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Research resource allocation

Determining regional priorities

M. von Oppen and James G. Ryan

The paper presents a methodology to assist in the determination of an appropriate regional allocation of research resources to mandate crops in mandate regions of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). Priority indices are developed on the basis of 10 criteria chosen for equity and/or efficiency considerations. Applying alternative weights to these criteria yields alternative priority indices, which are compared with the Institute's present research resource allocation. The approach helps to make explicit criteria which may have implicitly been followed in past resource allocation and the results indicate that a more regionally-spread focus for ICRISAT's future activities would seem appropriate.

Keywords: Resource allocation; Semi-arid tropics; Agricultural research

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Increasing constraints on international agricultural research centre budgets mean that greater efforts are needed to ensure that research is focused on the most relevant problems of mandate areas. Among the many dimensions of the International Crops Research Institute for the Semi-Arid Tropics' (ICRISAT) problem of where to direct what type of research and when (eg basic versus applied research; research station versus farmers' fields), the question of assigning priorities to regions and countries is of particular importance.

The allocation of research resources based upon an assessment of regional priorities is appropriate under the following conditions: (1) the problems encountered by the researchers in their mandate areas are perceived as being primarily region specific and not universal, and (2) regional research can be undertaken on such a scale that a 'critical mass' of scientific effort to achieve the required level of interdisciplinary collaboration is possible. The amount of funding available will influence the judgement on both these conditions.[1]

Another aspect, which is a corollary of the critical mass argument, is the size of the parent centre. While a minimum number of scientists is required to assure a sufficiently wide interdisciplinary spectrum for addressing the complex problems of tropical agriculture (the precise minimum may vary between five to eight according to Mosher)[2] there exists an optimum number of scientists beyond which effective integration becomes increasingly difficult so that possible gains from growth in size are offset by costs. This is because with more individuals, the time and space required for all individuals to meet and work together increases at an exponential rate of around two. These demands on individuals' time increasingly compete for time devoted to research and, keeping overhead costs constant, all scientists are competing for increasingly limited space and resources. Of course, it can be argued that under such conditions the possibility of selective communication will make the time spent in meetings which are relevant more effective. Nevertheless, experience would suggest that at numbers beyond 30 to 40 principal scientists, communication can become more difficult, leading to excessive interaction at the expense of action.

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The following discussion of regional research priorities is based on accumulating evidence at ICRISAT that at least some research programmes face region-specific problems which are proving to be increasingly difficult – if not impossible – to solve by research conducted primarily at ICRISAT. Funds to finance regional research groups above a critical minimum size seem to be available in view of an increasing interest by donors in special project funding. This approach seems feasible, especially if complementary research from a parent centre is effective. With a staff of principal scientists presently around 50 at Hyderabad, India, ICRISAT may have grown beyond its optimum size. In saying this we recognize that questions of efficiency of conduct of research depend not just on the size of the parent centre, but also on the nature of the organization and devolution within it.

The methodology used in this paper expands on previous work by introducing nine other criteria to the one used to evaluate the congruence of ICRISAT's regional research resource allocations with a pattern suggested by that criterion.[3] The additional criteria used here contain elements which effect the efficiency of the conduct of agricultural research and/or the likely equity implications. In this way the paper attempts to make operational some of the concepts in the *ex ante* allocation of research resources discussed by Binswanger and Ryan.[4] It is assumed that there are seven regions that are relatively homogeneous or functional, at least from the standpoint of research requirements, although it is agreed that this may vary somewhat depending on the type of research (Table 1).

The analyses in the paper are not intended to be a panacea for regional resource allocation decisions. However, we believe they do

[1]Another aspect in this context is lead time required for success. We assume that the intention is to minimize lead time. See F.G. Jarrett, 'Location specificity critical mass and the allocation of resources to agricultural research', *Agricultural Administration*, Vol 11, 1982, pp 49–65.
[2]A.T. Mosher, *Some Critical Requirements for Productive Agricultural Research*, International Service for National Agricultural Research, The Hague, the Netherlands, 1982.
[3]J.G. Ryan, *Agriculture and Research in the Semi-Arid Tropics*, Prepared for Quinquennial Review of ICRISAT, ICRISAT Economics Research Program Report, Patancheru, AP, India, 1978.
[4]H.P. Binswanger, and J.G. Ryan, 'Efficiency and equity issues in *ex-ante* allocation of research resources', *Indian Journal of Agricultural Economics*, Vol 32, No 3, 1977, pp 217–31.

Table 1. The seven functional regions of the developing world with countries having semi-arid tropical zone.

I *West Africa*	IV *India*
Cameroon	India
Central African Republic	
Chad	
Benin	V *Other Asia*
Gambia	Burma
Ghana	Pakistan
Guinea	Sri Lanka
Mali	Thailand
Mauritania	
Niger	
Nigeria	
Guinea Bissau	
Senegal	VI *Near East*
Togo	Iran
Upper Volta	Oman
	Saudi Arabia
II *Eastern Africa*	Yemen Arab Republic
Ethiopia	Yemen Democratic Republic
Kenya	
Somalia	
Sudan	
Tanzania	VII *North, Central and South America*
III *Southern Africa*	Argentina
Angola	Bolivia
Botswana	Brazil
Madagascar	Guyana
Malawi	Paraguay
Mozambique	Venezuela
Namibia	El Salvador
Zimbabwe	Mexico
Zaire	Nicaragua
Zambia	

represent a necessary part of the body of information on which to base such decisions. Factors not explicitly taken into account, such as the history of previous research in the regions, present national programme allocations, and probabilities of success, are of great importance and they must also enter into the assessment. For an international agricultural research centre the problem of allocating research resources to mandate crops in mandate regions is probably more complex than it is for a national agricultural research organization. However, for this very reason the need for decision tools to complement subjective and/or political decision processes is all the more important.[5] 'All *ex ante* evaluation procedures are inherently subjective. The only differences among them are where subjectivity enters the procedure and how it is processed.'[6]

Methodology

Ten criteria were used to assess the relative importance of the seven regions of the semi-arid tropics (SAT) in terms of the allocation of ICRISAT's research resources (Table 2). These criteria represent a mixture of both equity and efficiency concerns.

Regions with low per capita income should receive the highest priority, other things being equal. Such regions are poorer and hence more in need of research to generate increased income streams on the grounds of equity. Even the ardent neoclassical economist Harry Johnson recognized the value of locating R and D institutions in depressed regions as a preferred long-run way of alleviating poverty.[7] If a region's Gross National Product (GNP) is growing slowly relative to its present level, for similar reasons this suggests more research effort should be devoted to that region. Those regions with the largest populations and largest population growth rates should similarly receive high priority. A research effort that will potentially benefit large and growing numbers of people should have obvious equity benefits as well as spread the resource costs over more people.

Regions whose production growth rates have been low could presumably benefit more from research than those whose production growth has been high. Hence on efficiency grounds, the low-growth regions should receive greater research attention. On equity grounds, regions with low food intakes also deserve greater attention, as do regions where the centre's mandate crops contribute more to the region's food supplies.

[5]For a discussion of such decision tools at the national level see C.R. Shumway, 'Models and methods used to allocate resources in agricultural research: A critical review', in T.M. Arndt *et al*, eds, *Resource Allocation and Productivity in National and International Agricultural Research*, University of Minnesota Press, Minneapolis, MN, USA, 1977; C.R. Shumway 'Ex-ante research evaluation: Can it be improved?', *Agricultural Administration*, Vol 12, 1983, pp 91–102. The issues at national and international levels are discussed by G.E. Schuh and H. Tollini, 'Costs and benefits of agricultural research – the state of the art', World Bank Staff Working Paper No 360, Washington, DC, 1979.
[6]Shumway, 1983, *ibid.*
[7]H.G. Johnson, *Technology and Economic Interdependence*, Macmillan, London, 1975.

Table 2. Criteria for determining regional research resource allocation priorities.

Criterion	Highest priority	Justification Efficiency	Equity
Income per capita	Lowest income		x
Income growth/income per capita	Lowest ratio		x
Population	Highest population	x	x
Population growth rate	Highest growth		x
Crop production growth rate	Lowest growth	x	
Current food consumption status per caput (calories, protein, fat intake)	Lowest intake		x
Crop contribution to current food status	Highest contribution	x	x
Regional contribution to SAT crop production	Highest contribution	x	
Yield stability (R^2 of trend lines)	Highest instability (ie lowest R^2)	x	x
Man-land ratio	Highest ratio	x	

The regions which produce the largest shares of the total production of the centre's mandate crops require more research resources because the possible impact of research can be spread over a larger area and production.[8] Regions with more yield instability deserve added research to alleviate the adverse effects on rural populations. In such areas strategies aimed at alleviating yield-reducing factors such as drought, disease and pests can be successful. Where present population pressure on the land is greater, research aimed at enhancing yield per hectare is more likely to succeed. These areas are also likely to be those where the natural resource base is most precarious and where the populations are most at risk and in need of technology to enhance productivity.

To make the choice of, and assign priorities to regions and countries within this multidimensional space implies *a priori* that a set of relative values relating all of these dimensions exists. For instance, nutritional deficits of as many people as possible need to be removed; however at the same time regions with stagnant production trends leading to possible future food deficits should also have priority. This implies that in a graph with nutrient intake along the vertical axis and production trends along the horizontal axis, regions located in the lower left hand side would be generally more in need of attention than regions in the upper right corner. In addition, the numbers of people involved and the contribution of the crop to nutrient intake help to weigh the importance of a region under consideration.

A graphical analysis, however, cannot accommodate all 10 research resource allocation criteria.[9] Several priority indices (PIs) were devised, constructed from numerical values of the 10 criteria. By assigning different weights to each criterion based on subjective assessments of the relative importance of equity versus efficiency concerns and adding up these weighted index values, a composite index was obtained for each region, reflecting its relative priority.[10]

In order to calculate the initial index values for each criterion and to allow for changes in the weights used, regions were ranked on a scale of 0 for the region with lowest priority, to 100 for the region with highest priority (Table 2). The remaining regions were then expressed as percentages of the highest priority region for that criterion. The original data from which the index values were calculated are shown in Appendix Tables 7 to 11.

In the past, ICRISAT has implicitly assigned regional priorities for its five Crop Improvement Programs, and the Farming Systems Research and Economics Programs. This is reflected in its present allocation of research resources across the seven regions of the SAT.[11] By comparing the present regional resource allocations with those suggested by assigning various weights to the 10 criteria in Table 2 and deriving PIs for each region, it is possible to determine their degree of congruence. This creates a better position from which to assess the rationale for present allocations and decide if any changes are required to ensure better congruence.

Derivation of priority indices

Several weighting procedures were used in the analysis (Table 3). Compared to the other six criteria, method A gives double the weight to present population, food status, crop contribution to food status and regional contribution to crop production. This is an *ad hoc* weighting

[8]The methodology does not allow for explicit consideration of the potential for new crops in various regions. The assessment of the potential which a new crop has in an area where it is not being grown presently is difficult. It has to be based on information about agronomic performance and other criteria determining the supply potential as well as factors, such as food habits and market systems, which determine the demand potential. Since by definition this information is scanty for new crops, research resources should be allocated by first conducting limited agronomic trials from which the regional potential can be extrapolated. Detailed market demand studies should be initiated on the degree to which these extrapolations are promising; while accelerating research efforts in this fashion, an information base is created to enable meaningful conclusions to be made. An interesting case is the successful introduction of soybeans in India. (See M. von Oppen, *Soybean Processing in India: A Location Study on an Industry to Come*, INTSOY Series No 4, College of Agriculture, University of Illinois at Urbana-Champaign, IL, USA, 1974, and M. von Oppen, 'Prospects of grain legumes in Asia', *Grain Legumes Production in Asia*, Asian Productivity Organization, Tokyo, 1982, pp 191–211.)

[9]For the graphical analysis refer to an earlier draft of this paper, M. von Oppen and J.G. Ryan, *Determining Regional Research Resource Allocation Priorities at ICRISAT*, prepared for a meeting of the Program Committee of the ICRISAT Governing Board, ICRISAT, Patancheru, AP, India, 1981.

[10]The advantages and disadvantages of additive and multiplicative scoring models have recently been discussed by J.R. Anderson and K.A. Parton, 'Techniques for guiding the allocation of resources among rural research projects: state of the art', *Prometheus*, Vol 1, No 1, 1971, pp 180–201. The consensus seemed to be that additive scoring techniques were preferable to multiplicative models.

[11]Ryan, *op cit*, Ref 3 for a discussion of the allocation of ICRISAT's research resources among the five Crop Improvement and the Farming Systems Research and Economics Programs.

Table 3. Weights used to derive alternative priority index values.

	Ad hoc	Efficiency 2: Equity 1	Equity 2: Efficiency 1	Region's share of SAT production 1: Others 0	Ad hoc (A')[a] weighted by regional contribution D
	A	B	C	D	E
Income per capita	1	1	2	0	b
Income growth/income per capita	1	1	2	0	b
Population	2	2	2	0	b
Population growth rate	1	1	2	0	b
Crop production growth rate	1	2	1	0	b
Current food consumption status per capita	2	1	2	0	b
Crop contribution to current food status	2	1	2	0	b
Regional contribution to crop production in SAT	2	2	1	1	c
Yield stability	1	2	2	0	b
Man-land ratio	1	2	1	0	b

Note: [a]A' is ad hoc A without regional contribution; [b]The weights of these criteria are same as in A and enter into index through A'; [c]The weight of this criterion enters through D.

method. Method B assigns a weight of two to all five criteria having any efficiency justification and one to all others. Method C assigns the seven criteria with equity elements a value of two and all others one. In discussions with plant breeders at ICRISAT it seemed that several preferred to give primary weight to the proportion the region's production represented of the total for the crop of their particular concern. They were in effect saying that they preferred to rely on the efficiency argument. Method D assumes that the benefits of research will be larger the larger the region. To illustrate the effect of an interaction between D and the other methods, an index E was computed by multiplying A (without the regional contribution) times D and setting the total equal to 100.

Sorghum

The ranking of regions changes very little for sorghum when PI methods A, B or C are used (Table 4). If equity is more important than efficiency, India declines slightly in importance, but not to any substantial degree. Comparing the PI values from A, B and C with the 1980 allocation of principal-scientist equivalents by ICRISAT to each region, it seems that there is a substantial overinvestment in West Africa and India at the expense of Eastern and Southern Africa, the Near East and Other Asia.[12] Even using PI method D, based on the region's share of total sorghum production in the SAT, the conclusion that emerges is of a substantial overinvestment in West Africa *vis-à-vis* all other regions. If the North, Central and South American regions are deleted (because most sorghum is produced for livestock feed) then India is seen to have an underinvestment along with all other regions except West Africa. India's share of total foodgrain sorghum production in the SAT is more than a half, while that of West Africa is less than a quarter. By comparison, index E more closely reflects ICRISAT's actual resource allocation even though it too weighs West Africa lower and North, Central and South America higher than the actual allocation of scientist equivalents by ICRISAT.

This is not to say that the 'overemphasis' on West Africa as reflected in the ICRISAT scientist allocations shown in Table 4 should be corrected. Other considerations must be taken into account before such a conclusion is reached. For example, India has a well developed and

[12]The concept of principal-scientist equivalents should not be confused with principal-scientist positions. The principal-scientist equivalent for a region is computed by dividing the total amount of research funds allocated to staff in the region for a particular crop by the annual budget amount for a principal scientist in that region. Since the annual budget amount for a principal scientist for instance in India is less than in West Africa, the same amount of money allocated would buy more principal-scientist equivalents for India than for West Africa. This measure of principal-scientist equivalents appears to be the most feasible basis for comparing research allocations across regions.

Table 4. Congruence of various priority index values for sorghum and pearl millet and present ICRISAT research resource allocations.

Crop/region	PI values (percentage) using as weights[a] Ad hoc A	Efficiency 2: Equity 1 B	Equity 2: Efficiency 1 C	Region's share of SAT production 1: Other criteria 0 D	Ad hoc (A') weighted by regional contribution D E	ICRISAT 1980 principal scientist equivalents allocated[b] (percentage)
Sorghum						
India	20	19	16	35	46	35
East Africa	17	17	18	10	13	10
West Africa	17	15	17	15	19	51
Southern Africa	13	13	14	2	2	0
Other Asia	11	13	12	1	1	0
North, Central and South America	9	9	9	34	16	4
Near East	13	14	14	3	3	0
Total	100	100	100	100	100	100
Pearl millet						
India	21	21	17	35	37	42
East Africa	12	10	13	7	5	4
West Africa	22	19	20	50	52	54
Southern Africa	13	12	14	3	2	0
Other Asia	12	14	12	3	2	0
North, Central and South America	8	10	11	2	1	0
Near East	12	14	13	1	1	0
Total	100	100	100	100	100	100

Note: [a] See Table 3 for weights used for each criterion in Table 2; [b] See Ref 12.

highly successful sorghum breeding programme, while in many countries of West Africa there are virtually no national sorghum programmes. In these circumstances one may be able to justify the lack of congruence between the present ICRISAT allocations and the PI values. The merit of comparisons like those in Table 4 is that they encourage a centre's management to make explicit the criteria it is implicitly using to make decisions about present allocations.

Pearl millet

For pearl millet as for the other crops, the priority ranking of regions does not differ significantly among methods A, B or C (Table 4).

Using either A, B or C it is clear that West Africa and India receive excessive shares of ICRISAT's pearl millet budget. The present regional allocations correspond to the relative importance of the regions in total SAT production of pearl millet as shown by method D, and almost exactly congruent with index E. This reveals an implicit preference for efficiency considerations weighted by *ad hoc* criteria on the part of the ICRISAT management in the case of pearl millet. It is of interest to note that when questioned about his weighting preferences for the 10 allocation criteria in Table 3, the Leader of the Pearl Millet Improvement Program selected D. Comparing India and West Africa, similar arguments as for sorghum apply: India has a relatively well developed pearl millet breeding programme, while in many West-African countries very little effort is being made to improve pearl millet production. Consequently ICRISAT's research allocation to India is probably in excess of and to West Africa in deficit of what it might be.

Pigeonpeas

PI methods A, B and C all indicate a major imbalance in ICRISAT's pigeonpea research effort in India at the expense of all regions except perhaps the Near East and West Africa (Table 5). If equity, rather than efficiency is more important, then this imbalance is greater.

Obviously, as pigeonpea is predominantly an Indian crop, as revealed clearly by PI method D, ICRISAT has currently decided to allocate virtually its whole pigeonpea budget to India. There may be some justification for encouraging exploration of the prospects for increasing production of pigeonpeas in some of the other regions of the SAT by diverting some research resources from India. Candidates for this would be Southern Africa, Other Asia and Eastern Africa.

Chickpeas

Some overinvestment in chickpea research in India and the Near East is suggested by the comparison of the PI values using methods A, B or C and the 1980 ICRISAT budget allocation (Table 5). This is not as true when methods D or E are used, although there is a case to be made for giving more attention to Other Asian SAT countries, Southern Africa, and North, Central and South America at the expense of India. Pakistan is the major chickpea-producing country in the Other Asian region (Appendix Table 12), and ICRISAT chickpea research, particularly in North India, will undoubtedly be of direct relevance to Pakistan and not necessitate major ICRISAT resources to be diverted there in order for Pakistan to benefit.

Table 5. Congruence of priority index values for pigeonpeas, chickpeas and groundnuts and present ICRISAT research resource allocations.

Crop/region	PI values (percentage) using as weights[a] Ad hoc A	Efficiency 2: Equity 1 B	Equity Efficiency 1 C	Region's share of SAT production 1: Others 0 D	Ad hoc (A') weighted by regional contribution D E	ICRISAT 1980 principal scientist equivalents allocated[b] (percentage)
Pigeonpeas						
India	31	29	24	97	98	100
East Africa	10	9	11	1	0	0
West Africa	8	6	10	0	0	0
Southern Africa	18	18	19	1	1	0
Other Asia	13	14	12	1	1	0
North, Central and South America	13	17	16	0	0	0
Near East	7	7	8	0	0	0
Total	100	100	100	100	100	100
Chickpeas						
India	29	27	23	84	91	71
East Africa	12	11	13	2	1	0
West Africa	9	7	10	0	0	0
Southern Africa	13	11	15	0	0	0
Other Asia	14	13	13	11	6	0
North, Central and South America	10	14	11	2	1	0
Near East	13	17	15	1	1	29
Total	100	100	100	100	100	100
Groundnuts						
India	24	22	19	49	58	82
East Africa	10	9	12	8	5	0
West Africa	17	17	17	22	20	18
Southern Africa	16	14	16	7	7	0
Other Asia	15	16	15	6	5	0
North, Central and South America	11	15	13	8	5	0
Near East	7	7	8	0	0	0
Total	100	100	100	100	100	100

[a] See Table 3 for weights used for each criterion in Table 2; [b] See Ref 12.

Groundnuts

By any of the three measures A, B or C, ICRISAT in 1980 would appear to be overinvesting in groundnut research in India, particularly at the expense of Southern Africa, Other Asia, and North, Central, and South America (Table 5). The balance in West Africa would appear to be about correct. However method D and especially method E reflect better congruence. Regional contribution and *ad hoc* criteria have obviously entered the ICRISAT decision process in resource allocation.

ICRISAT is currently expanding its groundnut programme into the Southern African region and this should redress some of the apparent imbalances revealed in this analysis. However, Other Asia, dominated by Burma and Thailand (Appendix Table 12), and North, Central and South America, dominated by Brazil and Argentina, may require further consideration.

Farming systems and economics research

On the premise that the priority regions for the ICRISAT Farming Systems Research and the Economics Programs should largely be determined on the basis of where the priorities for the Crop Improvement Programs are determined, aggregate PI (Table 6) has been calculated by working out for each region the simple average of the shares for all five crops in Tables 4 and 5.

By PI measures A, B and C, India and West Africa receive far too much of the budget allocation of the farming systems research and the economics programmes. All regions except India, North, Central and South America, and the Near East, should receive about the same budget share according to methods A, B and C. The Near East should not receive major attention, nor should North, Central and South America. Using methods D and E, however, the congruence between present allocations and the PI is much better.

Conclusions

The methodology outlined in this paper is of use to those whose responsibility it is to make decisions about the regional allocation of limited research resources. Its merit is that it obliges research administrators to analyse the criteria they are implicitly using in allocating research resources. In this way, it is believed future decisions can be better informed and result in enhanced productivity of research along with desirable consequences for human welfare.

Table 6. Congruence of various aggregate priority index values for farming systems and economics with present ICRISAT research resource allocations.

Programme/region	PI values (percentage) using as weights[a]					ICRISAT 1980 principal scientist equivalents allocated[b] (percentage)
	Ad hoc A	Efficiency 2: Equity 1 B	Equity 2: Efficiency 1 C	Region's share of SAT production 1: Others 0 D	Ad hoc (A') weighted by regional contribution D E	
Farming systems and economics						
India	25	24	20	60	66	58
East Africa	12	11	13	6	5	0
West Africa	15	13	15	17	18	42
Southern Africa	15	13	16	3	2	0
Other Asia	13	14	13	4	3	0
North, Central and South America	10	13	12	9	5	0
Near East	10	12	11	1	1	0

Note: [a] See Table 3 for weights used for each criterion in Table 2; [b] See Ref 12.

It is not suggested that the empirical results presented on the allocation of ICRISAT's research resources across the SAT are a panacea. However, they do suggest that ICRISAT ought to consider seriously investing substantially more resources in Southern and Eastern Africa, and other Asian countries, than in 1980. This is particularly so if it is accepted that ICRISAT's regional priorities should not be only based on the contribution of each region to total production of ICRISAT's mandate crops. Accepting that region-specific factors such as population, population growth, income and its growth should also condition the regional allocation of programme budgets in addition to crop-specific factors, implies a more uniform spread of ICRISAT's budget in the future. The details of this regionalization would depend upon the particular research programme. National or regional research capacity to undertake research on their own account should also condition the decisions.

A more regionally-spread focus for ICRISAT's future activities would seem appropriate for another reason. There seems to be increasing evidence from accumulating research experience that it may be difficult to develop improved cultivars at ICRISAT which will have wide adaptability across the SAT. Variations in day length, growing season, temperature, pests and diseases seem to preclude this. If this is true it means that to adequately serve the other major regions of the SAT and to increase the probabilities of success may indeed require more regionally-focused research activities. Finally, the size of the ICRISAT centre itself would to some appear to have already passed the limits beyond which effective scientific integration of research efforts is possible.

The arguments for strengthening research efforts on some mandate crops in certain mandate regions of the Institute should not be construed to mean that from the beginning the Institute should necessarily have been a decentralized organization of regional stations. Especially for a new and growing Institute such as ICRISAT during its first eight years, the critical mass argument weighs very heavily in favour of a centralized institution, as many concepts, research methodologies, philosophies and base data analyses have to be first developed by a strong interdisciplinary effort involving a larger group of scientists. However, once this has been achieved, further growth of the headquarters may yield decreasing returns. It is at this stage that the notion of strengthening regional research efforts perhaps deserves more explicit attention. We acknowledge the importance of technical and scientific considerations in determining any regional devolution strategy, even though we have emphasized the potential role of socioeconomic factors. It may even be true that the 'optimum' amounts of centralization and devolution are commodity- and/or problem-specific. If so, there may be no other way to decide such issues except on an *ad hoc* basis. We however believe data of the type assembled here can help research administrators make these decisions more informed.

It seems that if international agricultural research centres like ICRISAT have a mandate to undertake not just basic research, but also applied and development research, to use Tisdell's terminology,[13] then a degree of devolution or regionalism is required. The extent to which this should be based more on the international-national agricultural research centre dichotomy proposed by Trigo *et al* is an open question.[14]

Final decisions about regional devolution also require additional

[13]C.A. Tisdell, *Science and Technology Policy: Priorities of Governments*, Chapman and Hall, London, 1981.

[14]E.J. Trigo, M.E. Pineiro and J.A. Chapman, 'Assigning priorities to agricultural research: A critical evaluation of the use of programmes by product-line and production systems', *Agricultural Administration*, Vol 10, 1982, pp 23–34.

information which takes time to acquire. These are: the nature of the problems in different production systems and/or regions and the compilation of a portfolio of potential research projects to address them which attempt to assess benefits, costs and probabilities of success; the extent to which each of these problems can be addressed sensibly and efficiently as a general question at a central or headquarters location; the amount of resources necessary for an effective research effort on the problem, and the economies/diseconomies of provision of research support services on a regional versus a centralized basis; the history of previous research in the region by other institutions as well as current efforts; and technical and political considerations in establishing a research unit within particular regions, and the possible effectiveness of such a unit relative to an alternative one at a central location.

Appendix

Explanatory Tables 7–12

Table 7. Original data used to compile indices for sorghum.

Criterion	India	Eastern Africa	West Africa	Southern Africa	Other Asia	North, Central and South America	Near East
Per capita income (GNP in US$)	140	178	324	237	223	1288	2171
Annual per capita income growth per unit income	0.0114	0.0081	0.0115	0.0036	0.0107	0.0032	0.0025
1978 population (thousands)	660 976	82 033	128 098	71 564	172 555	240 311	50 263
Projected annual population growth 1978–90 (percentage)	2.23	3.25	4.14	2.89	2.66	2.84	3.26
Production trends annual compound growth[a] (percentage)	1.64	2.68	0.67	2.04	2.65	12.0	−3.11
Present food status (kilo calories per capita)	1 967	2 043	2 062	2 062	2 169	2 637	2 274
Sorghum contribution to regional food calories[a] (percentage)	6	13	13	2	1	0	8
Regional contribution to SAT total[a] (percentage)	34	10	15	2	1	34	3
Yield stability[a] (R^2 of linear trend)	0.54	0.15	0.53	0.47	0.55	0.88	0.03
Man-land ratio (people/ha)	3.82	2.98	1.61	2.90	3.55	2.60	2.78

Note: [a] Crop-specific indices, all others are region specific.

Table 8. Original data used to compile indices for pearl millet.

Criterion	India	Eastern Africa	West Africa	Southern Africa	Other Asia	North, Central and South America	Near East
Per capita income (GNP in US$)	140	178	324	237	223	1288	2171
Annual per capita income growth per unit income	0.0114	0.0081	0.0115	0.0036	0.0107	0.0032	0.0025
1978 population (thousands)	660 976	82 033	128 098	71 564	172 555	240 311	50 263
Projected annual population growth 1978–90 (percentage)	2.23	3.25	4.14	2.89	2.66	2.84	3.26
Production trends annual compound growth[a] (percentage)	1.32	2.88	1.01	−.51	−1.14	3.87	−5.0
Present food status (kilo calories per capita)[a]	1 967	2 043	2 062	2 062	2 169	2 627	2 274
Pearl millet contribution to regional food calories[a] (percentage)	3	4	18	3	1	–	2
Regional contribution to SAT total[a] (percentage)	35	7	50	3	3	2	1
Yield stability[a] (R^2 of linear trend)	0.23	0.44	0.08	0.05	0.02	0.01	0.25
Man-land ratio (people/ha)	3.82	2.98	1.61	2.90	3.55	2.60	2.78

Note: [a] Crop-specific indices, all others are region specific.

Table 9. Original data used to compile indices for pigeonpea.

Criterion	India	Eastern Africa	West Africa	Southern Africa	Other Asia	North, Central and South America	Near East
Per capita income (GNP in US$)	140	178	324	237	223	1288	2171
Annual per capita income growth per unit income	0.0114	0.0081	0 0115	0.0036	0 0107	0.0032	0.0025
1978 population (thousands)	660 976	82 033	128 098	71 564	172 555	240 311	50 263
Projected annual population growth 1978–90 (percentage)	2.23	3.25	4.14	2 89	2.66	2 84	3.26
Production trends annual compound growth[a] (percentage)	0.85	8.1	–	1 26	0.03	–4.8	–
Present food status protein (grams per capita)[a]	49	58	58	45	53	68	61
Pigeonpea contribution to regional food status proteins[a] (percentage)	3	0	–	0	0	0	–
Regional contribution to SAT total[a] (percentage)	97	1	–	1	1	0	–
Yield stability[a] (R^2 of linear trend)	0	0.65	–	0.06	0 11	0 10	–
Man-land ratio (people/ha)	3.82	2.98	1.61	2.90	3.55	2.60	2.78

Note: [a] Crop-specific indices, all others are region specific.

Table 10. Original data used to compile indices for chickpea.

Criterion	India	Eastern Africa	West Africa	Southern Africa	Other Asia	North, Central and South America	Near East
Per capita income (GNP in US$)	140	178	324	237	223	1288	2171
Annual per capita income growth per unit income	0.0114	0.0081	0.0115	0.0036	0.0107	0.0032	0.0025
1978 population (thousands)	660 976	82 033	128 098	71 564	172 555	240 311	50 263
Projected annual population growth 1978–90 (percentage)	2.23	3.25	4.14	2.89	2.66	2.84	3.26
Production trends annual compound growth[a] (percentage)	0.72	–.67	–	–	0.81	–4.2	–2.9
Present food status protein (grams per capita)[a]	49	58	58	45	53	68	61
Chickpea contribution to regional food status proteins[a] (percentage)	7	2	–	–	3	0	1
Regional contribution to SAT total[a] (percentage)	84	2	–	–	12	2	1
Yield stability[a] (R^2 of linear trend)	0.11	0.48	–	–	0.07	0.25	0
Man-land ratio (people/ha)	3.82	2.98	1.61	2.90	3.55	2.60	2.78

Note: [a] Crop-specific indices, all others are region specific.

Table 11. Original data used to compile indices for groundnut.

Criterion	India	Eastern Africa	West Africa	Southern Africa	Other Asia	North, Central and South America	Near East
Per capita income (GNP in US$)	140	178	324	237	223	1288	2171
Annual per capita income growth per unit income	0.0114	0.0081	0.0115	0.0036	0.0107	0.0032	0.0025
1978 population (thousands)	660 976	82 033	128 098	71 564	172 555	240 311	50 263
Projected annual population growth 1978–90 (percentage)	2.23	3.25	4.14	2.89	2.66	2.84	3.26
Production trends annual compound growth[a] (percentage)		1.61	9.2	–4.02	1.81	1.75	–2.5
Present food status fat (grams per capita)[a]	29	39	38	34	32	59	–
Groundnut contribution to regional food status fat[a] (percentage)	21	8	17	23	10	3	–
Regional contribution to SAT total[a] (percentage)	49	8	22	7	6	8	–
Yield stability[a] (R^2 of linear trend)	0.27	0	0.36	0.55	0.30	0.07	–
Man-land ratio (people/ha)	3.82	2.98	1.61	2.90	3.55	2.60	2.78

Note: [a] Crop-specific indices, all others are region specific.

Table 12. Major producing countries of ICRISAT mandate crops in each SAT region.[a]

Region/country	Sorghum (percentage)	Pearl millet (percentage)	Groundnut (percentage)	Chickpea (percentage)	Pigeonpea[b] (percentage)
West Africa					
Cameroon	–	–	6	–	–
Central African Republic	–	–	–	–	–
Chad	–	8	–	–	–
Benin	–	–	–	–	–
Gambia	–	–	5	–	–
Ghana	3	–	–	–	–
Guinea	–	–	–	–	–
Mali	–	12	7	–	–
Mauritania	–	–	–	–	–
Niger	6	13	–	–	–
Nigeria	75	42	17	–	–
Guinea Bissau	–	–	–	–	–
Senegal	–	9	41	–	–
Togo	–	–	–	–	–
Upper Volta	14	–	–	–	–
Region's share in SAT total	15	50	22	–	–
Eastern Africa					
Ethiopia	22	23	–	91	–
Kenya	7	14	–	–	–
Somalia	–	–	–	–	–
Sudan	51	49	89	–	–
Tanzania	7	15	6	7	100
Region's share in SAT total	10	7	8	2	0.6
Southern Africa					
Angola	–	16	–	–	–
Botswana	10	–	–	–	–
Madagascar	–	–	–	–	–
Malawai	21	–	18	–	100
Mozambique	43	–	14	–	–
Namibia	–	–	–	–	–
Zimbabwe	9	51	15	–	–
Zaire	–	–	40	–	–
Zambia	10	20	–	–	–
Region's share in SAT total	2	3	7	–	1.6
India					
India	100	100	100	100	100
Region's share in SAT total	34	35	49	84	96
Other Asia					
Burma	–	15	66	10	95
Pakistan	62	79	–	90	5
Sri Lanka	–	–	–	–	–
Thailand	37	–	23	–	–
Region's share in SAT total	1.4	3	6	11	1.5
Near East					
Iran	–	23	100	100	–
Oman	–	–	–	–	–
Saudi Arabia	13	12	–	–	–
Yemen Arab Republic	86	–	–	–	–
Yemen Democratic Republic	–	65	–	–	–
Region's share in SAT total	3	0.7	–	0.7	–
North, Central and South America					
Argentina	56	100	42	–	–
Bolivia	–	–	–	–	–
Brazil	–	–	44	–	–
Guyana	–	–	–	–	–
Paraguay	–	–	–	–	–
Venezuela	–	–	–	–	100
El Salvador	–	–	–	–	–
Mexico	37	–	7	96	–
Nicaragua	–	–	–	–	–
Region's share in SAT total	34	1.5	8	2	0.3

Note [a] Based on average production for 1974–78 from IFPRI computer data files. [b] Production for 1970–74 from FAO