RESEARCH IN SMALL DEVELOPING COUNTRIES

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R&D IN SMALL COUNTRIES

This introductory section focuses on the situation and particular problems faced by small developing countries (with a population of less than 10 million) in research and development (R&D) activities. Decisions on the level and direction of allocation of resources to research are, of course, those of the countries themselves. Nevertheless, an organization funding research in these countries has an interest in understanding the options so that its own decisions on the level and type of activity to support make the best possible contribution to strengthening national endeavours.

The contribution that R&D makes to the development process is widely accepted as vital. This process implies access to new knowledge and new ways of embodying and exploiting existing knowledge. The particular circumstances in which small countries gain access to existing knowledge, adapt it to their specific purposes, or contribute to generating new knowledge are part of an extremely complex global system of relations. The extent to which research can contribute depends on the level of resources (funds and staff for research) and the allocation of scarce resources to a multitude of needs; this goes hand in hand with the necessity to look at what mechanisms are most productive when the resources are as limited as they are in small-country cases.

The research "system" (really a misnomer because activities lack the interconnectedness that this implies) thought appropriate for a particular country will depend on its resource endowment and the development objectives and strategy. This gives rise to a vast range of different, individual situations and sets of choices for decision-makers. There are, however, some common considerations that deserve highlighting. One possible assumption is that small countries will have limitations in terms of potential economic size so severe that their development options will be significantly different from larger countries.

This section begins to explore whether there are also significant limiting factors in the type and level of R&D that can be economically justified. In many areas of research, a certain minimum critical mass is required in terms of human and financial resources before R&D can be productive. The low level of resources that small countries can devote to R&D may mean that the input required to achieve even this minimum is beyond their means. There is an additional economic argument that suggests that production-related research in small countries is likely to be more expensive per unit of production than in larger countries — the research costs required on a crop that is grown on 50 000 ha in one country and 150 000 ha in another may *not* vary greatly; the research cost per hectare under production will be quite different.

How Many Small Countries?

Clearly, any definition of "small countries" is arbitrary and depends on the issue or problem being investigated. The imprecision of the term requires a definition each time "small" is the focus. The principal criterion used here for labeling small countries is that of population. This also serves as a reminder that the richer industrialized countries with relatively small populations face particular problems of R&D strategy as well.

Studies of "small countries" have proliferated because many countries that have gained independence in the last 30 or so years belong in this category. Various reports have shown a general congruence between population size and other measures of size although not a clear correlation. A more detailed assessment of criteria would be necessary to classify individual countries, but this is not necessary for this review. We will use only the criterion of population size, recognizing that some countries with a small population may well have other elements that make some of the limiting factors less relevant. Depending on particular studies, the cut-off population size used varies between 5 and 10 million; here, 10 million has been selected as the upper limit to the category.

What numbers are included in our category? Table 1 shows that in 1985 about 67% of all developing countries (used here interchangeably with "Third World countries") had a population of less than 10 million and 52% less than 5 million. The gross national product (GNP) of all but five of the 77 small countries for which there are data is under US $10 billion. Sixty-six of these countries have a GNP below the US $5 billion mark. (World Bank and other internationally available data on GNP and R&D have been kept in US dollars.)

One consistent finding is that there is no relation between country size and GNP per capita. Smaller countries do not necessarily have lower per capita incomes. A growing literature now studies the relationship between country size and economic performance — some figures suggest that small countries exhibit wider growth rate fluctuations and have tended to experience recession more severely, but the evidence is far from conclusive. Other studies relate size and the distribution of imports and exports as a percentage of GNP; these suggest that imports and exports account for a greater percentage in smaller countries, with a consequently greater degree of dependence on international markets. So there appear to be some distinguishing features in economic development characteristics, although the evidence is preliminary. Are there distinguishing features in their research systems and potential?

Developing-Country Research

The access of small developing countries to the outputs of R&D — their own and others' — is crucial to their

Table 1. Country size and gross national product (GNP) in developing countries, 1985 (US $ billion).

	GNP					
Population (million)	**Less than 1**	**1–5**	**5–10**	**More than 10**	**No GNP data**	**Total**
0–10						
0–1	21	10	1	—	4	36
1–5	5	17	2	4	3	31
5–10	—	13	3	1	1	18
Sub total	26	40	6	5	8	85
More than 10						
10–20	—	3	5	5	4	17
More than 20	—	1	5	16	3	25
Total	26	44	16	26	15	127

Note: Intervals are rounded. 1 United States dollar (US $) = 1.33 Canadian dollars (CA $).
Source: World Bank Atlas, 1987.

Table 2. Research and development (R&D) expenditures by developed and developing countries, 1980 and 1984.

R&D expenditure (US $ billion)		Percentage share		
		R&D	GNP	Population
Global 1980	**207.8**			
Developed	194.9	94	79	19
Developing	12.9	6	21	81
Global 1984	**240.0**			
Developed	226.0	94	79	21
Developing	14.0	6	21	79
OECD 1984	**189.8**			
USA	98.1	52	44	29
Top 5	167.2	88	78	66
Bottom 5	0.5	<1	1	4
Countries less than 5 million population (6 total)	2.4	1	2	3
Countries less than 10 million population (12 total)	6.8	4	6	8
Third World (1980)	**12.9**			
Sub-Saharan Africa	0.8	6	8	11
Arab States	1.0	8	24	7
Latin America	3.9	30	31	11
Asia	7.2	56	37	71

Note: 1 United States dollar (US $) = 1.33 Canadian dollars (CA $). Percentages have been rounded.
Sources: Unesco 1985 Statistical Yearbook; *OECD Observer*, 1986; and IDRC internal documents.

development and their level of activities in this area is low even as a percentage of their limited resources. There are two important observations: first, the level of R&D activity in the Third World is low in comparison to the industrialized countries; second, much of this R&D is concentrated in the larger developing countries (e.g., Argentina, Brazil, China, India, Korea, and Mexico).

Global and national figures of expenditures on R&D are still extremely unreliable. The best estimates available indicate that global R&D expenditures for 1984 were some US $240 billion with the Third World accounting for 6% of the total or US $14 billion (Table 2). (These total figures include, of course, the considerable expenditure of a number of industrialized countries on defence research.) The developing countries' share of the world GNP is 21% with about 79% of the world population. As mentioned earlier, within the developing countries group, there are marked regional and country disparities. Using data for 1980, there is a clear concentration of R&D effort in Asia with 56% of total developing-country R&D expenditure followed by Latin America with 30%. Within regions, there is an even sharper contrast between countries. Nigeria accounts for 50% of sub-Saharan Africa's research effort (excluding the Republic of South Africa). In Asia, China is responsible for an estimated 40% of the regional total. Similarly, Brazil alone was responsible for 50% of the R&D effort in Latin America, and Argentina and Mexico raise the level of concentration to 77% of the regional total. What this means is that about US $8–9 billion of developing-country R&D expenditure of US $14 billion is accounted for by eight countries.

The OECD Case

This is not so different from the industrialized countries. In the Organisation for Economic Cooperation and Development (OECD) group of 24 industrialized countries, the largest five countries account for 88% of the total OECD expenditure on R&D. The head of the science and technology (S&T) indicators unit of OECD reported that the "second" five countries, which include Canada, spent a further 10% of all resources devoted to R&D in the OECD area and added "then there is a set of smaller countries spending 1–2%. This shows very clearly that research is an extremely concentrated activity and that for most countries the problem is not so much to *undertake research, but to gain access to research from elsewhere*" (emphasis added). These 14 smaller OECD countries nevertheless account for a total research budget of between US $2 and $4 billion (an average of US $140–280 million/country).

The OECD has considered the problem of "smallness" (in this case, defined by GNP) in relation to S&T policy and economic growth in its small member countries. Different industrial strategies have been suggested (e.g., finding niches in the market, cooperating with other countries, and specializing) requiring different R&D strategies to support them. These countries face the problem of not having big enough domestic markets to generate competitive economies of scale or, in some cases, to pay back R&D costs. Academic studies have proposed general guidelines for the identification of areas where small industrialized countries might establish relatively large R&D programs:

- Areas where it is important for the small country to pursue an indigenous R&D effort to meet its social and economic objectives;
- Areas where current R&D makes it natural to establish "axes of penetration";
- Areas in keeping with the small country's R&D capability regarding cost, workforce, type of activity, and field of science and technology; and
- Areas useful to a strategy for strengthening the small country's position relative to the international division of labour.

Size is mentioned as a specific factor limiting the scope of activities and requiring careful allocation of available resources in several OECD reviews of national science policy: for Iceland ". . . given its smallness and given that its competitors base their economic performance in large measure upon their ability to harness their own scientific and technological strengths, Iceland cannot afford not to have a clear science policy" and Norway "when discussing the features specific to their [S&T] system, Norwegians usually begin by saying quietly, with a hint of reserve — Norway is a small country. The examiners reporting on social sciences policy in Norway heard the same comment from nearly everyone they spoke to and added that the size of a country necessarily limits the range of research fields open to it and makes choices harder."

R&D in Small Developing Countries

This reference to the OECD experience underlines that small *developing* countries are not alone in having to make tough R&D decisions and to limit the areas in which they can build R&D capacity. The resource constraint is always present (indeed even for the larger industrialized countries) but it does "bind" at different levels. The situation of the small developing countries is difficult to describe in detail given the absence of reliable country data. Notwithstanding the relative weakness of the R&D effort, it is important to enumerate reasonably accurately the level

Table 3. Financial and human resources in R&D — estimates for selected developing countries.

Country	Population mid-1985 (million)	R&D budget: Total R&D (US $ million)	R&D budget: Percentage of GNP	Number of researchers	Sectoral funding focus (%)
Botswana	1.1	4.3 (1984/85)	0.4	235	Agriculture 75 Technology and energy 23
Costa Rica	2.6	5.2 (1981)	0.2	850	Agriculture 46 Social development 19 Health 15
Guatemala	8.0	14.8 (1983)	0.2	1094	Energy and industry 29 Agriculture 22
Honduras	4.4	9.2 (1985)	0.1	612	Agriculture 76 Social development 11 Health 9
Jordan	3.5	4.2 (1984)	0.1	1472	Industry, natural resources, and construction 42 Agriculture 21 Humanities 17
Malawi	7.0	4.5 (1984)	0.4	477	Agriculture 96
Mauritius	1.0	4.3 (1985/86)	0.4	263	Agriculture 94
Singapore	2.6	100.6 (1984/85)	0.6	2401	Engineering and technology 72 Medical sciences 13 Natural sciences 10
St Lucia	0.1	1.2 (1985)	0.7	27	Agriculture and environment 75 Health 25
Trinidad & Tobago	1.2	19.0 (1985)	0.3	186	Agriculture 49 Energy and industry 38 Marine and environmental 13

Note: 1 United States dollar (US $) = 1.33 Canadian dollars (CA $).
Source: Data obtained from national surveys and country studies undertaken for IDRC by local researchers.

of resources devoted to R&D and their sectoral concentration. It seems likely that even the cost of collection of information on resources devoted to research is more expensive per researcher or research institution in smaller research "systems."

Table 3 shows information on the R&D resources of a number of small developing countries from different regions of the world. In most cases, these come from studies of national research systems undertaken for IDRC by local researchers — but even these studies relied for the most part on existing, although sometimes difficult to access, information. In other cases, where studies were started with no existing information, reports have still to be submitted. A number of these cases are also illustrated by "boxes" in the text to give more feel for the context in which the allocation decisions of individual countries are made.

Most of the countries included in Table 3 have a relatively small number of institutions engaged in research, seldom more than 10, although each institution may contain several research units (e.g., departments or specialized centres within a university). In almost all cases, research is funded overwhelmingly from public funds; there is little private-sector research except where a parastatal institution is linked to a growers' interest group, usually in the case of an export crop such as sugar or coffee. Reliance on external support varies greatly depending on country and sector but can reach 50%.

Countries are typically devoting between 0.1 and 0.4 % of their GNP to research. Several have targets to increase research to 1 % of GNP (the major industrialized countries spend closer to 2 %), but even these targets seem elusive in the foreseeable future.

Figures for the number of researchers, in most cases, vastly overstate the real time devoted to research, because it is only one of several functions performed by staff of scientific institutions, particularly universities. Indeed, a number of country studies suggest that with increased university enrollment, staff time devoted to research is decreasing. In 1980, for example, staff time allocated to research in the Faculty of Agriculture of the University of Jordan was on average 50 % of the total available, whereas in 1984 it had fallen to 25 %. During 1980–84, the number of students enrolled had doubled but professional staff had increased by only 20 %. Country studies also comment on the need to take greater advantage of the research resource offered by universities and to link them into the national research effort, particularly in view of the overall shortage of resources and the wide range of issues requiring research.

The S&T issues facing small developing countries are complex; they are attempting to meet domestic economic and social needs, for which they require a contribution from domestic S&T, but are doing so in an international environment that is undergoing rapid technological change and in which "conventional" wisdom is in question. One convention was that basic industrial activity (the "mature" industries) requiring low capital and high labour inputs would eventually shift to countries that have a comparative advantage in those factors of production. Concomitantly, industrialized countries would shift into high technology, capital-intensive productive activities. There is some feeling that what is happening does not follow this convention. Basic industrial activities are becoming more technologically intensive. Consequently, some industries expected gradually to decline in the industrial countries are now experiencing a "renaissance" and are the subject of considerable R&D effort.

What this means is that as the large countries invest more at this level of productive activity, it will raise the technological content of commodities and, thus, increase the threshold level of S&T activity in terms of the necessary supporting S&T infrastructure. There are important economies of scale in the production of many major consumer goods. These may present major barriers to starting production except where countries can identify particular "niches" in the range of productive activities. It is also likely that the threshold level of capital to invest in R&D on industrial

In Swaziland, a veterinary scientist examines a goat for fleas, which can be vectors of diseases.

activities is increasing for manufactured commodities, limiting the range of feasible goods (and research) for small countries' production. The implications of a changing international division of labour and of the complexity of commercial and investment decisions facing small countries argue in favour of their building some independent capacity to carry out research on policy (economic, S&T, etc.). They need to ensure that they have adequate access to external technical and marketing information and an ability to analyze this information in such a way that major policies and investment decisions are based on the best available knowledge.

The Agricultural Sector

But for many developing countries, large or small, agricultural research is the most important research sector. The issues of economies of scale, minimum critical mass, and the potential to tap external research findings are relevant here. It is useful to explore some of these issues specifically for agricultural research as it is typically the largest and most organized sector (see Table 3 and boxes on individual countries). It is also the sector that is the best documented and where there has been some preliminary analysis of the specific factors mentioned earlier.

Jordan

With annual increases of 4.1% in GDP over the last 5 years, Jordan has a growth record that compares very favourably with other developing countries. The major contribution to GDP is from the services sector (64%) and the two main productive sectors are mining and manufacturing (28%) and agriculture (8%). A large part of the country's development effort has been in investment in all levels of education.

Research has developed markedly since the 1950s. Agricultural research, for example, was formally organized in a department within the Ministry of Agriculture in 1958. The University of Jordan was established in 1962 and has undertaken research in arts and humanities, economics and science, agriculture, medicine, and engineering. The Royal Scientific Society (RSS), founded in 1970, has carried out research in economics, industrial applications, solar energy, and construction.

The RSS has an active program of contracting its consultancy and research services to private- and public-sector institutions in Jordan and, to some extent, to other countries in the region. This has enabled it to generate substantial "independent" income. Other important institutions include the University of Yarmouk, established in 1976, which has undertaken research in sciences, social science, and engineering, and the University of Mu'ta, established in 1984.

Since the beginning of the 1980s, research planning and coordination have been the responsibility of a Department of Science and Technology in the Ministry of Planning. A priority of the present 5-year plan (1986–90) is that a working group appointed by the Prime Minister propose an appropriate national organization for S&T planning. In addition to providing for increased financial allocations to R&D, the plan also includes as major S&T goals:

- To organize national efforts in the area of social, economic, scientific, and technological information and to develop such information for use in planning;
- To control and organize the process of transfer and import of advanced technology to ensure the transfer of scientific and technical knowledge; and
- To expand cooperation programs and to work for Arab integration in S&T, to increase cooperation with developing and developed countries, and to encourage the establishment of regional and international scientific centres in Jordan.

It has been suggested that a minimum research mass is necessary in agricultural research. Much further work is required on this notion for this minimum will probably vary by kind of research (varietal crop selection, animal disease research, etc.) and be affected by the experience of researchers and their access to external information.

M.E. Piñeiro and E.J. Trigo of the Inter-American Institute for Cooperation on Agriculture (IICA) made estimates for the cost of a minimum module for research on one crop in 1982 and explored some of the implications of this concept. They suggest that a minimum package required annual expenditure of US $500 000 (90% operational expenses; 10% for innovations and equipment). This module included four chief researchers at the MSc or PhD level (3 person years in plant breeding/ agronomy and pest and disease control and 1 person year equivalent in socioeconomics and other specializations) with support costs, training, and so on. This cost was then compared to what might be available for research based on a percentage of agricultural production. In comparing this estimate to 1982 budgetary levels for agricultural research, only the larger countries would be in a position to finance a broad coverage (multiproduct) research infrastructure.

They looked at six basic commodities (wheat, rice, corn, potatoes, cassava, and beans) in Latin America and the Caribbean. Using their estimates of minimum annual expenditures, they estimated that the production value of individual crops was high enough to cover the minimum costs in only 40 of 114 possible crops programs if one assumed research expenditures equivalent to 1% of the crop value. In many cases, research expenditures on a crop are much less than 1% of the value of production of that crop. Of 17 "small countries," there were only 10 where the minimum research module for even one crop could be justified on the basis of these figures.

Later analysis was undertaken by W.K. Gamble and E.J. Trigo of the International Service for National Agricultural Research (ISNAR) on seven prime crops in 38 small countries in Central America, the Caribbean, and Africa (and presented at a workshop on agricultural research policy and organization in small countries in 1984). By using the same module but varying the costs, they arrived at an annual minimum research expenditure of US $309 000/ crop. They compared this to four different percentages of value of production being allocated to agricultural research: 0.5, 0.75, 1.0 and 2.0% (Table 4). According to their analysis "in Latin America and the Caribbean, of 102 country–product combinations for maize, rice, cassava, cotton, beans, and potatoes, in only 10 cases is the economic base large enough to support a minimum research effort if 0.5% of the value of production is spent on research. If expenditures are increased to 0.75% of production value, 14 cases would be viable, and at 1.0% (double the actual expenditures for 1980), the minimum research module could be supported in 16 cases."

According to Gamble and Trigo's analysis, "the African situation is not much different. Out of 105 cases covering five products, four combinations are feasible at the 0.5% level, 10 at 0.75%, and 11 at 1.0%. According to these calculations, not one of the countries examined could support sorghum research at the defined minimum level, only one could support maize research, and in two cases a minimum effort in rice would be viable. In cassava, there is a better situation, especially at the 0.5% and 1.0% level, where six and seven cases, respectively, are viable."

Admittedly, the concept of a minimum research module is still an artificial construct, and the actual levels required for crop research programs in different countries may vary widely. This kind of analysis does suggest, however,

Table 4. Country–product combinations (%) generating enough economic value to support a minimum research module, the Caribbean, Central America, and Africa.

Subregion/country	Maize				Rice				Cassava				Cotton				Beans				Potatoes/ sorghum[a]			
	0.5	0.75	1	2	0.5	0.75	1	2	0.5	0.75	1	2	0.5	0.75	1	2	0.5	0.75	1	2	0.5	0.75	1	2
Caribbean																								
Barbados																								
Cuba				X	X	X	X	X	X		X	X								X				X
Dominican Republic					X	X	X	X												X				
Grenada																								
Guadeloupe																								
Guyana					X	X	X	X																
Haiti				X		X	X	X				X								X				
Jamaica																								
Martinique																								
Trinidad & Tobago																								
Central America																								
Belize																								
Costa Rica					X	X	X	X								X								
El Salvador	X	X	X	X				X					X	X	X	X				X				
Guatemala	X	X	X	X				X					X	X	X	X		X	X	X				
Honduras		X	X	X										X	X	X				X				
Nicaragua				X				X					X	X	X	X			X	X				
Panama					X	X	X	X																
West Africa																								
Benin		X	X	X					X	X	X	X		X	X	X								
Guinea Bissau																								
Equatorial Guinea																								
Gambia																								
Liberia					X	X	X	X			X	X												
Sierra Leone					X	X	X	X																
Togo				X						X	X	X			X	X								
Comoros																								
Cape Verde																								
Reunion																								
East Africa																								
Mauritius																								
Somalia																								X
Central Africa																								
Burundi				X					X	X	X	X												
Gabon																								
Rep. Congo										X	X	X												
Rwanda										X	X	X												
São Tomé																								X
Southern Africa																								
Botswana																								
Namibia																								
Swaziland														X	X	X								
Lesotho																								

Note: X indicates if value is greater than US $309 000. (1 United States dollar [US $] = 1.33 Canadian dollars [CA $].)

Source: Adapted from Gamble, W.K., Trigo, E.J. 1985. Establishing agricultural research policy: problems and alternatives for small countries. In Agricultural research policy and organization in small countries. International Service for National Agricultural Research (ISNAR), The Hague, Netherlands. 41 pp.

[a]Potatoes in Cuba and sorghum in Somalia and São Tomé. Research on beans was not considered for Africa.

Mauritius

Mauritius is one of the most densely populated countries in the world. In spite of its lack of mineral resources, it has achieved favourable economic results since independence in 1968. Over the 1970–79 period, GNP grew annually in real terms at about 7.5%. In 1979, however, the end of the sugar boom and unfavourable climatic factors plunged the country into a severe economic recession. Corrective measures have had some success, and GNP continued to grow at 3.9% from 1980 to 1985.

Before 1968, Mauritius had almost all the characteristics of a monocrop island economy; its main crop, sugar, occupied 92% of agricultural land, accounted for 40% of its GNP, 82% of its export proceeds, and 40% of employment. Since then, the economy has become more diversified with the introduction and rapid development of new economic activities.

Organized research in Mauritius dates back to the establishment of an agricultural station in 1893 to conduct research on sugarcane and food crops. Sugar research has continued to be a major theme, now conducted by the Mauritius Sugar Industry Research Institute (MSIRI), a parastatal institution created in 1953. Research in fields other than agriculture received less attention before independence, but has seen considerable development since then. New institutions have been created, such as the University of Mauritius, the Mahatma Gandhi Institute, the Mauritius Institute of Education, and, more recently, the Albion Fisheries Research Centre and the Sir Seewoosagur Ramgoolam Medical Research Centre, in addition to research carried out in the various ministries.

There has been no overall research-coordinating agency, although a National Research Council has been considered. A step toward the creation of an overall mechanism has been made with the 1985 establishment of the Food and Agricultural Research Council. Agricultural research is at present carried out independently by three institutions: the Ministry of Agriculture, Fisheries and Natural Resources; MSIRI; and the School of Agriculture of the University of Mauritius.

The creation of the Sir Seewoosagur Ramgoolam Medical Research Centre under the aegis of the University of Mauritius should prove to be a major addition to existing health research activities carried out by the Ministry of Health. Other important areas of research have included energy, requiring the efforts of a number of different institutions; social sciences; and education. One novel feature in social sciences is the recent emergence of some research-oriented NGOs, such as the Institut pour le développement et le progrès, which has studied the socioeconomic environment of fishermen, and the Centre de documentation, de recherches et de formation indianocéaniques (CEDREFI), which has started work on regional cooperation and small planters' involvement in agricultural diversification.

that there are serious issues to be addressed in terms of economic levels of research programs.

The question of economies of scale is linked to the notion of the minimum research module but distinct from it. ("Economies of scale" refers to economies within the research process and to the research cost per unit of production.) In a smaller agricultural research system, research investment per hectare will have to be higher than in a larger system to achieve equal effectiveness. One review suggested that research is justified only where at least 100 000 ha is devoted in a particular country to the crop concerned. This would automatically exclude 48 developing countries where *total* arable land for all crops is less than 100 000 ha. A United States Agency for International Development (USAID) document discussing countries in Africa on this basis divided them into "technology generators" and "technology adaptors" where eight countries were in the former (only three with a population under 10 million) and 22 in the latter group.

The level of investment required for agricultural research will also be affected by agroclimatic differences within countries — the cost of developing productive farming systems for a small country with great agroclimatic variations will be greater than for another country with more homogeneity. V.W. Ruttan of the University of Minnesota has also pointed out that a small nation with a strong research program but a limited agricultural or industrial base cannot capture as high a proportion of the benefits from its investment in basic research as can a larger nation with a more diversified economic base.

The foregoing arguments (minimum research mass and economies of scale) concern the level and type of research activity that could be undertaken in a small country. It is clear that, just as in the case for the small countries in the OECD, small developing countries cannot by themselves solve the whole range of problems they face. They must look for ways to tap into external research programs. This requires adequate access to external information. However, even here there are indications of constraints on small countries. Studies suggest that the greater the investment in domestic R&D, the greater the potential for absorbing and utilizing external research. Estimates by R.E. Evenson and Y. Kislev of Yale University indicate that for a low-income country with average research capabilities, an investment of US $1000 for research performed in other countries located in a similar geographic and climatic zone would produce annual benefits of US $55000 for the receiving country. If the recipient country had no domestic research capabilities, the annual benefit of the same investment would be only US $1700. These figures obviously argue for the importance of achieving a minimum level of investment in agricultural research to ensure ability to benefit from advances in knowledge and technology being generated elsewhere.

Toward an R&D Strategy

This analysis, although based on assumptions that are complex and controversial, does serve to underline that the capacity of small developing countries to generate the technology and knowledge they require is severely limited. Further work and extension of the analysis to areas other than agriculture is required. The amount of resources that can be devoted to research *is* limited by size and the importance of overall production. The demands placed on the research system are much less so. The question of size has not often been addressed explicitly in countries' decisions on their R&D activities. Clearly, it has always been present as an implicit factor in allocating limited funds and trying for the greatest possible effect from these. Some of the key areas that require attention include the following:

Research or Borrow

Countries have major decisions to make as to what they should attempt to develop with their own research and what can be "borrowed" from external work. This choice suggests that small countries should probably focus on applied research tailored to particular national needs that are not likely to be covered by "importable" research. Clearly, many small countries are already pursuing this strategy. It also emphasizes the importance for these countries to have adequate capacity to undertake policy research to examine their investment decisions in general and, in this case, their S&T or R&D options.

Concentration

Countries have to consider how many research programs can be supported from the resources available for R&D and whether minimum critical requirements for productive research can be met.

Benefits from External Research

There are a number of options available to ensure that countries get the most out of research and information available elsewhere:

Best Possible Information Countries that are severely constrained in their own research require access to good information on activities and, particularly, the products of research undertaken elsewhere. The ability to assess this information for its applicability and usefulness in a particular national context itself requires considerable training and research experience. Information can be obtained in part through formal information systems, of which a number exist under regional and international auspices, and requires a national ability to access. But information is also available through the "invisible" colleges — researchers exchanging information at conferences, through networks and so on, which requires an active research participation — even if only in a narrow area of a broader field.

Costa Rica

The Costa Rican economy experienced substantial growth from 1950 to 1979, a period marked by extensive diversification and modernization of the productive sector and institutional development. In 1959, industrial production accounted for 13% of GDP; this rose to 20% by 1975 and 24% in 1986. Costa Rica suffered severely from the recession in 1981 and 1982, part of the "crisis" that forms the background to all discussion of the economic scene of the 1980s in Latin America, and it is now facing the challenge of restructuring and reorienting its economic development.

The area of S&T has been explicitly recognized as having a major contribution to make to development. In 1972, the Consejo Nacional de Investigaciones Científicas y Tecnológicas (CONICIT) was created to promote and coordinate S&T policy. In 1980, a department for this area was added to the Ministry of Planning and Economic Policy and, in 1986, the government created a Ministry of Science and Technology. The national program for S&T, part of the national plan for the period 1986–90, sets goals to enable the country to use scientific and technological development to accelerate export-led economic growth in the next 20 years. These include incentives for productive enterprises to undertake more R&D, which appears to have been limited up to now. The government is also borrowing US $20 million from the Inter-American Development Bank for S&T expenditure.

A study undertaken in the early 1980s identified 13 institutions involved in research (including universities, a national technology institute, and the ministries of agriculture and health). Research in universities accounted for 47.6% of total funding, government research centres for 42.8%, and private research for 9.6%. Government research played a significant role in agriculture and health. Private research was working primarily in two areas — agriculture and social science. In agriculture, the relationship between research and production is more visible than in other areas. Growers' associations have, in several cases, decided to set up their own research facilities and programs (e.g., ASBANA in banana production). In other cases, they fund research through government research centres, e.g., the coffee growers through OFICAFE. The government hopes that these close relations between research and production can be encouraged for industry as well.

The Central American region, of which Costa Rica is part, has some experience of regional research institutions. In spite of the major factors limiting the scope and possibility of cooperation in the region, a certain institutional base was established, and three or four institutions, such as the Centro Agronómico Tropical de Investigación y Enseñanza (CATIE), are concerned with research.

Support from Multilateral Research There exists a vast array of international and regional institutions that play a role in supporting developing-country research institutions. A survey of these (see *Searching 1985*) showed that they accounted for an annual research budget of more than US $400 million. Some, such as CATIE in Central America, exist particularly to provide services to a network of national research efforts in small countries. Others have a much wider clientele and may need to be encouraged to work more in support of small-country research (e.g., the institutions of the Consultative Group on International Agricultural Research) (CGIAR). The conclusions of the 1985 CGIAR study of potential address this need explicitly.

Support from Other National Research A number of countries continue to rely heavily on links with countries in the North — often as a continuation of relations established under external support to research. All too often, however, these links do not survive the end of a "project" under which assistance was granted. There are also enormous, partly untapped, opportunities for South–South collaboration between countries of a similar size through networks and information on research such as in the Southern African Development Coordination Committee (SADCC) subject networks in Southern Africa. In part, also, these South–South links may be those of smaller countries benefiting from research in larger developing countries facing similar problems.

The limited resources available to small developing countries may make them particularly interested in obtaining external funding from donors for R&D. With heavy reliance on external support for research, small countries risk being vulnerable when donor agencies may, sometimes unconsciously, determine research priorities or at least decide which of a range of priorities actually receives funding.

To alleviate some of these dangers, developing countries, and perhaps small countries in particular, need to have a clear view of the role they expect research to play and the priority areas in which they wish it to be undertaken. Some overall coordination of national research, and of external support to research, seems required.