up. Networking, contract research and regulatory mechanism may help coordinate and link upstream, applied and adaptive research. Equally important task would be to neutralise the externalities of proprietary technologies like neglect of sustainability issues and research needs of marginal areas and confusion arising from contradicting publicity to increase sales. Thus, the ICAR has to play a far more active and challenging role in the governance of research.

Third important issue is institutionalisation of improved research planning, monitoring and evaluation mechanism. Given the size and complexity of research system, a well structured information and decision support system is indispensable for improving the technical and allocative efficiency. Entire process of research planning including priority setting, monitoring and evaluation should be based on the principles of relevance, objectivity, transparency and simplicity. Present top-down planning process should be replaced with client focused, bottom-up approach. Similarly research approach should be system oriented and multidisciplinary. Evaluation process should have teeth and effective link with the incentive structure.

As regards extension, rigidity of extension approach and lack of incentive have constrained extension workers to innovate and respond to client needs. A need-based and flexible extension approach, making extension workers accountable to stakeholders and performance based incentive structure are critical to improve the efficiency of extension system. There should be additional incentives for extension workers in remote, difficult areas so as to make these areas attractive to work. Also, diversification of funding and delivery system involving private (for profit and non-profit sector should be encouraged through appropriate regulatory policies.

Some reforms like provision of contract research, increasing operating funds and developing information system have been initiated on the above suggested lines, particularly under the NATP. The success of these and other suggested reforms would depend on government's will and wherewithals to implement and ability of scientists and extension workers to avail them.

1 INTRODUCTION

1.1 Background

The development of the national agricultural research and extension systems (NARES) in India can be traced back to substantial investment made by the central and state governments, particularly since Independence. In the successive five year plans, concerted efforts were made to strengthen the central and state level research system. As a result, the NARES could grow in size and intensity of efforts. The accumulating body of evidence indicates that the Indian NARES have successfully addressed research needs of the country through the development and dissemination of appropriate technologies. Technological advancements have accelerated and sustained appreciable growth in agricultural production and the country is not only self sufficient in food production but also a net exporter of agricultural products. It has been shown empirically that the investment in agricultural research and extension is the main source of growth in agricultural total factor productivity in India and the rates of return are impressive (Evenson and Jha, 1973; Evenson and McKinsey, 1991; Rosegrant and Evenson, 1992; Kumar and Rosegrant, 1994). It is believed that compared to other alternatives, the investment in agricultural research and extension is much more productive in terms of accelerating the pace of development.

In India, unlike many other countries which witnessed decline in research funding, high rates of return ensured continuous higher allocations of public funds to research and extension. However, the development of certain economic forces in the recent past may result in reduced funding to the NARES in future. The most important among these forces is the policy of fiscal discipline adopted by the Indian government, emphasising substantial reduction in government expenditure to bring down fiscal deficit. Second, alternative sources of funding, particularly increasing participation of private sector in agricultural research and extension, have developed a psychological impression that the growth in public funding to the NARES could be slowed down. Third, it is believed that the size of the public NARES has reached its maxima. Emphasis should now be placed more on improving the efficiency of the system rather than its horizontal expansion.

At the same time, there are several new, complex research problems related to the development of Indian agriculture that need immediate attention. Research agenda has expanded further due to growing demand for conservation of natural resources for their sustainable use, besides acceleration of growth in productivity and alleviation of poverty. There is also urgent need for appropriate technologies to break yield barriers, improve product quality, and diversify product-mix towards high value products for attaining the household food and nutrition security Also, higher efficiency in production through technological advancements is necessary to compete in world market and to initiate export led growth in agriculture. The development of fragile areas, comprising arid, semi and hill zones, has to be accorded high priority for balanced regional development. In other words, sustainable agricultural development nee a complete shift from natural resource based to science based agriculture In this process, the development and transfer of information and s intensive technologies is critical. Obviously, all these call for higher deg of research and extension efforts, both in terms of intensity and quality

Reliable information on levels of funding and stock of research c extension thrust needs is necessary for resolving these conflicting view points. Research and development agenda is well articulated on several fora (DARE/ICAR, 1996 and Planning Commission, 1996). However, there is dearth of information on the levels of research and extension investment on regional basis. There have been some attempts to assess research intensity in the country. Mohan *et* al. (1973) developed research expenditure series from 1950 to 1968. These data were subsequently updated by Boyce and Evenson (1975) and Pardey and Roseboom (1989). In these studies research expenditure is delineated from the total expenditure which also includes education and extension, on the basis of share of research in the total expenditure of select institutions. This has underestimated research expenditure (Rajeswari, 1995). These studies have two critical gaps. First, regional investment dimension is adequately addressed. Even at the national level, it is difficult to comp the intensity with that in other countries because of differences in indicators of intensity. Second, These studies do not cover investment education and extension. A good amount of research is carried out post-graduate programmes and therefore exclusion of education may underestimate research efforts. There has been tremendous growth in NARES and the research and development thrusts are changing rapidly. It is, therefore, important to assess the current research and extension efforts with adequate emphasis on their regional dimension.

Apart from investment levels, there are several other issues investment in different research activities (basic, applied and adaptive research), factor shares and functional allocation (allocation across commodities and research problem areas) of research investment, and sources of funding which need indepth analysis. An insight into these issues is essential for augmenting and efficient use of research funds. Interactions between sources of funding and execution of research is important for raising the funding and developing appropriate institutional structure (Echeverria et al., 1996). For example, private sector can fund and conduct mostly applied or adaptive research. Therefore, adequacy of investment levels and institutional arrangements can be assessed only when research needs in terms of their levels, viz. basic and strategic, applied, and adaptive are made explicit. This study is an attempt to fill this information gap.

1.2 Objectives

The following are the specific objectives of this study:

I. To estimate the levels and pattern of the investment in agricultural research, extension and education;
II. To examine research resource allocations across states and commodities;
III. To study the determinants of public investment in agricultural research, extension and education, and
IV. To suggest measures to improve the efficiency of the national agricultural research and extension systems.

1.3 Outline of the report

The next chapter presents a historical perspective and contemporary institutional structure of the NARES. The estimates of research, extension and education investments are given in chapter 3. This chapter also gives regional and commodity allocations of research investment. Chapter 4 analyses the determinants of public investment in research, extension and education. Necessary adjustments in institutional arrangements for efficient provision of research and extension services and their funding implications are suggested in chapter 5. Finally, chapter 6 summarises main conclusions of the study.

2 THE NATIONAL AGRICULTURAL RESEARCH AND EXTENSION SYSTEMS

2.1 Historical Perspectives

Historically, agricultural research, extension and education in India have been in the public domain. The theory of public goods holds true for research and therefore, agricultural research was conducted in the research organisations which were administered and funded by the state. Besides this, lack of capital in private sector and low appropriability of technologies did not attract significant private investment in agricultural research in the country. The research and extension policies and regulations also were framed in the context of public institutions. However, research environment has gone a sea change over time and therefore, funding and execution of agricultural research and extension have changed accordingly. This chapter reviews the major developments in the Indian NARES.

2.1.1 Agricultural research and education system (This section is largely based on the information available in Randhawa (1979, 1983 and 1986))

In the early stage of education system in India, agricultural science was in the domain of public funded general universities, as a part of natural sciences. With advancements in science, agriculture, mainly crop science, was separated from natural sciences, but was still taught in the general universities. Crop research to some extent was also conducted.

The development of independent agricultural research and education institutions can be traced back to the late 19th century. The process started with the pioneering efforts of Lord Mayo, the then Governor General of India, leading to the establishment of Department of Revenue, Agriculture and Commerce in the Imperial and Provincial Governments in 1871. The Department was strengthened by adding staff after the report of Famine Commission (1880). Main functions of the Department of Agriculture, as defined in the resolution of 1881, were agricultural enquiry, improvement and famine relief. During the last decade of the 19th century, experts were recruited in the Department of Agriculture, and research and teaching in agriculture and forestry was started at few places. The foundation of the Imperial Bacteriological Laboratory (now Indian Veterinary Research Institute, Bareilly) was laid at Pune in 1890, to start organised livestock research. It was subsequently shifted to Mukteswar in the Kumaon hills in 1893. The Civil Veterinary Department was created in 1889 and five veterinary colleges were also established at Babugarh (1877), Lahore (1882), Bombay (1886), and Madras and Calcutta (both in 1893).

Agricultural research and education got major support in the first decade of the 20th century when Lord Curzon was the Viceroy of India. The most significant milestone was the establishment of the Imperial (now Indian) Agricultural Research Institute (IARI) at Pusa in Bihar in 1905. The 'Pusa' institute suffered from a devastating earthquake in 1934 and was therefore, shifted to New Delhi, a central place, in 1936. The development of research work at the IARI over time led to the origin of a number of research institutions. Also in 1905, six agricultural colleges were established in important provinces at Pune (Maharashtra), Kanpur (Uttar Pradesh), Sabour (Bihar), Nagpur (Maharashtra), Faisalabad (now in Pakistan) and Coimbatore (Tamil Nadu) with an annual grant of Rs 2 million from the Government of India. These colleges were adequately equipped with staff and laboratories and were charged with the responsibility of research and teaching.

Another significant development was the establishment of the Imperial (now Indian) Council of Agricultural Research (ICAR) in 1929, an autonomous body, on the recommendation of the Royal Commission on Agriculture (1926). The ICAR was mandated to promote, guide and coordinate agricultural research in the country. With a non-lapsing fund of Rs 5 million, the ICAR was expected to supplement research activities of provinces and train scientific manpower. However, the ICAR had no administrative control over research institutions in the provinces. The establishment of the ICAR, in a way, was empowerment of agricultural research in India. Concomitantly, a number of central commodity committees were constituted, mainly for commercial crops (cotton, 1921; lac, 1931; jute, 1936; sugarcane, 1944; coconut, 1945; tobacco, 1945; oilseeds, 1947; arecanut, 1949; and spices and cashewnut, 1958). These committees were semi-autonomous bodies financed by grants from the

Government of India and/or by income from cesses and were expected to promote overall commodity development, including research. In fact, many committees established research stations. These committees had representation of various stakeholders like producers, trade and industry, agricultural department, etc., and Vice-President of the ICAR was ex-officio President of the committee. The funding of these committees from cesses was the first attempt to link research funding with the beneficiaries.

The commodity approach to research lacked coordination between commodities and neglected research areas applicable across commodities like soil management. The need was, therefore, recognised to initiate research on cross-commodity basis. Also, the idea of regionalisation research was getting momentum. These forces led to the establishment of Composite Regional Stations for research on cotton, oilseeds millets in 17 regions in 1956. These stations were under the administrative control of the ICAR and research progress was monitored by the regional coordination committees. The research expenditure was shared by Indian Central Cotton Committee, the Indian Central Oilseeds Committee and the ICAR.

Although the ICAR was established as a coordinating body, effective research coordination was missing because the ICAR did not have administrative control over many of the central or any of the provincial research stations. In order to provide effective coordination to commodity research, the concept of coordinated research project for improvement was introduced. In 1957, the first All India Coordinated Project on maize was started with the technical support from Rockfeller Foundation. The project was multidisciplinary in nature pooled staff working in different regions. This was the beginning research planning on the basis of agro-climatic zones, cutting ac political boundaries. The project was extremely successful and paved way for establishment of a series of all India coordinated research projects.

On the recommendation of the Agricultural Research Review T (1964), the ICAR was reorganised in 1965 for coordinating, directing promoting agricultural research in the country. All the commodity committees were abolished and research institutes under these committees and Central Department of Agriculture and Food gradually transferred to the ICAR. This led to centralisation of funding execution and management of agricultural research with greater autonomy and empowerment to the ICAR. A Department of Agricultural Research and Education (DARE) was created in 1973 in the central Ministry Agriculture to establish direct linkages of the ICAR with central and state governments, and international organisations. The Director General of ICAR, a scientist, was concurrently designated as Secretary to the DARE For centre-state coordination, eight regional committees were formed. Several new research institutions under the ICAR came into existence However, major expansion under the ICAR took place on the line commodity research. Funds for these research institutes were channelled through the ICAR from the central government. Research stations under the administrative control of the state governments continued to be funded by state governments.

Although a number of agricultural and veterinary colleges were functioning under the Department of Agriculture in the states, agricultural education maintained a low profile. These colleges were crippled with administrative and financial constraints. There was virtually no coordination between agricultural and veterinary colleges. The University Education Commission (1949) felt the need for establishing rural (agricultural) universities in the states. Subsequently, the two Joint Indo-American Teams (1955 and 1960) endorsed the establishment of state agricultural universities (SAUs). The SAUs were set up on land-grant pattern of the American universities. The first one was started in 1960 at Pantnagar in Uttar Pradesh. The SAUs were given autonomous status and direct funding from the state governments. These universities imparted education on all aspects of agriculture on the same residential campus and integrated teaching with research and extension. The US Agency for International Development (USAID) and the American land-grant universities helped development of SAUs in India. Subsequently, implementation of the recommendations of the Education Commission (1964-66) and Review Committee on Agricultural Universities (1977/78) streamlined their functioning and all matters related to agricultural research in the states were transferred to the universities.

The regional research capacity in the states was further strengthened by establishing the regional agricultural research stations under the National Agricultural Research Project (NATP) in 1979 with assistance from the World Bank. These research stations, in different agro-climatic zones of the states, were under the administrative control of SAUs. Addressing zonal research needs and fostering linkages between research, extension and farmers were the main responsibilities of these research stations (Ghosh, 1991).

Meanwhile, there has been tremendous growth in non-agricultural universities and other scientific organisations, notably, Council of Scientific and Industrial Research (CSIR), Department of Biotechnology (DBT), Defence Research and Development Organisation (DRDO) and Department of Science and Technology (DST). These organisations also continued to strengthen, directly or indirectly, agricultural research and education.

The participation of industries both in public and private sectors in agricultural research was absent until 1950s. With the adoption of new seed-fertilizer technology in the mid-sixties, there was phenomenal growth in the industrial sector for the production of inputs. However, research activities in these industries were at the margin. The entry of private sector in seed research started in the 1970s with the popularisation hybrids. The passage of new policy on seed development in ' streamed seed research in the private sector, allowing participation transnational seed companies.

2.1.2 Agricultural extension system

The national agricultural extension system also evolved with establishment of the Department of Agriculture in the Imperial provincial governments. Efforts to strengthen this Department continued up to the time of Independence. Agricultural extension was one of activities of the Department and no special attention was paid accelerate transfer of technology efforts. However, some isolated attempts were made to start special rural development programmes, including improvement of agriculture (Prasad, 1989). Soon it was realised sporadic and adhoc programmes might not be effective and that there was a need for sustained rural (including agricultural) development programmes. A nationwide, multi-purpose extension network backed with professionals became indispensable. Consequently, 55 Comma Development Projects were started in 1952. Each project covered villages with a village level worker for a group of 10 villages. For e project, extension officers-technical persons in agriculture, animal husbandry, cooperation, village industries and rural engineering-w provided. The programme was based on the philosophy of integrated rural development. In 1953, the National Extension Service Program identical to the community development programme but with less resource intensity, was launched with a view to cover the entire country 1960/61. The programme aimed to accelerate the pace of rural development, including increased employment and production by application of scientific methods in agriculture. The programme greatly emphasised the principle of development through self-help and peoples participation. The central government largely bore the cost of programme.

Front-line extension work also was initiated as agricultural research system grew in the ICAR and SAUs. A department or directorate extension was established in the ICAR institutes and SAUs. The basic objective of these departments was to conduct extension research demonstrate latest technologies, provide feedback to scientists, a provide training support to State Department of Agriculture. Besides, the ICAR started three major front-line extension projects, *viz.* National Demonstration Project (1965), Operational Research Project (1972) and Lab-to-Land Project (1979). Another significant development in front-line extension was the establishment of Krishi Vigyan Kendras (KVKs) and Trainers' Training Centres (TTCs) in 1974. These KVKs and TTCs were aimed to improve technical literacy of farmers including rural women on the principle of 'teaching by doing and learning by doing'. These KVKs are currently managed by the ICAR institutes, SAUs and nongovernmental organisations (NGOs) with financial support from the ICAR.

The central government also launched several schemes to achieve self-sufficiency in food production. The important programmes were: Intensive Agricultural District Programme (1961) and Intensive Agricultural Areas Programme (1964). These programmes concentrated on the transfer of 'package of practices' and supply of critical inputs to farmers. In other words, extension strategy combined technical information with the supply of inputs. However, this strategy was discontinued with the reorganisation of the extension system under the Training and Visit (T&V) System in 1974-75. The T&V system emphasised single-purpose professional extension workers, regular training of extension personnel and transfer of technology through personal contact with farmers. This concept was further strengthened through establishing research-extension-farmer linkages under the National Agricultural Extension Project (NAEP) in 1979.

Another significant component of the extension system is the input industry, both in the public and private sectors. As noted earlier the industrial sector entered in a big way in the dissemination of chemical and mechanical technologies in the 1960s. The late 1980s marked real beginning of private sector in seed business. Input industry promotes the use of modern inputs through mass media and linking information with the supply of inputs. Several NGOs also got involved in agriculture and rural development activities during the period.

2.2 Contemporary Institutional Structure of the NARES

2.2.1 Agricultural research and education system

The national agricultural research and education system (NARS), as evident from the historical developments reviewed above, is dominated by the public sector. Although agriculture is a state subject in the constitution of India, major components of the research system were initiated and funded by the Union Government. The NARS has three main institutional set up with different mandates. These are: ICAR institutes to cater to upstream research needs, SAUs engaged in teaching and research for respective states, and ZARSs to undertake zonal-specific research. A structural diagram depicting these institutions and their linkages with other actors like public research organisations, international research centres and private sector is shown in Figure 2.1. The direction of research linkages is shown with arrows. The ICAR is the apex body at the centre to promote, undertake and coordinate research in all fields of agriculture in the country. The ICAR is linked with the Union Ministry of Agriculture through the DARE. The Council also coordinates directly with state governments and international organisations through the DARE. The Governing Body consisting of eminent agricultural scientists, academicians, legislators and farmers' representatives as its members, is the chief executive and policy making authority and the General Body is the supreme body of the ICAR.

By the end of the Eighth Plan, the ICAR had established a network of 45 research institutes, 10 project directorates (PDs), 30 national research centres (NRCs), 4 national bureaux (NB) and 86 all India coordinated research projects (AlCRPs), etc. Four research institutes have the status of national institute and the rest are named as central institutes. The major research activities of these ICAR institutions are given in Table 2.1.

A large number of the ICAR research institutes conduct basic/strategic, and applied research in discipline-based divisional set-up (Table 2.1). IARI, NDRI, IVRI, CIFE with the status of 'deemed university' also undertake post-graduate teaching in agriculture. The AlCRPs have their research centres at the SAUs and are engaged in applied research. Some AlCRPs are elevated to the status of project directorate to provide backstopping research. The NRCs conduct research on specific problems in mission mode, non-divisional set-up. Although ICAR institutes are mandated to do basic and strategic research, a good deal of applied research is also conducted due to low research intensity in the SAUs. All the ICAR research institutions are managed by the management committee and research advisory committee. The management committee has wide representation, while research committee is a body of research professionals. Most of the ICAR institutions are organised on commodity pattern and very few are resource or discipline based.

The SAUs are autonomous institutions for meeting educational and research needs of the states and these are managed by the board of management and academic council. All the states have at least one SAU. The ZARSs under the SAUs are mandated to cater to research needs of the zones. The SAUs are largely funded by state governments, but they also get regular grant from the ICAR. One Central Agricultural University with funding from the Union Government is also established for northeastern states.

Figure 2.1
Institutional structure of the Indian agricultural research and educational system

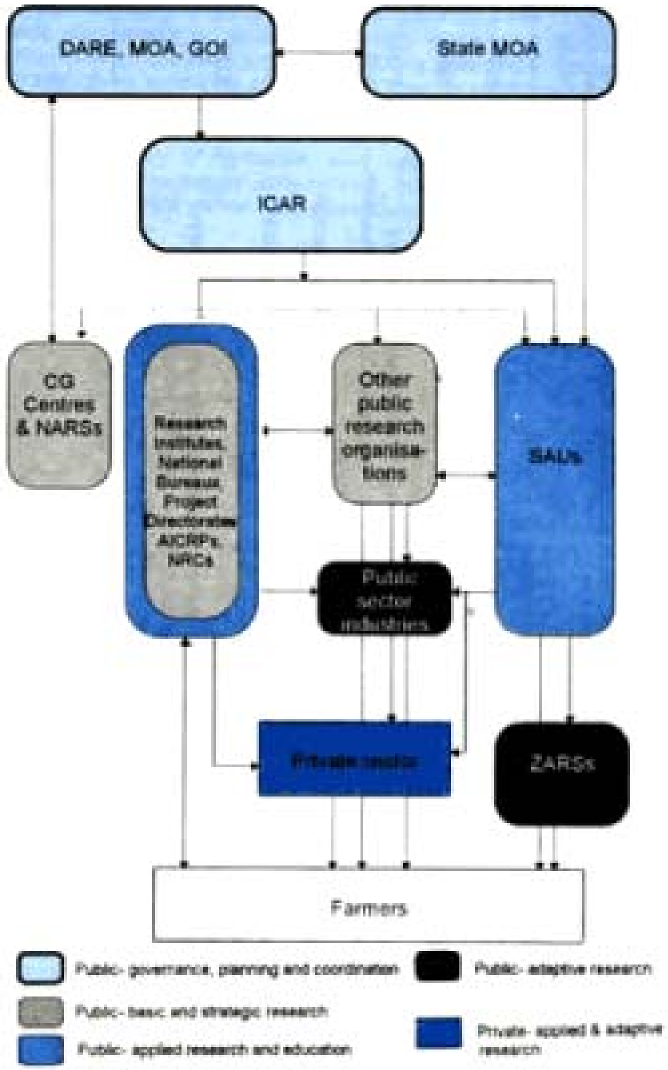
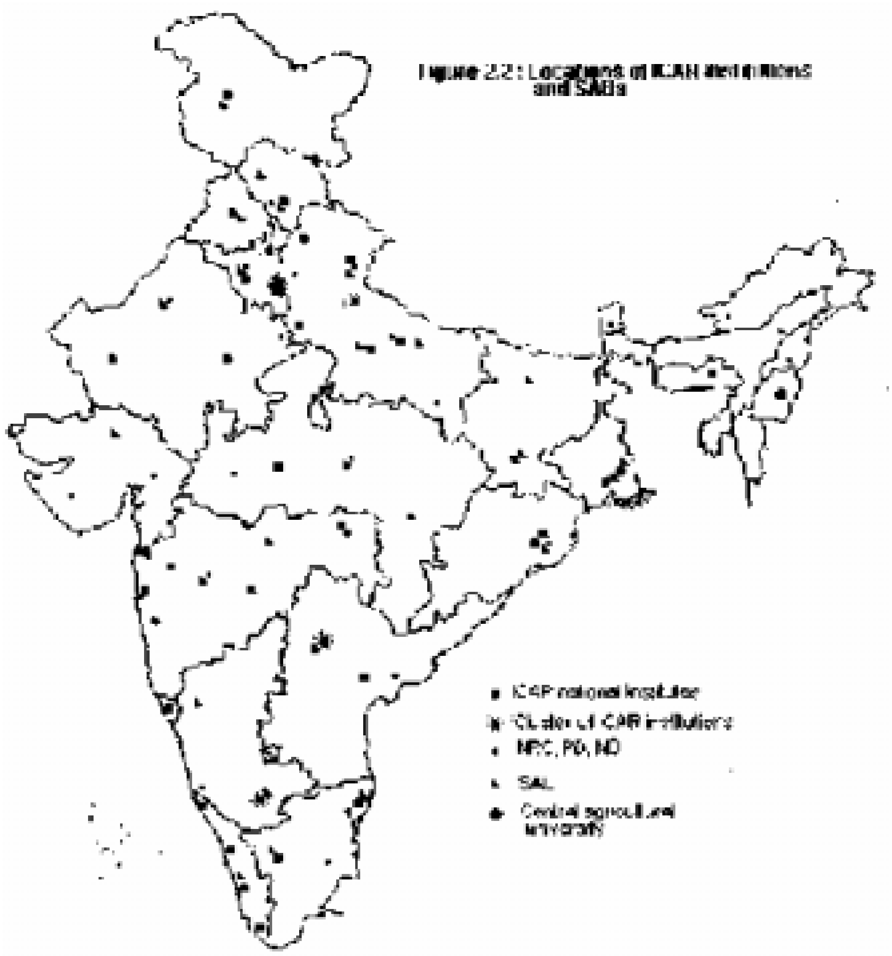


Table 2.1
Major activities of the ICAR and SAUs research system

Institution	**Number**	**Main activities**	**Budget (1994/95)* (Rs, million)**
ICAR			
National research institute	4	Basic and strategic research of national importance, education, man-power training	827
Central research institutes	41	Commodity/resource specific basic and strategic research with divisional set-up, education	1526
National bureaux	4	Conservation and exchange of germplasm, soil survey	113
Project directorates	10	To fill critical research gap in All India Coordinated Research Projects, research coordination	319
National research centres	30	Commodity/resource/discipline based strategic research in mission mode	228
All India coordinated research projects	86	Coordination of commodity/resource specific research in different zones of the country	861
Agricultural universities			**5327**
Central agric. university	1	Applied research and education for north eastern states	
SAUs	28	Applied research for the state and education	
Zonal research stations**	120	Adaptive research for the zone	

Source: ICAR (1996/97),
** Ghosh (1991);
* ICAR (1995/96)

Figure 2.2 shows geographical spread of ICAR institutions and SAUs in the country. All important states have at least one SAU and most of the SAUs are multi-campus. Some states have established new SAUs by elevating old campus to university. Although efforts were made to establish ICAR institutions in the major producing state of the mandated commodity, there appear to be some influence of political-economic factors. For example, a large number of institutions were established in the northern and southern states- the states having larger representation in the Union Ministry of Agriculture, while western and north-eastern states were given low priority. Only recently, one agricultural university with the central assistance has been established.



A large number of non-agricultural universities, government organisations and public sector undertakings are also involved directly or indirectly in agricultural research. Some universities like Banaras Hindu University, have independent faculty for agricultural research and education, while government departments or scientific organisations like DST, DBT, CSIR, DRDO, etc. conduct or support agricultural research directly or indirectly. The public sector industrial units are also involved in agricultural research, mainly on inputs, to some extent.

Private sector undertakes research for the development of embodied technologies, *viz.* chemical, mechanical and biological (only hybrids). However, private sector research so far is adaptive in nature and is expected to intensify in the years to come with the adoption of favourable industrial and regulatory policies. Several private foundations, both national and international, also conduct and/or invest in agricultural research in the country.

Research linkages and coordination

Considering the size and multi-institutional set-up of the NARS, developing research linkages and coordination is a formidable challenge. The task is further complicated by the fact that the responsibility of agricultural research and development lies with state governments. The ICAR as an apex body, coordinates research and promotes inter-institutional research linkages. Since the ICAR supports SAUs through regular grants, it has direct participation in the management of the SAUs. Besides, regional committees were formed in 1975 to assess the status of research, extension and education in the ICAR institutes and SAUs in the eight regions of the country. These committees also make recommendations to undertake research on immediate problems of the region. Officials from the ICAR, ICAR institutes, SAUs, state line department, NGOs, members of parliament and farmers representatives are members of these committees. The geographical coverage of these regions is given in Appendix I.

Another informal but effective link between various research institutions is the cross-nomination of members in various committees and scientific panels. As noted above, these committees and scientific panels have major say in planning and management of research. Efforts are made to ensure effective use of research resources and to avoid duplication of research efforts.

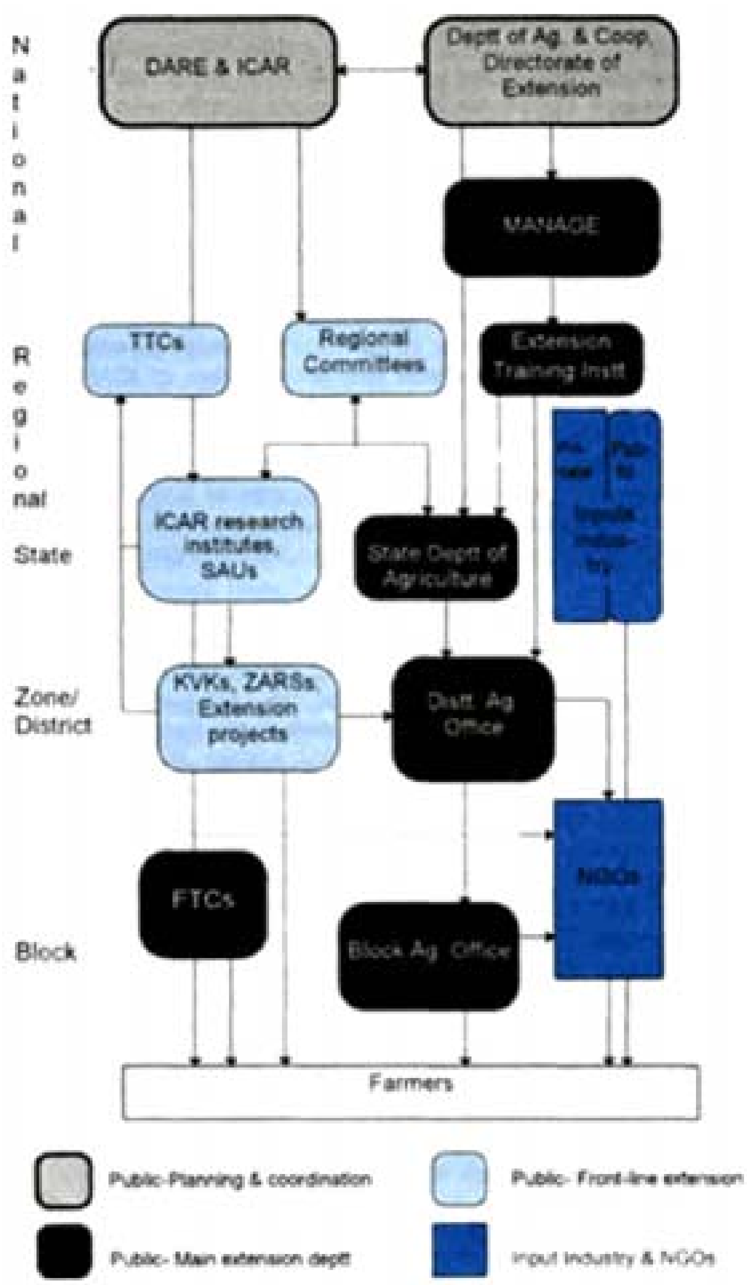
Research collaboration with the CGIAR system, NARSs and research foundations overseas, etc. is operationalised by the ICAR through the DARE. However, SAUs can also directly collaborate with these international organisations. Linkages with the national private research organisations are direct. Public research institutions extend support such as supply of germplasm and training facilities to the private sector. Also, private research companies can collaborate directly with multinational companies or private research foundations abroad under the existing regulations which recently have been liberalised to a great extent (for detailed discussion, see Singh et al., 1995).

2.2.2 Agricultural extension system

Broadly, there are four major components of the Indian extension or transfer of technology system: (i) agricultural extension service with the state governments, (ii) extension education system of ICAR and SAD system, (iii) extension programme of input industries in public and private sectors and NGOs, and (iv), special rural development programmes of the central and state governments. However, main responsibility of transfer of technology rests with the state governments as agriculture is a state subject. The central government also implements several schemes having transfer of technology component, through the state governments.

Institutional structure of the Indian extension system is shown in Figure 2.3. The main extension system comprises the Directorate of Extension in the Union Ministry of Agriculture at the centre and T&V system under the state Department of Agriculture. In the T&V system, professional extension workers work with contact farmers for the transfer of information and skill. Training support to the T&V system is provided by the ICAR/SAU system (for details of T&V system, see Misra, 1990). The Directorate of Extension plans extension activities at national level and disseminates information through mass media and publication of literature. For training of extension staff, there is a three-tier training system. At the national level for training of senior and middle level staff, an autonomous institute, namely, National Institute of Agricultural Extension Management (MANAGE) was established. There are four regional extension training institutes and several state training institutes for training of extension workers. Several development programmes like integrated rural development programme, watershed development programme, operation flood, technology mission for crops, etc. sponsored by other government departments contain transfer of technology component. In 1994, the scope of extension was widened under the broadbased agricultural extension' in farming system approach to include all landbased activities.

Figure 2.3
Institutional structure of the Indian agricultural extension system



The ICAR/SAU front-line extension system plays a catalytic and supportive role. It develops extension methodology, refines and transfers front-line technologies, and provides feedback to scientists. This system has three approaches. First is the special transfer of technology programmes like National Demonstration (ND), Operation Research Project (ORP), and Lab-to-land Programme (LLP). Most recent in the series is the Institute-Village Linkage Programme started in 1995/96 for technology assessment and refinement. The second approach comprises the transfer of technology and training by the KVKs and TTCs on the principle of 'learning by doing'. There are 261 KVKs functioning in the country under the ICAR institutes, SAUs and NGOs. Front-line extension programmes (ND, ORP, LLP) are presently merged with the KVKs. Eight TTCs provide training to the KVK staff. In the third approach, ICAR/SAU system provide training to the master trainers (subject matter specialists) working in the state line department through monthly workshops.

Private input companies are involved only in the transfer of chemical (fertilizers, pesticides), mechanical and biological (hybrid seeds) technologies developed/produced by them. Public sector companies and seed corporations also undertake transfer of technology activities related to the sale of their products i.e., farm inputs. Commodity groups/boards also promote commodity specific extension activities. Many NGOs also undertake extension activities as part of their development programmes. Some NGOs are also managing ICAR-supported KVKs.

Research-extension linkages

Efforts have been made to institutionalise research-extension linkages at national, regional, state and zonal levels. At the national level, under the ICAR-DAC interface joint meetings of the senior officers from the ICAR and Department of Agriculture and Cooperation (DAC) are organised twice a year to discuss critical research and development issues. At the regional level, eight regional committees were constituted to review research and development status in the ICAR institutes and SAUs located in the region. These committees represented by the senior research and extension officers, farmers representatives and NGOs meet once in two years. The Zonal Agricultural Research and Extension Advisory Committee meetings and seasonal workshops at the zonal level facilitate close interaction between researchers, extension workers and farmers. In the T&V system, research-extension linkages are institutionalised through monthly/bimonthly workshops for the training of master trainers or subject matter specialists in state line department by the researchers.

To sum up, it may be concluded that although the Indian NARES have grown in size and efforts, they are still dominated by government funded and administered institutions. There have been some initiatives like provision of contract research, rationalisation of seed regulations and entry of trans-nationals, in the recent past to diversify the NARES by encouraging private sector and NGOs. These efforts should be strengthened in future for efficient provision of research and extension services to farmers through diversified institutional arrangements.

3 INVESTMENTS IN AGRICULTURAL RESEARCH, EXTENSION AND EDUCATION

As seen in chapter 2, the national agricultural research and extension systems (NARES) in India are dominated by government-funded institutions. This chapter, therefore, mainly presents the estimates of government or public investments in agricultural research, extension and education (hereafter, research, extension and education). An attempt also is made to assess private investment in research and extension in the country. First, combined investment in research and education is discussed as research and education are highly complementary activities and the national agricultural research system (NARS) is pursuing both these activities jointly. Moreover, the distinction between research and education expenditures was not uniformly maintained in the government accounts, making delineation of 'research' expenditure difficult. This is followed by analysis of public investment in extension.

Government investment includes the expenditure made by the Union and all the State governments, and Union Territories. These data were compiled from various official accounts of the Union and State governments (GAG, MOF and RBI) and contain all plan and non-plan expenditures on revenue as well as on capital accounts. The sources of data are given in Appendix II. The terms, investment and expenditure, are used interchangeably throughout this report, as all expenditure (revenue or capital) generate new knowledge or technology, i.e., research assets.

3.1 Investment in Agricultural Research and Education

Funds from the Union Government support the ICAR, the apex body charged with the responsibility of policy planning, execution and coordination of research. Besides supporting a network of ICAR institutions, a part of funds are transferred to SAUs in the form of research schemes and annual grants. The State governments support SAUs which are entrusted with the responsibility of imparting education and conducting state or location specific research. Some government funds are also used to support research in public organisations like Agro-economic Research Centres and commodity research stations outside the ICAR and SAU system. Research funding from commodity boards like tea, coffee, etc. are not included here. Actual year-wise expenditure on research and education incurred by the Union and State governments since 1960/61 is given in Appendix III.

3.1.1 The investment intensity : All India

The trends in total government investment in research and education at 1981/82 prices in the country since 1960/61 are shown in Figure 3.1. This figure shows impressive growth in real investment made by the central and state governments. The real investment (centre+state) in 1994/95 registered more than five-fold increase since the 1960s. The phases of change in the real investment correspond to organisational changes in the NARS. The low and declining central investment during the late 1960s coincides with the shift from multi-channel research funding (various commodity committees, ICAR, etc.) to centralised funding to the ICAR. The establishment of the SAUs accelerated the state funding in the 1960s and the state funds contributed all the growth in total investment in the country. Reorganisation of the ICAR in 1973 and substantial increase in the investment in the Fifth Plan (1974-78) set a sharp uptrend in the central funds. Efforts to strengthen the decentralised research capacity with the implementation of the National Agricultural Research Project and much higher allocations in the Eighth Plan (Table 3.8) have further accelerated the growth in total investment. The decade-wise growth rates (Table 3.1) indicate that the total investment, in real terms grew at the rate of 5.4 per cent since 1960s. The investment made by the states grew much faster than the central in the 1960s and 1980s, whereas the growth in the latter was remarkably high during the 1970s.

Table 3.1
Annual compound growth rates of government real investment in research and education (%)

Period	Centre	States	Total
1960/61 to 1969/70	-16.71	9.07	6.52
1970/71 *to 1979/80*	6132	-0.05	9.57
1980/81 to 1994/95	5.88	6.83	6.29
1960/61 to 1994/95	11.99	3.46	5.38

The changing emphasis on the structure of the NARS over time has changed the share of centre and state governments in the national investment. As seen from Table 3.2, during the 1960s and 1970s state governments' funds contributed most of the total investment. Their share rose from 80 per cent in the early sixties to 97 per cent in the early seventies. However, more than proportionate increase in the central funding raised the center's share substantially (55 per cent) in the early nineties.

Figure 3.1
Trends in government real research and education investment in India (at 1981/82 prices)

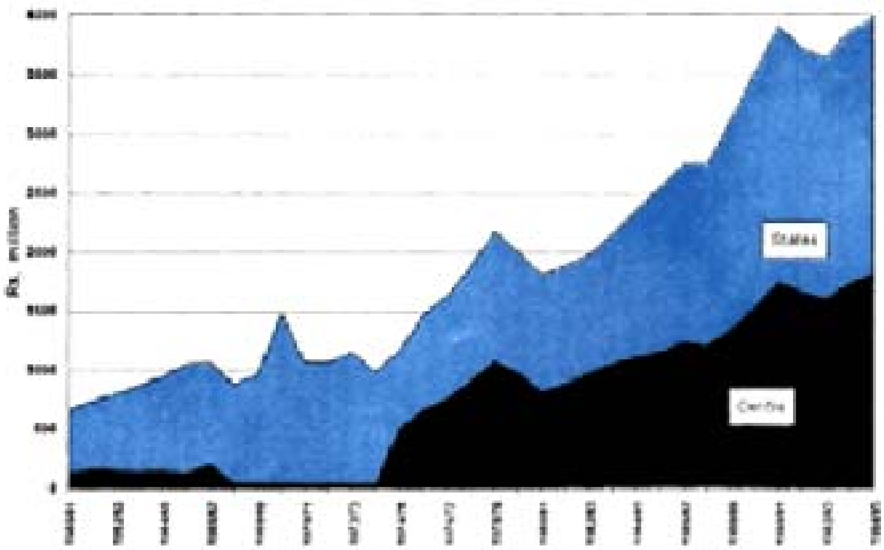


Table 3.2
Share (%) of central and state governments in the national investment

Period (three-year average)	Centre	States
1960/61 to 62/63	20.1	79.9
1970/71 to 72/73	3.3	96.7
1980/81 to 82/83	46.9	53.1
1991/92 to 93/94	44.6	55.4

As seen from Table 3.3, research and education intensity, as measured by the investment as percentage of agricultural (excluding forestry) gross domestic product (AgGDP), rose from 0.23 in the early seventies to 0.39 in the early eighties and to 0.49 in the early nineties. Also, the real investment per ha of gross cropped area (GCA) increased over time, reaching Rs 20.65 in the early nineties.

These intensity ratios indicate that the investment in research and education is growing since 1960s, but the major jump came in the 1980s, almost doubling research intensity in the country.

Another important investment indicator is the number of scientists, which is not readily available. Recent data compiled by the ICAR (ICAR, 1995/96) and Rao and Muralidhar (1994) indicate that there are about 22,249 scientists engaged in research and teaching in ICAR/SAU system. With these data annual nominal investment per scientist during the early nineties works out be Rs 0.4 million.

Apart from governments, industries in public and private sectors also invest in research on seeds, fertilizers, pesticides, machinery, drugs, sugar, and food and leather processing. Adding this industrial investment to government investment, gives aggregate 'research' intensity (net of education) in the country. Government 'research' expenditure was obtained by taking out education expenditure from the total. The share of 'research' is 86.9 per cent in ICAR and 53.5 per cent in SAUs (Arrived at by charging all and half of administrative expenses to research for the ICAR and SAUs, respectively) (Table 3.9). Aggregate 'research' intensity (Table 3.4) shows that during 1992-94 (three-year average), governments contributed 80 per cent to national research investment. The contribution of public sector industries was only 5 per cent, raising the share of public investment to 85 per cent.

Table 3.3
Intensity of government research and education investment: All India

Indicator	1960-62	1970-72	1980-82	1992-94
1. Investment at current prices (Rs, million)	142	409	1858	9617
2. Investment at 1981/82 prices (Rs, million)	729	1081	1887	3831
3. Ratio of investment to AgGDP (%)	0.21	0.23	0.39	0.49
4. Investment/ha of GCA (Rs)				
- at current prices	0.93	2.47	10.49	51.85
- at constant prices	4.77	6.57	10.65	20.65
5. Number of scientists	*	*	*	22249
6. Investment/scientist (000 Rs)				
- at current prices	*	*	*	432.27
- at constant prices	*	*	*	172.18
7. Area/scientists (000 ha of GCA)	*	*	*	8.34

Note: Figures are three-year averages
* number of scientists are not available

Only 15 per cent investment came from the private sector. All together the country spends 0.42 per cent of AgGDP on research, which is quite low as compared to other countries. It is about 0.5 per cent for developing countries and 2.4 per cent for developed countries. Efforts should be made to raise the intensity to at least a commonly described norm of 1 per cent of AgGDP (Previously the World Bank followed a norm of 2 per cent, but now a goal of 1 per cent of AgGDP is suggested for low-income developing countries (Derek Byerlee, personal communication))

Another important indicator of research intensity is the annual research expenditure per scientist. There are 11,048 full-time equivalent (FTE) scientists in the country. Of these, 3,977 are working with the ICAR and 7,071 with the SAUs. Annual nominal research expenditure per scientist is much higher in the ICAR Rs 0.9 million as against Rs 0.4 million in the SAUs, giving an average expenditure of Rs 0.6 million per FTE scientist.

3.1.2 Factor shares in research and education investment

It is important to balance the factor shares in total investment. Shortage of funds for a critical factor may seriously impair the efficiency of the system. The share of various factors, namely, salary, capital and operating expenses are not readily available, especially for SAUs. The data compiled from ICAR budget book (1994/95) give some idea about factor share in the total expenditure. As seen from Table 3.5, salary or establishment cost cornered 46 per cent of the total funds and 37 per cent went to meet operating and equipments cost in the 1980/81. The share of salary rose to 63 per cent in the mid-nineties, whereas the share of operating and equipments cost decreased to 23 per cent. Expenditure analysis done during the preparation of Agricultural Technology Project (NATP) also indicates substantial reduction in the share of 'operating expenses' (net of equipment cost) in the ICAR expenditure. The share of 'operating expenses' is even lower in (about 20 per cent) the SAUs (ICAR/World Bank NATP documents, personal communication) Furthermore, infrastructure maintenance constitutes large part of operating cost, leaving operating funds for research projects at margin. Thus the share of operating expenses in India is much lower than that in other developing countries which is 25 per cent of total expenses and 30 per cent of total recurring expenses. The corresponding figures for the US are 23 per cent and 25 per cent, respectively (Pardey et al., 1991). Given comparatively higher prices of capital goods, there is a strong case for correcting the current factor shares by raising operating and capital expenses. This can be done by improved financial planning and by encouraging scientists to raise research funds.

Table 3.4
Agricultural research intensity: All India

Indicator	1992-94*	
1. Research investment (Rs, million at current prices)		
Public research investment	6993	(85)
Government investment	6578	(80)
Centre (86.9% of the total)	3728	(45)
States (53.5% of the total)	2850	(35)
Public sector industries**	414	(5)
Private sector**	1223	(15)
Total investment (public and private)	8216	(100)
2. Number of scientists (FTE)***		
ICAR		3977
SAUs		7071
3. Annual research expenditure/ FTE scientist (000 Rs)		
ICAR		905
SAUs		421
Average (ICAR and SAUs)		595
4. Research investment/ha of GCA (Rs)		44.30
5. Research investment as % of AgGDP		
India		0.42
Asia and Pacific (1991)****		0.55
China (1991)****		0.36
Developing countries (1991)****		0.51
Developed countries (1991)****		2.39
All countries (1991)****		0.81

Note:
Figures in parentheses are percentage to the total investment.
* Three-year average
Source:
** CMIE (1994) for 1992-93 and for seed, Pray and Umali (1997)
*** Computed from the data available in ICAR (1995/96) and Rao and Muralidhar (1994)
**** Alston era/. (1997)

Table 3.5
Composition of ICAR expenditure

Factor	Per cent share	
	1980/81	**1995-96'**
Establishment costs	46.29	63.39
Travelling costs	1.56	0.98
Operating cost including cost of equipments	37.47	23.28
Civil works	12.54	10.71
Other costs	2.13	1.64
Total	**100.00**	**100.00**

* Two-year average
Source: Based on data in ICAR Budget Book (various years)

3.1.3 Agricultural research and education investment by states

Since state-wise data on government investment in research and education are available over time, and government investment dominates the national investment, state-wise analysis is done for the government investment. State-wise annual compound growth rates and the intensity ratios are presented in Table 3.6. This table reveals that only the state of Tamil Nadu maintained steady growth in the investment since the 1960s. Growth in real investment became negative in the 1970s in some states, notably, Assam, Himachal Pradesh, Jammu & Kashmir, Madhya Pradesh and Uttar Pradesh. All the states showed impressive investment growth in the 1980s. In the 1980s, in majority of the states the annual growth was more than 6 per cent and the growth was remarkably high in the states of Madhya Pradesh (13.3 per cent) and Tamil Nadu (12.3 per cent), whereas the growth was moderate in West Bengal (2.35 per cent). Impressive growth maintained during the 1980s can be attributed to the investment made under the NARP. However, in spite of appreciable investment growth, the investment intensity remained well below 1 per cent of AgGDP in all the states, except Himachal Pradesh. Only five states, namely, Assam, Himachal Pradesh, Kerala, Tamil Nadu and Maharashtra have achieved an intensity which is comparable with or higher than that for the country as a whole (0.49 per cent). Large and less developed states of Madhya Pradesh, Uttar Pradesh, Bihar,

Rajasthan, and Orissa have very low research and education intensity (less than 0.2 per cent). Although the investment in Punjab was increasing about 7 per cent per annum, its intensity was still low. The low intensity in Punjab may be because of specialised cropping system (rice-wheat) of the state which, to some extent, provides economy of size to research efforts. In contrast, the establishment of four SAUs in Maharashtra, mainly on socio-political grounds, and two SAUs in Himachal Pradesh have raised their research and education intensity.

The increased intensity was also reflected in terms of research and education investment per hectare. Real investment per hectare increased in 1990s over 1980s in all the states, with marked increase in the states of Jammu and Kashmir, Himachal Pradesh, Kerala, and Tamil Nadu. On the other hand, marginal increase in the expenditure gave very low intensity on per hectare basis in the states of Bihar, Madhya Pradesh, Orissa, Rajasthan, Uttar Pradesh and West Bengal.

Table 3.6 further shows that there is wide variations in the annual expenditure per scientist across the states. The nominal annual expenditure ranged from Rs 145 thousand in Madhya Pradesh to Rs 545 thousand in West Bengal. Only in three states, *viz.* West Bengal, Kerala and Maharashtra, expenditure per scientist is close to that for the country as *a* whole. Interestingly, none of the states has per scientist annual expenditure equal to that in the ICAR (Rs. 0.9 million), indicating that scientist in ICAR institutes are better funded. As seen earlier, low per scientist expenditure also indicates low operating expenses in the SAUs, reducing overall research efficiency.

Regional congruence

Another important aspect of research efforts is the congruence between actual and desired allocation of research resources across states. Normative resource allocation pattern suggested by Jha et al. (1995) was computed by considering efficiency, equity, sustainability and export as research objectives. The actual investment by states is arrived at by pooling the State and ICAR investments. Investment on ICAR institutes was added to the state in which they are located (Expenditure on ICAR institutes can also be allocated on the basis of state's share in total area under mandate crops. But this crop area share basis allocation would bias the analysis as crop area is one of the criteria for computing normative allocation. Further, in the absence of well established priority setting mechanism at institute level, institutes largely focus on addressing regional problems). This is a weak assumption as it implies that technologies originating from ICAR institutes have equal regional spill-over/in effects. Expenditure for seven institutes, *viz.* IARI, NDRI, IVRI, NAARM, CIFE, IASRI and NCAP having national mandates of strategic research, was allocated among all the states. Following three criteria were used for the allocation:

IARI, IASRI, NCAP	:	state's share in total gross cropped area
NDRI, IVRI	:	state's share in total livestock population
NAARM	:	state's share in the number of scientists
CIFE	:	state's share in total fish production

Table 3.6 Statewise growth rates and intensity ratios of government investment in research and education

States	Growth rate (%) of real investment			Investment as % of AgGDP		Investment (Rs)/ha				Investment scientist (000 Rs, at current prices) 1992-94
						(at 1981 / 82 prices)		(at current prices)		
	1960s	1970s	1980s	1980-82	1992-94	1980-82	1992-94	1980-82	1992-94	
Andhra Pradesh	-0.09	12.18	7.48	0.17	0.26	5.40	12.90	5.32	32.23	357
Assam	7.49	-0.09	6.25	0.30	0.41	11.19	20.88	11.12		291
Bihar	1.37	12.30	6.26	0.14	0.16	4.60	9.94	4.50	24.93	222
Gujarat	12.33	-0.01	7.17	0.21	0.38	5.94	13.34	5.84	33.41	355
Haryana	-	31.25	4.69	0.30	0.31	11.52	17.91	11.31	44.86	227
Himachal Pradesh	-	-0.12	9.39	0.67	1.23	21.59	51.88	21.21	130.16	225
Jammu & Kashmir	18.34	-0.12	6.85	@	@	12.87	69.93	12.64	68.70	152
Karnataka	-0.15	13.75	7.79	0.20	0.29	4.99	10.88	4.90	27.34	240
Kerala	2.06	21.12	7.42	0.33	0.49	18.10	42.94	17.77	107.50	488
Madhya Pradesh	-0.08	-0.08	13.32	0.07	0.14	1.08	3.36	1.06	8.35	145
Maharashtra	16.62	-0.01	5.65	0.42	0.46	9.27	16.16	9.11	40.57	453
Orissa	-0.05	7.19	7.01	0.11	0.21	2.40	4.67	2.36	11.64	196
Punjab	-0.01	4.70	7.16	0.26	0.30	10.62	20.57	10.42	51.66	262
Rajasthan	-0.02	4.46	9.32	0.13	0.21	1.92	4.45	1.90	11.16	241
Tamil Nadu	1.37	3.68	12.28	0.23	0.42	7.67	24.57	7.56	61.62	329
Uttar Pradesh	12.19	-0.11	4.88	0.14	0.16	4.78	7.42	4.68	18.73	316
West Bengal	5.58	13.52	2.35	@	@	8.31	9.68	8.19	24.53	545
All India (centre+state)	6.52	9.51	6.29	0.39	0.49	10.65	20.65	10.49	51.85	432

Note: Except growth rates, data are three-year averages;
@ Consistent AgGDP data were not available.

Congruence index (CI) was computed to assess the closeness of existing investment with the near optimal one, assuming equal per unit pay offs. The index is derived as: $CI = 1-\Sigma_i (R_i-V_i)^2$; where R_i is the actual share of i^{th} state in the national investment, and V_i is the normative share of i^{th} state. The value of CI is 0.99, indicating high congruency in regional investment pattern. But, last two columns of Table 3.7 indicate that the current investment pattern differed with the near optimal one in some states. For instance, the share of Bihar, Madhya Pradesh, Orissa, Uttar Pradesh and West Bengal in the national investment is much lower. Interestingly, in these low intensity states, the share of state in the total investment is comparatively lower. On the other hand, the current share is comparatively higher than the desired in the states of Haryana, Himachal Pradesh, Kerala and Maharashtra. In contrast to general belief, the share of small states comprising north eastern states, except Assam, is not less than the optimal one. The deviations between the current and optimal shares appear to be small in percentage points, but in nominal terms, one per cent change in current investment level implies a reallocation of Rs 66 million. Therefore, an enhanced research investment in the low research intensity states would maximise research benefits in the country. It is essential to raise the investment in these states. However, there is hardly any visible attempt in the planning process to increase research investment in the low intensity states. The share of these states in the total plan investment and ICAR grants and expenditure is comparatively lower. The state of Maharashtra, which has four SAUs claimed about 14 per cent of the total ICAR grants, indicating that states with higher research investment were also getting higher ICAR financial support. Similarly, the states of Andhra Pradesh, Haryana, Kerala and Maharashtra received higher ICAR expenditure. This strategy may not optimise research benefits. A judicious approach would be to develop regional research capacity which can maximise overall research benefits, avoiding problems of research overlapping and 'free riding'. The ICAR can temporarily bridge the gap, but a lasting solution would be to allocate higher plan funds to those states which have low research intensity and a share lower than the desired one in the national investment. Assam, Bihar, Madhya Pradesh, Orissa, Uttar Pradesh and West Bengal are in this category.

Table 3.7
Actual and normative share of states in the national research and education investment

States	ICAR grants to SAUs #	ICAR institutes expenditure $ (Rs, million)	Total (State+ ICAR+grant)	ARI as % of AgGDP	% share of State funds in the total	% share in in Plan funds ***	% share in national investment	
							Actual	Optimal&
	(1992-96)*	(1993/94)	(1992-94)**			(1993/94)	(1992-94)**	
Andhra Pradesh	4.8 (3.8)	307 (10.7)	723	0.46	56.8	3.5	8.7	9.8
Assam	5.4 (4.3)	20 (0.7)	223	0.46	88.6	8.9	2.7	3.6
Bihar	5.0 (4.0)	82 (2.8)	320	0.22	72.8	2.6	3.8	7.1
Gujarat	•6.7 (4.5)	71 (2.4)	444	0.46	82.7	5.8	5.3	4.8
Haryana	6.3 (5.0)	286 (10.0)	555	0.65	47.3	3.0	6.6	2.8
Himachal Pradesh	9.8 (7.8)	64 (2.2)	200	1.94	63.1	5.1	2.4	0.5
Jammu & Kashmir	4.2 (3.4)	10 (0.3)	89	@	84.0	3.6	1.1	0.7
Karnataka	10.4 (8.3)	134 (4.6)	484	0.42	70.2	12.9	5.8	6.8
Kerala	7.0 (5.5)	242 (8.4)	576	0.86	56.8	5.3	6.9	3.9
Madhya Pradesh	8.5 (6.8)	179 (6.2)	386	0.27	51.4	7.2	4.6	8.8
Maharashtra	13.7(10.9)	271 (9.4)	1138	0.61	74.9	4.5	13.7	7.6
Orissa	5.1 (4.1)	141 (4.9)	256	0.49	42.9	2.9	3.1	4.7
Punjab	4.9 (3.9)	40 (1.4)	435	0.34	89.6	6.2	5.2	4.4
Rajasthan	7.0 (5.6)	240 (8.4)	472	0.43	47.6	4.2	5.6	5.8
Tamil Nadu	9.1 (4.8)	100 (3.5)	545	0.53	80.0	14.7	6.5	6.5
Uttar Pradesh	13.5 (10.8)	450 (15.7)	945	0.32	50.9	3.9	11.3	12.8
West Bengal	5.2 (4.1)	140 (4.9)	355	@	59.1	2.9	4.2	7.3
Others	~	89 (3.1)	171	@	47.9	2.5	2.1	1.9

* Fiver-year average;
** three-year average;
@ AgGDP data are not available. Source:
\# Education Division, ICAR;
$ Based on data in ICAR Budget Book (1994/95);
*** Data compiled from Planning Commission;
& Jha *et al.* (1995).

3.1.4 Allocation of research investment by commodity groups

Allocation of plan funds in the successive plans indicates the changing research emphasis among the commodities. Plan-wise allocation of ICAR funds, given in Table 3.8, shows that reseated claimed nearly three-fourth of ICAR resources since the Sixth Plan. Within research, traditionally, focus has been on crop research which accounted for one-third of total research outlay. The share of crop research went down in the eighties but it was restored in the Eighth Plan. Since 1980, major expansion has taken place in non-commodity, resource-related research, which now accounts for one-third of total plan outlay for research. The Eighth Plan emphasised research on horticulture and fisheries, raising their share in the total research outlay. Animal science research, after a period of expansion in the seventies, continued to account for 10 per cent of the total plan outlay. Education, which accounted for nearly one-third of ICAR plan allocations in the seventies, now accounts for nearly 12 per cent. There has been a remarkable growth in the allocations for front-line extension and transfer of technology programmes which currently claims nearly 13 per cent of ICAR plan funds.

The plan expenditure constitutes a small proportion of the national investment and major share comes from the non-plan funds. Activity-wise breakup of current total investment (plan and non-plan) for ICAR and SAUs during the early nineties (Figure 3.2 and Table 3.9) revealed that about three-fourths of the ICAR funds are spent on research. Within research, 27 per cent of total ICAR funds went to field crops followed by 15 per cent to animal sciences, 12 per cent to soil, agronomy and agro-forestry, 9 per cent to horticultural crops, and 7 per cent to fisheries. About 11 per cent resources are spent on information management, administration, etc. It is interesting that equal amount (6 per cent) was spent on education and extension. Higher expenditure on extension is the result of more than proportionate allocation of plan funds to extension during the Seventh and Eighth Plans, mainly at the cost of education (Table 3.8).

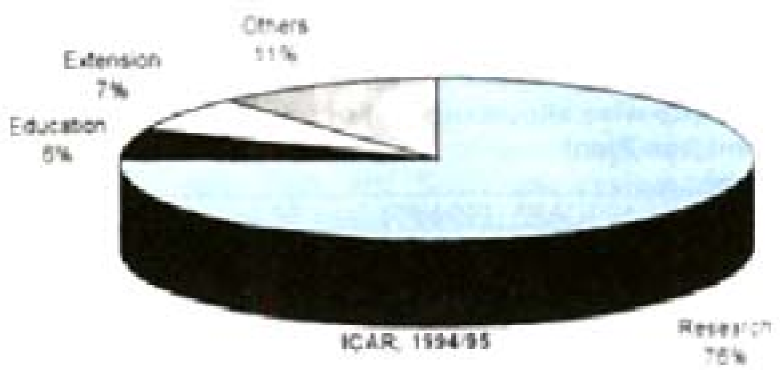
As expected, the SAUs spent 33 per cent of their resources on education, as teaching is the primary mandate of SAUs. Research claimed 45 per cent resources followed by administration (17 per cent), much higher than the ICAR, and extension (5 per cent). The SAUs placed greater emphasis on research on soils, agronomy and agro-forestry presumably because of their location specificity, followed by crops and livestock. Fisheries research received very little attention in the SAUs. The proportion of ! resources devoted exclusively to economics and statistics in the SAUs appears to be higher than that in the ICAR. But if we include economics component in agro-biological research institutes, resources spent on economics and statistics would be equal or higher than those in SAUs.

Table 3.8
Activity-wise and commodity-wise breakup of (CAR plan allocations (Rs, million)

Plan	Research						Education	Extension	Other	Total
	Crop	Horticulture	Animal science	Fisheries	other	Total				
IV Plan (1969-74)	200 (21.9)	74 (8.1)	152 (16.6)	34 (3.8)	119 (13.0)	579 (63.4)	316 (34.6)	18 (1.9)	1 (0.1)	914 (100.0)
V Plan (1974-78)	319 (20.8)	93 (6.1)	259 (16.9)	81 (5.3)	179 (11.7)	932 (60.7)	525 (34.2)	71 (4.6)	07 (0.4)	1535 (100.0)
VI Plan (1980-85)	698 (20.5)	222 (6.5)	356 (10.5)	178 (5.2)	1042 (30.6)	2497 (73.4)	739 (21.7)	149 (4.4)	14 (0.4)	3400 (100.0)
VII Plan (1985-90)	904 (21.3)	237 (5.6)	446 (10.5)	188 (4.4)	1396 (32.9)	3172 (74.6)	78 (16.7)	321 (7.5)	49 (1.2)	4250 (100.0)
VIII Plan (1992-97)	3228 (24.8)	1000 (7.7)	1400 (10.8)	650 (5.0)	3233 (24.9)	9512 (73.2)	1554 (11.9)	1600 (12.6)	334 (2.6)	13000 (100.0)

Note: Figures in parentheses are percentage of total outlays.
Source: Jha et al. (1995)

Figure 3.2
Allocation Of ICAR And SAUs Funds (Plan and non-plan) by activity



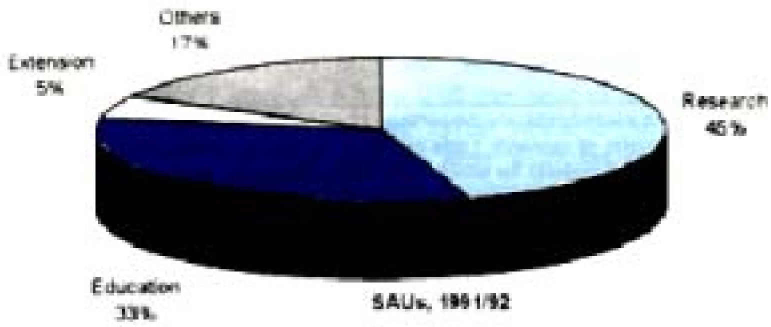


Table 3.9
Activity-wise allocations (%) of total expenditure (Plan and non-Plan)

Head	ICAR * (1994/95)	SAUs ** (1991/92)
Research	75.5 (100)	45.0 (100)
Crops	26.8 (35.5)	10.6 (23.6)
Horticulture	9.2 (12.2)	4.2 (9.4)
Soil, agronomy and agro-forestry	12.3 (16.3)	18.7 (41.6)
Agricultural engineering	4.2 (5.6)	2.5 (5.6)
Animal sciences	14.9 (19.7)	5.3 (11.8)
Fisheries	6.9 (9.1)	0.6 (1.3)
Agricultural economics and statistics	1.2 (1.6)	3.0 (6.7)
Education	6.3	33
Extension	6.8	5
Others	11.4	17

Notes: i) Figures in parentheses are percentage of respective total 'research' funds.
ii) The allocation of research funds by SAUs is based on information compiled from research projects for which expenditure data were available.

Source:
* ICAR Budget Book 1995/96,
** Rao and Muralidhar (1994).

Although the allocation of research funds in the ICAR and SAUs is quite wide-spread among disciplines, some adjustments are necessary. For example, allocations to agricultural engineering can be rationalised as corporate investment (public and private) is substantial in this area. Similarly, there is scope for reduction in the expenditure on front-line extension. On the other hand, allocations to research on livestock and horticulture may be increased to achieve optimal resource allocation (Jha et al., 1995). Social science research is another area which needs greater emphasis in the ICAR/SAU system. Currently, we are spending 7.5 per cent on social sciences (economics, statistics, extension education and management research) as against 18 per cent in the CGsystem (Farrington et al., 1997).

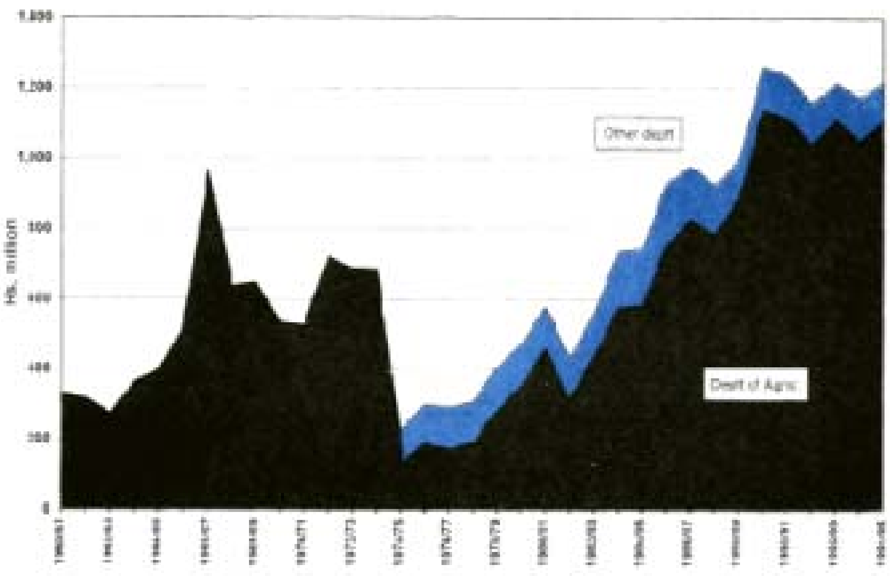
3.2 Investment in Agricultural Extension

Extension activities are supported with funds from revenue account of the state governments, and expenditure on capital account is absent, except negligible expenditure on animal husbandry for few years in some states. The estimates of government extension investment reported here, therefore, cover only expenditure on the revenue account. State-wise extension investment data since 1960/61 are given Appendix IV.

3.2.1 Trends in extension investment: All India

Primary responsibility of transfer of technology rests with the state governments, and ICAR and SAUs are involved only in front-line extension. This fact is clearly visible from the sources of extension investment, indicating that more than 90 per cent investment is made by the states. Most of the expenditure was channelled through the 'Department of Agriculture' of state governments. As shown in Figure 3.3, government investment on extension has grown since 1960/61, except abrupt changes in two years. In 1966/67, the investment rose sharply because of substantial increase in the investment in Bihar, Tamil Nadu and Maharashtra. On the contrary, there was drastic fall in the investment in 1974/75, particularly in Andhra Pradesh, Bihar, Haryana, Kerala, Punjab and Tamil Nadu (Appendix IV). In fact, this fall is more because of changes in the accounting heads of the governments, rather than systematic efforts on the part of state governments to reduce the investment (A careful study of expenditure under 'education and training' head indicates some amount of education expenditure in some states up to 1973/74).Since 1974/75 extension investment by the governments maintained steady growth of 7 per cent. As shown in Table 3.10, extension intensity increased from 0.09 per cent of AgGDP in the early 1960s to 0.14 per cent in the early 1970s, which further rose marginally to 0.15 per cent in the early 1990s after slight fall in the early 1980s. Annual investment in extension by governments during the triennium 1992-94, in nominal terms, is Rs 3008 million, giving an investment of Rs 16.22 per ha. Annual expenditure per extension worker is 26 thousand (average of all departments), whereas it is as low as Rs 15 thousand for the main extension system, i.e., Department of Agriculture. Even making allowances for high proportion of low qualified extension workers (70 per cent of the total wooers are intermediate or below; Misra, 1990), there are hardly any operational funds which are essential for mobility of extension workers. Macklin (1992) estimated that the share of non-salary component in total extension expenditure in Tamil Nadu decreased from 48 per cent in 1981/82 to 4 per cent in 1990/91.

Figure 3.3
Trends in government real investment in extension in India (at 1981/82 prices)



Like research, private and public sector companies also undertake extension work to promote sales of their products, however, their extension expenditure data are not available. The private companies spend slightly higher amount on publicity and on an average they spend about 4 per cent of their turnover on research and 1 per cent on publicity (Singh *et al*., 1995; Pray and Ribeiro, 1990). We have, therefore, taken 20 per cent and 25 per cent of research expenditure of the public and private companies, respectively, as extension expenditure. This is very crude, underestimation of private expenditure on extension, as private companies also spend on marketing of inputs and maintaining of field staff. Adding the private expenditure to the government investment gives an extension intensity of 0.2 per cent of AgGDP and Rs 21.32/ha in the country (Table 3.11). This level of extension intensity in India is much lower than that in developing and developed countries (0.4 per cent and 0.9 per cent, respectively, Judd et al., 1986) in the early eighties. Of the total investment, 92 per cent is public investment and the rest 8 per cent is made by the private sector. Among the public funds, about 76 per cent of the national expenditure is spent by the state departments, 14 per cent by the ICAR/SAU system and 2 per cent by the public sector companies. Thus, unlike research, extension is the major responsibility of the state governments. Private sector's participation in extension will grow along with the increase in its research investment and with the increase in farmers' ability to pay for extension services.

3.2.2 Extension intensity : States

Trends in the intensity of government or public investment in extension by states are given Table 3.12. State-wise intensity is presented since 1974/75 as uniformity in accounting of investment data across states was observed since 1974/75. The growth in extension investment during the period 1974/75 to 1994/95 was negative in the high productivity states of Haryana and Punjab. These states were joined by the states of Karnataka, Kerala, Orissa and West Bengal during the period 1984/85 to 1994/95. In contrast, the states of Uttar Pradesh, Tamil Nadu, Jammu and Kashmir, Gujarat and Assam, registered impressive growth in the investment during the second period. Although the nominal expenditure production environment of other states needs higher level of extension efforts. Even in Punjab and Haryana, there is a need for intensive extension work as there would be greater role of crop and resource per ha increased in all states in the early nineties, it declined in real terms in the states of Haryana, Orissa, Punjab and West Bengal. The proportion of AgGDP spent on extension also declined in Bihar, Haryana, Karnataka, Kerala, Orissa and Punjab, and this decline is serious because the intensity was already very low (0.06 per cent or less) in these states, except Bihar. Extension intensity in Himachal Pradesh and Tamil Nadu was more than twice of that for the country as a whole. These results, thus, underline the need for increasing extension intensity in low productivity states, particularly in Andhra Pradesh, Kerala, Karnataka, Madhya Pradesh and Orissa.

Table 3.10
Growth and intensity of agricultural extension investment by government: All India

Intensity indicator		**1960-62**	**1970-72**	**1980-82**	**1992-94**
1. Investment (Rs, million)					
Current prices		59	243	513	3008
Constant prices		306	645	524	1201
2. Investment as % of AgGDP		0.09	0.14	0.11	0.15
3. Investment/ha (Rs)	Constant prices	2.00	3.89	2.96	6.48
4. Investment/extension worker	Overall	@	@	@	25.58
(in 1988, 000 Rs, current prices)	Main department				15.29
5. Deparment allocation of investment (%)					
Agriculture		100	100	76.66	90.66
Soil & water conservation		*	*	1.67	2.17
Animal husbandry		*	*	13.43	2.53
Dairy		*	*	1.16	0.97
Fisheries		*	*	7.00	3.70
6. Share of states in national investment (%)		97.87	99.80	94.33	92.87
7. Growth in real investment** (%)			10.74	-0.07	7.02

Note: Figures are three-year averages;
® Number of extension workers is not available.
* investment started since 1974/75;
** The growth rates are for 1960-69, 1970-79 and 1980-94.

Table 3.11
Agricultural extension intensity: All India

	Indicator	Investment (Rs., million) 1992-94	
1.	Public investment	3649	(92.3)
	Government:		
	Main extension system	3008	(76.1)
	ICAR/SAU system	558	(14.1)
	Public sector industries (20% of R&D cost)	83	(2.1)
2.	Private investment (25% of R&D cost)	306	(7.7)
3.	Total investment (public and private)	3955	(100.0)
4.	Total investment *as %* of AgGDP		0.20
5.	Investment (Rs)/ha of GCA		21.32

Note: Data are three-year average for government investment.
Figures in parentheses are percentage to the total investment.

The wide variations in extension intensity across the states are rather puzzling. These variations can partly be attributed to inter-state differences in the funding under the NAEP. Nevertheless, these differences need further discussion. For instance, the case of Punjab and Haryana is interesting in the sense that these states have high technology adoption levels, despite of very low extension intensity. The plausible reason could be the dominance of irrigated production environment in these states which is conducive for rapid adoption of technology. Farmer-to-farmer spread of technology is much faster in the homogeneous, irrigated production environment. Moreover, these states have very high levels of inputs use, inviting greater attention of private input companies which also undertake transfer of technology activities. Thus, heterogenous management technologies in these states and farmer-to-farmer spread of management technology is comparatively slow.

Table 3.12
Growth and intensity of government investment in agricultural extension by states

State	Investment/000 ha (Rs. at 1981/82 prices)		Nominal investment (000Rs)	Growth rate (%) of real investment		Investment as % of AgGDP	
	1980-82	1992-94	1992-94	1974-1994	1984-1994	1980-82	1992-94
Andhra Pradesh	645	1045	33876	5.30	4.00	0.02	0.02
Assam	4043	11155	106080	11.30	5.70	0.11	0.11
Bihar	12421	16469	389462	7.40	4.40	0.37	0.27
Gujarat	- 3777	8002	221042	11.50	5.80	0.13	0.23
Haryana	1895	1634	24222	- 0.90	- 0.03	0.05	0.03
Himachal Pradesh	3430	22961	55321	14.50	1.90	0.11	0.54
Jammu & Kashmir	4520	26500	70854	17.20	7.50	@	@
Karnataka	1200	1330	41798	2.90	- 0.01	0.05	0.04
Kerala	2627	3253	24965	2.40	- 0.01	0.05	0.04
Madhya Pradesh	734	1527	87185	3.20	2.60	0.05	0.06
Maharashtra	1396	8005	422141	12.90	1.70	0.06	0.23
Orissa	1681	1274	29812	5.60	- 0.05	0.08	0.06
Punjab	1817	823	15552	- 3.50	- 0.09	0.04	0.01
Rajasthan	3353	5326	269811	12.20	4.00	0.23	0.25
Tamil Nadu	9022	24195	830267	11.60	8.30	0.27	0.42
Uttar Pradesh	257	6436	413421	18.70	24.50	0.01	0.14
West Bengal	6423	4354	91923	6.20	- 0.06	@	@
All India	2958	6475	3008317	9.14	4.37	0.11	0.15

Note: Except growth rates, figures are three-year averages;
@ Consistent AgGDP data were not available.

It is difficult to suggest some desired level of extension intensity, however, one can judge current extension intensity vis-a-vis the task ahead. Given current stock of technologies, there is tremendous scope for yield increase. It is estimated that excepting few states, there is untapped yield potential of 40-94 per cent in most important crops of the states (Jha *et* al., 1995). This, coupled with complexity of second generation technologies and heterogeneity of production environments warrant much more intensive extension efforts. Extension services should be strengthened by scaling up investment levels and improving the quality of extension. This is especially important for low extension intensity states like Andhra Pradesh, Kerala, Karnataka, Madhya Pradesh and Orissa. The first step in this direction should be to enhance the availability of operating funds.

4 DETERMINANTS OF AGRICULTURAL RESEARCH AND EXTENSION INVESTMENTS

Research, extension and education compete with other investment opportunities for scarce public resources. Decision makers wish to maximise total benefits by allocating public resources among alternatives. If one follows the principle of neo-classical economics, total benefits would be maximum when resources are allocated to equate marginal benefits with marginal costs. In reality this situation can hardly be realised, as benefits of most of the investment options, particularly social benefits, are difficult to measure. Long gestation period, coupled with uncertainty of benefits in some investment alternatives, especially research, further complicate the measurement problem. Therefore, availability of total investible resources and politico-economic factors are more important for making resource allocation decisions. Some economists have measured the effects of above mentioned factors on research and extension investments (see Fox, 1987). Guttman (1978) used a theory of public interest groups in the study of research expenditure in the US. Some researchers also applied the Hayami-Ruttan's induced innovation hypothesis to study research investment behaviour. In a large number of studies, political-economy model was used to study the determinants of research investments in developed and in developing countries (Important studies using this model are Huffman and Miranowski (1981), Rose-Ackerman and Evenson (1985), Judd et al. (1987), Pardey et at. (1989), Dinar (1991), and Evenson (1991)). In the Indian context, Rajeswari (1995) considered historical development of the NARS to explain temporal changes in research investment.

4.1 Model Specification (Useful discussion with NCAP scientists in a seminar and Dr Carl E. Pray on this topic is gratefully acknowledged)

Considering the planning process in India, it is realistic to assume that both economic and political factors influence allocation of public resources across sectors and states. We have, therefore, used a political-economy model to study research and extension investment behaviour. In this model three sets of variables, *viz.* economic, economic-political and political are used. Specific variables included in the model are discussed below.

Economic variables: The most important variable in this category is per capita AgGDP which shows the demand for agricultural commodities. It is expected that an increase in the demand for agricultural commodities will induce more investment in research and extension. Per capita AgGDP represents the induced innovation hypothesis as high demand for a commodity, reflected through higher commodity prices, will induce more research and extension. Similarly, as alternate sources of agricultural growth, notably land, become scarce, there will be more demand for research to save scarce land by developing new land-saving technologies. Thus, per capita GCA was used to capture the effect of alternative sources of growth. Irrigation expansion is another possible source of growth. But this is also reflected by GCA as irrigation expansion increases GCA through higher cropping intensity. Besides alternate source of growth, an increase in irrigated area will also decrease the demand for extension because of high farmer-to-farmer spread of technologies. Therefore, per capita irrigated area (GCA) was included in the extension model as one of the explanatory variables.

Another important economic variable included in the model is agricultural terms of trade which is defined as the ratio of implicit deflators of agricultural to non-agricultural GDP. It is expected to have positive effect on research and extension investments as favourable terms of trade will increase the returns to research and extension investments compared to other investments. Agricultural diversification is another important variable. It is expected that the more diversified agricultural production the more will be the demand for research. The diversification may not be so important for extension as critical minimum extension efforts can cater to diversified extension needs. The diversification index was computed as $1/\Sigma S_i^2$ where S_i is the share of ith crop area in total GCA.

Economic-political variables: These variables are the share of agriculture expenditure in total government expenditure and per capita government revenue. Per capita government revenue is expected to have positive effect on research and extension investments. An increase in per capita government revenue indicates that more resources are available with government for investment and therefore government is likely to invest more. The share of government expenditure on agriculture can affect research and extension investments both ways. It can have positive effect if higher agriculture allocations are also going to research and extension. On the other hand, if other investment options in agriculture get high priority, an increase in total allocations for agriculture may not increase research and extension expenditure.

Some researchers have also included other economic-political variables like share of agricultural exports in total exports or share of exports in total agricultural production. Since state-wise data on agricultural exports are not readily available, this variable was not included in the model.

Political variable: Rural population (per cent of total population) was included in the model to indicate influence of rural interest groups. A high proportion of rural population shows strong rural constituency, influencing public investment decision in their favour. For extension, positive influence of higher rural population is also expected because more resources are needed to contact large number of farmers. Rural literacy, a proxy for farmers' education, is expected to accelerate adoption of new technology. Educated farmers which are more informed about research benefits, can form interest groups to influence resource allocations in favour of research and extension.

Apart from above mentioned variables, technology spillin effects also influence research investment decisions. This is best captured by research investment in the regions with similar agro-climatic conditions. Given the agro-climatic variability within states, it was difficult to find out groups of states with homogeneous agro-climatic conditions. The same was true for international agricultural research. Therefore, variables capturing the 'free-riding' behaviour or the effect of technology spillin possibilities were not included in the model.

Model estimation: The model was estimated using state level cross-section and time-series data from 1981/82 to 1993/94. The dependent variable was per capita expenditure. For research it includes expenditure made by state governments and ICAR on research and education (for state-wise allocation of ICAR expenditure, see chapter 3). In the case of extension, only state governments' expenditure is considered as it constitutes almost entire extension investment in the country. All monetary variables in the model were deflated using implicit GDP deflator with 1980/81 as base year. Necessary data pertaining to different variables were compiled from various sources (Appendix II). Means and standard deviations (SD) of data set are given in Table 4.1.

Pooling of cross-section and time-series data poses some estimation problem. Two methods, namely, dummy variables model (DVM) and error components model (ECM) can be used for the estimation. The DVM is estimated by ordinary least squares (OLS) using dummy variables for cross-section units (in our case states), whereas generalised least squares (GLS) method is used for ECM. The choice of model mainly depends upon relative sizes of N (cross-section units) and T (time-series units), and possible relationship between immeasurable individual attributes and measurable time-varying attributes (explanatory variables). The estimates of ECM will be consistent and efficient when $T \geq 3$ and $N-K \geq 9$, where K is number of parameters excluding dummy variables (Judge et al., 1988, p 489-490). In our case T = 13, N = 14 and K = 10. The relative sizes of N and T does not satisfy the condition of applying ECM as N-K is less than 9. Also, we suspect some association between unmeasurable state attributes and explanatory variables, supporting the use of DVM. We have therefore used DVM. State dummy variables are used taking the state of Andhra Pradesh as base.

Second problem in the estimation was of simultaneity bias. It is reasonable to expect the problem of simultaneity between per capita AgGDP and research and extension investments. This problem was overcome by taking per capita AgGDP as lagged (one year) variable. We may also expect simultaneity bias between research and extension equations. The Hausman Specification test was used to test the simultaneity between research and extension equations, which confirmed the presence of simultaneity bias. Under this situation, both the equations were estimated simultaneously using Two Stage Least Squares (2SLS) estimation procedure.

Table 4.1
Means and standard deviations of data set

	Variable	Mean	SD
1.	Per capita real research and education expenditure (Rs)	4.41	3.29
2.	Per capita real extension expenditure (Rs)	0.99	0.90
3.	Per capita real AgGDP (Rs)	804.94	376.47
4.	Per capita GCA (ha)	0.27	0.11
5.	Per capita irrigated area (ha)	0.10	0.09
6.	Diversification index	5.89	2.26
7.	Terms of trade (%)	95.74	10.73
8.	Share of Ag expenditure (%)	11.01	6.15
9.	Per capita real government revenue (Rs)	539.19	199.03
10.	Rural literacy (%)	44.99	14.75
11.	Share of rural population (%)	74.80	11.66

4.2 Results

The results, given in Table 4.2, show that the model is successful in explaining inter-state differences in research and extension investments in the country. With some exceptions, variables included in the model have expected sign. Presence of endogeneity in research and extension model is consistent in view of concomitant efforts made to strengthen the research and extension system, particularly under the NARP and NAEP. Among the economic variables, per capita AgGDP and per capita irrigated area have significant impact. The negative and significant effect of per capita AgGDP on extension investment is contrary to our expectations. This perhaps indicates economies of scale in the provision of extension services. The negative and significant coefficient of per capita irrigated area in the extension model is consistent with our expectations. This supports our hypothesis that low extension efforts are required in irrigated areas as there is rapid farmer-to-farmer spread of technologies. Also, expansion of irrigation is an alternate source of growth in agricultural production, reducing the need for higher extension investment. However, this relation was not found in the research model. Surprisingly, neither diversification index nor agricultural terms of trade has significant coefficient.

The share of agricultural expenditure in total government expenditure has positive and significant coefficient for research and negative and significant for extension. This shows that increased expenditure for agriculture was also allocated to research, but extension was not investment priority. Extension expenditure increased only when there was increase in government resources as shown by positive and significant coefficient of per capita government revenue.

Consistent to our expectations, rural literacy has very strong positive effect on research investment. It was difficult to estimate the extension model with rural literacy variable because of multicollinearity problem and therefore the model was estimated excluding rural literacy. Rural population has significant coefficient only in the extension model and the coefficient was positive, indicating that farmers were able to lobby for higher extension investment through extension system which is in direct touch with farmers. Also, higher rural population requires more extension efforts in the T&V system which works through contact farmers and therefore the coefficient is positive. The coefficient of rural population was not significant for research as stronger farmers organisations which can lobby for specialised activities like research are absent in India.

Table 4.2
2SLS estimates for government research and extension investments model

Variables		Per capita real research & education investment	Per capita real extension investment
1.	Per capita real research & education 'investment (Rs)		0.487*** (6.30)
2.	Per capita real extension investment (Rs)	0.976*** (2.65)	
Economic variables			
3.	Lagged per capita real AgGDP (Rs)	0.002*** (2.56)	-0.001*** (3.84)
4.	Per capita GCA (ha)	-0.684 (0.27)	1.183 (0.65)
5.	Per capita irrigated area (ha)		-19.571** (1.96)
6.	Diversification index	-0.090 (0.73)	
7.	Terms of trade (%)	-0.002 (0.26)	-0.005 (1.20)
Economic-political variables			
8.	Share of agril. expenditure in total govt. expenditure (%)	0.030** (2.39)	-0.014* (1.72)
9.	Per capita real government revenue (Rs)	-0.0004 (0.54)	0.0008**(2.14)
Political variable			
10.	Rural literacy (%)	0.146***(2.51)	
11.	Share of rural population (%)	-0.069 (0.73)	0.123*** (2.99)
12.	State dummy		
	Bihar	-2.052** (2.26)	-0.011 (0.02)
	Gujarat	-3.942*** (7.05)	2.017***(4.72)
	Haryana	5.643***(6.47)	0.141 (0.06)
	Himachal Pradesh	2.803 (1.11)	-4.852*** (4.52)

	Karnataka	-2.099*** (2.93)	0.401 (1.01)
	Kerala	-5.380* (1.69)	-2.610*** (3.85)
	Madhya Pradesh	-1.310** (1.96)	-0.062 (0.18)
	Maharashtra	-4.727**(1.93)	3.631*** (2.53)
	Orissa	-1.808 (1.09)	-0.974* (1.77)
	Punjab	-2.064** (2.27)	5.806** (2.06)
	Rajasthan	0.052 (0.06)	1.364** (2.22)
	Tamil Nadu	-5.861***(9.65)	2.741*** (5.05)
	Uttar Pradesh	-0.895 (1.55)	0.447 (1.13)
13.	Constant	2.960 (0.35)	-8.011** (2.27)
	Adjusted R^2 'F' value	0.97 273.65***	0.79 34.26***
	N = 14, T= 13		

***, **, * significant at 1, 5 and 10 per cent level, respectively.
Figures in parentheses are T values.

The coefficients of nine state dummy variables are significant in both the models, indicating the importance of unmeasurable state attributes. These coefficients can be explained taking Andhra Pradesh as base. Most of the coefficients are negative in the research model, indicating higher levels of per capita research expenditure in Andhra Pradesh because of higher expenditure on ICAR institutes.

Both the models were also estimated using trend as one of the explanatory variables (results not reported here). Trend variable did not make any change in the extension model, whereas it was significant and negative in the research model and rural population has negative and significant coefficient, which is rather unexpected.

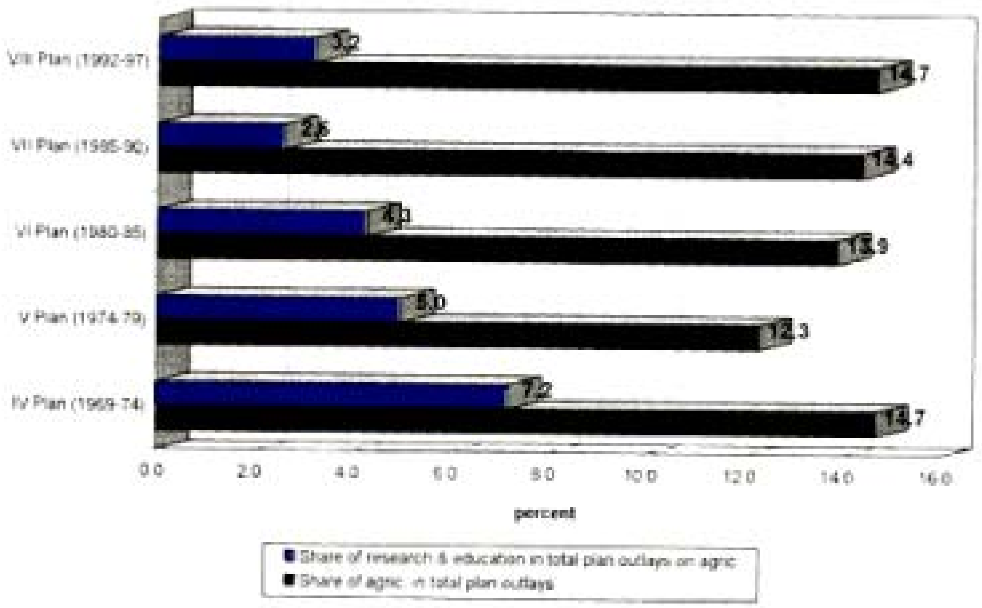
Investment intensity model

In order to test the consistency of results, we have also estimated the investment intensity model. Here dependent variables in the research and extension models are defined as research and education expenditure as percentage of AgGDP and extension expenditure as percentage of AgGDP, respectively. In this specification, real AgGDP is also taken as one of the explanatory variables to test economies of scale. Alternate sources of agricultural growth were defined as growth in GCA (ratio of current GCA to GCA in 1980/81) and per cent irrigated area.

The results (Appendix V) show that although real AgGDP has negative sign in both the models, it was not significant showing absence of economies of scale. The results, however, are largely consistent with the per capita investment model, except agricultural terms of trade which has unexpected negative coefficient in the extension model, and government expenditure variables which are nonsignificant in both the models. Rural literacy has positive and significant effect on extension intensity which was not captured in the per capita investment model.

One can infer from the results presented here that the demand for agricultural products has significant effect on research and extension investments decisions. Alternate sources of growth influenced extension investment adversely, whereas there were concerted efforts to invest in research and education irrespective of alternate sources of growth. Political and economic-political factors also affected the investment decisions, particularly for extension. However, extension was given low priority in agricultural investments. Had there been a very strong influence of political factors like lobbying by farmers, there would have been constant increase in the share of research and education in total plan allocations to agriculture. On the contrary, as seen from Figure 4.1, there is a sharp decline in the share of research and education in total outlays on agriculture in spite of the share of agriculture and allied activities remaining constant around ,14 per cent. The share of research and education outlays decreased from 7.2 per cent in the Fourth Plan (1969-74) to 2.6 per cent in the Sixth Plan (1985-90) which further rose marginally to 3.2 percent in the Eighth Plan (1992-97). Marginal improvement in the share in the Eighth Plan might be because of greater awareness about research benefits, thereby consolidating of interest group of farmers as well as researchers. Another plausible reason for low plan outlays for research and education could be reasonably well development of research and education system in the past and presently most of the expenditure is non-plan. But this does not mean that the intensity should not be increased by allocating more resources to research and extension.

Figure 4.1
Share of agricultural research and education in tital plan outlays for agriculture



5 STRENGTHENING THE NATIONAL AGRICULTURAL RESEARCH AND EXTENSION SYSTEMS

The national agricultural research and extension systems (NARES) in India have evolved over time, incorporating several innovative organisational and funding concepts. The accumulating body of evidence indicates impressive rates of return to investment in research and extension. Nevertheless, there are certain operational problems, typical of public organisations. Recently, a number of reforms were initiated in the NARES, particularly in the research system. This chapter assesses the current process of reforms and its consistency with the measures required to strengthen the NARES in the changing scientific and economic environment.

A number of changes have taken place at the national and at international levels. New trade regime under the WTO, trade-led growth, integration of i the economy with rest of the world, declining role of state, increasing reliance on market forces, etc. are some of the 'new rules of the game'. Obviously, these new rules have major implications on the national research and development (R&D) policy, as technological advancement is going to be decisive factor in economic development. The NARES have to be more strong, efficient and client oriented. Necessary measures required in this direction are discussed below.

5.1 Increase research and extension investments

The present level of research and extension intensity is inadequate to meet the emerging R&D challenges. Early signals of new stresses in agricultural production call for immediate increase in research and extension intensity, lest these multiply beyond repair. The increase in research and extension intensity should address three main issues: (i) increasing research and extension intensity, (ii) rationalising resource, allocation across regions and commodities, and (iii) correcting factor shares in the expenditure. In view of the higher intensity in other countries, efforts should be made to double the public investment in research and extension. The concomitant growth in the private investment would give a intensity level which is comparable to other countries. Higher research and extension investment is justified on economic grounds. As seen from Table 5.1, rates of return to past investments in research and extension are impressive. It is important to note here that these rates of return are for the sectoral or sub-sectoral level and not for few successful technologies, thereby justifying the higher investment. Further, these rates of return are much higher than those realised in other investments. For example, rates of return to investment in irrigation for the World Bank funded projects were less than 10 per cent and the minimum acceptable rate of returns suggested by the Nitin Desai committee for investment in irrigation is 9 per cent (cited from Gulati et al., 1994). Even making allowance for low utilisation of irrigation potential, rates of return from research and extension are still higher, justifying a quantum increase in public investment in research and extension.

Table 5.1
Returns to investment in research and extension

Study	Commodity	Rate of return	
		Research	Extension
Evenson and Jha (1973)	Aggregate	50	14
Feder et al. (1987)	Farm level		15
World Bank (1990)*	NAEP		50
Evenson and Mckinsey (1991)	Aggregate	218	177
Rosegrant and Evenson (1992)	Aggregate	63	52
Kumar and Rosegrant (1994)	Rice	60	

* cited from Macklin (1992).

The states of Assam, Bihar, Madhya Pradesh, Uttar Pradesh, West Bengal and Orissa should get high priority for increased research investment. For extension, priority states are, Andhra Pradesh, Karnataka, Kerala, Madhya Pradesh and Orissa. In terms of commodity focus, research on horticulture and livestock should be strengthened. Social science research has been at the periphery in ICAR/SAU system. Higher allocations for social sciences would not only strengthen social science research per se but also improve the relevance and efficiency of agrobiological research, as social scientists are better equipped to articulate client needs, emerging demand patterns, and research strategies to address these.

The need for enhanced research and extension funding is also necessary for correcting imbalances in the factor shares. There has been a sharp decline in the non-salary expenses. The attempt to correct these imbalances under the NATP with a target ratio of 30:70 for non-salary and salary expenses is timely. However, in view of high capital cost, the ratio of 40:60 would be more appropriate. This ratio should be even better for extension which requires high mobility of field workers.

5.2 Diversify the institutional structure

There will always be need for public sector's participation in the provision of research and extension services. Provision of education and basic research, and interaction between research and education will always justify public investment in research. Similarly, transfer of information-based technologies having low appropriability will need public investment. This implies that much of the increased research and extension efforts have to be supported by governments. This does not mean that there is no role for other organisations in the provision of research and extension services.

The principles of institutional economics have been applied to identify role of various organisations in the provision of goods and services. The issues involved are formation of interest groups, collective action, organisation theory, transaction cost, and technological change. Besides growing opportunities and information, transaction cost is also influenced by nature of goods and services. The characteristics of subtractability or non-rivalry (extent to which a product can be consumed by one person) and excludability (exclusion of non-authorised users) give dichotomy of public and private goods (For details, see Coase (1960), Williamson (1975 and 1985) and North (1990)). This simple dichotonomy is inadequate to describe the role of various forms of organisations. Picciotto (1995) and Gerrard (1995) classified the institutional arrangements into hierarchy (government), market (firms) and collective action (NGOs, cooperatives, etc.). Political and social theory explains the behaviour with hierarchy, whereas neo-classical theory explains market behaviour. Collective action to achieve common goals are governed by conventions, customs and code of conduct.

The application of above stated concepts to three stages of research, viz. basic and strategic or upstream research (generating new knowledge or intermediate research products), applied research (developing usable technologies and information) and adaptive research (adapting technology to specific, local environment), suggests appropriate institutional arrangements. As shown in Table 5.2, research products at these three stages differ in the degree of subtractability and exludability, inviting myriad forms of institutions. The presence of public research organisations is essential to provide basic and strategic, and applied management research support, as these may have characteristics of public good (low or negligible subtractability and excludability). Other applied research developing embodied technologies like hybrids, pesticides, machines and fertilizers, can be provided efficiently by private organisations. Embodied technologies have two components, *viz.* input which is a private good and technology or process (e.g., parents of hybrid) which is a public good. In these embodied technologies, private investment grows to minimise transaction cost. If market transaction cost of technology is high, private firms integrate technology production and sale with technology development i.e. research. However, private research investment would be sub-optimal and therefore some degree of public sector involvement is essential.

Apart from public and private sectors, there are several organisations like NGOs, para-statal agencies, farmers associations, etc. which can also undertake and/or support research and extension (Echeverria et al., 1996). Unfortunately, participation of these organisation is in low profile and they largely depend on public financial support. Efforts should be made to encourage their active participation.

The presence of private sector in research is growing, albeit at slow pace. The size of market for technology and scientific opportunities or probability of research success which also affect appropriability (Roe and Pardey, 1991), are very much favourable in India. Efforts have been made to attract private research investment by exempting research investment from corporate tax. Recently, policy reforms lifting restrictions on entry of foreign-owned companies in seed research and import of germplasm for research purposes, supported with economy-wide reforms have encouraged private research investment (Singh et al., 1995 and Pray and Umali, 1997). Private research investment can be further increased by institutionalisation and effective enforcement of intellectual property rights (IPRs) (Roe and Pardey, 1991). The Indian Patent Act of 1970 excludes products, and agriculture and horticulture from patentability. The revised IPRs consistent with the WTO requirement is under debate. The placement and enforcement of new IPRs is expected to accelerate the pace of private research investment, particularly in biotechnology.

Till such time when participation of private sector and other voluntary organisations is strong, public sector (ICAR/SAUs) will remain involved in all kinds of research. Eventually, it should concentrate on basic and strategic research, applied management research, manpower training and regulation and coordination of research. Public research on post-harvest, mechanical, chemical and to some extent on biological technologies will need to be scaled down. The SAUs should provide applied research support, besides education. Post-graduate teaching and research may serve the link between basic and strategic, and applied research in the SAUs. In research, crop and resource management research which is mostly location specific, should largely be concentrated in the SAUs and ZARSs, as these institutions are mandated to location specific problems.

Table 5.2
Efficient provision of agricultural research and extension services

Stage	**Type of product**	**Degree of Subtractability and excludability**	**Appropriate institution**	**Example**
Research				
Basic and strategic research	Knowledge	Low	Public	New knowledge, methodology
Applied research				
Biological	Embodied technology Embodied technology	Low Medium to high	Public Public/private	Varieties Hybrids
Mechanical	Embodied technology	Medium to high	Public/private	Machines
Chemical	Embodied technology	Medium to high	Public/private	Fertilizers, pesticides
Management	Disembodied technology or information	Low	Public	Crop and resource management practices
Adaptive research	Embodied technology	Medium to high	Local organisations, NGOs, private	Information on seeds
	Disembodied technology or information	Low	Local organisations, NGOs, public	Management practices
Extension	Information	Low	Public	Weather & market information
	Specialist information	Low to medium	Public, NGOs, private	Soil and water analysis
	Skill	Medium to high	Private, NGOs	Use of technology (e.g., grafting)

Source: Based on information in Morris *et al.* (1998), Smale and Gerrard (1995), Umali (1992), Thirtle and Echeverria (1994) and Umali (1997).

It is difficult to maintain research linkages in a multi-institutional setup. The most crucial aspect would be linking basic/ strategic and applied research. This is particularly important when basic and strategic research will be in public domain and applied research in the private. The ICAR should continue to formulate and enforce national research policy/ regulations. Research linkages and networking will help coordinate research with SAUs and even with international research systems. But a mix of regulations, strategic research support, manpower training, contract research, etc. may be effective in coordinating research in private for-profit and non-profit sectors.

Private sector can also provide specialised extension services and can charge for transfer of specialised information and skills, besides promoting adoption of embodied technologies (Umali, 1997). But majority of resource poor farmers may not be able and/or willing to pay for private extension services. The demand for private extension services will, therefore, initially come from commercial, large farmers. Private extension have to be more efficient as margin between price (charge per visit) and cost which is usually low (Dinar, 1996), may further erode due to low demand. Another serious limitation of private extension services is that in the wake of competition, they can send conflicting messages to farmers on the use of technology. Also technologies originating from private sector may have some negative externalities which should be known to farmers (Sulaiman, 1995). Therefore, some degree of public sector involvement in extension is essential to ensure competition and quality of extension services. In addition to the public and private sectors, extension through NGOs, farmers groups, etc. should be encouraged. Efforts on this line in Rajasthan are found to be encouraging (Farrington et al., 1997).

5.3 Improving research and extension efficiency

Research: The issues involved in improving research efficiency are funding procedures, research planning and management, information system, human capital development and incentive and reward system. Present practice of assured funding with non-plan funds does not ensure efficient utilisation of research resources. On the other hand, competitive funding is costly in terms of time and money spent on the preparation and review of research proposals (Huffman and Just, 1994). Therefore, a balance between core and competitive funding should be maintained.

Allocation of core-funds within the ICAR and SAUs to various institutes and divisions should be objective and transparent. Formal resource allocation criteria used in macro-level priority setting can help in this regard. The move to shift from institute to project-based funding under the NATP is a welcome step in this direction. Also implementation of the Johl Committee recommendations to raise resources through contract research (ICAR, 1997) is a great leap forward to sustain research funding.

There is a scope for improving research planning and monitoring. Efforts are initiated to strengthen perspective planning (Vision 2020 document of ICAR institutes) and to institutionalise formal priority setting, monitoring and evaluation (PME) mechanism in the ICAR and SAD system. Success of these efforts would depend upon the use of simple, objective and transparent PME methods, and integration of PME into research management process. Improved PME would not only ensure rational allocation and efficient use of resources but also integrate clients' needs into research programmes. However, demand driven research programmes developed through improved PME would require a shift from commodity and discipline oriented to multi-disciplinary, system oriented research approach. This implies that top-down approach of research planning should be replaced with bottom-up approach.

A pre-requisite of institutionalisation of improved PME is development of agricultural research information system (ARIS). A well structured ARIS not only serves as decision support system but also improves communication in the system. Efforts to create ARIS with the NATP support would go a long way in strengthening research management process.

Another important aspect of institutional efficiency is human capital development and personnel policies, including incentive and reward system. Human capital development activities are being strengthened through in-house training and training under the World Bank aided Agricultural Human Resource Development Programme. There is, however, uniform recruitment procedure, performance assessment criteria and incentive structure for the scientists engaged in basic, applied and adaptive research. Basic research requires higher level of scientific calibre, which can't be attracted with an incentive structure at par with other scientists. Uniform performance assessment criteria like number of publications alienates main research from farm realities. Scientists, in general, do not prefer on-farm research for their professional advancement. Researchers engaged in basic research should, therefore, be assessed based on their contribution to new knowledge e.g., scientific publications, methodological developments, etc., whereas applied

researchers should be best judged by his contribution to the development of usable technologies. Thus, it is necessary to have appropriate scientific skill, performance evaluation criteria and merit based incentive system in place for different stages of research spectrum.

Extension: Extension system is fraught with many problems and misconceptions. Extension system of the Department of Agriculture feels encroachment of its domain by research system, while researchers feel gap in transfer of technologies to farmers. As noted above, ICAR and SAUs should slice down front-line extension activities. It would be more appropriate if KVKs are transferred to or merged with ZARSs. The results of extension diversification involving private sector, NGOs, farmers groups and para-extension workers have been very encouraging and therefore support the case of institutional diversification (Keynan et al., 1997 and Picciotto and Anderson, 1997).

The main extension system, *viz.* T&V system, has several operational problems. Besides lack of operational funds, ritualistic nature of extension approach and inadequate training for skill up-gradation constrain the effectiveness of the system (Picciotto and Anderson, 1997). Frequent changes in placement of extension workers and high proportion of vacant posts in remote areas have further reduced the efficiency of the system (Farrington et al., 1997). Immediate action to correct these problems would give tremendous boost to the system. Some measures in this direction are proposed under transfer of technology component of the NATP.

Heavy reliance on contact farmers needs to be rationalised by making use of mass media for dissemination of general information on new technologies. For the provision of specialised information and skills, some combination of personal contact and farmer-led extension approach may be used. The approach should be flexible enough to allow extension workers to identify farmers needs and respond them in a bottom-up approach. Further, the approach should be flexible enough to suit to local conditions. For example, greater emphasis on land-based, non-crop activities may be more appropriate for rainfed areas, whereas crop or commodity based extension may be useful for highly specialised, irrigated production areas.

Financial viability and incentive structure are other areas which need some improvement. Currently, there is hardly any merit based promotion scheme for extension workers, discouraging them to innovate and improve their efficiency. Perhaps making extension workers accountable to client groups and incorporating their feed back into performance evaluation can help improve the efficiency. To make remote areas attractive, there should be provision of additional incentives. Once extension system is efficient and accountable to clients, there could be a provision of charging for specialised extension services. In addition to this, extension agencies should be encouraged to raise resources to sustain financial viability.

In light of the foregoing discussion, recent changes initiated in the research and extension systems are significant. However, in some areas de novo approach is essential. Success of these changes is contingent upon the way senior managers perceive and implement them. In order to create a conducive environment, commitment at the highest level and strengthening of training capacity to implement the reforms is indispensable.

6 CONCLUSIONS

Acceleration and sustenance of agricultural growth is a prerequisite for alleviating poverty and transforming Indian rural economy. Accordingly, a target of 4.5 per cent agricultural growth is fixed in the Ninth Plan. In order to achieve this target, investment in agriculture, particularly research and extension, has to be stepped up. Research and extension merit special attention as these activities can raise productivity and attain competitiveness in international market in a cost effective manner. At the same time, available resources should be utilised efficiently. With this background, this paper traces the historical development of research and extension systems, analyses investment intensities and their determinants and suggests broad areas of reforms to improve research and extension efficiency. This chapter summarises important conclusions of the study.

Research and extension systems in India are dominated by government funded institutions. At the centre, the ICAR and its research institutions are funded by the Union Government. The SAUs engaged in education and applied research are funded by the State governments. Some funds from the ICAR are also transferred to SAUs in the form of regular grants and research schemes. Extension system is with the states and therefore is funded by the State governments.

Public investment intensity in research and education has increased from 0.21 per cent of AgGDP in the early 1960s to 0.49 per cent in the early 1990s. Adjusting this intensity with the proportion of total expenditure spent on Education in the ICAR and SAUs, and adding private research investment, gives a research intensity of 0.42 per cent in the early 1990s, which is far below that in developed countries. Of the total investment, 85 per cent is public and the rest 15 per cent is private. The intensity of public investment in extension is 0.15 per cent of AgGDP. Adding to this private extension investment gives the intensity of 0.2 per cent, which is also very low compared to other countries. There are wide inter-state variations in the public investment in research and extension. Research intensity is very low in Bihar, Madhya Pradesh and Uttar Pradesh. In the states of Orissa and Rajasthan, although the intensity of State research funds is low, overall research intensity is higher because of higher ICAR expenditure in these states. Extension intensity is low in Andhra Pradesh, Karnataka, Kerala, Madhya Pradesh and Orissa. Punjab and Haryana are also spending less on extension, but in view of homogenous production system and greater concentration of private input companies, levels of public expenditure on extension appear to be adequate.

Research and extension systems have witnessed a persistent reduction in the share of non-salary expenses in the total expenditure. It is suggested that research and extension intensity should be doubled and the ratio of salary to non-salary expenses should be at least 60:40. The intensity can be increased by three ways. First and foremost is the higher plan allocations for research and extension in the Ninth Plan. Obviously, most of these funds would be utilised by government funded institutions in the ICAR and SAU system, and state line department. Some public funds can be used to sub-contract private sector for research and/or extension services. Secondly, public funded research institutions can raise funds through commercialisation of their research products. This would not only help augment research resources, but also foster demand driven research agenda. As initiated by the ICAR, public research institutions can also raise funds through contract research with corporate sector, both in public and private sectors. Third option is to attract private investment in research and extension directly. For this, basic and strategic research support of public research institutions, protection of proprietary material and conducive regulations are essential. Lessons from other sectors like pharmaceutical, communication, etc. indicate that entry of private sector including multinationals, has increased use of technology and lowered prices. In agriculture too, liberalisation of seed sector in the late 1980s has paid dividends. This trend should be encouraged to allow private sector to play its due role in agricultural development.

The analysis of determinants of public investment in research and extension indicates that the investment is positively associated with the demand for agricultural commodities and negatively with the alternate sources of growth. Interestingly, the effect of economic-political factors shows that unlike research, extension is not a priority for government investment. Extension investment is enhanced only when additional investible resources are available with state governments. This should be corrected by treating extension at par for investment purposes.

Economic theory and experience of developed countries suggest that a diversified funding and institutional arrangements can provide research and extension services more efficiently. Apart from public and private institutions, NGOs, para-statal agencies, farmers organisations, etc. can undertake or support research and extension. All these institutions should undertake those activities in which they have comparative advantage. For example, the ICAR can concentrate on basic and strategic research and SAUs can focus on applied research, besides education. Private sector can efficiently conduct applied research for developing embodied technologies. Similarly, private sector and voluntary groups can provide extension services. Public sector should ensure competition and quality of research and extension services through enforcement of appropriate regulatory policies like pricing of public services, exchange of material and information and IPRs.

Present research resource allocation process is informal and influenced by past investment decisions, leading to imbalances in regional and commodity research focus. Since formal research priority setting and resource allocation methods are considerably developed, these should be institutionalised to bring more objectivity, transparency and relevance to research. On-going efforts in this direction should be given unconditional support at all levels.

Scientific performance evaluation criteria giving high weightage to number of publications may alienate main research system from ground realities, as scientists do not prefer on-farm research for their professional advancement. Therefore, performance evaluation criteria should be according to the nature of research work and incentives should be linked with performance. The experience from all over the globe has shown that provision of merit-based incentive with adequate transparency is essential for scientific excellence. In the extension system, rigidity in approach and lack of incentives for good performance has constrained extension workers to take initiative to respond to farmers needs.

Absence of adequate information system hinders management and evaluation of research and extension efforts. Progress is evaluated simply based on quantum of efforts, e.g., number of programmes initiated or resources committed to various programmes. Given the size and complexity of research and extension systems, a well structured information and decision support system is indispensable. The proposal on development of ARIS and technology information depository under the NATP is significant.

To sum up, several measures on institutional, investment and management fronts are suggested to improve allocative and cost efficiency of research and extension systems in the country. A number of steps have been initiated and many more are on the anvil. These steps are de novo, deviating from past top-down to system oriented, bottom-up approach. Efficiency of these steps are contingent upon government's will and wherewithal to implement, and ability of scientists and extension workers to avail them. An early action in this direction would benefit millions of farmers and consumers in the country.

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Appendix I

Regions for the ICAR-state coordination in research and development

Region	States covered
I	Himachal Pradesh, Jammu & Kashmir, hills of Uttar Pradesh
II	Assam, West Bengal
III	Sikkim, Mizoram, Arunachal Pradesh, Nagaland, Meghalaya, Tripura, Manipur, Andaman & Nicobar Islands
IV	Bihar, Punjab, plains of Uttar Pradesh, Delhi
V	Orissa, Andhra Pradesh, east Madhya Pradesh
VI	Haryana, Rajasthan, Gujarat, UTs: Dadra & Nagar Haveli, Daman & Diu
VII	Maharashtra, west and central Madhya Pradesh, Goa
VIII	Kerala, Karnataka, Tamil Nadu, Pondicherry, Lakshadeep Islands

Source: ICAR (1966/97)

Appendix II

Data and their sources

-	Data	Period	Source
1.	Research and education invest Government investment Revenue and capital accounts	1960/61-94/95	CAG, MOF, RBI
	Corporate investment	1992-93	CMIE*, Pray and Umali (1997)
2.	Extension investment Revenue account	1960/61-94/95	CAG, MOF
3.	AgGDP, GDP (new series)	1980/81-93/94	CSO, computer cell
4.	Number of scientists		
	ICAR	1996	ICAR (1996/97)
	SAUs	1992	Rao and Muralidhar (1994)
5.	Number of extension workers	1988	Misra (1990)
6.	Gross cropped area, rural population and literacy, price indices, irrigated area	1980/81-94/95	CMIE (1996a)
7.	Government expenditure on agriculture, total government expenditure, government revenue	1980/81-1994/95	CAG, CMIE (1996b)
8.	State-wise crop area	1980/81-1994/95	DES**
9.	Plan allocations to research and education, and agriculture and allied activities	various plans	Planning Commission CMIE (1994)
10.	Commodity-wise allocations of research investment		
	ICAR	1994/95	ICAR (1995/96)
	SAUs	1992	Rao and Muralidhar (1994)

* These data are compiled by the DST.
** Thanks are due to Dr. P. S, Birthal for providing the data set.

Appendix III

Government investment in agricultural research and education by states (000 Rs at current prices)

Year	Centre	Arunachal Pradesh	Goa, D&D	Mizoram	Pondichery	Andhra Pradesh	Assam	Bihar
1960/61	25,414					9,891	10,517	8,517
1961/62	30,309					8,833	6,645	9,524
1962/63	29,990					9,851	9,667	9,758
1963/64	30,253				39	9,509	14,393	1 1 ,233
1964/65	35,275				57	9,380	15,577	1 1 ,734
1965/66	31 ,865		16		64	9,125	29,473	11,544
1966/67	57,275		11		151	9,600	29,474	13,653
1967/68	12,316		1,526		275	6,977	22,979	15,754
1968/69	14,367		1,435		236	7,804	26,642	16,921
1969/70	13,284		146,225		77	9,184	22,580	18,655
1970/71	12,313		873		71	9,801	19,722	16,626
1971/72	14,040		1,506		95	11,845	22,347	5,396
1972/73	14,229		1,621		184	12,266	46,320	6,289
1973/74	17,405		1,670		234	16,251	32,548	7,335
1974/75	302,846		516	78	1,517	24,588	9,818	22,817
1975/76	396,562	122	818	162	551	31 ,328	1 1 ,476	25,873
1976/77	463,339	83	568	469	1,014	34,978	13,957	26,029
1977/78	589,719	79	427	741	919	40,112	21 ,429	29,849
1978/79	693,184	125	581	366	1,321	46,115	26,990	33,492
1979/80	741,016	359	1,196	326	1,575	51 ,736	31,710	43,475
1980/81	730,356	246	637	807	977	56,227	29,329	45,449
1981/82	872,884	120	689	1,184	803	73,374	39,214	51,122
1982/83	1,019,476	248	688	249	1,418	73,354	53,183	44,904
1983/84	1,175,330	531	761	782	1,570	87,447	52,414	36,413
1984/85	1,319,000	937	865	1,003	1,691	112,423	66,770	50,679
1985/86	1 424,902	1,264	1,022	1,392	1,611	132,745	96,748	113,283
1986/87	1621 ,837	1,869	1,529	205	1,692	145,628	140,543	184,045
1987/88	1,718,937	1,581	4,644	1,491	4,929	121,744	130,683	114,112
1988/89	2,046,442	1,299	2,085	1,494	4,298	190,341	79,952	114,112
1989/90	2,512,755	1,270	3,792	482	6,160	219,646	152,193	126,085
1990/91	3,172,036	16,208	5,211	544	13,124	250,189	224,700	159,948
1991/92	3,429,096	4,600	3,599	900	14,038	315,228	181,000	182,600
1992/93	3,644,272	5,900	3,146	1,100	na	395,702	212,400	195,300
1993/94	4,270,473	12,200	5,840	1,600	na	401 ,497	193,400	250,900
1994/95	4,956,300	8,900	3,500	1,300	na	435,900	190,600	253,600

Year	Gujarat	Haryana	Himachal Pradesh	Jammu & Kashmir	Karnataka	Kerala	Madhya Pradesh
1960/61	5,366			753	3,908	3,991	10,879
1961/62	6,598			1,141	4,688	1,771	9,102
1962/63	6,802			1,630	5,765	3,549	1 1 ,641
1963/64	10,592		3,809	1,975	7,298	2,195	13,818
1964/65	13,185		6,647	2,559	8,765	2,468	12,325
1965/66	20,837		7,522	3,102	9,591	3,172	10,779
1966/67	23,753	1,187	7,976	3,751	781	4,176	7,252
1967/68	21,121	2,541	10,719	3,204	1,281	5,103	9,486
1968/69	24,015	2,891	11 ,049	6,219	1,469	5,261	9,058
1969/70	23,779	2,854	14,085	8,898	9,503	5,923	11,242
1970/71	29,370	2,668	17,897	9,028	10,768	6,716	12,687
1971/72	33,147	3,005	16,231	5,642	10,455	7,268	17,592
1972/73	31,263	4,086	22,343	13,145	12,319	1,837	22,725
1973/74	31,746	4,482	25,728	13,030	13,090	3,602	27,956
1974/75	31,606	24,094	12,875	3,418	25,726	15,064	11,414
1975/76	33,015	26,376	10,264	4,223	36,760	21 ,476	13,502
1976/77	47,420	29,662	11,179	3,435	37,558	26,108	17,576
1977/78	52,201	29,942	1 1 ,767	5,311	44,120	27,456	18,799
1978/79	47,279	33,698	12,682	7,327	48,098	37,138	16,865
1979/80	61 ,383	49,209	21,413	9,061	54,965	33,174	17,711
1980/81	61,019	55,555	18,731	8,167	52,315	45,513	20,387
1981/82	55,502	58,422	19,862	12,968	52,011	59,575	22,509
1982/83	73,416	64,983	21 ,909	16,631	60,068	48,248	26,430
1983/84	95,910	79,073	22,623	27,674	64,472	71,201	29,371
1984/85	120,428	87,499	24,553	41 ,086	83,843	90,100	38,838
1985/86	132,592	108,284	29,497	43,710	85,197	131,884	51,585
1986/87	146,468	112,733	28,720	63,707	99,419	109,383	1,564
1987/88	185,406	128,425	59,478	61 ,994	120,900	112,220	71,465
1988/89	208,342	147,866	90,541	53,153	163,400	122,651	100,521
1989/90	250,650	165,506	83,442	53,981	172,162	149,959	111,852
1990/91	263,102	177,958	88,857	82,452	182,599	178,464	177,476
1991/92	325,636	223,168	106,574	80,800	237,931	278,977	179,905
1992/93	340,770	238,378	110,148	54,600	269,133	305,522	208,796
1993/94	357,309	259,501	128,195	63,600	374,346	314,261	182,523
1994/95	404,700	289,600	141,600	107,100	374,400	362,900	205,400

Year	Maharashtra	Manipur	Meghalaya	Nagaland	Orissa	Punjab	Rajasthan
1960/61	11 ,892				2,097	8,090	4,556
1961/62	18,594				2,898	8,730	4,962
1962/63	19,178				3,088	8,638	8,729
1963/64	28,242	45			4,777	7,664	3,086
1964/65	38,323	93			6,895	10,764	3,741
1965/66	56,867	76			3,605	11,622	4,803
1966/67	69,098	73			3,190	9,231	6,120
1967/68	74,700	81			3,356	13,020	7,597
1968/69	80,300	99			3,432	11,253	6,794
1969/70	79,118	155			3,186	14,738	6,996
1970/71	74,181	176	4,424		6,281	15,066	7,631
1971/72	77,595	178	3,984	2,335	7,089	20,198	9,465
1972/73	80,745	3,355	6,244	0	6,021	28,095	1 1 ,266
1973/74	71 ,341	223	6,318	0	6,296	34,577	13,981
1974/75	89,353	546	1,145	1,010	8,624	32,697	14,388
1975/76	98,339	490	1,022	1,125	10,650	40,125	21 ,401
1976/77	105,481	590	1,005	1,240	8,552	41 ,907	20,723
1977/78	109,406	652	1,187	1,187	17,581	44,108	20,582
1978/79	131,088	1,175	1,234	112	34,643	51,125	21 ,995
1979/80	135,788	896	1,571	2,165	15,049	57,330	25,050
1980/81	167,588	3,630	1,954	3,353	18,290	66,694	28,910
1981/82	177,984	4,123'	2,103	2,564	22,179	73,120	36,897
1982/83	192,831	387	2,356	5,199	20,440	74,951	37,199
1983/84	232,330	4,149	2,779	4,173	28,531	96,494	42,192
1984/85	241 ,732	5,102	3,123	24,178	32,829	104,994	47,406
1985/86	271 ,435	5,851	3,580	23,720	29,175	121,352	54,516
1986/87	326,058	6,048	185	6,066	39,105	139,615	63,934
1987/88	445,738	16,177	10,300	8,672	48,313	186,263	92,335
1988/89	472,869	23,023	13,800	8,531	44,469	184,700	115,604
1989/90	534,090	22,300	9,200	6,572	55,433	406,962	132,492
1990/91	613,221	17,600	11,800	9,064	87,155	270,738	168,163
1991/92	642,243	19,100	11,400	13,800	119,526	302,959	188,511
1992/93	751 ,980	12,000	16,400	14,000	114,697	337,482	192,858
1993/94	828,799	15,700	14,500	13,300	98,515	384,695	231 ,278
1994/95	978,800	13,500,	21,300	15.500	115,600	448,300	250,800

Year	Sikkim	Tamil Nadu	Tripura	Uttar Pradesh	West Bengal	All India
1960/61		6,021		11,198	2,904	125,997
1961/62		4,630		21,111	2,876	142,415
1962/63		4,585		23,152	2,445	158,470
1963/64		4,709	1,246	27,320	2,617	184,825
1964/65		5,505	1,199	36,040	2,728	223,263
1965/66		5,167	1,513	43,378	2,804	266,931
1966/67		6,886	2,119	46,101	4,606	306,467
1967/68		7,652	2,514	55,779	6,314	284,300
1968/69		8,001	2,768	61 ,980	7,354	309,353
1969/70		12,518	3,251	74,861	6,847	487,965
1970/71		13,333	4,950	86,128	9,901	370,618
1971/72		14,541	6,236	90,091	11,116	391 ,403
1972/73		15,393	13,675	98,585	12,224	464,237
1973/74		15,538	12,044	108,876	15,284	479,562
1974/75		26,41 1	1,052	25,277	22,483	709,368
1975/76	121	28,661	790	39,092	30,844	885,174
1976/77	620	30,479	896	42,620	38,175	1,005,671
1977/78	453	27,096	836	69,312	54,709	1,219,984
1978/79	664	35,906	948	87,981	41,917	1,414,056
1979/80	373	35,047	1,012	77,970	52,862	1,523,427
1980/81	355	40,125	979	114,574	51,428	1,623,598
1981/82	1,745	53,781	1,206	118,505	61,113	1 ,875,567
1982/83	1,413	52,845	1,205	113,615	67,762	2,075,414
1983/84	1,509	50,404	898	142,272	81 ,451	2,432,759
1984/85	2,088	79,589	1,043	158,814	90,272	2,830,890
1985/86	2,818	70,018	1,024	163,661	94,339	3,197,211
1986/87	2,330	88,768	na	197,421	115,907	3,645,810
1987/88	na	105,284	600	80,168	110,478	3,944,670
1988/89	na	170,101	1,900	331 ,656	130,098	4,825,582
1989/90	5,297	202,393	1,400	300,700	138,968	5,825,746
1990/91	5,065	325,060	2,000	481 ,500	152,791	7,137,029
1991/92	na	296,955	2,700	392,900	158,769	7,717,982
1992/93	5,573	369,614	3,000	359,114	153,511	8,329,437
1993/94	5,403	463,617	2,200	510,945	200,967	9,599,607
1994/95	6,069	473,200	3,500	573,300	274,000	10,923,708

na: Not available

Appendix V

2SLS estimates for government research and extension intensity model

	Research & education intensity (%)	Extension intensity (%)
1. Research and education intensity (%)		No endogeneity
2. Extension intensity (%)	1.171*** (4.80)	
Economic variables		
3. Lagged real AgGDP (000 Rs)	-9.346E-10 (0.45)	-1.611E-09 (1.19)
4. Growth in GCA (%)	-0.106 (0.60)	-0.739*** (5.15)
5. Percent irrigated area		-0.013*** (4.92)
6. Diversification index	-0.020 (0.97)	
7. Terms of trade (%)	-9.917E-04 (0.86)	-0.001* (1.65)
Economic-political variables		
8. Share of agril. expenditure in total govt. expenditure (%	1.222E-04) (0.06)	-0.002 (1.44)
9. Per capita real government revenue (Rs)	5.223E-05 (0.43)	3.314E-05 (0.40)
10. Rural literacy (%)	0.009** (1.92)	0.027***(7.69)
Political variable		
11. Share of rural population (%)		0.029*** (3.97)
12. State dummy		
Bihar	-0.587***(5.27)	-0.144 (1.49)
Gujarat	-0.406***(4.27)	-0.269*** (3.23)
Haryana	0.167* (1.65)	0.122 (1.03)
Himachal Pradesh	0.485*** (2.71)	-1.158*** (5.27)
Karnataka	-0.149 (1.28)	-0.337*** (5.05)
Kerala	-0.172 (0.58)	-1.856*** (7.83)
Madhya Pradesh	-0.194*** (3.46)	-0.330*** (4.89)
Maharashtra	-0.239*** (2.93)	0.334 (1.51)
Orissa	-0.325*** (2.87)	-0.742*** (5.40)
Punjab	-0.412** (3.11)	0.373** (2.44)
Rajasthan	-0.203*** (2.60)	0.063 (1.35)
Tamil Nadu	-0.728*** (7.07)	0.253***(3.52)
Uttar Pradesh	-0.161 (1.46)	0.092 (1.09)
13. Constant	0.499** (2.40)	-1 .638*** (2.52)
Adjusted R^2	0.94	0.82
'F' value N = 14, T = 13	139.23***	41.54***

***, **, * significant at 1, 5 and 10 percent level, respectively
Figures in parenthesis are 't' values.