SUBJECT II
AGRICULTURAL RESEARCH AND EXTENSION IN INDIA:
ACHIEVEMENTS AND FAILURES AND DIRECTIONS FOR THE FUTURE

Research Priorities for Faster, Sustainable and Inclusive Growth in Indian Agriculture

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ABSTRACT

The present study assesses the priorities for Indian agricultural research by regions and commodities. Using multi-criteria scoring approach, priorities for agricultural research have been assessed taking into consideration the developmental goals of growth, equity, sustainability and research capacity. Assessment of regional priorities have been suggested to give emphasis in allocation of resources to north-eastern, eastern, western, and hill states over their existing shares. States that see a drop in their share are in a relatively better economic condition than those who gain. Priority states for commodity groups such as cereals, oilseeds, pulses, fibres, sugarcane, horticulture, livestock, fisheries, and agro-forestry have been identified with their importance of resource allocation. By commodity or commodity group, livestock research demands one-third (33.9 per cent) of the total resources, followed by cereals (24.3 per cent), horticulture (11.7 per cent), oilseeds (6.5 per cent), fisheries (5.2 per cent), and pulses (3.1 per cent). A higher allocation of resources to livestock and horticultural research is necessary because of the rapid increasing demand for animal products and fruits and vegetables, and also of their pro-poor nature. A comparison between the proposed and the existing pattern of priority scores by states and commodity suggests reallocation of resources so as to reduce interregional and interpersonal disparities.

Keywords: agricultural research, regional priorities, multi-criteria approach, value of production

JEL classification: Q16, R11

I

BACKGROUND

Enhancing agricultural growth remains an important concern in India despite a continuous decline in the share of agricultural sector in India's gross domestic product to less than 15 per cent in 2012-13 from 45 per cent in 1970-71. The importance of agriculture goes beyond its income contribution. The sector supports more than half of the country's population directly, and engages millions of people indirectly in secondary agriculture, i.e., manufacturing and services. It is widely recognised that agricultural research has helped to increase productivity, improve

food security and reduce food prices (in real terms) enabling millions of poor to have affordable access to food (Chand *et al.,* 2012; Spielman and Pandya-Lorch, 2010; Kumar, 2001; Evenson, 2001).

However, now agriculture is facing complex challenges of declining factor productivity, degrading soil and water resources, rising food and energy prices, and increasing frequency of extreme climatic events. On the other hand, resources for research are scarce; India spends only about 0.6 per cent of its agricultural gross domestic product in agricultural research, much less than the average of about 2-2.5 per cent in developed countries (Beintema and Stads, 2008; Chand *et al*., 2012). These challenges call for a judicious allocation of scarce resources, so as to enhance research efficiency and improve food and nutrition security in a sustainable manner.

Priority setting exercises generate information that can aid in research resource allocation decisions while addressing these concerns in a more objective and transparent manner. Priority-setting is a process of making choices amongst a set of potential research activities given the limited resources. Until recently, research resource allocation relied mainly on subjective assessments to manage the technical constraints. However, considering the large size of the national agricultural research system (NARS) of India, the emerging complex challenges and resource constraints, quantitative and formal methods of assessing priorities using socio-economic data is needed to improve the allocation decisions. Jha *et al.* (1995) attempted agricultural research allocation using the socio-economic inputs in the mid-1990s. Subsequently, some other studies were undertaken focusing on either commodity or regional perspective (Birthal *et al.,* 2002; Mruthyunjaya *et al.,* 2003; Jha and Kumar 2006; Das and Khunt, 2008; Kumar *et al.,* 2010). Most of these studies were based on data pertaining to the early or late 1990s. Since, significant changes have taken place in the socio-economic, technological, environment and market conditions, these changes might have definitely influenced the consumption preferences, which need to be captured in deciding future priorities. This study is an improvement over earlier ones on three counts: (i) this study has attempted in a dynamic framework,[1] while past studies have been analysed in static framework; (ii) It uses recent available data to capture the significant socio-economic, technological and ecological changes that have occurred over past one decade; and (iii) It makes an assessment of the regional priorities to evince the usefulness of priority-setting exercise on regular intervals.

II

DATA AND METHODOLOGY

Priorities for agricultural research have been assessed for all the States and Union Territories[2] of India. This has some advantage from national point of view, as state is the main unit for resource allocation by the central government in India. Research priorities have also been assessed for individual commodities or their groups using the data for triennium ending (TE) average 2008- 2009.

Priorities for agricultural research have to address multiple goals and objectives to achieve national goals. The study has used modified scoring approach[3] to assess the priorities. The approach is simple, transparent and capable of addressing multiple goals and research objectives. This approach allocates research resources with the relative importance of decision units (for example, region, commodity) to achieve the objectives. It implicitly assumes that opportunities for research are equal across commodities and regions, and the research benefits are proportional to the value of output. The analysis is based on the current value of production/output and assumes constancy of relative shares. A number of priority-setting studies focusing on Indian agriculture (Jha *et al.* 1995; Birthal *et al.* 2002; Mruthyunjaya *et al.* 2003; Kumar *et al.* 2010) also followed this approach because of its simplicity, transparency and flexibility. A brief description of the approach is presented below.

Identification of Goals, Research Objectives and Extensity Parameters

The developmental goals outlined in India's Five-Year Plan documents and specified in subsequent DARE/ICAR Plan documents serve as a basis for identification of goals, research objectives and the parameters reflecting the objectives. The objectives identified for agricultural research for development include increasing efficiency, improving equity, sustaining production and strengthening research capacity. These objectives and their related extensity parameters along with their weights[4] are given in Table 1. A comprehensive data set was compiled from published government records and used in this exercise. The data pertained to the year 2008-09 (average of triennium ending).

TABLE 1. GOALS, RESEARCH OBJECTIVES AND EXTENSITY INDICATORS FOR
AGRICULTURAL RESEARCH SYSTEM IN INDIA

Goals (1)	Research objectives (2)	Extensity parameters (3)	Weight (4)
Growth acceleration	Increase in productivity	Value of production	0.25
Equity	Improve income equity	Number of people below poverty line	0.125
	Improve nutrition security	Number of underweight children (< 5 years)	0.125
Sustainability of production	Sustainable use of natural resources	Land area	0.25
Research system capacity	Balanced development of research system	Expenditure on agricultural research and education	0.25

The first step in priority setting exercise is to construct an initial baseline (IBL) based on the size of the problem to be addressed by the research system. The extensity parameters signifying dimensions of the social, economic and environmental problems are described below:

(i) *Efficiency:* Value of production (VOP) is the main extensity parameter selected to meet the objective of increasing efficiency. The VOP can be

adjusted by supply-side factors like probability of research success, level of technology adoption and research spill over. But these were not considered owing to lack of prior data on these aspects. The VOP unadjusted to supply side factors means assuming equal probability of research success and equal or no spill-over effects across states and commodities. State-wise data on value of production[5] of 80 commodities (72 crops, 5 livestock, 2 fisheries and 1 agro-forestry) at current prices were collected from the National Accounts Statistics published by the Central Statistical Office of the Government of India, is considered as an important measure of efficiency in allocation of research resources.

(ii) *Equity*: The issue of equity has been described in terms of number of the poor and number of underweight children. This parameter was selected to strengthen research activities further in the region where their number is relatively higher.

(iii) *Sustainability*: Land area defined to include arable, grazing and forest lands is taken as a proxy for sustainability. The idea is to bring more area under cultivation to increase production.

(iv) *State research capacity*: Expenditure on agricultural research and education in different states is considered as a measure of research capacity.

Construction of Initial Baseline (IBL)

Initial baseline (IBL) is the weighted sum of all extensity indicators. The construction of IBL can be illustrated by the following steps:

(i) Compute distribution of each extensity indicator across states (P_{ij})

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

where P_{ij} is the share of i-th state in j-th extensity parameter, A_{ij} is value of j-th extensity parameter in i-th state, n is the number of states, and k is the number of extensity parameters.

(ii) assign weight (W_j) to each extensity parameter.

(iii) compute initial baseline (B_i) for each state

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

where B_i is the baseline for i-th state, W_j and P_{ij} are as above.

The sum of IBL across states is 100 and therefore, IBL shows the initial relative priority by states.

Modification of Initial Baseline: Selection of Modifiers

Since IBL based allocation of resources does not fully consider the intensity of the problems, and, therefore, appropriate intensity parameters/modifiers have been used to modify the IBL (Table 2). The idea is that a higher priority should be given to states where the intensity of problem is higher. A modifier may have influence on IBL positively or negatively. For instance, a state with large yield gap should be accorded a higher priority in research. To reflect this, a positive sign is attached with this. On the other hand, the state with low per capita net state domestic product (indicating intensity of economic inequality) should be given a higher priority, and thus, the direction of its impact is negative. The direction for other selected modifiers and their weight are given in Table 2.

TABLE 2. PARAMETERS USED TO MODIFY INITIAL BASELINE (IBL),
THEIR DIRECTION AND WEIGHTS

Goals (1)	Research objectives (2)	State modifiers (3)	Weight (4)	Sign (5)
Growth acceleration	Increase in production	(i) Scope for production growth (Gap in economic productivity, per cent)	0.125	+
		(ii) Scope for cropping intensity increase	0.125	+
Equity	Improve income equity	(i) Per capita net state domestic product	0.0625	-
		(ii) Per capita landholding (ha)	0.0625	-
		(iii) Share of women in total farm workers	0.0625	-
	Improve nutrition security	(i) Underweight children (< 5 years)	0.0625	+
Sustainability of production	Sustainable use of natural resources	(i) Stage of groundwater development	0.0625	+
		(ii) (Degraded land area	0.0625	+
		(iii) Per capita forests cover	0.0625	-
		(iv) Population density	0.0625	+
Research system capacity	Balanced development of research system	(i) Expenditure on agricultural research and education	0.125	-
		(ii) No. of crops occupied cropped area > 70 per cent	0.125	+

Having selected the modifiers, the next step is to decide the weight to be attached to each modifier while quantifying its impact on the IBL. In this analysis, equal weight is given to each modifier, and weight is equally divided if more than one modifier is chosen to represent one objective. It is noted that giving higher weight to some objective/modifier brings in considerable distortion in the relative ranking of regional priorities (CGIAR, 1992).

The impact of modifiers is estimated as:

$$B_i' = \sum_{j=1}^{m} [1 \pm \{M_{ij} / \text{Max} (M_j)\} \times W_j] \, B_i$$

New priority distribution

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

where, B_i' denotes modified baseline for j-th state, M_{ij} denotes data for the j-th modifier for the i-th state, Max $(M_{j)}$ denotes the maximum value of the j-th modifier, W_j is the weight for j-th modifier, and B_{ij}'' denotes the new priority distribution.

The above procedure applies when modifiers have positive signs. The impact of modifiers with negative signs is obtained by subtracting $\{M_{ij}/\text{Max } (M_j)\}$ from 1. The impact of each modifier is then aggregated to arrive at the total impact of all the modifiers.

Research priorities have been assessed for regions and commodities. A sensitivity analysis of priority ranking to changes in weights to specified objectives has been attempted to see whether changes in weight to a developmental objective of research makes any significant alteration in the priority ranking.

III

RESULTS AND DISCUSSION

Regional Assessment

Assessment of regional priorities on the sole criterion of increasing efficiency suggests relatively greater emphasis in allocation of resources to Uttar Pradesh (14.6 per cent), followed by Andhra Pradesh, Maharashtra, Punjab, West Bengal, Gujarat, Rajasthan, Tamil Nadu, Madhya Pradesh, and Karnataka (Table 3). These states together contribute more than three-fourths to agricultural value of production (VOP).

When equity is considered together with efficiency, Uttar Pradesh consolidates its position further and Bihar gains considerably moving to the second position in priority ranking. Among other states, Madhya Pradesh and Odisha gain in priority order, while Andhra Pradesh, Gujarat, Haryana, Punjab and Tamil Nadu lose their positions.

With further addition of sustainability dimension, Uttar Pradesh continues at the top of priority order, but loses marginally. Other states that gain in priority ranking/scores include Karnataka, Madhya Pradesh, Maharashtra, and Odisha, while, Punjab, Tamil Nadu and West Bengal lose substantially compared to efficiency based allocations. The concerns for sustainability thus bring in considerable trade-off in regional allocation. The final iteration with addition of all the extensity parameters (including research capacity) provides the construction of the initial baseline (IBL).

TABLE 3. INITIAL BASELINE WITH DIFFERENT OBJECTIVES AND MODIFIERS IMPACTS

(per cent)

States	VOP	VOP and EQTY	VOP, EQTY and SUSTY	IBL	FBL	Ratios	
						IBL/VOP	FBL/VOP
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Andhra Pradesh	9.53	7.07	7.59	8.02	7.99	0.84	0.84
Arunachal Pradesh	0.09	0.10	0.77	0.64	0.62	7.11	6.63
Assam	1.69	2.28	2.19	2.39	2.38	1.41	1.41
Bihar	3.14	9.30	7.12	6.23	6.28	1.98	2.00
Chhattisgarh	1.62	2.31	3.16	2.57	2.55	1.59	1.57
Goa	0.17	0.11	0.11	0.12	0.12	0.71	0.73
Gujarat	6.89	5.66	5.69	6.13	6.11	0.89	0.89
Haryana	4.45	3.07	2.53	3.09	3.06	0.69	0.69
Himachal Pradesh	0.73	0.51	0.78	1.18	1.16	1.62	1.60
Jammu & Kashmir	1.16	0.86	0.98	2.18	2.14	1.88	1.84
Jharkhand	1.35	2.67	2.63	2.34	2.34	1.73	1.74
Karnataka	4.96	4.45	5.11	5.39	5.41	1.09	1.09
Kerala	3.47	2.30	1.96	2.50	2.46	0.72	0.71
Madhya Pradesh	5.08	6.76	7.98	6.54	6.59	1.29	1.30
Maharashtra	8.91	8.15	8.94	9.84	9.96	1.10	1.12
Manipur	0.19	0.21	0.39	0.43	0.42	2.26	2.14
Meghalaya	0.19	0.23	0.41	0.35	0.35	1.84	1.87
Mizoram	0.06	0.06	0.29	0.22	0.21	3.67	3.79
Nagaland	0.24	0.18	0.31	0.33	0.33	1.37	1.34
Odisha	2.71	3.21	3.84	3.36	3.38	1.24	1.25
Punjab	7.83	4.50	3.57	3.86	3.83	0.49	0.49
Rajasthan	6.14	5.82	7.69	6.50	6.58	1.06	1.07
Sikkim	0.04	0.03	0.08	0.06	0.06	1.5	1.65
Tamil Nadu	6.06	4.66	4.42	5.61	5.52	0.93	0.91
Tripura	0.30	0.26	0.29	0.36	0.35	1.20	1.17
Uttar Pradesh	14.61	17.24	14.15	13.14	13.20	0.90	0.90
Uttarakhand	0.79	0.71	1.14	1.44	1.41	1.82	1.78
West Bengal	7.32	6.82	5.42	4.76	4.78	0.65	0.65
Union Territories	0.27	0.48	0.44	0.41	0.41	1.52	1.53
All-India	100.00	100.00	100.00	100.00	100.00	-	-

Note: VOP = value of production; EQTY = equity; and SUSTY = sustainability.

The IBL based allocation suggests that 72 per cent of the resources should be allocated to 10 major states, viz., Uttar Pradesh (13.1 per cent), Maharashtra (9.8 per cent), Andhra Pradesh (8.0 per cent), Madhya Pradesh and Rajasthan (6.5 per cent, each), Bihar (6.2 per cent), Gujarat (6.1 per cent), Tamil Nadu (5.6 per cent), Karnataka (5.4 per cent), and West Bengal (4.8 per cent) in the priority order.

With IBL based allocation, majority of the states in the eastern (except Uttar Pradesh and West Bengal) and north-eastern region gain over efficiency based allocation (IBL/VOP). In the western region Madhya Pradesh, Maharashtra and Rajasthan gain in priority scores, while Goa and Gujarat lose marginally. In southern region, majority of the states lose their priority score marginally (except Karnataka). In the northern regions, Punjab and Haryana lose immensely, while Himachal Pradesh, Jammu & Kashmir, and Uttarakhand gain sizeably over their VOP shares. Thus, the concerns of equity (poverty and nutrition security), sustainability, and research capacity help these states to have an edge over simple VOP based allocations.

Modification of the Initial Baseline

IBL based priority reflects only the size of the problem, while intensity of the problem is also important in determining the priorities. We have, therefore, modified IBL using intensity indicators given in Table 2. The idea is that the states where the intensity of problem is higher should receive a higher allocation. The direction of modifiers' impact depends on sign (positive or negative) attached to each modifier. The impact of modifiers on the IBL and final baseline (FBL) are shown in Table 3.

In the final allocation, priority scores of Andhra Pradesh, Assam, Gujarat, Haryana, Himachal Pradesh, Jammu & Kashmir, Kerala, Maharashtra, Punjab and Tamil Nadu decline marginally over IBL based allocation, while other states have either gained or maintained their priority shares. This implies that ignoring of intensity dimensions may lead to sub-optimal allocation of research resources (Table 3).

The trade-offs become more evident when the FBL based priority scheme is compared with VOP based scheme. The FBL/VOP ratios reflect these. In the absence of trade-off among research objectives, the ratio (FBL/VOP) would be near to unity (say, between 0.95 and 1.05). A ratio of greater than 1 implies a gain in the emphasis due to objectives other than economic efficiency. Conversely, a ratio of less than one infers a relatively less emphasis. The impacts of modifiers on resource allocation are presented in Table 4. The ratios (FBL/VOP) for Karnataka and Rajasthan are closer to unity. This implies that their shares in total research resources remain unchanged whether these are distributed based on economic efficiency criterion or all the criteria. The ratios for other states indicate that concerns for equity, sustainability and research capacity have significant impact on resource allocation. The north-eastern and eastern states (except West Bengal and Uttar Pradesh) gain over VOP based allocation. In the western states, Madhya Pradesh, Maharashtra and Rajasthan receive higher priority, while Goa and Gujarat lose over VOP based allocation. Amongst northern states, Himachal Pradesh, Jammu & Kashmir and Uttarakhand (all hill states) gain in the FBL scheme, while Punjab and Haryana lose. In southern region, all states, except Karnataka, lose in the FBL scheme.

TABLE 4. TRADE-OFFS IN REGIONAL RESEARCH PRIORITY

Ratio (FBL/VOP) (1)	States (2)
> 2.00	Arunachal Pradesh, Manipur, and Mizoram
1.50 to 2.00	Bihar, Chhattisgarh, Himachal Pradesh, Jammu & Kashmir, Jharkhand, Meghalaya, Sikkim, Uttarakhand, and Union Territories
1.10 to 1.50	Assam, Madhya Pradesh, Maharashtra, Nagaland, Odisha, and Tripura
0.95-1.05	No states qualified strictly in this range, however, Karnataka and Rajasthan are having ratio near to upper limit of this category.
< 0.95	Andhra Pradesh, Goa, Gujarat, Haryana, Kerala, Punjab, Tamil Nadu, Uttar Pradesh and West Bengal

The impact of modifiers is more apparent for some states than others (Table 3). The FBL based scheme proposes large reduction in shares of Punjab (51 per cent), West Bengal (35 per cent), Haryana (31 per cent), Kerala (29 per cent), Andhra Pradesh (16 per cent), Gujarat (11 per cent), Uttar Pradesh (10 per cent) and Tamil Nadu (9 per cent). The shares of north-eastern states however increased considerably. The increase is 17 per cent for Tripura, 34 per cent for Nagaland, 41 per cent for Assam, 65 per cent for Sikkim, 87 per cent for Meghalaya, 114 per cent for Manipur, 279 per cent for Mizoram to as high as 563 per cent for Arunachal Pradesh. The hill states gained over 60 per cent for additional resources. It is noted that the states that lose in the FBL scheme are in the fairly advanced stage of agricultural development. The results imply that overlooking the long-term social and environmental concerns in allocation of resources for agricultural research may intensify the regional disparities.

Commodity Assessment

The main goal of research is to improve production potential and thereby the supply of agricultural commodities. Thus, commodity is the basic unit of research and resource allocation has significance.

Priority by Commodity Groups: All-India

The FBL scheme accords high priority to livestock research (33.9 per cent of the total resources) (Table 5). Cereals with a share of 24.3 per cent rank second in priority, while fruits and vegetables and oilseeds and pulses demand 12 per cent and 10 per cent of research resources, respectively. The other commodity groups in priority order are fisheries (5.2 per cent), agro-forestry (4.7 per cent), fibres, plantation crops, and condiments and spices. The analyses have shown that the share of livestock in total agriculture was 23 per cent during the early 1990s (Jha *et al.,* 1995). The large increase in production and prices of dairy products and livestock commodities have improved the share of livestock in priority ranking. The livestock sector is now being considered as an engine of agricultural growth (Government of India, 2011b). It is noted that share of agro-forestry increased significantly from 0.12 per cent in the early 1990s to about 5.0 per cent in 2008-09.

How the concerns of equity (economic and nutritional), sustainability and research capacity influence commodities priorities? These have been addressed in Table 5. The analysis has shown that priority towards cereals generally promotes efficiency; towards livestock, pulses, oilseeds, horticulture and agro-forestry promote equity and sustainability. Also, more emphasis on pulses, horticulture and agro-forestry promote equity. Nevertheless no significant trade-offs in resource allocation are observed when all the objectives are taken together. The FBL/VOP ratio reflects this. A ratio of greater than one for a commodity indicates additional allocation on

this at the cost of other for which FBL/VOP ratio is less than one. Thus the ratio suggests higher priority for pulses, agro-forestry and condiments and spices, essentially by shifting incremental resources from fibres, plantation crops, sugarcane and fisheries. Surprisingly, the priority-setting exercise attempted here has generated some interesting findings keeping in view the future demand, particularly for high-value commodities (like oilseeds, horticulture and livestock).

TABLE 5. DISTRIBUTION OF PRIORITY SCORES BY COMMODITY GROUPS

Commodity group (1)	VOP (2)	VOP and equity (3)	VOP, equity and sustainability (4)	FBL (5)	Ratio (FBL/VOP) (6)
Cereals	25.62	24.37	24.38	24.28	0.95
Pulses	2.72	3.12	3.12	3.09	1.14
Oilseeds	6.27	6.56	6.58	6.54	1.04
Fibres	2.96	2.65	2.66	2.68	0.91
Other crops*	4.16	3.96	3.96	3.99	0.96
Horticulture	11.20	11.71	11.68	11.72	1.05
Plantation crops	2.42	2.16	2.14	2.20	0.91
Condiments and spices	1.58	1.66	1.65	1.67	1.06
Livestock	33.46	33.91	33.95	33.91	1.01
Fisheries	5.56	5.16	5.15	5.22	0.94
Agro-forestry	4.06	4.74	4.72	4.70	1.16
Total	100.0	100.0	100.0	100.0	1.00

*include crops like sugarcane, tobacco, other drugs and guar seed.

Priority by Individual Commodities: All-India

Relative priorities within commodity group at all-India level is attempted and described here. Amongst cereals, highest priority should be accorded to paddy (47.6 per cent), followed by wheat (40.3 per cent), maize (6.4 per cent), and pearl millet (2.6 per cent). Priority scores for pulses suggest higher resources for gram (42.6 per cent), Arhar (19.0 per cent), moong (11.5 per cent), urad (9.0 per cent), and other pulses (17.8 per cent). Among oilseeds the priority order is: rapeseed and mustard and soybean (29 per cent, each), groundnut (26.6 per cent) and sunflower (5.1 per cent). Banana (35.3 per cent), mango (18.7 per cent), citrus (9.7 per cent), apple (9.2 per cent), and tapioca (7.5 per cent) should receive higher emphasis in horticultural research. Livestock research should target milk (76.2 per cent), meat (19.5 per cent) and eggs (4.3 per cent).

Priority of Commodity Groups by States

Determining priority for a commodity group by state is yet another dimension of priority-setting. This can be related to a question that, if 100 rupees are available for research for a commodity group in India, how much of it should be spent in each state? The results show that cereals research should be emphasised more in Uttar Pradesh, Punjab, Bihar, Madhya Pradesh, Rajasthan, West Bengal, Haryana, Andhra

Pradesh, Odisha, Chhattisgarh, and Karnataka (Table 6). Priority research for pulses should target mainly Madhya Pradesh, Maharashtra, Rajasthan, Uttar Pradesh, Karnataka, Andhra Pradesh and Chhattisgarh.

TABLE 6. PRIORITY OF COMMODITY GROUPS BY STATES

Commodity group (1)	Priority states (covered 80 per cent share) (2)
Cereals	Uttar Pradesh (22.6 per cent), Punjab (8.8 per cent), Bihar (7.5 per cent), Madhya Pradesh (6.7 per cent), Rajasthan (6.0 per cent), West Bengal (5.8 per cent), Haryana (5.4 per cent), Andhra Pradesh (5.1 per cent), Odisha (4.9 per cent), Chhattisgarh (4.5 per cent), and Karnataka (4.3 per cent)
Pulses	Madhya Pradesh (26.8 per cent), Maharashtra (15.4 per cent), Rajasthan (10.9 per cent), Uttar Pradesh (9.7 per cent), Karnataka (8.9 per cent), Andhra Pradesh (6.2 per cent), and Chhattisgarh (4.4 per cent)
Oilseeds	Madhya Pradesh (20.8 per cent), Rajasthan (20.3 per cent), Gujarat (15.5 per cent), Maharashtra (9.4 per cent), Andhra Pradesh (8.8 per cent), and Tamil Nadu (5.3 per cent)
Fibres	Gujarat (35.7 per cent), Maharashtra (28.3 per cent), Andhra Pradesh (10.1 per cent), Punjab (5.3 per cent), Madhya Pradesh (5.0 per cent), and Haryana (4.3 per cent)
Horticulture	Maharashtra (16.6 per cent), Tamil Nadu (12.0 per cent), Uttar Pradesh (9.3 per cent), West Bengal (7.1 per cent), Andhra Pradesh (6.6 per cent), Gujarat (6.4 per cent), Karnataka (5.6 per cent), Bihar (5.6 per cent), Odisha (4.2 per cent), Jharkhand (3.6 per cent), and Assam (3.5 per cent)
Plantation crops	Kerala (39.4 per cent), Assam (28.7 per cent), and Karnataka (20.3 per cent)
Condiments and spices	Karnataka (21.2 per cent), Andhra Pradesh (14.4 per cent), Assam (9.6 per cent),NE States (8.0 per cent), Rajasthan (7.8 per cent), Kerala (7.0 per cent), Gujarat (6.3 per cent), and Madhya Pradesh (5.7 per cent)
Livestock	Uttar Pradesh (13.3 per cent), Andhra Pradesh (9.9 per cent), Bihar (8.8 per cent), Maharashtra (8.5 per cent), Rajasthan (7.9 per cent), Tamil Nadu (5.3 per cent), Madhya Pradesh (5.0 per cent), Gujarat (4.9 per cent), Karnataka (4.2 per cent), West Bengal (4.1 per cent), Punjab (4.0 per cent), and Jammu and Kashmir (3.9 per cent)
Fisheries	Andhra Pradesh (17.6 per cent), West Bengal (13.0 per cent), Tamil Nadu (12.5 per cent), Gujarat (10.4 per cent), Kerala (6.8 per cent), Bihar (6.5 per cent),Odisha (5.6 per cent), Maharashtra (5.4 per cent), and Assam (4.7 per cent)
Agro-forestry	Maharashtra (12.6 per cent), Karnataka (10.1 per cent), Uttar Pradesh (9.3 per cent), Chhattisgarh (9.1 per cent), Jharkhand (7.6 per cent), Uttarakhand (6.8 per cent), Rajasthan (5.7 per cent), Bihar (4.9 per cent), Tamil Nadu (4.5 per cent), Andhra Pradesh (4.0 per cent), Odisha (3.8 per cent), and Assam (3.2 per cent)

Note: Figures in parantheses indicate relative share of respective state.

For oilseeds, the main priority states are Madhya Pradesh, Rajasthan, Gujarat, Maharashtra, Andhra Pradesh, and Tamil Nadu. Sugarcane research is important for the states of Uttar Pradesh, Maharashtra, Tamil Nadu, Andhra Pradesh, Karnataka, Gujarat, Madhya Pradesh, and West Bengal. Horticultural research should target Maharashtra, Tamil Nadu, Uttar Pradesh, West Bengal, Andhra Pradesh, Gujarat, Karnataka, Bihar, Odisha, Jharkhand, and Assam. Also, the important states for priority for research for livestock, fisheries, plantation crops and spices are indicated.

Sensitivity Analysis

How sensitive is the priority ranking/ scores to changes in weights to the specified research objectives? Three schemes of weights change and their influence on priority ranking by states and commodity groups are described in this section.

In scheme I, equal weight is assigned to all the specified objectives (Table 7). In scheme II, weight to efficiency is doubled (0.50), weight to equity is kept unchanged (0.25), and the weights to sustainability and research capacity are reduced to 0.15 and 0.10, respectively. High weight to efficiency is because the emphasis of research is largely on improving production potential of agriculture. In scheme III, weight to equity is increased to 0.35 with a view that agricultural growth can improve equity and reduce nutritional security. The emphasis on efficiency kept high though the weight is reduced to 0.40, and weights to all other objectives are kept same as in scheme I.

TABLE 7. WEIGHTING SCHEMES USED FOR SENSTIVITY ANALYSIS

Objectives	Weighting scheme		
	I*	II	III
(1)	(2)	(3)	(4)
Extensity parameters			
Efficiency	0.25	0.50	0.40
Equity	0.25	0.25	0.35
Sustainability	0.25	0.15	0.15
Research capacity	0.25	0.10	0.10
Modifiers			
Efficiency	0.25	0.50	0.40
Equity	0.25	0.25	0.35
Sustainability	0.25	0.15	0.15
Research capacity	0.25	0.10	0.10

Note: *This scheme is adopted for the study.

Effect on Regional Priorities

With higher weight to efficiency at the cost of sustainability and research capacity (scheme II); Punjab, Haryana, Kerala, Uttar Pradesh and West Bengal gain in their priority score, while the north-eastern states, Madhya Pradesh and Maharashtra lose heavily. The states that remain less affected are Andhra Pradesh, Bihar, Gujarat, Rajasthan, and Tamil Nadu. Uttar Pradesh gain with a higher emphasis on efficiency and equity. In a nutshell, no significant changes in regional resource allocation are observed except in extreme cases. For example, relatively higher emphasis on efficiency favours states that are in advanced stage of agricultural development (Andhra Pradesh, Punjab and Haryana) or are in the process of development (Gujarat, Kerala and Tamil Nadu). Emphasis on efficiency and equity favours higher allocation to backward states (Odisha, Bihar and north-eastern states).

Effect on Commodity Group Priorities

The results have shown that ranking of commodities remain more or less the same with different weighting schemes. Higher emphasis on efficiency (doubled) over sustainability and research capacity (scheme II) causes marginal increase in shares of cereals, other crops (sugarcane and guar seed) and fisheries, while

allocation to pulses, oilseeds, horticulture, plantation crops, livestock, and agro-forestry declines marginally. Further increasing emphasis on efficiency and equity over sustainability, and research capacity (scheme III) favours a marginal increase for cereals.

Congruity in Research Resources Allocation

How far the proposed resource allocation for agricultural research is congruent with the existing pattern of allocation? This is done by comparing the proposed and existing allocation patterns by states and commodity (Table 8).

TABLE 8. EXISTING AND PROPOSED ALLOCATION OF RESOURCES FOR
AGRICULTURAL RESEARCH BY STATES

(per cent)

States (1)	Existing (2)	Proposed (3)	Deviation (4)	Ratio (proposed/existing) (5)
Andhra Pradesh	9.30	7.99	-1.314	0.859
Arunachal Pradesh	0.24	0.62	0.375	2.531
Assam	3.00	2.38	-0.617	0.794
Bihar	3.50	6.28	2.750	1.779
Chhattisgarh	0.79	2.55	1.758	3.220
Goa	0.16	0.12	-0.043	0.736
Gujarat	7.42	6.11	-1.312	0.823
Haryana	4.76	3.06	-1.698	0.643
Himachal Pradesh	2.41	1.16	-1.247	0.482
Jammu & Kashmir	5.79	2.14	-3.647	0.370
Jharkhand	1.50	2.34	0.845	1.565
Karnataka	6.21	5.41	-0.805	0.870
Kerala	4.11	2.46	-1.650	0.599
Madhya Pradesh	2.21	6.59	4.377	2.978
Maharashtra	12.56	9.96	-2.597	0.793
Manipur	0.55	0.42	-0.127	0.768
Meghalaya	0.19	0.35	0.158	1.823
Mizoram	0.004	0.21	0.206	52.50
Nagaland	0.39	0.33	-0.062	0.842
Odisha	1.92	3.38	1.456	1.757
Punjab	4.73	3.83	-0.905	0.809
Rajasthan	2.92	6.58	3.663	2.256
Sikkim	0.01	0.06	0.049	5.455
Tamil Nadu	9.18	5.52	-3.661	0.601
Tripura	0.57	0.35	-0.217	0.617
Uttar Pradesh	10.10	13.20	3.096	1.306
Uttarakhand	2.34	1.41	-0.933	0.602
West Bengal	2.75	4.78	2.030	1.738
Union Territories	0.33	0.41	0.075	1.224

Data on public spending on agricultural research and education (R&E) by states was compiled from the CAG Reports[6] for the period triennium ending (TE) 2009-10. The total amount on agricultural R&E includes spending on capital and expenditure accounts. The spending by sectors was obtained from the published documents of the Council (ICAR, 2012).

Data in Table 8 show the distribution pattern of existing and proposed allocations of research resources by states. There is a wide variation in the ranking of states between existing and proposed allocations. This suggests for a large reallocation of additional resources. The analysis has shown to reallocate resources to the tune of 31 per cent for Uttar Pradesh, 56 per cent for Jharkhand, 74 per cent for West Bengal, 76 per cent for Odisha, and 78 per cent for Bihar over current allocation. The analysis has also revealed the need for large scale reallocation of incremental resources over the existing level for some states between more than 2-4 folds (i.e., 125 per cent for Rajasthan, 153 per cent for Arunachal Pradesh, 198 per cent for Madhya Pradesh, 222 per cent for Chhattisgarh, and 445 per cent for Sikkim). These findings indicate that there is a considerable subjectivity in the existing allocation decisions. It is expected that correction in the existing allocation pattern in future would help in reducing interregional and interpersonal variability. This reallocation of resources is merely to respond to the proposed pattern and it should be a state initiative, as agriculture is a State subject. Centre may also respond to meet the need of additional resources for creating infrastructure and recruiting manpower.

Table 9 presents the proposed and existing allocations of research spending by major theme for which data was carved out from ICAR. Data shows that wide variability in the ranking of themes between two schemes. Increased amount of reallocation of resources for livestock is seen to support this sector to grow of its full potential and become an engine of growth for agriculture sector in future.

TABLE 9. PROPOSED AND EXISTING PATTERN OF RESOURCES BY SECTORS

(per cent)

Sector	Existing	Proposed	Deviation
(1)	(2)	(3)	(4)
Crops	48.6	45.3	+ 3.3
Horticulture	15.9	15.6	+ 0.3
Livestock	23.9	33.9	-10.0
Fisheries	11.6	5.2	+ 6.4

IV

CONCLUSIONS AND POLICY IMPLICATIONS

Priorities for research have been assessed taking into consideration the national goals of growth acceleration, inclusiveness and natural resource management. Assessment of regional research priorities on sole criterion of increasing efficiency accords higher priority in resource allocation to Uttar Pradesh, Andhra Pradesh, Maharashtra, Punjab, West Bengal, Gujarat, Rajasthan, Tamil Nadu, Madhya Pradesh, and Karnataka. With the addition of other socio-economic and ecological concerns over efficiency, priority ranking changed and nearly 50 per cent states lose their scores. Further, incorporation of the intensity dimension in resource allocation, priority scores for many noted states decline marginally over IBL base allocation. This infers that ignoring of intensity dimensions may lead to either over or under-

investment of research resources and this may lead to intensifying regional and interpersonal disparities further. FBL based commodity group priority suggests the highest allocation for livestock, followed by foodgrains and oilseeds, fisheries, agro-forestry, fibres and others. The analysis has established that micro-level priorities are more useful and provide convincing evidence and signify the importance for undertaking priority exercises at regular intervals. The study has also clearly shown the need for reallocation of additional resources to states and commodity group/sectors.

NOTES

1.   Priority-setting is a dynamic and continuous exercise, while the time-series data on value of production (VOP) related to year triennium ending (TE) 2008-09 and static in nature. Given that agricultural research has substantial lag times between investment and new technology, their availability, and wide adoption in farmers' fields, it is important to consider the future breakdown of production values as the context for current and future research. This is done by incorporating long-term trend growth in the existing VOP data (Raitzer and Maredia, 2012).

2.   India is a union of twenty-eight states and seven union territories (UTs). State units are independently run under rule of Union Government, while UTs are under administrative control of Union/Central Government. Also, agriculture is less important sector in most of the UTs economies. Therefore, all the seven union territories are grouped together as one unit and termed as 'Union Territories' for analytical purpose.

3.   For details about other priority-setting methods applied in agriculture including their merits and demerits, see Norton (1987), Alston *et al*., (1995), and Jha *et al.,* (1995).

4.   Giving an equal importance to each research objective was the main reason of assigning equal weight to each extensity parameter, because the random and deliberate weighting scheme to specified research objectives in past years did not yield desired outcomes as expected. Also, no prior data for weighting of research objectives were available, hence equal weight (0.25) was assigned to each objective. Intensity indicators have also been assigned equal weight.

5.   Value of production (VOP) of individual commodities were collated from the report on '*State-wise Estimates of Value of Output from Agriculture and allied Activities* (2004-05 to 2008-09) and downloaded from the website http://www.mospi.nic.in (Government of India, 2011a). The VOP generated from agriculture and allied activities is projected for 22 years ahead by using long-term trend growth considering substantial lag times between investment and the generation and adoption of new technologies on farmers' fields.

6.   Comptroller and Auditor General of India (CAG) brings out annually a document on '*Combined Finance and Revenue Accounts of the Union and State Governments in India*'. Public spending on agricultural research and education (R&E) by states is reported in above document under headings of crops, soil and water conservation, livestock, and fisheries. Data collected were analyzed for triennium ending (TE) average 2009-10 to remove fluctuations in the data.

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