POLICY PAPER 3

RESEARCH PRIORITIES IN INDIAN AGRICULTURE

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FOREWORD

Indian Agriculture has made a rapid stride in the past three decades making the country self-sufficient in foodgrains. The most important factor responsible for such an achievement is the technological innovation in agricultural production which, in turn, is brought about by agricultural research, both within and outside the country. In the developmental dynamics technological changes are inevitable to occur and with the economic liberalisation agricultural research and technology generation has become highly competitive, both domestically and internationally. Privatisation is being considered an alternative to public research to make research more relevant, meaningful and efficient. However, research resource as compared to any other resource is in shorter supply, especially in qualitative terms and hence an optimal allocation of this scarce resource is of paramount importance. Furthermore, in view of globalisation of our economy and the establishment of the World Trade Organisation, changes in cropping patterns, infra-structural and institutional facilities are bound to take place and policy analysis aiming at allocation of research resource among commodities and regions has not only to take a hard look at the present realities but also to objectively assess the probable changes in the future so that a near-optimal allocation is possible and research becomes the mainspring of development. Since research results have a longer gestation period the task of prioritisation of research has become all the more difficult.

In this study an attempt has been made to identify commodity and regional priorities for investment in agricultural research. The methodology in general and the criteria in particular used in this study are simple, albeit soft and sloven with a number of restrictive assumptions, and leave the scope for further debate wide open. Notwithstanding these shortcomings the results provide broad guidelines which would probably improve the research resource allocation decision of research administrators and planners.

May 1995
New Delhi

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Director

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An earlier draft of this report was circulated to senior officers of ICAR and other professional colleagues. Detailed comments were received from A.K.Sinha (A.D.G., ICAR), Derek Byerlee (World Bank), and Phil Pardey (IFPRI). We have attempted to address their concerns to the extent possible in this report. Needless to say, there are errors and omissions, which remain our responsibility.

May, 1995 Authors

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SUMMARY

Several enonomic forces have emerged over the recent past which necessitate a careful evaluation of agricultural research priorities at national and regional levels. First, the size of research investments in India has now reached levels which demand more objective methods. Second, as Indian agriculture moves beyond the narrow confines of domestic consumption towards aggressive participation in world trade, a restructuring of the research portfolio is inevitable. This is reinforced by other needs, such as focus on high value products, need for more equitable growth, greater attention on sustainability issues, and so on. With these complexities to reckon with, research managers need to supplement their traditional deductive tools with more objective data and analysis. This study provides these additional insights.

The study spells out relative research priorities in terms of regions (states) and individual commodities. Data on output, prices and values for 68 commodities (57 crops, 8 livestock, 2 fisheries, 1 agro-forestry) in each of the 25 state units were collected from different published sources centered round the year 1990. These provided the benchmark for further analyses.

A modified congruence approach was used in this study. It begins with an initial baseline of value of output (VOP) shares and then modifies these successively to incorporate other goals (like povety alleviation, sustainability, export orientation, etc.) and arrives at a final baseline (FBL). Both extensity and intensity dimensions are considered in these calculations. This approach has been quite extensively used, particularly since its application for priority setting by the Consultative Group on International Agricultural Research (CGIAR 1986). Ideally agro-ecological zone should be used as the primary unit, but output and other data are not available at this level.

It needs to be borne in mind that this exercise is normative; it tells how research resources ought to be allocated if the objectives (growth,

equity, sustainability, etc.) are to be maximized. Information on current research resource allocation has to be compared with that recommended by the present exercise. Only this will reveal the true extent of needed adjustments, which will doubtless be much more startling than a simple comparison of VOP and FBL shares presented in this exercise. Compilation of such an inventory should be a priority task for ICAR, since data on current research resource allocation are non-existent.

An analytical review of ICAR's plan expenditures data since the IV Plan (1969-74) indicated that (a) agricultural extension and transfer of technology projects have claimed disproportionate attention; (b) in general, ICAR has responded well to national priorities, focussing on areas (like pulses, oilseeds, dryland, export crops) where stress and opportunities have developed or are likely to develop; (c) decline in emphasis on agricultural education has probably been a critical error of judgement. As a long-term institution building process, sustained support is absolutely crucial for this activity. The aggregative plan expenditures data donot permit more detailed scrutiny.

The final results on regional (statewise) research resource allocation indicated that in order to achieve the goals of poverty alleviation, regional equity, sustainability and enhancing export potential, some readjustments in VOP-based allocations would be necessary. The eastern region comprising the states of Assam, Bihar, Orissa and other North-Eastern states, would need about 4 percent more research resources as compared to the VOP-based allocation. The predominantly dryland states of Andhra Pradesh, Madhya Pradesh and Karnataka would also need adjustment of a similar magnitude. These additional resources would come from the northern states of Uttar Pradesh, Punjab, Haryana, Himachal Pradesh, Jammu & Kashmir and from Gujarat, Kerala and Goa. For West Bengal in the eastern zone and Rajasthan and Maharashtra in the dry zone, research resources should be allocated on the basis of VOP.

Analysis of state-level data by Randhawa *et al* indicates that these priority regions donot spend enough on agricultural research, even on the basis of the economic importance of agricultural (VOP) sector (Randhawa *et al.*,1993). This implies far more significant shifts in resource allocation than the 4 percent figure arrived at by the present exercise. It should be noted that even in terms of purely Plan allocations, a 4 percent shift in ICAR resources implies a hefty sum of Rs. 52 crores ! In general, the directions indicated by this analysis are consistent with regional priorities articulated by ICAR and the Ministry of Agriculture.

Results on commodity-based allocations are presented in Figure 1, in terms of commodity groups. These indicate that 25.6 percent of research resources should go to cereals (CLS), 22.7 percent to livestock (LVS), 13 percent to fruits and vegetables (FVG) and about 10 percent to oilseeds (OLS). Fisheries (FIS), plantation crops (PLN), and pulses (PLS) would claim 7-8 percent each. In terms of shift between efficiency (VOP) and a comprehensive (FBL) goals structure, cereals and sugarcane (SGC) will need to surrender some resources to provide additional support to research on pulses, fibres (FBR), oilseeds, fruits and vegetables, spices (SPC) and agro-forestry (AGF).

In terms of individual commodities, the results indicate a shift away from :

> Wheat, bajra, barley, rapeseed and mustard, castor, cotton, sugarcane, coconut, cashew, rubber, sapota, apple, tobacco, pepper, cardamom, raw wool, milk, marine fisheries.

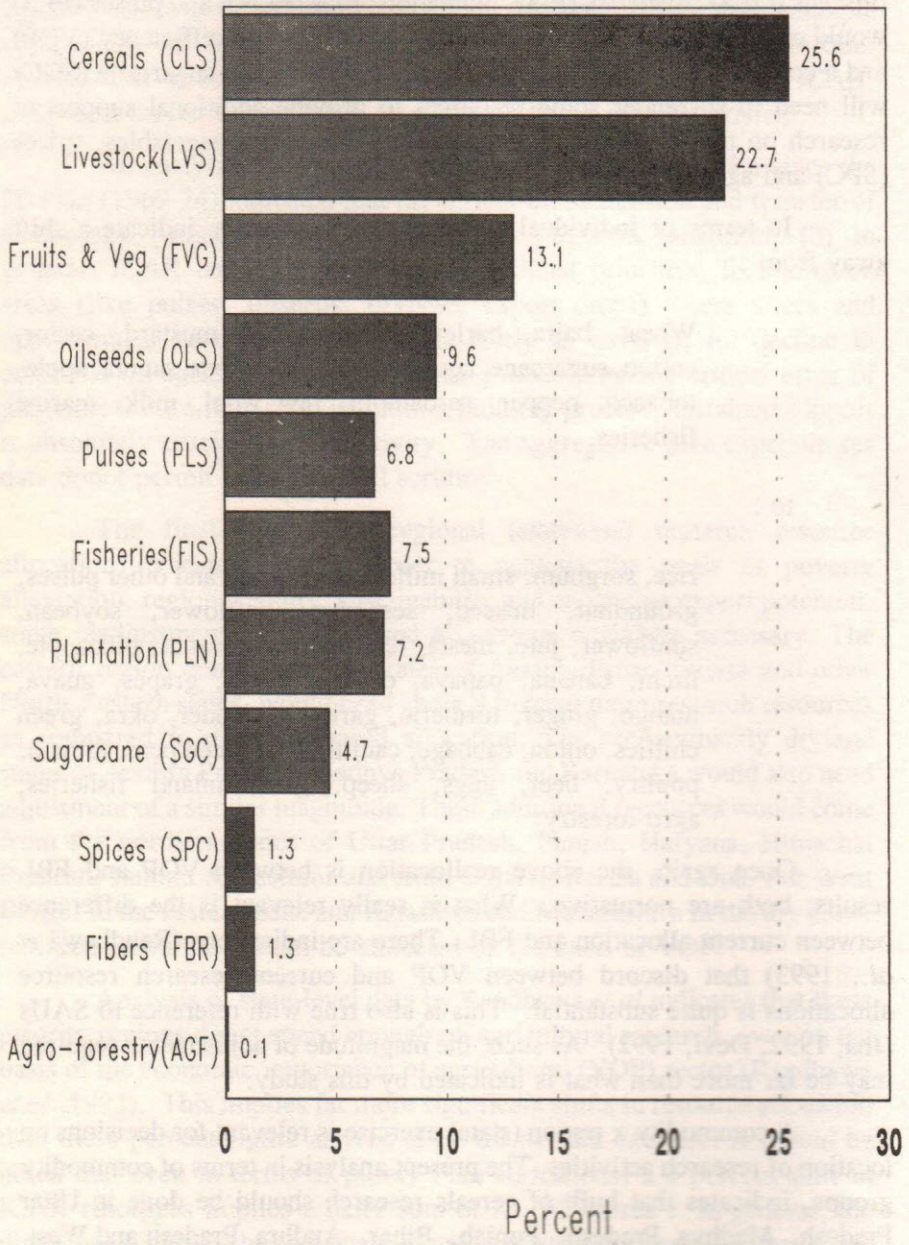
to :

> rice, sorghum, small millets, ragi, gram and other pulses, groundnut, linseed, sesamum, safflower, soybean, sunflower, jute, mesta, tea, coffee, arecanut, pineapple, litchi, banana, papaya, orange, citrus, grapes, guava, mango, ginger, turmeric, garlic, coriander, okra, green chillies, onion, cabbage, cauliflower, green peas, tomato, poultry, beef, eggs, sheep, goat, inland fisheries, agro-forestry.

Once again, the above reallocation is between VOP and FBL results; both are normative. What is really relevant is the difference between current allocation and FBL. There are indications (Randhawa *et al.*, 1993) that discord between VOP and current research resource allocations is quite substantial. This is also true with reference to SAUs (Jha, 1992; Devi, 1992). As such, the magnitude of adjustments required may be far more than what is indicated by this study.

A commodity x region (state) exercise is relevant for decisions on location of research activities. The present analysis in terms of commodity groups, indicates that bulk of cereals research should be done in Uttar Pradesh, Madhya Pradesh, Punjab, Bihar, Andhra Pradesh and West

Figure 1. Research Resource Allocation by Commodity Groups



Bengal. Some should be done everywhere except Himachal Pradesh, Kerala and Jammu & Kashmir. Pulses research should be mainly located in Madhya Pradesh, Uttar Pradesh, Maharashtra, Orissa, Rajasthan and Andhra Pradesh. Similar prescriptions have been provided with respect to other commodity groups in Chapter 5, and on the basis of results of this analysis, may be applied to individual commodities.

Similarly, results have also been provided for commodity-wise allocation in each of the 25 states. These should be useful to research managers at the state level.

Finally, the study evaluated the implications of using alternative weighting schemes for different research objectives. This sensitivity exercise indicated that there were only marginal differences in the results. The overall conclusions regarding regional and commodity priorities summarised above are robust.

In conclusion, this study provides a basic guideline for research resource allocation in agriculture and allied sectors. There are obvious limitations of data and to this extent, research administrators will need their experience and wisdom to moderate the results. Nevertheles, we believe that by presenting factual data and objective analysis of the trade off between efficiency and other goals, we have contributed towards making the process more objective and transparent.

The most significant data constraint confronting us has been the one on current research resource allocation -- at the central, state and zonal levels. Reallocation and redeployment has no operational significance in the absence of such data. This has been identified as the most important step in the next phase. Also, it focuses exclusively on a commodity/region (state) matrix. Natural resource related constraints are indirectly incorporated through sustainability-related parameters. Explicit incorporation of resource (soil, water, energy, climate, etc.) related research, and issues like spillover effects, etc. have to be accorded high priority in future analyses of this kind.

In terms of the next phase, the study concludes and emphasises the need for (a) disaggregative data on research resource allocation, (b) more comprehensive data on natural resources, their exploitation etc., (c) use of more sophisticated analytical models, and (d) compilation of data base at agro-ecological zone level.

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INTRODUCTION

Background

The national agricultural research system in India is a two-tiered system comprising the Indian Council of Agricultural Research (ICAR) and its institutions at the national level, and the state agricultural universities (SAUs) and associated zonal research stations at the state level. Several other agencies such as general universities, scientific organizations (like Council of Scientific and Industrial Research, Indian Council of Medical Research, Indian Council of Social Science Research, Bhabha Atomic Research Centre, Department of Science and Technology, Department of Bio-technology etc), private and voluntary institutions also participate in research activities related to agriculture.

The ICAR has concurrent responsibility for funding, coordinating, and conducting agricultural research, education and frontline extension. To fulfil its research mandate, the ICAR has, over the years, established a network of research institutes (45), national bureaus (4), project directorates (9), coordinated research project (79) and national research centres (30). It employs about 6000 scientists. It provides funding and advisory support to the 26 SAUs located in different states. A massive programme of strengthening regional (zonal) research capacity has been going on for the last decade and a half under the National Agricultural Research Project (NARP). Thus, since independence, the ICAR has gone through a period of consolidation in which disparate institutes inherited from the past, as well as major new initiatives, have been moulded into a coherent national system. It is rated as one of the strongest NARSs in the world in terms of resources employed, level of scientific activity and productivity.

Experience over the last thirty years in terms of growth pattern of agricultural output, commodity and regional imbalances, continuing rural poverty and unemployment, natural resource impoverishment and

compulsions of liberalisation, necessitate an agricultural growth strategy which emphasises efficiency, equity, sustainability, employment and exports. These concerns are reflected in the National Agricultural Policy statement and in the objectives of the Eighth Five Year Plan.

The challenges are enormous both in terms of size and diversity. Despite its strengths, the national research system will need to double up and reorient its programmes if it is to effectively contribute to these goals. Moreover, in the light of the current resource crunch and the associated need to justify public investments, it is imperative for the national system to initiate systematic analysis of research priorities. Historically, ICAR has relied mainly on informed opinion regarding scientific opportunities to tackle specific problems. These judgements formed the basis of research resource allocation choices. Evaluations have shown that these choices have been quite efficient in generating high rates of returns to research investments in the past. *However, the size of the national research system and the complexities of problems confronting us today demand a more objective approach to research resource allocation.* Such an exercise provides a quantitative framework to assist agricultural research planners to assess research priorities in relation to multiple national goals, so that scarce research resources are used more effectively

As research budgets tighten, it becomes necessary to be selective in choosing the nature and focus of research one supports. This becomes more difficult when multiple and often conflicting goals like efficiency, equity, sustainability etc., are to be met. Using a comprehensive, transparent and analytically robust approach is, therefore, essential. The idea is not to replace scientific judgement but to augment and organise the information available so that these decisions are improved.

The goal of this exercise is to provide ICAR decision makers with more analytical information. When combined with sound scientific judgement, this will enrich the system's capacity to rationalize and justify their decisions and enable it to interact more effectively with policy makers, funding agencies and client groups.

Objectives

1. To determine commodity and regional priorities which will maximise benefits from agricultural research.
2. To assess the impact of variables like export potential, equity, sustainability, research system capacity etc. which

are important objectives of national agricultural policy, on research priority assessment.

An Interpretative Review of ICAR's Resource Allocation Strategies

ICAR has a key role in shaping the national research system and in setting national and state research agenda, though the state system has also become mature and assertive. Therefore, an assessment of ICAR resource allocation profile is of considerable interest. This section focusses on ICAR plan allocations (investments). It does not portray the full picture. Nevertheless, these investments act as trend setters.

Table 1. ICAR outlays through different Five Year Plans

Plan	Agriculture and allied sectors plan outlay (Crores Rupees)	ICAR Plan outlay (Crores Rupees)	Share of ICAR in total Agric. outlay (%)
IV plan (1969-74)	2320	91.4	3.9
	(2197)	(86.5)	
V plan (1974-78)	4865	153.6	3.2
	(2755)	(86.9)	
VI plan (1980-85)	5695	340.0	6.0
	(1973)	(117.7)	
VII plan (1985-90)	10524	425.0*	4.0
	(2596)	(104.8)	
VIII plan (1990-97)	22467	1300.0	5.8
	(3707)	(214.5)	

* Relates to approved plan allocation. The approved allocation of VII plan was Rs.425 crores, however, the final adjustment came to Rs.438.15 crores.

Note: Figures in parentheses denote outlay at constant (1970-71) prices.

Sources: ICAR Five Year Plan and Annual Plan documents, *Indian Agric. in Brief* (23rd Ed.)

Table 1 shows that though ICAR plan outlay in nominal terms has increased more than fourteen fold since the IV Plan (1969-74), its share in agriculture sector outlay has not shown consistent and impressive buoyancy. ICAR's share in agriculture and allied sector outlay has risen from 3.9 percent in the IV plan to 5.8 percent in the VIII Plan. Though the relative size of these grants are relatively small but there is a broad indication that the priority accorded to ICAR has been maintained.

Except for a dip in the VII Plan, ICAR share has been significantly higher in the post 1980 period. The table shows that in real terms, ICAR expenditure was stagnant at about Rs. 87 crores through the seventies. There was an increase in the VI Plan which could not be fully matched in the VII Plan. Thus, in the eighties too there was stagnation. A major revamping has been attempted in the VIII Plan.

Table 2 shows the break-up of ICAR outlays in terms of major activities. It shows that agricultural research has claimed nearly three fourth of ICAR resources since the VI Plan period. Agricultural education, which accounted for nearly a third of ICAR plan allocations in the seventies, now accounts for only about 12 percent. Massive expansion in the agricultural universities network and the associated capital expenditures during the seventies pushed up the education share in this period. Since then there has been a decline. Note, however, that most SAUs face crippling funding constraints as the respective state governments are unable to provide sufficient resources. There is a strong case for increased ICAR funding for this activity. Most remarkable has been the growth in extension and transfer of technology activities, which now claim nearly 13 percent of ICAR plan funds.As indicated in the last row, while agricultural research expenditure have grown by 81 percent in real terms between VI and VIII Plans, extension has grown by 412 percent and education has remained stagnant.

Within agricultural research, the traditional focus has been on crop research. It accounted for a third of the total research outlay. This share went down in the eighties but has been restored in the VIII Plan. Since 1980, major expansion has taken place in non-commodity (other) research, which now accounts for a third of total research outlay of ICAR. These cover resources-related research. The VIII Plan emphasises research in horticulture and fisheries; their share in total research outlay has been increased. Animal sciences research, after a period of expasion in the seventies, has languished at around 10 percent of total outlay of ICAR.

These changes are explicitly evaluated in Table 3 which shows changes in allocation in real terms. Total real (at constant 1970-71 prices) change in ICAR outlay is partitioned in terms of the share of various activities. The changes are depicted between IV and V Plans (the seventies), V and VII Plans (eighties), and VII and VIII Plans (nineties).

These numbers indicate several interesting trends. Despite dramatic evidence of success during IV Plan, there was practically no

Table 2. Activity-wise breakup of ICAR Plan allocations **(Crores Rupees)**

Plan	Research						Education	Extension	Others	Total
	Crops	Horti-culture	Animal Science	Fisher-ies	Other research	Total research				
IV plan (1969-74)	20.0	7.4	15.2	3.4	11.9	57.9	31.6	1.8	0.1	91.4
	(21.9)	(8.1)	(16.6)	(3.8)	(13.0)	(63.4)	(34.6)	(1.9)	(0.1)	(100)
V plan (1974-78)	31.9	9.3	25.9	8.1	17.9	93.2	52.5	7.1	0.7	153.5
	(20.8)	(6.1)	(16.9)	(5.3)	(11.7)	(60.7)	(34.2)	(4.6)	(0.4)	(100)
VI plan (1980-85)	69.8	22.2	35.6	17.8	104.2	249.7	73.9	14.9	1.4	340.0
	(20.5)	(6.5)	(10.5)	(5.2)	(30.6)	(73.4)	(21.7)	(4.4)	(0.4)	(100)
VII plan (1985-90)	90.4	23.7	44.6	18.8	139.6	317.2	70.8	32.1	4.9	425.0
	(21.3)	(5.6)	(10.5)	(4.4)	(32.9)	(74.6)	(16.7)	(7.5)	(1.2)	(100)
VII plan (1990-1997)	322.8	100.0	140.0	65.0	323.3	951.2	155.4	160.0	33.4	1300.0
	(24.8)	(7.7)	(10.8)	(5.0)	(24.9)	(73.2)	(11.9)	(12.6)	(2.6)	(100)
Percent growth between IV and VIII Plans (at 1970-71 prices)	181	136	61	233	373	186	-14	1452	-	148
Percent growth between 1980 and 1997	120	114	87	74	48	81	*	412	-	82

* Less than 0.5 percent.

Note: Figures in parentheses are percentage share of total.

Source: ICAR Five Year Plan and Annual Plan documents provide the basis for these estimates.

Table 3. Shifts in ICAR resource allocation over different periods at constant (1970-71) prices

Activity	Change at constant prices during					
	Seventies		Eighties		Nineties	
	Crores Rs.	Percentages	Crores Rs.	Percentages	Crores Rs.	Percentages
1. Total change in resource allocation	0.4	0.5	17.9	20.6	109.7	104.6
(a) Research	-2.1	-3.7	25.4	48.1	78.7	100.6
(b) Education	-0.2	-0.7	-12.3	-41.2	8.2	46.8
(c) Extension	2.3	136.0	3.9	97.7	18.5	233.0
(d) Others	0.3	333.0	0.8	210.2	4.3	359.0
2. Research						
(a) Crops	-0.9	-4.7	4.2	23.3	31.0	138.9
(b) Horticulture	-1.7	-24.1	0.6	10.6	10.7	182.0
(c) Animal Sciences	0.3	2.3	-3.7	-25.1	12.1	110.0
(c) Fisheries	1.3	40.5	0.1	1.5	6.1	131.0
(d) Others	-1.1	-9.9	24.3	239.3	18.9	55.0

growth in ICAR resources in the seventies. Even during the eighties there was a modest rise of about 21 percent. It was only in the VIII Plan that a sizeable expansion (105 percent) in real outlays has been proposed. Of course this may not actually be realized if inflation rate rises steeply during the remaining period of the plan. Yet, there is clear intention of raising the level of resources for agricultural research.

In the seventies, there was decline in real resources for research and education. Incremental (plan) resources were shifted largely to extension. In the eighties, the decline in education further accelerated, but research was a gainer and extension continued to expand at a high rate. This latter trend has persisted over the VIII Plan, which has also added net real resources for education. In terms of plan allocations over time, extension has received maximum emphasis, followed by research. Education has suffered. This analysis broadly supports the conclusion drawn from Table 2.

In the seventies, fisheries research claimed most of the incremental real resources alongwith animal sciences, at the cost of other categories. In the eighties, resources-based research was the major new thrust, though crops research was also strengthened. Animal sciences was the big loser. The VIII Plan added net real resources to all categories of research. In terms of percent change over the VII Plan, highest growth occurred in horticulture, followed by crops, fisheries and animal sciences research. These are in line with current priorities, except for animal science which had suffered a setback in the eighties.

Several indications emerge from this analysis. First, agricultural extension and transfer of technology has claimed disproportionate attention over time. This implies a clear conviction that viable technologies are available, it is inefficient transfer process which is a major constraint. The factual base behind this conviction is shaky at best as technologies developed are rarely subjected to viability analysis, and systematic and objective evaluation of ICAR's 'front line extension' activities has been lacking. Second, there has been a clear attempt to respond to national priorities. Increased allocations for export-oriented commodities and strengthening of research on natural resources in recognition of sustainability challenges testifies to this. Third, the Council has, perhaps, erred on judging the capacity of state governments. Research is a long-term activity, while political realities at the state level force attention mainly on short term and expedient solutions. There is a strong case for strengthening support for agricultural education. In the long-run, ICAR's

success will be judged by its role in institution building in the states and not by extension-oriented innovations on the scale presently envisaged. The state agricultural universities have an extremely important role, not only in terms of strengthening local research capacity, but also in terms of human resource development. The central institution (ICAR) has pivotal role in this.

Outline of the report

The next chapter describes briefly the analytical framework, the methodology and data used in this study. Results with respect to regional and commodity priorities are presented and discussed in Chapters 4 and 5. The last chapter summarises the main conclusions. Part II of the report contains details of methodology, data and statistical appendices.

3

METHODOLOGY

Approach

Studies on research priority setting have used five general approaches, singly, or in combination. These are scoring (weighted criteria) model, economic surplus/benefit-cost analysis, mathematical programming, econometric models and simulation. The advantages and limitations of each are discussed in published literature (Norton, 1987). The scoring model approach, also called the congruence approach has been used in this study. Time constraints, data availability, and ease of manipulations dictated this choice. The objectives of this study are complex and involve multiple trade-offs. The scoring model captures multiple objectives by modifying the traditional measure of impact of research -- changes in value of production -- to take into account concerns such as equity, sustainability, export, strength of the research system etc., in order to prioritize demand for research. All these factors are, in fact, taken into account while making research resource allocation decisions, but in an intuitive and subjective manner. The scoring model is more objective and transparent. It also makes the trade-offs explicit.

Stated simply, the congruence model allocates research resources in proportion to the relative value of production by region or commodity. It implicitly assumes that opportunities for research are equal across commodities, and that the value of new knowledge generated by research is proportional to the value of output. The analysis is based on present values and assumes constancy of relative shares. These restrictive assumptions imply that results of this exercise provide only a starting point in rationalizing research resource allocation. It does, however, considerably enhance the information base available to research managers and provides analytical support to decisions based on scientific judgement. The Technical Advisory Committee (TAC) of the Consultative Group on International Agricultural Research (CGIAR) also opted for this approach

because of its simplicity, transparency and flexibility in its study on priorities for international agricultural research (CGIAR, 1986).

The objectives of this study require identification of priorities by commodities and regions. The methodology involves calculation of an initial baseline matrix consisting of value of output from different agricultural, livestock, fisheries and agro-forestry products in different regions. A composite baseline is then developed using value of output (efficiency), poverty, sustainability and export potential indicators. The main results presented subsequently, assign equal weights to these four parameters. However, we have evaluated the implications of using alternative weight structure. The congruence approach always emphasises efficiency : if research has to enhance production, it is better done where the value of production is large; if it has to contribute to poverty alleviation, it is better done where the number of poor people is large; if it has to focus on sustainability, it is best done where there are large areas of land in use, and so on.

Initial priority determination based on extensity parameters does not reflect many other important factors. To take these into account, the composite initial baseline is modified by using intensity parameters. In this study, seven modifiers, representing growth potential, equity, sustainability and state research system capacity, were used as intensity parameters. Details regarding these variables, their direction and weights are provided in Part II of the report. We thus arrive at a final baseline (FBL) which incorporates multiple objectives. We have used our judgement to identify and specify the objectives, extensity and intensity parameters and weighting schemes. The model permits evaluation of other alternatives as well.

Regions

The concept of homogenous agro-ecological zones as basic units of agricultural planning, has been well established. This is even more relevant for agricultural research which is characterized by high location specificity. The Planning Commission has delineated 14 agro-ecological regions, and the ICAR has identified more than 120 agro-ecological zones. The latter constitute the basic units of a network of zonal research stations. The World Bank-assisted National Agricultural Research Project (NARP) has strengthened these zonal research stations for zone-targetted research. These are the ideal units for any priority setting exercise.

However, it was not possible to use agro-ecological zones in this study. Data on value of output etc. are not available at this level. Moreover, for several commodities, information on extensity and intensity parameters, is available only at the state level. Hence, we had to use states as the basic unit and the regional dimension is provided at this level. There is some merit in this because decisions on resource allocation are taken at this level and state level analysis is easier to comprehend. In all, 25 units were considered. The seven north-eastern states were aggregated in one unit so that we have 19 regional units. The states are :

Andhra Pradesh, Assam, Bihar, Gujarat, Haryana, Himachal Pradesh, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Orissa, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh, West Bengal, Jammu and Kashmir, Goa, North-Eastern states (Manipur, Meghalaya, Tripura, Arunachal Pradesh, Nagaland, Mizoram and Sikkim).

Data

A comprehensive data set was compiled for each state, covering a large number of variables. The data are centered around the year 1990. These were obtained from various published sources described in Part II and are enumerated below :

Extensity parameters

1. Value of output (VOP) : Current value of 68 commodities (57 crops, 8 livestock, 2 fisheries, 1 agro-forestry), by states
   Rice, Sorghum, Pearl Millet, Maize, Finger Millet, Wheat, Barley, Tapioca, Small Millets, Pigeonpea, Gram, Other Pulses, Soybean, Groundnut, Linseed, Rapeseed and Mustard, Sunflower, Sesamum, Castor, Safflower, Cotton, Jute, Mesta, Sunhemp, Sugarcane, Coconut, Tea, Coffee, Arecanut, Cashewnut, Tobacco, Potato, Onion, Cabbage, Cauliflower, Okra, Green Peas, Tomato, Green Chillies, Banana, Papaya, Orange, Apple, Citrus, Grapes, Guava, Litchi, Mango, Pineapple, Sapota, Ginger, Turmeric, Pepper, Coriander, Cardamom, Garlic, Rubber, Raw Wool, Pork, Beef, Eggs, Poultry, Sheep, Goat, Milk, Marine Fish, Inland Fish, Agro-forestry
2. Poverty: Number of people below the poverty line in each state
3. Sustainability: Land area (arable, grazing and forests) in each state

4. Export potential: State's share in national production (in some cases, area) of exported agricultural commodities

Intensity parameters

1. Growth potential: Yield gap for major crops in each state
2. Per capita net domestic product, by state
3. (a) Ground water potential achieved, by state
   (b) Degraded land area in each state
   (c) Per capita forest area in each state
   (d) Population density in each state
4. State agricultural research expenditures in each state

The analytical steps involved in moving from the initial baseline to the final baseline (FBL) are described in Part II of this report.

Limitations

1. The data base has limitations of coverage and reliability, particularly with reference to commodities not routinely covered in agricultural statistics reporting.
2. This approach does not consider past research investments which have obvious bearing on research resource allocation.
3. There is need to develop and use other modifiers to take into account projected agricultural situation, scope for spill-over, and other important factors.

4

RESEARCH PRIORITY SETTING : REGIONAL PERSPECTIVE

Extensity parameters

Value of agricultural production (VOP)

It is the initial indicator in an efficiency-oriented priority setting excercise. At all India level, crops currently account for 69.4 percent, livestock for 23 percent, agro-forestry for 0.12 percent* and fisheries for 7.4 percent of the total value of agricultural production. As shown in Table 4, value of production from crops varies from about 52 percent of the total in Goa to more than 80 percent in Orissa and Assam. Similarly, value of production from livestock shows a range from 11 percent (Orissa) to 34 percent (Rajasthan). The share of fisheries is high in Kerala, West Bengal, Goa and Gujarat, all coastal states. Among land-locked states, those in the north-west have insignificant fisheries sector. Going by the gross value of output, states like Uttar Pradesh, Andhra Pradesh, Maharashtra and Madhya Pradesh, which contribute heavily to gross national output, would claim high priority. The first column of Table 5 shows the distribution of gross VOP across states. In an efficiency-oriented allocation scheme, research resources would be regionally allocated in terms of these shares.

Poverty

The number of people below the poverty line is taken as an indicator of the extent of poverty. Table 5 shows the distribution of poor people across states. Uttar Pradesh has the maximum number of poor, followed by Bihar, Madhya Pradesh, Maharashtra, Andhra Pradesh and others. Emphasis on poverty alleviation would result in higher priority to these states.

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* There may be underestimation but this is our best judgement based on current data availability.

Land use

Table 5 also shows the distribution of land area by states (indexed to 100 at all India level). Land area includes cropped area, current fallows, permanent pastures and grazing land and forest area. Madhya Pradesh ranks first followed by Uttar Pradesh, Maharashtra, Rajasthan and Andhra Pradesh. Concern with land use sustainability would result in greater importance to these regions.

Exports

It is the fourth parameter used to determine initial priorities. It is defined as the percentage contribution of each state to national production (or area) of major exported commodities. The current export portfolio comprises cotton and its products, fish, fruits and vegetables including

Table 5. Percent distribution of value of output (VOP), poverty (POOR), sustainability (LAND) and exports (EXPO), by states.

States	VOP	POOR	LAND	EXPO
Andhra Pradesh	8.376	8.319	8.183	10.634
Assam	2.895	2.017	2.253	7.742
Bihar	6.113	13.906	5.778	2.416
Gujarat	5.486	2.999	4.378	8.822
Haryana	3.764	0.754	2.220	5.237
Himachal Pradesh	0.762	0.188	1.139	0.224
Karnataka	5.955	5.697	6.251	8.752
Kerala	5.082	1.952	1.470	6.014
Madhya Pradesh	7.152	9.584	15.109	3.334
Maharashtra	7.297	9.095	10.534	7.795
Orissa	3.883	5.584	5.977	3.364
Punjab	6.123	0.576	2.768	8.707
Rajasthan	5.670	4.237	9.020	4.837
Tamil Nadu	6.539	7.230	3.911	6.690
Uttar Pradesh	15.622	19.268	11.767	3.584
West Bengal	6.972	7.414	3.553	10.138
Jammu & Kashmir	1.054	0.423	1.485	0.225
Northen Eastern States	0.936	0.720	4.105	1.089
Goa	0.320	0.036	0.098	0.394

cashew kernels, processed foods, tea, oilcakes, tobacco, spices and condiments, sugar and molasses, meat, jute etc. These were used to calculate our export indicator. Data base on sporadic exports of other items is extremely unsatisfactory, hence it was decided to use items in the present export portfolio only. Table 5 shows the distribution (indexed to 100 at all India level) of this indicator across states.

Baseline for agriculture (Initial priority setting)

In terms of ICAR goals, the highest pay-offs will be obtained by making investments in research in areas where (a) there is high level of production, (b) there are large numbers of poor people, (c) the land area available for sustainable use is large and (d) where the value of exportable commodities is high. All the four extensity parameters were accorded

Table 6. Initial baseline (IBL) with different objectives

States	Initial baseline with			
	VOP	VOP and poverty	VOP,poverty and sustainability	All objectives
Andhra Pradesh	8.38	8.35	8.29	8.88
Assam	2.90	2.46	2.39	3.73
Bihar	6.11	10.01	8.60	7.05
Gujarat	5.49	4.24	4.29	5.42
Haryana	3.76	2.26	2.25	2.99
Himachal Pradesh	0.76	0.47	0.70	0.58
Karnataka	5.95	5.83	5.97	6.66
Kerala	5.08	3.52	2.83	3.63
Madhya Pradesh	7.15	8.37	10.61	8.79
Maharashtra	7.30	8.20	8.98	8.68
Orissa	3.88	4.73	5.15	4.70
Punjab	6.12	3.35	3.16	4.54
Rajasthan	5.67	4.95	6.31	5.94
Tamil Nadu	6.54	6.88	5.89	6.09
Uttar Pradesh	15.62	17.44	15.55	12.56
West Bengal	6.97	7.19	5.98	7.02
Jammu & Kashmir	1.05	0.74	0.99	0.80
Northen Eastern States	0.94	0.83	1.92	1.71
Goa	0.32	0.18	0.15	0.21

equal weights and a baseline was calculated (indexed to 100 at all-India level). This is reported in the last column of Table 6.

The VOP indicator accords high priority to the states of Uttar Pradesh, Andhra Pradesh, Maharashtra, Madhya Pradesh, Tamil Nadu and West Bengal followed by others. When VOP and poverty are considered together, Uttar Pradesh consolidates its position, but Bihar comes second. When land area is added, Uttar Pradesh continues to rank first, but Madhya Pradesh comes second and Bihar third. When all the four extensity parameters are considered together, there is some more change. In the final iteration, most of eastern states (Bihar, Orissa, Assam and Northen Eastern States) and states where dryland agriculture dominates (Gujarat, Karnataka, Madhya Pradesh, Rajasthan and Andhra Pradesh) improve their shares. In other words, consideration of factors like poverty, sustainability and exports results in greater emphasis on the above states as compared to simple VOP-based allocation.

Modification of the baseline

The initial baseline was modified to take into account the intensity parameters (see Part II for details). The impact of these modifiers on the initial baseline and the final results on regional (state-wise) priorities are shown in Table 7.

The shares of different states change as we incorporate extensity parameters and modifiers, as indicated by the FBL column in Table 7. It implies that exclusive dependence on the efficiency criterion (VOP) would lead to sub-optimal research resource allocation since other social and long-term goals would be neglected. This trade-off is illustrated below. If there was no trade-off, that is, the VOP and FBL shares were identical, the FBL/VOP ratio would be close to unity (say, between 0.95 and 1.05). A ratio of greater than one implies a gain in emphasis for the concerned state or region, induced by objectives other than economic efficiency. Conversely, a ratio of less than one implies a relative decline in emphasis. Table 8 illustrates the results more clearly.

In terms of regional research resource allocation, these results imply that most of the eastern states (Bihar, Orissa, Assam and North Eastern states) and the dryland areas of Andhra Pradesh, Karnataka and Madhya Pradesh would need more then their proportionate share in terms of VOP. Even West Bengal in the former and Maharashtra and Rajasthan in the latter category would retain their importance in terms of sizeable

share in the kitty. The states from where these additional resources will implicitly come are those in the bottom category. In this sense, there is substantial agreement in the priority articulation of ICAR, the National Agricultural Policy statement, and our analysis.

Changes in proportionate shares of different states between VOP and FBL-based allocations appear trivial (Table 7). For example, the VOP vs. FBL readjustment implies a 2.76 percent reduction in the share of Uttar Pradesh, and 1.57 percent increase in the case of Madhya Pradesh. These are the maximum values; in other cases, the changes are small. Lest these are dismissed as non-significant and unimportant for operational purposes, two points need to be noted. First, an analysis by Randhawa *et al.* indicates that regional (state-wise) research expenditures are way out of line with VOP, indicating substantial under-investment in some states (Randhawa *et al.*, 1993). Secondly, one percent of Rs. 1300 crores, the VIII Plan outlay for ICAR amounts to Rs. 2.6 crores per annum. Using Randhawa *et al* data on expenditures per scientist at ICAR institutes, this amounts to over 80 scientists per annum ! This, by any standard, implies a sizeable scientists pool. Moreover, these are only Plan expenditures, the Non-Plan complement, when added, would inflate these numbers dramatically. In this sense, even a 0.1 percent shift would imply enough resources to man a full-sized (15-20 scientists) research unit.

Unfortunately, reliable data on research expenditures or research resource allocation by regions/states are not available. Hence it is not possible to attempt even a first approximation of necessary adjustments dictated by the analysis presented above. Even the World Bank, which sponsored the massive NARP project over the last 15 years, did not include monitoring these basic data. The ICAR has made some efforts to look at commodity-based marginal (plan) expenditures in the VIII Five Years Plan, but there are no reliable estimates of total investments or total resource deployment. Compilation of these data must be accorded high priority.

5

RESEARCH PRIORITY SETTING : COMMODITY PERSPECTIVE

Priority by commodity groups : All India

Relative priority by groups of commodities at the national level is presented in Table 9. The FBL calculations incorporate all extensity and intensity concerns. The relative position alongwith distribution (indexed to 100 at all-India level) across commodity groups, ranks cereals, livestock, fruits and vegetables, oilseeds, pulses, fish, plantation crops,

Table 9.Distribution of priorities with extensity and intensity parameters by commodity groups

Commodity groups	Priorities with				
	Efficiency (VOP)	Efficiency and equity	Efficiency, equity and sustainability	FBL	FBL/VOP
Cereals	26.387	26.137	26.087	25.637	0.971
Pulses	6.243	6.883	7.349	6.758	1.082
Oilseeds	9.024	8.932	9.464	9.604	1.064
Fibres	1.299	1.208	1.217	1.322	1.018
Sugarcane	4.950	5.232	4.974	4.699	0.949
Fruits & Vegetables	12.798	13.704	13.500	13.084	1.022
Plantation crops	7.536	6.628	6.079	7.258	0.963
Spices	1.181	1.105	1.256	1.278	1.082
Livestock	22.940	22.686	22.954	22.726	0.991
Fisheries	7.525	7.362	6.984	7.508	0.998
Agro-forestry	0.112	0.123	0.136	0.127	1.124
Total	100.00	100.00	100.00	100.00	

sugarcane, spices, fibres and agro-forestry in that order. The most visible aspect of the distribution is that the livestock sector becomes almost as important as the cereals sector in terms of priority.

The table demonstrates how relative priorities across commodity groups change as we bring in concerns of equity, sustainability, international trade, and others. These calculations reveal that research resource allocation towards cereals promote efficiency; towards livestock promote sustainability and towards fisheries and plantation crops promote exports. Further, greater emphasis to agro-forestry and pulses promote equity and sustainability, while focus on oilseeds, fibres and spices promote sustainability and exports. There are some trade-offs as conflicting objectives are incorporated but the final iteration reflects all considerations. These are reflected in (Table 10) in terms of FBL/VOP ratios. A ratio greater than unity implies added emphasis at the cost of those commodity groups which have ratios of less than one.

Table 10.Impact of FBL/VOP trade-off on research resource allocation by commodity groups.

Ratio FBL/VOP	Commodity groups
>1.02	Pulses, Oilseeds, Fruits and Vegetables, Spices Agro-forestry
0.98-1.02	Livestock, Fibres, Fisheries
<0.98	Cereals, Sugarcane, Plantation crops

On balance, our analysis suggests relatively greater emphasis on pulses, oilseeds, fruits and vegetables, spices and agro-forestry essentially by shifting some resources from cereals, sugarcane, and plantation crops. Note, however, that the latter would still claim sizeable resources in absolute terms. Not surprisingly, the prioritisation exercise attempted here matches closely with the requirements for the decade of nineties and beyond. For example, ICAR (1991) has observed, that the decade of nineties will constitute the most critical decade in our agricultural history.

It will require : (i)Large increase in production of pulses, oilseeds, fodder, food grains, fuelwood, fruits, vegetables, milk, meat and eggs. (ii) A wide range of industrial crops and plantation crops.

Table 9 shows that about a third of research resources should be oriented towards cereals and pulses. Livestock and fisheries would claim nearly 30 percent ;fruits and vegetables, oilseeds and plantation crops would need another 30 percent of research resources.

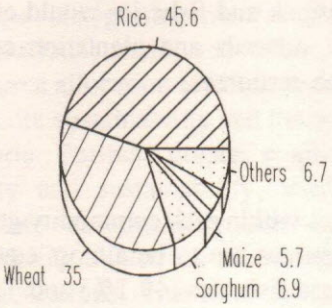
Individual commodities

Figure 2 shows the relative priorities within each commodity group other than fisheries. In fisheries the resources are to be almost equally devided between marine (50.9%) and inland fisheries (49.1%) and Table 12 contains data on FBL with respect to each commodity at the national level, alongwith the adjustment ratio (FBL/VOP). The table shows that among cereals, sorghum, rice and small millets; in oilseeds, soybeans, linseed, sunflower, sesamum, safflower; and in fibres, jute and mesta, need added emphasis. These shifts are summarized in Table 11.

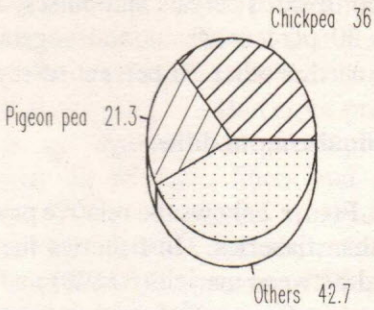
Table 11. FBL/VOP trade-offs in research resource allocation by commodities.

Ratio (FBL/VOP)	Crops
>1.20	Soybean, Mesta, Pineapple, Ginger
1.10-1.19	Ragi, Sunflower, Jute, Tea, Coffee, Okra, Green Chillies, Litchi, Turmeric, Pork, Poultry
1.01-1.09	Rice, Jowar, Small Millets, Gram, Other pulses, Groundnut, Linseed, Sesamum, Safflower, Arecanut, Onion, Cabbage, Cauliflower, Green Peas, Tomato, Bananas, Papaya, Orange, Citrus, Grapes, Guava, Mango, Coriander, Garlic, Beef, Eggs, Sheep, Goat, Inland fisheries, Agro-forestry
0.98-1.00	Maize, Arhar, Potato
0.80-0.97	Bajra, Wheat, Barley, Rapeseed and mustard, Castor, Cotton, Sunhemp, Sugarcane, Coconut, Cashew, Tobacco, Cardamom, Raw Wool, Milk, Marine Fisheries
>0.80	Sapota, Pepper, Rubber, Apple

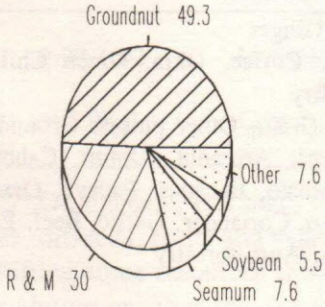
Figure 2. Relative Priorities by Commodity



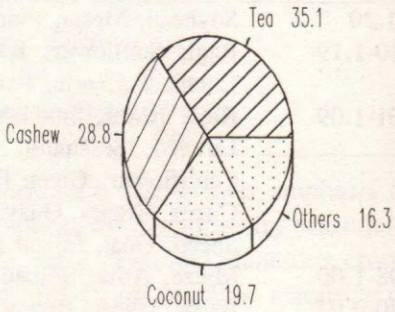
Cereals



Pulses

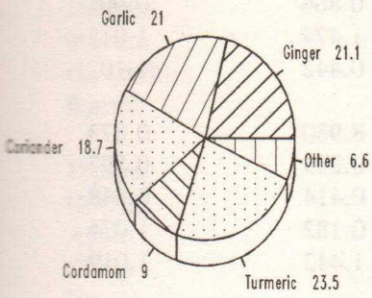


Oilseeds

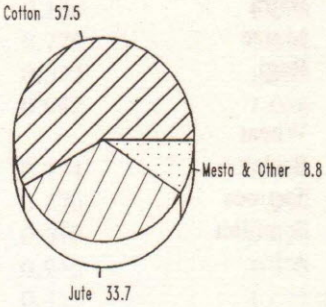


Plantation crops

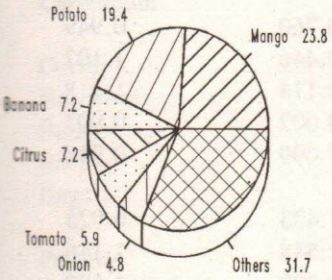
Figure 2-continued



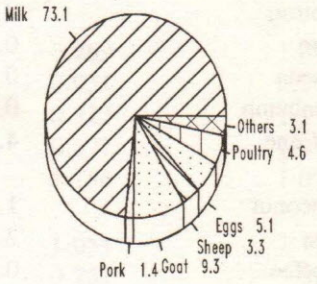
Spices



Fibres



Fruits & Vegetables



Livestock

Table 12. Commodity-wise priorities : All-India

Crops	VOP	FBL	FBL/VOP
Rice	11.241	11.697	1.041
Jowar	1.646	1.767	1.073
Bajra	0.898	0.866	0.964
Maize	1.457	1.474	1.012
Ragi	0.401	0.442	1.102
Wheat	10.282	8.980	0.873
Barley	0.256	0.229	0.897
Tapioca	0.488	0.414	0.848
S. millet	0.169	0.182	1.074
Arhar	1.415	1.442	1.019
Gram	2.335	2.431	1.041
Ot Pulses	2.675	2.886	1.079
Soybean	0.437	0.531	1.216
G.nut	4.395	4.740	1.079
Linseed	0.190	0.207	1.090
R & M	2.967	2.881	0.971
Sunflower	0.213	0.239	1.118
Sesamum	0.665	0.726	1.092
Castor	0.242	0.228	0.942
Safflower	0.049	0.052	1.065
Cotton	0.801	0.760	0.949
Jute	0.403	0.446	1.107
Mesta	0.086	0.114	1.318
Sunhemp	0.002	0.002	0.903
S Cane	4.965	4.699	0.946
Coconut	1.549	1.433	0.925
Tea	2.284	2.548	1.116
Coffee	0.278	0.308	1.108
Arecanut	0.264	0.287	1.087
Cashewnut	2.242	2.093	0.933
Tobacco	0.322	0.317	0.955
Potato	2.576	2.543	0.987
Onion	0.614	0.629	1.024
Cabbage	0.266	0.290	1.090

Table 12-continued

Crops	VOP	FBL	FBL/VOP
Cauliflower	0.356	0.383	1.075
Lady's finger	0.263	0.305	1.162
Gn Peas	0.157	0.160	1.020
Tomato	0.709	0.775	1.094
Gn Chillies	0.470	0.532	1.133
Banana	0.883	0.942	1.066
Papaya	0.145	0.154	1.064
Orange	0.248	0.270	1.089
Apple	0.731	0.510	0.698
Citrus	0.856	0.940	1.098
Grapes	0.402	0.416	1.037
Guava	0.132	0.140	1.068
Litchi	0.220	0.252	1.145
Mango	2.948	3.110	1.055
Pineapple	0.185	0.226	1.222
Sapota	0.119	0.092	0.775
Ginger	0.206	0.270	1.312
Turmeric	0.266	0.301	1.133
Pepper	0.109	0.084	0.772
Coriander	0.224	0.239	1.064
Cardamom	0.121	0.115	0.953
Garlic	0.257	0.269	1.045
Rawwool	0.232	0.031	0.971
Pork	0.285	0.322	1.129
Beef	0.663	0.677	1.022
Eggs	1.119	1.156	1.033
Poultry	0.943	1.054	1.119
Sheep	0.733	0.752	1.027
Goat	2.015	2.110	1.047
Milk	17.210	16.623	0.966
M Fish	3.967	3.759	0.948
I Fish	3.484	3.749	1.076
Agforestry	0.116	0.127	1.095
Rubber	0.345	0.271	0.787

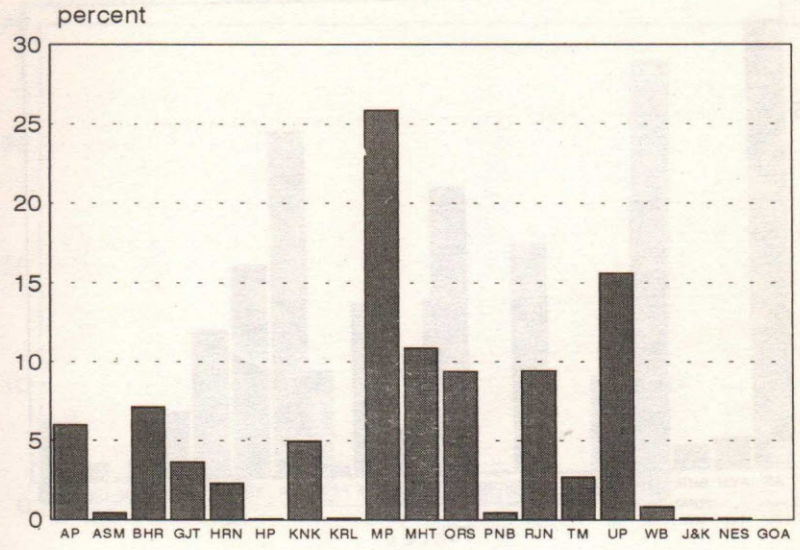
What the FBL column in Table 12 indicates is the proportion in which national research resources ought to be allocated among commodities in order to achieve the multi-faceted agricultural development goals. For example, rice research should recieve 11.7 percent of the total research resources, sorghum should claim 1.8 percent and so on. The trade-off picture shown above indicates how these normative allocations change as multiple objectives are incorporated in the simple efficiency-based exercise.

Relative Priorities of Commodity Groups by States

Yet another dimension is the distribution of priorities of a commodity group by states. In other words, the question is, if 100 rupees are available for cereal research in India, how much of it should be spent in each State ? These are given in Figure 3. The results suggest that bulk of cereal research should be done in Uttar Pradesh, Madhya Pradesh, Punjab, Bihar, Andhra Pradesh and West Bengal. Some should be done everywhere except Himachal Pradesh, Kerala and Jammu & Kashmir. Pulses research should be mainly located in Madhya Pradesh, Uttar Pradesh, Maharashtra, Orissa, Rajasthan, Bihar and Andhra Pradesh. For oilseeds research the major states are : Andhra Pradesh, Rajasthan, Madhya Pradesh, Gujarat, Karnataka, Tamil Nadu and Uttar Pradesh. For fibre crops, West Bengal, Maharashtra, Andhra Pradesh, Gujarat and Punjab appear more important. Sugarcane is important in Uttar Pradesh, Maharashtra, Karnataka and Tamil Nadu. Fruits and Vegetables research should target Bihar, Andhra Pradesh, Uttar Pradesh, Maharashtra and Karnataka though all states except Goa would need some research effort. Similarly, the relative importance of states in terms of plantation crops, spices, livestock, fisheries and agro-forestry is indicated in Figure 3. These calculations are important in evaluating location of commodity research. Data available with us permit these calculations by individual commodities also and this may be more relevant since individual commodities are usually the basis of resource allocation. Appendix I contains these data with respect to each commodity. Those familiar with ICAR and the state research systems will find evidences of consistency as well as contradictions in the rationalized scheme presented in Appendix I and existing resource allocation profile of the national research systems.

Figure 3. Relative Priorities of Groups by State

Pulses



Cereals

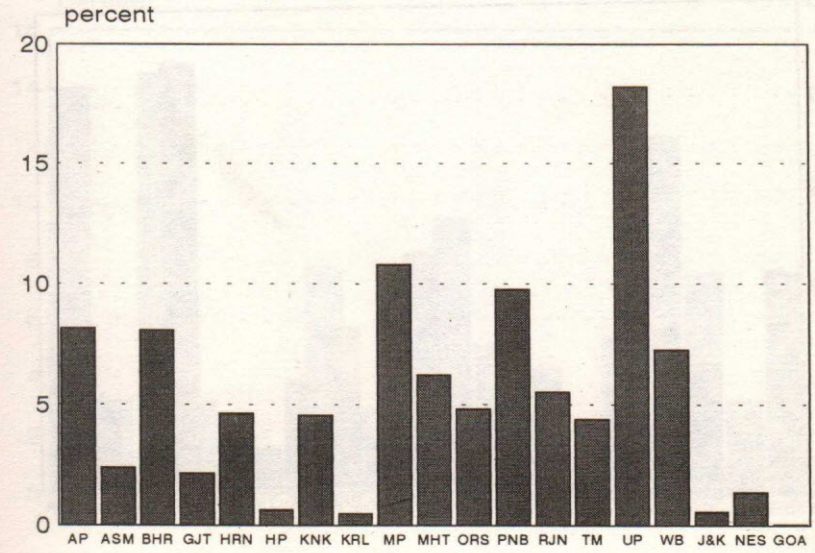
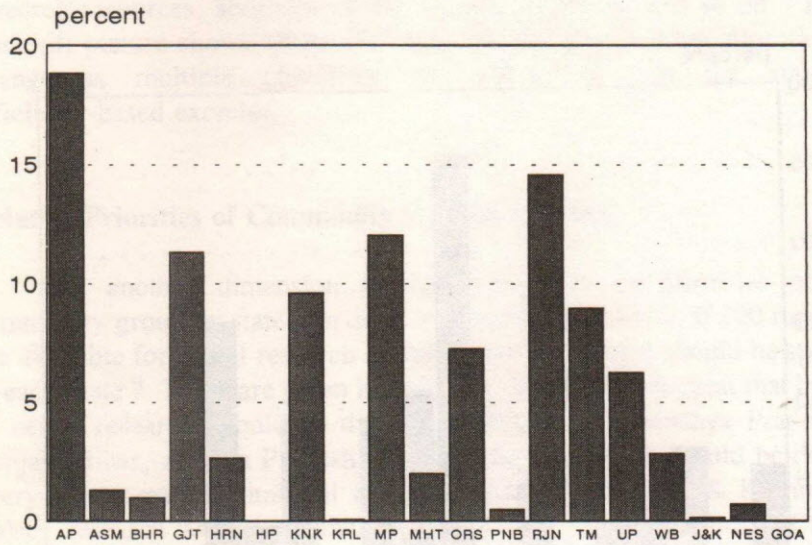
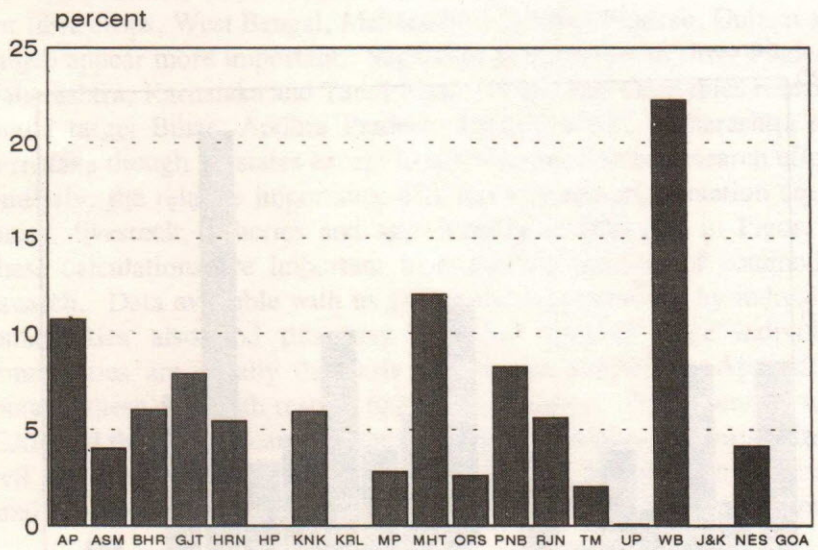


Figure 3–continued

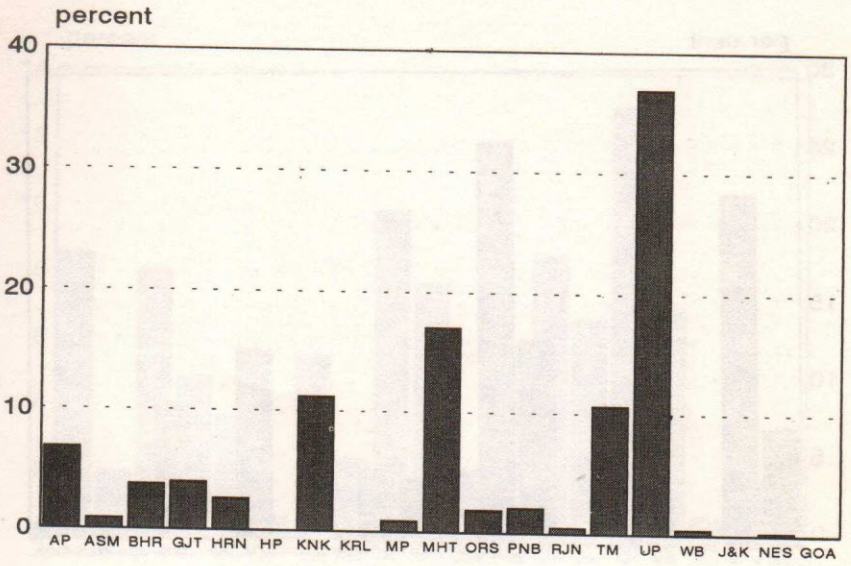
Oilseeds



Fibres



Sugarcane



Fruits & Vegetables

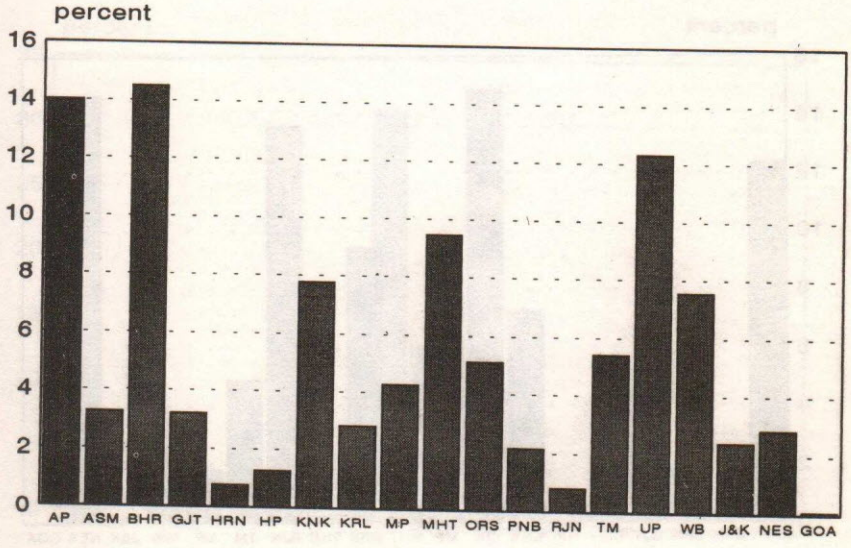
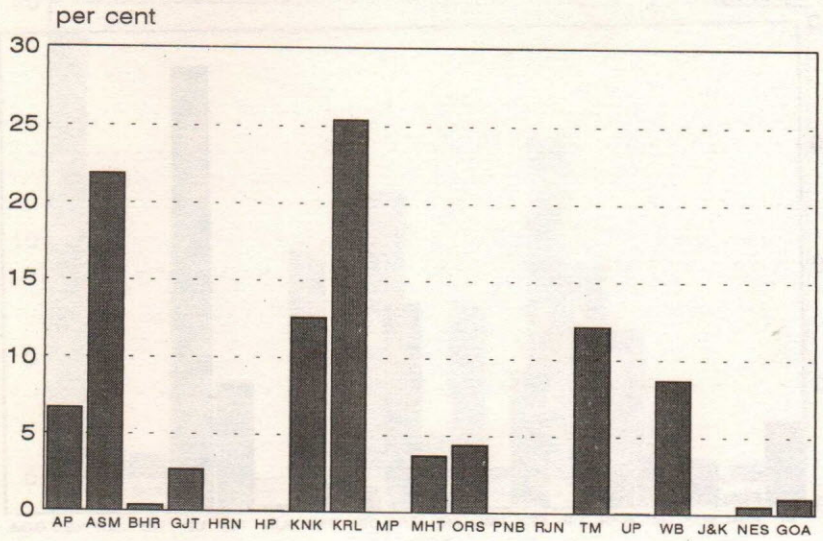


Figure 3–continued

Plantation crops



Spices

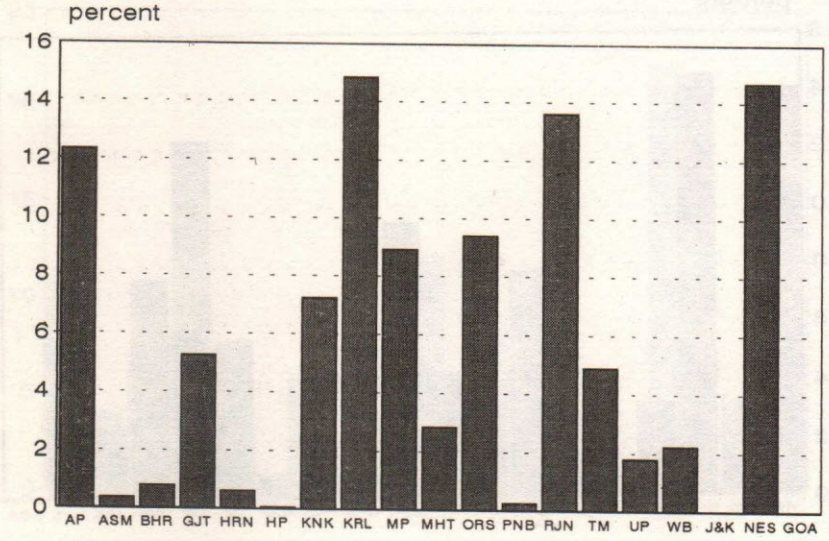
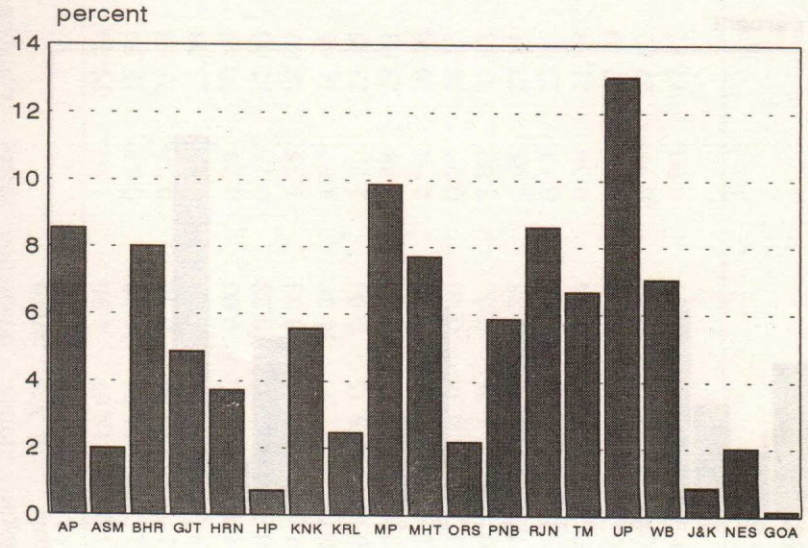


Figure 3—continued

Livestock



Agro—forestry

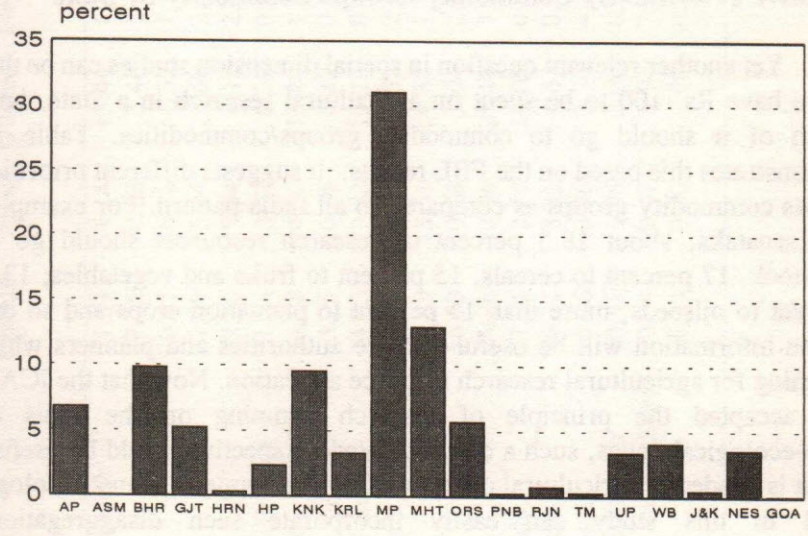
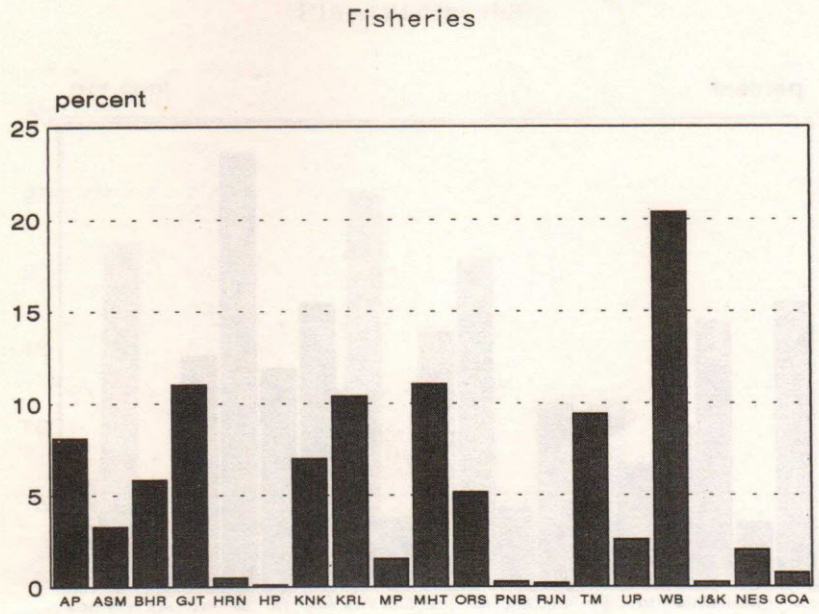


Figure 3–continued



Relative Priorities by Commodity Groups/Commodity by State

Yet another relevant question in spatial dimension studies can be that if we have Rs. 100 to be spent on agricultural research in a State, how much of it should go to commodity groups/commodities. Table 13 demonstrates this based on the FBL results. It suggests different priorities across commodity groups as compared to all India pattern. For example, in Karnataka, about 18.5 percent of research resources should go to livestock, 17 percent to cereals, 15 percent to fruits and vegetables, 13.5 percent to oilseeds, more than 13 percent to plantation crops and so on. These information will be useful to State authorities and planners while planning for agricultural research resource allocation. Now that the ICAR has accepted the principle of research planning on the basis of agro-ecological zones, such a disaggregated perspective would be useful. What is needed is agricultural output data by each zone. The methodology used in this study can easily incorporate such disaggregation. Unfortunately, at this time these data are not available.

Table 13. Priority by group of commodities

State	Cereals	Pulses	Oilseeds	Fibres	Sugar-cane	Fruits & Veg	Plantation crops	Spices	Livstock	Fisheries	Agro-forestry
Andhra Pradesh	21.33	4.14	18.44	1.45	3.26	18.67	4.96	1.60	19.83	6.23	0.09
Assam	17.15	0.83	3.46	1.49	1.13	11.86	44.48	0.13	12.59	6.89	0.00
Bihar	29.15	6.78	1.32	1.12	2.50	26.66	0.36	0.14	25.60	6.19	0.17
Gujarat	11.49	5.14	22.68	2.17	3.87	8.71	4.04	1.40	23.09	17.27	0.14
Haryana	42.50	5.64	9.12	2.58	4.43	3.60	0.00	0.28	30.49	1.35	0.01
Himachal Pradesh	31.64	0.77	0.20	0.00	0.08	32.71	0.28	0.12	32.05	1.57	0.59
Karnataka	16.98	4.90	13.48	1.15	7.67	14.82	13.33	1.35	18.47	17.67	0.18
Kerala	3.25	0.16	0.12	0.00	0.00	1.57	14.38	4.87	14.46	20.08	0.11
Madhya Pradesh	14.33	19.82	13.11	0.42	0.48	6.35	0.00	1.29	25.45	1.29	0.45
Maharashtra	20.90	9.62	2.52	2.09	10.53	16.23	3.50	0.48	23.03	10.89	0.22
Orissa	26.29	13.51	14.87	1.74	1.87	14.27	6.79	2.56	10.66	8.29	0.15
Punjab	56.53	0.68	1.04	2.47	2.24	6.38	0.00	0.07	30.13	0.45	0.01
Rajasthan	24.38	10.96	24.10	1.28	0.41	1.86	0.00	3.00	33.63	0.28	0.02
Tamil Nadu	17.11	2.78	13.09	0.41	7.61	10.78	13.38	0.95	23.11	10.77	0.01
Uttar Pradesh	36.32	8.21	4.67	0.01	13.50	12.52	0.01	0.18	23.06	1.50	0.03
West Bengal	25.56	0.76	3.76	4.03	0.30	13.53	8.64	0.39	21.97	20.99	0.07
Jammu & Kashmir	20.61	1.06	2.06	0.00	0.03	45.97	0.00	0.01	27.30	2.87	0.08
Northern Eastern States	20.64	0.47	3.94	3.19	0.65	21.71	2.91	10.97	27.02	8.88	0.26
Goa	6.74	0.00	0.06	0.00	0.56	4.59	39.39	0.00	17.81	30.24	0.04

Sensitivity Analysis

The above analysis is subject to the criticism that it is based on equal weights to all research objectives. For example, while poverty alleviation is an overriding social objective, research may have a relatively minor direct role in achieving this goal. It should attach greater importance to growth and sustainability. The results would change if an alternative weighting scheme is used. In this section, summary results are presented with respect to three weighting schemes, as under :

Variables/objectives	Weighting scheme		
	I*	II	III
Extensity parameters			
Efficiency	0.25	0.40	0.30
Equity	0.25	0.10	0.10
Sustainability	0.25	0.30	0.30
Exports	0.25	0.20	0.30
Modifiers			
Efficiency	0.25	0.40	0.30
Equity	0.25	0.10	0.10
Sustainability	0.25	0.30	0.30
Research capacity	0.25	0.20	0.30

* This was the basic scheme used in the study.

Table 14 and 15 present the results with respect to regions (states) and commodity groups, respectively. The former shows that the optimum research shares (FBL) of different states are readjusted as a result of changing weights. But there are only minor changes in the relative rankings of different states. The final three columns indicating the FBL/VOP ratios suggest similar pattern of shifts in inter-state allocation. Because of increase in relative emphasis on efficiency and sustainability (and lower emphasis on equity) in weighting schemes II and III, Bihar loses ground, and states like Gujarat and Rajasthan gain a little.

The overall conclusion that eastern states (except Bihar in the reduced poverty weight scenario) and predominantly dryland states need more resources is borne out in all situations.

Similar overall conclusions emerge from the commodity level exercise (Table 15). As compared to scheme I, fibres and plantation crops

gain a little and fruits and vegetables became marginally less important in scheme III. In general, de-emphasing poverty results in a somewhat better correlation with VOP-based allocations. The important analytical point is that the trade-offs between alternatives are not very large.

Table 14.Impact of alternative weighting schemes on regional priorities

Region/ State	FBL			FOL/VOP*		
	Weighting Scheme			Weighting Scheme		
	I	II	III	I	II	III
Andhra Pradesh	9.80	9.91	10.00	+	+	+
Assam	3.57	3.38	3.83	+	+	+
Bihar	7.11	5.78	5.46	+	0	-
Gujarat	4.80	4.85	5.25	-	-	0
Haryana	2.79	3.34	3.39	-	-	-
Himachal Pradesh	0.51	0.66	0.57	-	-	-
Karnataka	6.85	6.76	7.07	+	+	+
Kerala	3.89	4.28	4.27	-	-	-
Madhya Pradesh	8.82	8.74	8.55	+	+	+
Maharashtra	7.63	7.76	7.84	0	+	+
Orissa	4.69	4.39	4.42	+	+	+
Punjab	4.42	5.40	5.56	-	-	-
Rajasthan	5.80	5.91	6.07	0	0	+
Tamil Nadu	6.57	6.48	6.36	0	0	0
Uttar Pradesh	12.86	12.45	11.29	-	-	-
West Bengal	7.30	6.96	7.22	0	0	0
Jammu & Kashmir	0.69	0.85	0.72	-	-	-
Northern Eastern States	1.71	1.86	1.90	+	+	+
Goa	0.19	0.23	0.24	-	-	-

* +, 0 and - indicate FBL/VOP ratios of > 1.05, 0.95-1.05, and < 0.95, respectively.

Table 15. Impact of alternative weighting scheme on commodity priorities

Commodity groups	FBL			FOL/VOP*		
	Weighting Scheme			Weighting Scheme		
	I	II	III	I	II	III
Cereals	25.64	25.85	25.63	-	0	-
Pulses	6.76	6.64	6.56	+	+	+
Oilseeds	9.60	9.60	9.72	+	+	+
Fibres	1.32	1.34	1.37	0	+	+
Sugarcane	4.70	4.66	4.54	-	-	-
Fruits & Vegetables	13.08	12.87	12.75	+	0	0
Plantation crops	7.26	7.32	7.58	-	0	+
Spices	1.28	1.31	1.32	+	+	+
Livestock	22.73	22.86	22.80	0	0	0
Fisheries	7.51	7.45	7.59	0	0	0
Agro-forestry	0.13	0.13	0.13	+	+	+

* +, 0, and - indicate FBL/VOP ratios of > 1.02, 0.98-1.02, and < 0.98, respectively.

The Missing Element

A research administrator initiating a research programme *de novo* would directly benefit from the above exercise. The Indian research system is nearly 90 years old and over time, has been investing in a widely diverse research portfolio -- both regionally and commodity-wise. There is no clean slate; on the contrary, we have a highly diverse research and knowledge stock. This must enter and modify the resource allocation recommendation presented above which is based on current commodity profile. An operational research resource allocation exercise must, therefore, include information on past and current research investments.

There is no factual information on these aspects. While there have been attempts to estimate aggregate research investments (Evenson and Jha, 1974; ISNAR, 1992), accurate commodity-wise data are just not available. The ICAR which has the national mandate to guide and coordinate agricultural research in the country, has been doing so entirely on the basis of subjective (not necessarily inaccurate) judgements.

Ex-post research evaluation studies indicate that these have, by and large, been efficient.

Till date, there are no data on region (state-wise) or commodity-wise research resource allocation. Even fifteen years of World Bank assistance under NARP has not accomplished this basic need. A very partial analysis, based only on ICAR (not total) resource allocation, by Randhawa *et al* indicates the following picture (Table 16).

Table 16. Value of output of some crops* and ICAR's research expenditures in 1991-92

Commodity	Value share (V)	Research share (R)	R/V
Rice	47.2	19.1	0.4
Wheat	23.6	8.9	0.4
Sugarcane	14.8	14.4	1.0
Tuber crops incl. potato	6.4	15.9	2.5
Fibre crops/Post harvest tech.	6.4	30.6	4.8
Tobacco	1.5	11.0	7.3

* The shares are based on the total for six commodities only

Source : Randhawa et al 1993 : Adapted from table 10.

These data are only illustrative but do reflect the fact that there could be wide discord and inconsistencies in current resource allocation. Any effort for readjustment along the lines suggested by this exercise would need substantial effort in inventorying and documenting, in quantitative as well as qualitative terms, the current deployment of national research resources. In addition, a decentralized research system would require information on agro-ecological zone basis. These data can be easily generated by the institutions concerned. But, at the moment, these are not available.

6

CONCLUSIONS & POLICY IMPLICATIONS

This study represents the first attempt towards an economic assessment of agricultural research priorities in India. In the past, the Indian Council of Agricultural Research (ICAR) has depended exclusively on informed scientific judgements for identification of critical technical constraints and determination of research resources needed to tackle these. This has been quite efficient in the past as indicated by a number of ex-post evaluation studies on returns to research investments.

Over time, there have been quantitative and qualitative changes in the agricultural research scenario which render subjective approaches less efficient. First, the size of ICAR plan expenditure has grown from a modest Rs. 91 crores in the IV Plan (1969-74), to Rs. 1300 crores during the VIII Plan (1992-97) period. This size of investment itself makes the task difficult. As the kitty expands, chances of inefficient and arbitrary allocation increase. A disproportionate focus on extension, pointed out in Chapter 2, illustrates this malady. More objective and analytical approaches to supplement and enrich prioritization and resources allocation decisions are now essential. Second, the goals and objectives of the national agricutural research system have become far more complex now. From exclusive concern for food self-sufficiency, we now expect the research system to contribute directly towards growth, equity, sustainability, export potential, and so on. These objectives are often in conflict, and simplistic approaches cannot address these trade-off issues.

This study attempts to provide an objective analytical baseline which will enrich decision making. Scientific judgements will still govern the process but more factual information will improve this process. The modified congruence approach used in this study is essentially normative. It sets up an initial baseline incorporating regions(states) and commodities, and provides a benchmark based on value of output. This is then modified to incorporate other objectives and a final baseline is arrived at which allocates resources across regions and commodities. It is a simplistic

excercise , involving several restrictive assumptions. But it is fact-based, transparent and easily comprehensible.

Regional orientation of research resources

In the absence of adequate data base at the agro-ecological zone level, state level data were used to arrive at state-wise priorities. This has some advantage because from the national point of view, state is the unit for resource allocation. Results on how research resources should be allocated between states are given in Chapter 4. As a test of validity of the approach, we just look at two regions-predominantly dryland states, and states in the eastern region. These have been identified as priority regions in the VIII Plan and also in the Agricultural Policy Statement. Does our analysis bear this out? In Table 17, we show how the emphasis on these regions changes as we bring along modification in the initial baseline.

Table 17. Shift in emphasis towards priority regions as a result of modification of the VOP baseline

Region/States	Proportional allocation based on		
	VOP	FBL	%change
Dryland states Andhra Pradesh, Madhya Pradesh, Maharashtra, Karnataka, Rajasthan, Gujarat*	39.90	43.70	(+) 3.80
Eastern states Bihar, Orissa, West Bengal, Assam, Northern Eastern States	20.80	24.38	(+) 3.58
Other states	39.30	31.92	(-) 7.38

* In this state, the FBL shows a decline, but as a group, dryland areas gain.

The table shows that based purely on economic efficiency considerations, the predominantly dryland states would recieve about 40 percent of research resources, and the eastern states about 21 percent. The FBL shows nearly 4 percent increase in each of these priority regions,

and a corresponding decline in the shares of other states. In the category of losing states belong Uttar Pradesh, Punjab, Haryana, Himachal Pradesh, Kerala, Goa, Jammu & Kashmir and Gujarat. Others maintain their relative shares. Overall, the FBL results bear out the priorities.

Lest these figures of 3-4 percent are dismissed as trivial, it should be noted that in terms of plan (VIII) allocation of ICAR only, these amount to Rs 39-52 crores ! And when one takes into account non-plan and state expenditures the figures would become very large in rupee terms.

Commodity based allocation

Very broadly, the analysis presented in Chapter 5 indicated a shift away from cereals and sugarcane to pulses, oilseeds, fruits and vegetables, spices and agro-forestry. These were prompted by equity, sustainability, export and other modifying objectives. With regard to other commodity groups, such as livestock, fisheries, plantation and fibre crops, it would be efficient to allocate research resources on the basis of their output contribution. Information have been provided in the present exercise which provide useful guidelines regarding location of commodity research.

The next phase

This analysis, despite limitations, provides the initial setting for improving rationality of research resource allocation. The process is objective and transparent. One can see the effects of changing the values or weights of different extensity and intensity parameters. Both the concept and the analytical framework are easily understood by non-economists also.

The regional and commodity research resource allocation profiles generated by the model are normative. Existing resource allocation patterns need to be moulded and directed towards these norms. That is the *raison d'etre* for this excercise. Unfortunately , data on existing resource allocation along the above lines are non-existent. Researchers have occasionally attempted to generate such data but these are always crude guesstimates particulary at aggregate level. It is amazing that despite more than a decade of massive external assistance for agricultural research, neither the centre nor the states have any systematic idea regarding resource allocation. This is the first task which must be undertaken on a priority basis. Without comprehensive inventory of

current agricultural research resource allocation, no rationalisation is possible.

Secondly, this analysis is essentially driven by socio-economic compulsions, though it does incorporate some other technical considerations like sustainability. This is what social scientists can do. We have provided a region x commodity matrix of priorities. This tells nothing about a research agenda. We have shown that dairy/dairy products are important, for example, but what the research issues in this sector and the relevant research programmes and strategies are, can only be determined by scientists in animal sciences. Of course, social scientists will have an input at this stage also because prioritization will be involved. Invariably there are alternative research strategies and a choice has to be made among them. But the present aggergative excercise does not address such questions. This is the logical next step in which both agro-biological and social scientists will be involved. Such steps will be needed from research programmes down to individual research projects.

Third, we have been able to identify commodity-wise priorities at the state level. This has to be disaggregated further to the level of agro-ecological zones within the state. Under the National Agricultural Research Project, technical constraints and research themes have, in fact, been identified at the zonal level, but there is no analysis of relative priorities among zones and commodities within zones. The SAUs can employ the methodology developed here to do so. This will require collection and compilation of data at the zonal level. The ICAR could provide assistance to enable them to do so.

Finally, even though sustainability concerns are incorporated in the analytical framework, resource-based research has not been explicitly examined. Soil, water, climate, ecology, genetic resources -- all require significant research attention. Some of these will surface as commodity based research programmes and projects as designed, but there is a need to explicitly introduce this dimension in future excercise.

PART II

METHODOLOGY AND DATA

Methodological Framework

Assessing research priorities is difficult and uncertain. It builds on the body of knowledge gained from *ex-post* analysis of research, and also involves more demanding prediction of expected effects on a speculative basis.

Many priority setting models have been proposed, e.g., Shumway (1973), Norton and Davis (1981), Ruttan (1982), Anderson and Parton (1983), Parton, Anderson and Makeham (1984), Norton and Pardey (1987) and Norton *et al.* (1992), but few have been institutionalized into the decision making practice of National Agricultural Research Systems. A crucial factor in the non-use of formal models undoubtedly has been the lack of a rigorous yet cost effective procedure which can incorporate the large number of commodities and research areas as well as the multiple goals and criteria found in most decision making situations.

Methods reported for agricultural research priority setting can be grouped into five categories: (1) scoring approach, (2) benefit-cost analysis, (3) programming models, (4) simulation model and (5) econometric models. A description of each method is presented below.

Scoring/Weighted Criteria Model

It is a commonly used method which involves identification of objectives for research system and choosing a set of criteria or measures of the contribution of commodities or types of research to the objectives. Criteria may be qualitative or quantitative in nature. Information on the commodities or research area may be collected on each criterion from primary and secondary sources. Finally, weights are assigned to criteria to obtain priority ranking by commodity or research area. Thus, it can be used to rank commodities or research areas according to their overall contribution to research objectives.

Scoring models have the advantage that they can be administered in a relatively short period of time and are transparent, which facilitates their

understanding particularly by administrators. They can be used to rank a long list of commodities as well as research areas, including nonproduction-oriented research. Qualitative as well as quantitative information can be used and perhaps most importantly, they facilitate the weighting of multiple goals and objectives. These models are often criticised because of their subjective weighting of objectives. Applications of these models are found in several studies like in the United States (Mahlstede, 1971), Argentina (Moscardi, 1987), Gambia (Sompo, 1989) and TAC review of priority and strategy for CGIAR (1992).

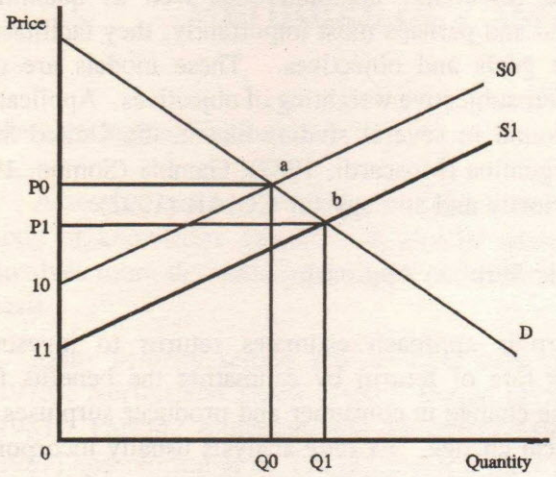
Benefit-Cost (Economic Surplus) Approach

The economic surplus approach estimates returns to investment (generally, an average rate of return) by estimating the benefits from research in terms of the change in consumer and producer surpluses that result from technological change. *Ex ante* analysis usually incorporates expert opinion to determine projected research impacts, adoption rates, and probabilities of research success and provide estimates of the economic efficiency and distributional implications of agricultural research resource allocation.

Figure 4 illustrates the effect of technological change on economic surplus. The supply curve with the original technology is S_0 and the demand curve is D. The resulting equilibrium price and quantity are P_0 and Q_0, respectively. Adoption of new technology, which reduces the unit cost of production (by raising yield) shifts the supply curve down from S_0 to S_1. This results in a new equilibrium price and quantity P_1 and Q_1. Consumers gain from the adoption of the new technology because they can consume more at a lower price, and producer gain because their unit production costs fall. Net social benefit is the sum of consumer and producer surplus. The size of this benefit depends on the elasticities of demand and supply curves and on the size of supply shift.

The benefit cost approach has the major advantage of incorporating several criteria related to economic efficiency and distribution into one or two measures. It can also be used to examine the general equilibrium effects of research; to assess the spillover of research benefits among different technologies, commodities, regions or countries; and to estimate the effects of agricultural policies on benefits arising from research. This method can be difficult to apply to a large number of commodities or research areas because types of data necessary for the analysis often do

Figure 4. Effect of technological change on economic surplus.



not exist for all commodities. It is also not well suited to rank non-commodity research areas. Applications of this method are found in studies in Peru (Norton *et al.*, 1987), in eastern Carribbean (Norton and Douglas, 1989) and Australian Centre for International Agricultural Research (1987).

Programming Models

These rely on mathematical optimisation to choose a research portfolio through maximising a multiple goal objective function given the resource constraints of the system. They have the advantage of explicitly incorporating the budget, human resource and other constraints in the system. Like scoring models, they facilitate the inclusion of multiple objectives. If constructed in a multi-period format, they can identify how the research portfolio should change over time. However, they require a great deal of analytical ability, data and time. An example of the use of this method is a study by Russel (1977) in the U.K.

Simulation Models

In simulation models, mathematical relationships among variables are exposed to different scenarios to assess the best outcome. They can incorporate many factors that affect research priorities, such as multiple goals, research constraints, socio-economic variables, risk and uncertainty.

The advantage of simulation models is their flexibility. They can be constructed as relatively simple or complex tools, can incorporate optimizing or ranking procedures and can readily include probabilistic information. Their major disadvantage is that, to be useful they must be relatively complex and typically require extensive amounts of both data and time of skilled analysts. Pinstrup-Anderson and Franklin (1977) and Lu, Quance and Liu (1978) have used this method.

Econometric Methods

The results of *ex post* analysis can also provide useful guidance for *ex ante* research resource allocation decisions if appropriately incorporated into systematic *ex ante* procedure. The most common *ex post* approach, in addition to the *ex post* benefit cost analysis, is the econometric estimation of production or supply functions incorporating research variables. These econometric models assess the contribution of research to changes in production of different agricultural commodities. To be useful in *ex ante* analysis, econometric approaches must be applied with a high degree of disaggregation and good historical data on production, farm inputs and research expenditures.

Numerous studies have estimated these models (production functions, supply functions, profit functions etc.) for *ex post* evaluation of agricultural research. While the results of these studies have been used to justify additional research funds for particular commodity; no research system has systematically used the results of a comprehensive econometric analysis for all its major commodities to help in setting research priorities.

There is no single approach that is suited for every situation. Each has advantages and disadvantages that affect its suitability for specific evaluation purpose, and in fact, it may be appropriate to combine different methods. The scoring and economic surplus approaches have been used more than the others. Table 18 presents comparison among major *ex ante* priority setting methods.

Table 18. Comparison among major research priority setting methods

Characteristics	Sc	B-C	Si	MP
1. Requires explicit elicitation of goals	Yes	No	No	Yes
2. Determines distributional effects on consumers and producers at various income levels	No	Yes	Yes	No
3. Considers trade-off among goals	Yes	Sometimes	Yes	Yes
4. Evaluates benefits to "aggregate" research	No	Yes	Yes	Yes
5. Evaluates benefits to commodity research	Yes	Yes	Yes	Yes
6. Evaluates benefits to non-production or non-commodity oriented research	Yes	Difficult	Sometimes	Yes
7. Provides ranking of research projects based on multiple goals	Yes	No	No	Yes
8. Quantifies spillovers	No	Yes	Yes	No
9. Relative ease of comprehension by decision makers	High	Medium	Low	Low

Note : Sc = Scoring, B-C = Benefit-cost, Si = Simulation method, MP = Mathematical programming
Source : Based on Norton and Davis (1981)

Selection of Methodology

The approach selected for the present exercise is popularly known as scoring model or modified congruence approach. This approach can capture the multiple objectives of ICAR, viz., efficiency, equity, sustainability and exports. The priority index developed could be used for distribution of research resources across regions and commodities. The approach is considered to be a demand side approach as it explicitly considers the concerns of the research beneficiaries. The other major advantage of this approach is that it is most transparent particularly to administrators. It also involves scientists and administrators in the selection of objectives and therefore, facilitates building a consensus that the method and results are valid. Finally, this approach is comparatively less data intensive and can be applied in a shorter time frame. (McCalla and Ryan 1992)

The modified congruence approach involves seven broad steps. These are :

- Identification of goals of the organisation, research objectives and extensity parameters.
- Selection of weights of extensity parameters.
- Selection of research priority dimensions.
- Construction of initial baseline (IBL).
- Modification of IBL.
- Deriving final baseline (FBL).
- Priority setting by commodity and state.

Identification of Goals, Research Objectives and Extensity Parameters

The identification of research objectives, and their extensity parameters (indicators) and weights for the construction of initial baseline is the most crucial step in the priority setting exercise. In the construction of initial baseline only extensity parameters are taken as these reflect the size of the problem to be addressed by research system. Accordingly, research activities should concentrate more in those regions where the magnitude of the problem to be addressed by research system is large. The identification of research objectives and their relevant extensity parameters are influenced by national policy goals and the availability of relevant data. For our analysis, national goals documented in the VIII Five Year Plan and the goals specified in ICAR Plan (GOI, 1992; ICAR, 1992-97) were taken as guiding factors for the identification of research

objectives. The selected research objectives and their extensity parameters are given in Table 19.

Table 19. Goals, objectives and extensity parameters for the Indian agricultural research system

	Goal	Research objective	Extensity parameter
1.	Growth acceleration	Increase in productivity	Value of production
2.	Equity	Increase in income of people below poverty line	Number of people below poverty line
3.	Sustainability of production	Sustainable use of natural resources	Land area
4.	Improve balance of payment	Promotion of exports	Agricultural export earnings

Value of Production

The benefits of research are generally enhanced manifold by its adoption in larger area without affecting the cost of research. Therefore, the value of research is proportionate to the value of production. Hence, the value of production (VOP) reflects the research objective of increase in productivity. The VOP can be adjusted by supply side factors like probability of research success, expected level of adoption of research, research spillover, etc. But these were not considered in this exercise due to lack of a prior information on these aspects. The VOP unadjusted to supply side factors tantamounts to assuming equal probability of research success and equal or no spill-over effects across the states and commodities. The value of production for all the commodities were obtained as production of agricultural commodities evaluated at current market prices (Directorate of Economic and Statistics, Ministry of Agriculture and National Horticultural Board). The triennium averages (1989-91) of production and wholesale prices were taken to iron out the year-to-year fluctuations.

Number of People Below Poverty Line

This extensity parameter was selected to further strengthen research activities in the area where number of poor people is comparatively more. This would help in reducing interpersonal and interregional disparities in the country. The data on number of people below poverty line were taken from Centre for Monitoring Indian Economy (CMIE) publication (1991 & 1993).

Land Area

Agricultural production can be sustained through conservation of natural resources, particularly land and water. Considering the land based agricultural production system and availability of data, land area was selected as one of the extensity parameters and the necessary data were taken from Bansil (1992). Land area comprises arable, grazing, and forest lands.

Agricultural Exports

Since the need for improvement in the balance of payment situation has led to a series of structural reforms in India, agricultural exports promotion was considered as one of the research objectives. This is further supported by the fact that India has comparative advantage in several agricultural commodities (Gulati and Sharma, 1991). The extensity parameter selected for this objective was agricultural export earnings. Since, state-wise data on agricultural export earnings were not available, the share of state in the country's export earnings from a commodity was assumed to be equal to state's share in the country's production and in some cases area of that commodity (Economic Survey, various issues). The export earnings thus obtained were added to arrive at state-wise total export earnings.

The consideration of various extensity parameters in the analysis emphasises efficiency. This means that if research system has to be efficient in achieving a specific research objective(s); whether in increasing productivity, alleviating poverty, sustaining land use or promoting exports; research activities should focus in the area (state) where value of corresponding extensity parameter(s) is high. The data base generated for all the four extensity parameters is given in Appendix II.

Selection of Weights of Extensity Parameters

Initial baseline is the weighted sum of extensity parameters. To compute this, the selection of weights for various extensity parameters is essential. In the absence of precise prior information on relative importance of different objectives, equal weights (0.25) were assigned to all the extensity parameters. However, the methodology permits the use of different weights to reflect the differences in the importance of various objectives, as has been shown in Part I of this paper. Also, one may observe the trade-off between various objectives (for example trade-off between efficiency in production and equity) by using different weights or by adding objectives one by one in the construction of initial baseline.

Selection of Research Priority Dimensions

Agricultural research prioritisation could have spatial, commodity and research area dimensions. However, research area prioritisation for a commodity is much more data intensive and requires more interaction with researchers. This dimension was not considered in the present analysis.

Spatial Dimension

Most of the priority setting exercises have identified homogenous agro-climatic regions for this purpose to ensure uniform distribution of research benefits in a region. However, agro-climatic regions identified for India cut across the administrative boundaries. Consequently, necessary data are not readily available by agro-climatic region. Therefore, analysis was carried out taking state as a spatial unit. All the major states in the country were included in the analysis. Small states in the north-eastern region were pooled together for reporting.

Commodity Dimension

The study translated research priorities by state into research priorities by commodity. For this, individual agricultural commodities and groups of commodities were considered. The commodity groups are : cereals, pulses, oilseeds, fibres, spices, fruits and vegetables, plantation crops, livestock, fisheries, sugarcane and agro-forestry.

Construction of Initial Baseline (IBL)

As stated earlier, initial baseline is the weighted sum of extensity parameters and is constructed by state. The construction of initial baseline can be illustrated by the following steps :

1. Compute percentage distribution of each extensity parameter (P_{ij})

$$P_{ij} = (A_{ij} / \sum_{i=1}^{n} A_{ij}) \times 100; \text{ and } i = 1, \ldots n; j = 1, \ldots k$$

where A_{ij} is value of jth extensity parameter in ith state, n is the number of states and k is the number of extensity parameters.

2. Assign weight (W_j) to each extensity parameter.

3. Compute initial baseline (B_i)

$$B_i = (\sum_{j=1}^{k} W_j P_{ij}) ; \text{ and } i = 1, \ldots n$$

where B_i is the baseline for ith state, W_j is the weight for jth extensity parameter.

In our analysis, initial baseline was constructed using equal weights (0.25) for all the four extensity parameters. The results are reported (for few states) as illustration (Table 20). The sum of initial baseline over the states is 100 and therefore, initial baseline shows the initial relative priorities by state. This means that available research resources may be allocated among the states according to their initial relative priorities.

Table 20. Construction of initial baseline (Illustration)

State	Percentage share in all-India				Initial base-line
	Value of production	Number of poor people	Land area	Export earnings	
Andhra Pradesh	8.38	8.32	8.18	10.63	8.88
:					
Gujarat	5.49	3.00	4.38	8.82	5.42
:					
Uttar Pradesh	15.62	19.27	11.77	3.58	12.56

Modification of the Initial Base Line

Initial priority setting for research resource allocation based on the extensity indicators does not fully consider the major concerns of ICAR namely growth, equity, sustainability and exports. For example, while number of people below poverty line was used as an extensity indicator to address the concern of absolute level of poverty, the other dimension of poverty, namely the intensity of poverty in a particular state which is equally important while prioritising research could not be captured because this calls for the use of intensity parameters which cannot be aggregated across states, as in an extensity parameter framework. An approach was therefore developed and standardized for the inclusion and use of appropriate parameters as modifiers in order to modify the initial base line which would eventually reflect both extensity and intensity of growth, efficiency, equity and sustainability concerns while setting priorities for research resource allocation.

(a) Selection of modifiers

Fourteen modifiers were initially considered. The list included scope for production growth, urgency for production growth, employment, malnutrition, per capita state net domestic product, deforestation, availability of forest cover, ground water potential utilised, degraded land area, biotic pressure on natural resources, carrying capacity of the land, smallness of states, number of scientists and expenditure on agricultural research and education. Ultimately, based on the appropriateness arrived through collective judgement, seven modifiers were chosen for the study. Correlation matrix generated for the chosen modifiers (not reported) revealed that the highest correlation coefficient between any two modifier is 0.51, indicating only minor duplication among the modifiers chosen for the study.

The intensity parameters selected as modifiers to address different goals and objectives are given in Table 21.

Table 21. Goals, objectives and modifiers for the Indian agricultural research system

Goal	Research objective	State Modifiers
Growth acceleration	Increase in productivity	Scope for production growth
Equity	Increase in income of people below poverty line	Per capita state net domestic product
Sustainability of production	Sustainable use of natural resource base	Ground water potential achieved, Degraded land area, Per capita forest cover, Population density
Research system capacity	Balanced development of research system infrastructure	Expenditure on agricultural research and education

Scope for production growth (efficiency modifier)

The difference between potential production levels as documented in several multi-locational demonstrations across the states by the research/extension agencies and actual production levels realised by the farmers exhibits considerable variation among the commodities as well as the states. While this gap is attributed to differences that exist in terms of inputs/management, the magnitude of such gaps are the determinants for strategic or applied research focus. The scope for production growth is defined as the gap between potential and actual production expressed as the percentage of potential production. Thus, greater this percentage figure, higher will be the scope for production growth through applied research for bridging the gap. However, in case of states like Punjab and Haryana, where scope for production growth is likely to be low, the emphasis has to be on strategic research to break the biological barriers to elevate the potential yield levels further.

The potential production level, reflecting maximum attainable productivity given the current production technologies, vary by crop and state, which need to be incorporated while defining the scope for

production growth as a modifier. However, in the absence of adequate, well documented, productivity gap data set, even for the major crops of the state, it was resolved to select the most important crop for each state based on its area share. For the selected crop and the state, the productivity data based on national demonstrations in that state were taken as potential production level and state average actual productivity data were taken as actual production level to estimate the scope for production growth which is applicable across all commodities of that particular state (ICAR, 1987-88). The scope for production growth was thus estimated for all the states.

Per capita state net domestic product (equity modifier)

To capture the intensity of poverty, per capita state net domestic product was selected as a modifier. For promoting equity, it was proposed to give higher priority for research resource allocation to the states where per capita net state domestic product is low. The use of per capita net state domestic product as an equity modifier favours eastern states like Bihar and Orissa by shifting the emphasis away from Punjab, Haryana and Maharashtra.

Thus, by using number of people below poverty line as an extensity indicator and per capita net state domestic product as a modifier, both the dimensions of poverty namely magnitude and intensity of occurrence were taken care of.

Sustainability (sustainability modifier)

Sustainability concern is multi-faceted involving the overall degradation of natural resources. It encompasses soil degradation, ground water mining, deforestation and overall biotic pressure to name a few. Given the availability of data set, it was decided to use four modifiers namely degraded land area, ground water potential achieved, per capita forest cover and population density to reflect different facets of sustainability issue. Use of four modifiers to address sustainability concern instead of one as in the case of efficiency and equity concerns is, in our judgement, more appropriate to check the regional distortions that might occur with only one sustainability modifier.

(i) Degraded land area

Degraded land area was arrived at by adding up the area affected by erosion problems and area affected by water logging, salinity and alkalinity (Bansil, 1990). Larger the degraded land area, more will be the sustainability concern in the immediate future and therefore, relatively more will be the research emphasis to arrest and reverse the degradation process to promote sustainability. This would therefore call for greater emphasis while distributing the priorities for research resource allocation. Use of degraded land area as a sustainability modifier favoured bigger states like Rajasthan, Madhya Pradesh and Maharashtra where the magnitude of degraded lands is much larger than that of the other states.

(ii) Ground water potential utilised

Ground water potential utilised, expressed as a percent of ground water potential estimated, was used as a sustainability modifier (*Bhu-Jal News*, 1991). The phenomenal increase in ground water development since 70's has resulted in uneven distribution, even to the extent of over exploitation and mining of ground water in some of the areas. The consequences are many, like salt water intrusion in coastal areas of Gujarat, fast depleting ground water table in Punjab and Haryana, and so on. Consequently, higher the percentage of ground water potential achieved, greater should be the emphasis in terms of research resource allocation for promoting sustainability in the use of ground water resource. Use of ground water potential achieved as one of the sustainability modifiers facilitated greater emphasis to be placed on states like Punjab, Haryana and Gujarat where the sustainability concern is already gaining ground.

(iii) Per capita forest cover

The per capita forest cover is used as one of the sustainability modifiers to capture the pressure on forest resources leading to encroachment, degradation and deforestation of the forest cover (Remote Sensing Agency; GOI, 1989). To meet the fuel, fodder and timber requirements, the pressure on forest resources is expected to be high if the per capita forest cover is low. In such states, it is important to promote appropriate research to balance the pressure on forest resources by improving the productivity of agricultural lands. All these would entail greater emphasis on states with least per capita forest cover while deciding

the priorities for research resource allocation. Use of per capita forest cover as one of the sustainability modifiers favoured states like Haryana, Punjab, West Bengal, Gujarat and Uttar Pradesh.

(iv) Population density

Due to inadequate data availability, only three modifiers as stated above have been selected to reflect the concerns of degradation in land, water and forest resources (CMIE, 1991 & 1993). However to capture the overall pressure on natural resources and the production environment in totality, population density expressed as number of persons per square km was used as yet another sustainability modifier. Higher the population density more will be the pressure on natural resources, aggravating the sustainability problems. Use of population density as one of the sustainability modifiers favoured states like Kerala, West Bengal, Bihar and Uttar Pradesh.

All the four sustainability modifiers were individually used to quantify their impacts on initial base line. It was however finally decided to integrate the quantitative impact of all the four modifiers into one sustainability modifier by giving equal weights (0.25) to all the four.

State Research System Capacity

State research system capacity was estimated through the budgetary allocation to agricultural research and education by Government of India as per VII Five Year Plan (Department of Environment; GOI, 1992). To promote balanced development of research infrastructure among different regions it was considered essential to place more emphasis in terms of research resource allocation to strengthen and activate the state agricultural research system, where the current budgetary allocation is relatively low. Such an approach would facilitate a broader research infrastructure base. Use of the budgetary allocation to agricultural research and education as a measure for state research system capacity modifier favoured the small states like North-Eastern states besides Madhya Pradesh, Andhra Pradesh, Rajasthan and Karnataka where the existing state research system capacity in terms of budgetary allocation is relatively low as compared to the states like Maharashtra, Gujarat, Assam and Haryana.

(b) Selection of Weights and Signs

Having selected the modifiers as discussed above, the next step is to decide about the weight and sign to be attached to each modifier while quantifying its impact on the initial base line. What weights should be given to each modifier would directly influence the relative emphasis on any particular concern and this represents the explicit weight of the modifier. Besides this, the variability in the distribution of a modifier across the states would exert an indirect influence which is called the implicit weight of the modifier. Thus, recognising the role of implicit weight of the modifier in impacting the initial base line, it was decided not to introduce varied explicit weights to the modifiers. The experience of CGIAR study has shown drastic distortions in the relative priority rankings of regions with higher weights for the modifiers. Taking into consideration the desirability of reflecting all the stated concerns, without introducing undue distortions in the relative priority setting, an uniform weighting pattern of 0.25 to each of the modifiers was used for this study. The judgement regarding the weighting scheme is, thus, subjective but the transparency of this approach provides enough flexibility to apply alternative weighting patterns and trace their impacts on the initial base line. This has been shown in Part I of this paper.

The sign (positive or negative) to be attached to each modifier will decide the direction of modifier's impact on the initial base line. For example, let us consider scope for production growth as the growth modifier. Lesser the scope for production growth with the existing technology, greater should be the emphasis on strategic research. Such an approach would help in breaking the biological yield barriers in those regions. Therefore, negative sign was used while quantifying the impact of this modifier on the initial base line. However, if one were to consider in terms of applied and adaptive research, greater emphasis need to be placed for those regions where scope for production growth is greater. Such an approach would facilitate the realisation of untapped reservoir of production potentials. This would imply using a positive sign while quantifying the impact of this efficiency modifier on the initial base line. In case of equity modifier, to promote equity among the states, negative sign was used while quantifying the impact of per capita net state domestic product. For sustainability modifier, four modifiers were independently considered before integrating them into single sustainability modifier impact. While quantifying the impacts of each sustainability modifier, different signs were used. In case of degraded land area, positive sign

was selected to give greater emphasis to states with larger area under degraded lands. For 'ground water potential utilised', again positive sign was used to provide relatively higher priority towards those regions with a high percentage of ground water potential utilised for reasons of promoting sustainability based research. In case of per capita forest cover, a negative sign was used. For population density, higher the density, higher should be the priority to balance the pressure on natural resources by improving the productivity of resources on sustainable basis. To reflect this, a positive sign was assigned. The assessed impacts of all the four sustainability modifiers were then, integrated into a single one by giving equal weights to each sustainability modifier. For the state research system capacity modifier, negative sign was selected to ensure higher priority to states with weak existing research system set up.

Thus, the sign of the modifiers should be appropriately considered to target the impact of the modifier in the desired direction while modifying the initial base line.

The judgement about the signs is again subjective, largely in tune with the perceived strategies of the managers of research. The simplicity of this approach facilitates the application of different signs to the modifiers and evaluating their impacts and trade-offs in terms of priority setting reflecting different objectives.

(c) Quantitative Impact of Modifiers

After selecting the modifiers, their weighting scheme and respective signs or direction of their impact, the steps followed in quantifying modifier's impact while constructing new priortiy distribution are summarised below :

(i) Modified base line construction

$$B_i' = [1 + \{M_{ij} / \text{Max}\,(M_{ij})\} x\, W_j]\, B_i$$

(ii)New priority distribution

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

Where;

Maharashtra while Bihar is having relatively less area under degraded situation. In third row, the degraded land distribution among the states is standardized by dividing the row by the maximum degraded land area. In fourth row, weight is introduced by multiplying third row by 0.25, which is the weight attached to this modifier. Using fourth row, initial base line has to be modified as given in fifth row. Fifth row gives the magnitude of adjustment needed to be done with the initial base line. This is done in sixth row which is obtained by adding first and fifth row. This adjustment leads to the total priority distribution exceeding 100 points. Since the analysis is done by adjusting the total to 100, the sixth row is again modified to the total of 100, to get the new priority distribution along with the relative rankings which is given in seventh row. The deviation from initial baseline highlights that the direction of the impact is positive in four states. Also, the magnitude of impact of degraded land modifier is maximum for Rajasthan which requires greater emphasis because of relatively larger area under degraded lands as compared to other states. Consequently, the ranking of Rajasthan has improved from nine in initial base line to five in new priority setting because of the introduction of sustainability concern through degraded land area as a modifier. Similarly, positive impacts and improvement in relative ranking position was observed in case of Madhya Pradesh and Maharashtra. Bihar gets lower ranking in new priority setting.

Thus, the magnitude and direction of modifier impact are incorporated into the analytical framework to quantify the impact of different concerns addressed through state modifiers in the overall priority setting framework.

In the example considered above, the modifier carried positive sign. However in case of a negative sign, the direction has to be reversed after third row. This is done by subtracting third row from 1 before proceeding to fourth row and the remaining steps remain same.

Construction of Final Base Line (FBL)

The impact of each one of the modifier in terms of sign and magnitude is then aggregated to get the total impact of all the four modifiers. Using this aggregate impact of all modifiers, the initial base line is modified to get the final base line. Table 23 gives the initial base line, aggregate net impact of all modifiers and final base line for few states. It is seen that with the incorporation of all modifiers, the relative priority distribution in

case of Andhra Pradesh improves by nine points while relatively better placed states in terms of productivity, poverty etc. like Gujarat gets relatively lesser priority in the final base line.

Table 23. Final base line construction

Regions	Initial Baseline	Modifier Impact	Final Baseline
Andhra Pradesh	8.9	+ 0.9	9.8
	(2)		(2)
Uttar Pradesh	12.6	+ 0.3	12.9
	(1)		(1)
Gujarat	5.4	- 0.6	4.8
	(10)		(10)
All India	100		100

Note : Figures in parentheses indicate the relative ranking of different states.

Priority Setting by Commodity

(a) Adjustment of Value of Production

The relative emphasis on different states based on the final base line varies considerably from the relative priority ranking based on VOP alone. The shifts in relative emphasis among different states has to be translated in terms of commodities produced in respective states. This is achieved by adjusting the value of production of each commodity in each state. The factor for adjustment is generated for each state by taking the ratio of the priority distribution based on final base line and value of production. In Table 24, the derivation of ratios for adjusting the value of production in respect of few selected states is shown. The ratio of relative priorities based on final base line and value of production is higher than one in case of Andhra Pradesh, and less than one in case of U.P. and Gujarat. This implies that an upward adjustment in value of production is warranted in case of Andhra Pradesh whose relative priority has increased with the introduction of equity, sustainability and exports related concerns into the analysis. In case of states like Gujarat, on account of its better placement *vis-a-vis* other states in terms of the above parameters, its relative priority has decreased in the final base line warranting a downward adjustment in the value of production of the commodities produced in that state. By using the respective ratios of

Table 24. Ratio calculation (Illustration)

State	Relative priorities based on		Ratio
	VOP	Final baseline	
Andhra Pradesh	8.4	9.8	1.2
	(2)	(2)	
Uttar Pradesh	15.6	12.9	0.8
	(1)	(1)	
Gujarat	5.5	4.8	0.9
	(11)	(10)	
INDIA	100	100	

Note: Figures in parentheses indicate relative ranking of different states.

adjustment for different states, the relative priority emphasis as reflected in the final base line is translated into the commodities by adjusting their value of production.

(b) Priorities by Commodity and State

The value of production as adjusted by the state-wise ratios is given in Table 25 for few states and few commodities. In case of Andhra Pradesh, it is seen that the value of production of crops like rice,

Table 25. Value of production adjustment (Illustration)

(Million Rs.)

State	Ratio	Crops	VOP	Adj. VOP
Andhra Pradesh	1.2	1. Rice	21037	25244
		2. Sorghum	1705	2046
		3. Pearl millet	338	406
		4. Maize	1494	1793
Uttar Pradesh	0.8	1. Rice	21672	17338
		2. Sorghum	1251	1001

sorghum, pearl millet and maize are adjusted upwards by using the ratio of 1.2. Such adjustments in the value of production of each commodity

were carried out for all the states. The adjusted value of production, commodity-wise and state-wise was used as the basis to generate relative priority setting by commodities and commodity groups and by states and country as a whole.

Appendix I:Commodity Priorities by States

State	Rice	Jowar	Bajra	Maize	Ragi	Wheat	Barley	Tapioca	S.Millets	Arhar	Gram
Andhra Pradesh	14.88	8.01	3.24	8.38	7.63	0.02	0.00	2.99	11.45	4.30	1.11
Assam	4.99	0.00	0.00	0.17	0.00	0.27	0.00	0.00	0.57	0.23	0.04
Bihar	8.84	0.02	0.08	14.77	3.25	8.79	3.93	0.00	3.85	4.07	3.57
Gujarat	0.88	2.50	15.74	4.37	0.73	2.20	0.00	0.00	1.81	10.61	1.35
Haryana	1.73	0.25	5.37	0.41	0.00	10.15	5.66	0.00	0.00	1.45	5.35
Himachal Pradesh	0.09	0.00	0.00	4.70	0.10	0.85	1.84	0.00	0.50	0.00	0.03
Karnataka	3.85	15.14	4.63	9.24	51.87	0.30	0.00	0.00	6.77	8.22	1.79
Kerala	1.08	0.00	0.00	0.00	0.00	0.00	0.00	60.21	0.00	0.00	0.00
Madhya Pradesh	8.45	14.98	2.88	16.06	0.00	13.12	8.87	0.00	28.09	19.70	43.61
Maharashtra	3.08	47.08	19.09	1.42	7.53	1.86	0.00	0.00	8.76	20.81	6.54
Orissa	9.62	0.00	0.00	2.77	10.30	0.15	0.00	0.00	3.94	6.12	0.77
Punjab	0.32	0.00	0.14	2.87	0.00	18.99	5.93	0.00	0.00	0.37	0.51
Rajasthan	0.18	2.89	31.32	12.69	0.00	9.07	29.42	0.00	0.81	0.65	17.11
Tamil Nadu	7.81	5.14	5.02	0.57	11.93	0.00	0.00	36.80	8.58	3.76	0.00
Uttar Pradesh	10.48	4.00	12.39	13.68	5.73	32.38	42.87	0.00	19.30	19.28	17.77
West Bengal	14.78	0.00	0.00	1.21	0.43	1.27	0.88	0.00	0.57	0.19	0.37
Jammu & Kashmir	0.48	0.00	0.09	3.20	0.00	0.41	0.30	0.00	0.41	0.00	0.00
North Eastern States	2.36	0.00	0.00	3.49	0.43	0.16	0.31	0.00	4.59	0.23	0.07
Goa	0.11	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00
All India	11.70	1.77	0.87	1.47	0.44	8.98	0.23	0.41	0.18	1.44	2.43

Appendix I-continued

State	Otpulse	Soybean	G.Nut	Linseed	R&M	Sunflower	Sesamum	Castor	Safflower	Cotton	Jute
Andhra Pradesh	10.99	0.00	35.59	0.33	0.03	18.20	4.27	19.14	2.16	13.62	0.00
Assam	0.87	0.00	0.00	0.00	4.01	0.00	1.10	0.00	0.00	0.00	11.29
Bihar	11.65	0.00	0.00	12.31	2.21	0.00	0.67	0.00	0.00	0.00	15.10
Gujarat	2.12	0.00	13.92	0.00	7.46	0.00	6.59	72.20	3.66	13.73	0.00
Haryana	0.21	0.00	0.02	0.00	8.78	0.00	0.00	0.00	0.00	9.47	0.00
Himachal Pradesh	0.11	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.00
Karnataka	6.01	0.00	15.20	2.77	0.00	51.07	7.11	4.35	24.93	9.97	0.00
Kerala	0.22	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Madhya Pradesh	14.01	91.48	4.19	43.86	11.21	0.00	8.14	0.00	0.00	4.88	0.00
Maharashtra	9.53	0.00	0.00	11.97	0.00	29.25	8.50	0.00	69.26	20.46	0.00
Orissa	18.26	0.00	8.98	5.16	1.96	0.00	26.78	4.30	0.00	0.00	4.29
Punjab	0.43	0.00	0.13	0.00	1.25	0.00	0.55	0.00	0.00	14.37	0.00
Rajasthan	7.29	6.54	2.97	4.76	37.48	0.00	18.35	0.00	0.00	9.80	0.00
Tamil Nadu	4.45	0.00	17.36	0.00	0.00	1.48	4.60	0.00	0.00	3.56	0.00
Uttar Pradesh	11.97	0.92	1.48	17.75	16.43	0.00	2.12	0.00	0.00	0.02	0.00
West Bengal	1.51	0.00	0.00	0.81	7.12	0.00	9.24	0.00	0.00	0.00	65.36
Jammu & Kashmir	0.25	0.00	0.00	0.10	0.49	0.00	0.00	0.00	0.00	0.00	0.00
North Eastern States	0.10	1.05	0.05	0.19	1.57	0.00	1.85	0.00	0.00	0.11	3.96
Goa	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
All India	2.89	0.53	4.74	0.21	2.88	0.24	0.73	0.23	0.05	0.76	0.45

Appendix I-continued

State	Mesta	Sunhemp	S.cane	Coconut	Tea	Coffee	Arecanut	Cashewnut	Tobacco	Potato	Onion
Andhra Pradesh	33.87	0.00	6.81	9.66	0.00	0.00	0.09	16.59	0.00	0.05	4.53
Assam	2.36	0.00	0.86	1.10	58.08	0.00	32.06	0.00	0.00	3.26	0.31
Bihar	10.44	30.15	3.78	0.00	0.00	0.00	0.00	0.00	8.07	21.09	10.98
Gujarat	0.00	0.00	3.95	0.00	0.00	0.00	0.00	0.00	61.28	2.01	8.46
Haryana	0.00	0.00	2.62	0.00	0.00	0.00	0.00	0.00	0.00	0.85	1.06
Himachal Pradesh	0.00	0.00	0.01	0.00	0.06	0.00	0.00	0.00	0.00	0.41	0.20
Karnataka	2.38	0.00	11.18	15.61	0.63	85.49	39.24	10.80	19.28	4.17	21.01
Kerala	0.00	0.00	0.00	39.14	6.52	4.55	17.97	38.49	0.00	0.00	2.94
Madhya Pradesh	0.00	0.00	0.90	0.00	0.00	0.00	0.00	0.00	0.00	2.53	0.00
Maharashtra	3.40	0.00	17.09	1.29	0.00	0.00	0.97	11.74	0.00	1.36	34.52
Orissa	13.69	0.00	1.87	2.48	0.00	0.00	0.00	13.51	0.00	0.77	0.00
Punjab	0.00	0.00	2.11	0.00	0.00	0.00	0.00	0.00	0.00	3.72	0.76
Rajasthan	0.00	0.00	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.10	2.73
Tamil Nadu	0.00	0.00	10.64	26.78	13.25	9.96	1.45	4.49	3.48	0.43	5.29
Uttar Pradesh	0.00	69.85	36.94	0.00	0.04	0.00	0.00	0.00	0.00	29.80	7.00
West Bengal	2.07	0.00	0.46	3.11	20.60	0.00	2.71	1.35	7.90	26.46	0.00
Jammu & Kashmir	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
North Eastern States	31.77	0.00	0.24	0.09	0.81	0.00	5.20	0.03	0.00	2.98	0.22
Goa	0.00	0.00	0.02	0.74	0.00	0.00	0.33	3.01	0.00	0.00	0.00
All India	0.11	0.00	4.70	1.43	2.55	0.31	0.29	2.09	0.32	2.54	0.63

Appendix I-continued

State	Cabbage	Cauliflower	Okra	GN peas	Tomato	GN chillies	Banana	Papaya	Orange	Apple	Citrus
Andhra Pradesh	0.39	0.13	6.22	0.53	11.46	52.83	7.62	0.45	0.00	0.00	29.38
Assam	17.53	15.29	5.15	3.99	0.00	1.25	7.71	10.83	5.55	0.00	2.43
Bihar	14.11	24.74	38.49	0.00	14.42	0.00	4.92	0.00	0.00	0.00	6.34
Gujarat	2.88	2.75	1.13	0.00	1.55	0.00	10.56	17.41	0.00	0.00	3.48
Haryana	1.04	0.99	1.70	8.70	1.93	0.44	0.00	0.00	2.36	0.00	0.78
Himachal Pradesh	0.82	0.25	0.16	9.04	0.85	0.02	0.00	0.00	0.00	25.21	0.17
Karnataka	7.57	0.53	4.54	3.83	17.55	4.01	1.70	26.17	0.00	0.00	11.43
Kerala	0.00	0.00	0.00	0.00	0.00	0.07	2.72	5.01	0.00	0.00	0.00
Madhya Pradesh	1.46	3.72	4.17	55.87	8.75	1.82	10.48	3.32	14.73	0.00	5.89
Maharashtra	7.05	4.19	0.00	0.00	16.06	9.29	26.25	0.00	28.16	0.00	13.35
Orissa	27.23	25.99	35.30	0.00	12.85	10.81	4.01	16.25	0.00	0.00	2.36
Punjab	0.60	0.57	0.21	0.00	1.62	0.71	0.00	0.00	16.22	0.00	6.85
Rajasthan	0.24	0.23	0.39	1.73	1.52	6.15	0.01	0.26	2.57	0.00	1.64
Tamil Nadu	2.76	0.00	1.59	0.00	9.57	3.31	18.94	0.00	6.16	0.00	5.31
Uttar Pradesh	14.00	19.59	0.45	14.82	1.30	1.73	0.23	1.55	0.00	21.78	1.54
West Bengal	0.00	0.00	0.00	0.00	0.00	5.05	2.23	17.22	2.14	0.00	0.71
Jammu & Kashmir	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	50.83	0.34
North Eastern States	2.32	0.99	0.51	1.48	0.37	2.47	2.53	1.52	22.11	2.18	7.99
Goa	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00
All India	0.29	0.38	0.31	0.16	0.78	0.53	0.94	0.15	0.27	0.51	0.94

Appendix I-continued

State	Grapes	Guava	Litchi	Mango	Pineapple	Sapota	Ginger	Turmeric	Pepper	Coriander	Cardamom	Garlic
Andhra Pradesh	9.51	6.45	0.00	31.61	0.00	17.29	2.72	42.99	0.00	8.22	0.00	0.31
Assam	0.00	4.01	5.27	0.06	23.33	0.00	0.00	1.57	0.00	0.00	0.00	0.00
Bihar	0.00	24.25	79.67	18.44	4.91	0.00	0.47	1.15	0.00	0.83	0.00	1.25
Gujarat	0.00	6.29	0.00	3.04	0.00	18.83	0.12	3.60	0.00	0.00	0.00	20.79
Haryana	2.12	0.99	0.00	0.17	0.00	0.00	0.02	0.00	0.00	0.07	0.00	2.84
Himachal Pradesh	0.00	0.00	0.00	0.00	0.00	0.00	0.22	0.00	0.00	0.00	0.00	0.00
Karnataka	23.52	13.94	0.01	8.45	13.82	0.00	1.15	19.00	2.13	0.53	22.81	0.56
Kerala	0.00	0.00	0.00	2.00	3.77	0.00	17.36	1.15	96.94	0.00	49.88	0.00
Madhya Pradesh	0.00	15.41	0.00	2.49	0.00	0.00	1.09	0.16	0.00	13.11	0.00	29.46
Maharashtra	51.57	3.86	0.00	3.19	0.00	9.02	0.48	2.18	0.00	0.00	0.00	10.59
Orissa	0.00	0.00	0.00	3.82	1.03	0.00	8.61	10.46	0.00	5.26	0.00	19.63
Punjab	6.30	2.66	2.37	0.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.16
Rajasthan	0.07	0.75	0.00	0.44	0.00	0.00	1.76	0.13	0.00	63.82	0.00	6.10
Tamil Nadu	6.79	7.12	0.00	3.66	3.87	0.00	0.34	9.67	0.93	6.92	9.49	1.54
Uttar Pradesh	0.09	9.62	3.21	15.96	0.00	0.00	1.54	0.27	0.00	1.21	0.00	5.62
West Bengal	0.00	3.63	5.43	5.00	23.50	0.00	4.29	4.94	0.00	0.00	1.77	0.00
Jammu & Kashmir	0.03	0.00	0.00	0.10	0.00	54.48	0.00	0.00	0.00	0.00	0.00	0.04
Northern Eastern States	0.00	1.02	4.04	0.77	25.34	0.00	59.46	2.74	0.00	0.00	16.04	0.10
Goa	0.00	0.00	0.00	0.24	0.42	0.38	0.00	0.00	0.00	0.00	0.00	0.00
All India	0.42	0.14	0.25	3.11	0.23	0.09	0.27	0.30	0.08	0.24	0.11	0.27

Appendix I-continued

State	Rawwool	Pork	Beef	Eggs	Poultry	Sheep	Goat	Milk	M fish	I fish	Agroforestry	Rubber
Andhra Pradesh	4.94	7.15	7.51	20.38	14.73	19.19	5.54	7.32	6.63	9.64	6.78	0.00
Assam	0.00	6.64	4.67	2.85	4.55	0.18	2.50	1.57	0.00	6.56	0.03	0.00
Bihar	3.20	10.18	12.51	7.28	5.95	4.11	16.86	7.03	0.00	11.73	9.81	0.00
Gujarat	3.96	0.69	2.81	1.54	1.54	3.25	3.05	5.80	20.09	1.98	5.25	0.00
Haryana	2.67	2.09	0.84	1.33	1.24	1.51	0.43	4.74	0.00	1.01	0.32	0.00
Himachal Pradesh	2.39	0.01	0.76	0.17	0.16	1.70	0.91	0.73	0.00	0.21	2.37	0.00
Karnataka	11.18	2.96	6.07	6.95	5.79	12.94	4.33	5.30	10.01	3.98	9.59	3.51
Kerala	0.00	0.84	1.35	5.50	4.43	0.05	1.11	2.50	19.08	1.69	3.31	89.86
Madhya Pradesh	2.56	6.19	7.27	5.85	3.73	2.38	9.18	11.17	0.00	3.04	31.04	0.00
Maharashtra	3.73	2.96	9.19	10.04	8.42	7.17	9.30	7.39	18.36	3.75	12.95	0.00
Orissa	0.00	5.95	8.50	2.47	4.87	5.31	5.60	1.11	4.53	5.83	5.72	0.00
Punjab	2.67	0.59	1.05	5.98	3.58	0.85	0.38	7.23	0.00	0.53	0.27	0.00
Rajasthan	42.43	1.77	5.82	1.31	0.86	24.12	12.46	8.60	0.00	0.43	0.73	0.00
Tamil Nadu	9.18	5.59	4.89	12.01	7.00	5.06	5.73	6.58	13.97	4.87	0.30	6.63
Uttar Pradesh	3.67	16.52	11.24	1.98	2.49	4.23	8.99	15.42	0.00	5.15	3.37	0.00
West Bengal	1.32	7.92	8.98	10.97	12.12	3.59	12.04	5.90	5.90	34.92	4.09	0.00
Jammu & Kashmir	5.72	0.01	0.94	0.85	0.77	3.84	0.90	0.68	0.00	0.53	0.44	0.00
Northern Eastern States	0.40	21.50	2.18	2.28	17.66	0.50	0.65	0.89	0.00	4.06	3.57	0.00
Goa	0.00	0.43	3.43	0.25	0.11	0.00	0.01	0.03	1.43	0.09	0.06	0.00
All India	0.03	0.32	0.68	1.16	1.05	0.75	2.11	16.62	3.76	3.75	0.13	0.27

Appendix II : Data base for extensity parameters

State	Value of production (Rs. Crores)	Number of people below poverty line ('000)	Land area ('000 ha)	Agricultural export earnings (Rs. Crores)
Andhra Pradesh	11842.97	21083.0	21975.0	1079.70
Assam	4094.14	5110.4	6050.0	786.12
Bihar	8643.58	35240.6	15516.0	245.35
Gujarat	7757.22	7601.0	11756.0	895.72
Haryana	5321.96	1909.8	5962.0	531.70
Himachal Pradesh	1077.01	475.7	3058.0	22.77
Karnataka	8419.83	14437.6	16785.0	888.68
Kerala	7185.21	4946.7	3947.0	610.61
Madhya Pradesh	10112.49	24288.5	40572.0	338.56
Maharashtra	10317.58	23049.6	28287.0	791.42
Orissa	5490.59	14152.0	16050.0	341.54
Punjab	8658.49	1460.3	7434.0	884.12
Rajasthan	8017.52	10737.5	24222.0	491.17
Tamil Nadu	9246.63	18321.7	10502.0	679.32
Uttar Pradesh	22089.69	48828.3	31597.0	363.89
West Bengal	9857.69	18789.5	9542.0	1029.40
Jammu and Kashmir	1490.62	1072.9	3989.0	22.86
North Eastern States	1323.47	1825.0	11024.0	110.59
Goa	451.97	90.1	264.0	40.00
India	141398.70	253420.4	268532.0	10153.56

Appendix III: Data base for state modifiers

States	PGROWTH (%)	PCNDP (Rs.)	GWPOTAPN (%)	POPPERKM (No.)	PCFRSTHA (Ha)	DGLLKHA (Ha)	AGRESELK (Rs.)
Andhra Pradesh	24	1831	20.10	195	0.09	122.30	740
Assam	53	1799	2.28	254	0.13	30.00	2800
Bihar	67	1189	23.55	402	0.04	65.50	2000
Gujarat	81	2613	33.45	174	0.03	125.90	3033
Haryana	27	3499	70.16	292	0.00	41.60	2400
Himachal Pradesh	48	2190	21.75	77	0.31	19.10	1390
Karnataka	52	2055	33.93	194	0.09	114.00	680
Kerala	20	1886	9.55	655	0.04	19.40	1390
Madhya Pradesh	71	1729	12.46	118	0.25	207.20	500
Maharashtra	66	3522	22.04	204	0.07	198.50	3745
Orissa	71	1615	4.80	169	0.18	78.10	600
Punjab	24	3744	99.38	333	0.01	32.40	1400
Rajasthan	94	1898	37.08	100	0.04	373.90	504
Tamil Nadu	23	1965	46.76	372	0.04	38.20	1300

Appendix III-continued

States	PGROWTH (%)	PCNDP (Rs.)	GWPOTAPN (%)	POPPERKM (No.)	PCFRSTHA (Ha)	DGLLKHA (Ha)	AGRESELK (Rs.)
Uttar Pradesh	57	1628	36.48	377	0.03	131.20	1906
West Bengal	38	1979	16.54	615	0.02	43.00	1710
Jammu & Kashmir	43	1662	1.23	59	0.34	8.90	1450
Manipur	24	1850	0.07	64	1.26	7.30	251
Meghalaya	63	1697	0.07	60	1.17	11.10	100
Tripura	35	2239	9.16	196	0.26	2.80	100
Arunachal Pradesh	56	2377	0.07	8	10.88	26.50	60
Goa	42	4082	7.71	272	0.12	2.00	100
Nagaland	72	2388	0.07	47	1.85	4.90	200
Mizoram	59	2239	0.07	23	3.68	6.10	15
Sikkim	53	2239	0.07	45	0.99	3.00	65

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