Pardey.

RESOURCE ALLOCATION AND PRIORITY SETTING IN NATIONAL AGRICULTURAL RESEARCH SYSTEMS

Howard Elliott

Workshop

on

Agricultural Research Policies, Organization, and Management

Some Critical Issues

Damascus, Syria, 1 - 3 February 1987

RESOURCE ALLOCATION AND PRIORITY SETTING IN NATIONAL AGRICULTURAL RESEARCH SYSTEMS

1. Introduction

The title of this Workshop is "Agricultural Research Policy, Organization, and Management : Some Critical Issues". The title implicitly describes three broad components of the systems approach which ISNAR uses in helping to strengthen national agricultural research. Strong national systems usually demonstrate mutually supportive relationships among the policy environment, the structure and organisation of the system, and the management processes that have evolved to achieve the goals of the system. Opportunities to strengthen NARS may exist in each of the political, the structural, and the procedural areas.

In this paper, I propose to deal with the issue of resource allocation and priority setting in NARS. Since I have no comparative advantage in discussing the Syrian case, my objective is to present a) a framework for discussion of the issues, and b) enough information about the different approaches to stimulate a discussion of resource allocation in the Syrian agricultural research system.

I propose to treat the subject under the following headings:

1) The concept of the Agricultural Technology Management System;

2) The types of resource allocation decisions that must be made;

3) The difficulty of improving priority setting;

4) The contribution of Economic Analysis at the Macro level :

   a. research intensity measures (input measures)
   b. measuring the ex post return to investment in research

5) Economic Analysis in Strategic Planning

   a. congruence indices
   b. relevance factors and scoring models
   c. ex ante benefit-cost analysis (a consumer/producer surplus approach); and
   d. comparative advantage using domestic resource cost.

It is clear that formal economic analysis will be more useful for some of these decisions than for others. I would therefore like to discuss the general nature of the resource allocation problem, outline the questions that economics tries to answer, and describe the usefulness and limitations of the tools that economists use.

Although many books have been written and theses published about resource allocation proecedures, there are no systems where the informed judgement of good scientists is replaced by quantitive tools. However, there are some standard approaches to assessing the likely economic consequences of alternative strategies which could help research leaders defend their choice of strategies in clear economic terms to economists in the Finance and Planning Ministries.

2. The Complexity of Resource Allocation : An Analogy

Economic models are based on the notion of an equilibrium situation to which the system gravititates if all actors behave in a rational way. This approach offers a powerful way of predicting what should happen if some goal is to be achieved. However, it often does not help us understand some of the problems of conflict and dynamics which influence the points of equilibrium. Simon (1966) gives us a helpful analogy.

> Suppose we were pouring some viscous liquid -- molasses -- into a bowl of irregular shape. What would we need in order to make a theory of the form the molasses would take in the bowl? How much would we have to know about the properties of molasses to predict its behavior under the circumstances. If the bowl were held motionless, and if we wanted only to predict the behaviour in equilibrium, we would have to know little, indeed, about molasses. The single essential assumption would be that the molasses, under the force of gravity, would minimize the height of its center of gravity. With this assumption, which would apply as well to any other liquid, and a complete knowledge of the environment -- in this case, the shape of the bowl -- the equilibrium is completely determined. Just so; the equilibrium behaviour or a perfectly adapting organism depends only on its goal and its environment; it is otherwise completely independent of the internal properties of the organism.

Continuing the analogy, if were to shake the bowl rapidly, or want to know the behaviour of the molasses before equilibrium is reached, we would have to know something about the viscosity of the molasses and the rapidity with which it conforms to the bowl and moves towards its "goal" of lowering its center of gravity. Likewise, to predict the short-run behaviour of an adaptive organism, or its behaviour in a rapidly changing envrinoment, it is not enough to know its goals; we must know also a great deal about its internal structure and particularly its mechanisms of adaptation.

If, to carry the analogy one step further, we were to introduce new forces in addition to gravity (for example electromagnetism), we would have to know still more about the liquid to be able to predict its behaviour in equilibrium. Now its tendency to lower its center of gravity might be countered by a force to minimize electrical or magnetic potential operating in some lateral direction. We would have to know its relative susceptibility to gravitational and electrical or magnetic force to determine its equilibrium position. Similarly, in an organism having a multiplicity of goals, or afflicted with some kind of internal goal conflict, behaviour could be predicted only from information about the relative strengths of the several goals and the ways in which the adaptive processes responded to them.

To explain decision making behaviour in the face of complexity, the theory must incorporate some description of the processes and mechanisms through which the adaptation takes place.

It is not surpising, therefore, that a large part of the body of literature dealing with resource allocation concentrates on the mechanisms and institutional processes through which decisions are made.

3. The Agricultural Technology Management System

The conventional economic explanation of the process of technological change emphasizes the role of market mechanisms in ensuring an optimal path of technological development -- one which conserves the use of the scarcest factor of production.. In their theory of "induced innovation", Hayami and Ruttan contrast the nature of technological change in the United States, a labor-scarce economy, and Japan, a land-scarce economy. In the United States technological change was labor-saving (through mechanization) while in Japan productivity increased because of increased fertilizer and chemical use (land saving innovation).

However, in many countries the pattern of technological change diverged from what might be inferred from their factor proportions. The attempt to explain these divergencies gave rise to a "political economy approach" which looked at technological change as endogenous to the system. Its path was determined by distortions in the market forces and policies of the government which affected both the supply of and demand for new technology.

In a recent study, ISNAR and Rutgers University (1985) attempt to provide a framework for the analysis of Agricultural Technology Management Systems (ATMS). The ATMS describes the relationships among institutions and technologies and the mechanisms through which institutions in the System can internalize as many of the functions as are necessary to generate, assess, and diffuse improved technologies. A generic ATMS is presented in Diagram 1, which places the component parts of the system in relation to each other.

These components are :

* the "technology sector" with its subsectors (the technology generating sector, the technology transfer sector, and the technology using sector);

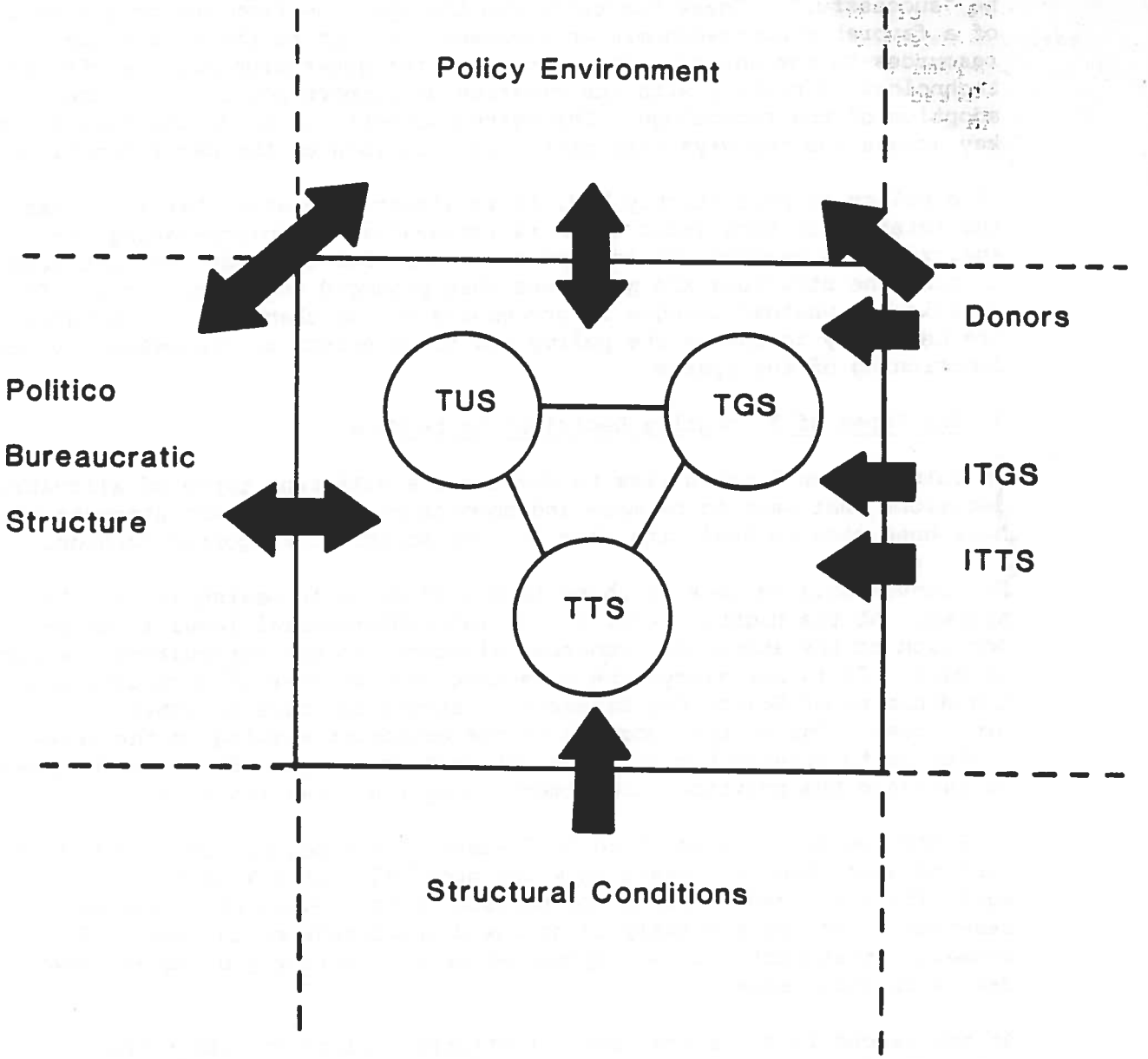
* the "politico-bureaucratic structure", composed of formal representatives of the government and decision-makers, and the channels through which interests of all groups in the system are made known to policy-makers;

* the "external sector", composed of donors, international technology generating institutions, and multinational firms engaged in technology generation and transfer;

* the "underlying structural conditions", which include primarily world markets for inputs and outputs and the resource base of the country; and

* the "policy environment", made up of all laws, regulations, customs and practices which limit the way in which components of the technology sector behave.

Diagram 1. The Agricultural Technology Management System



TGS - Technology Generating System
TTS - Technology Transfer System
TUS - Technology Using System
ITGS - International Technology Generating System
ITTS - International Technology Transfer System

These components of the system both influence and are influenced by events occurring elsewhere in the system.

The ATMS approach indentifies 13 key functions which the system must carry out if the process of generation and transfer of technology is to be "successful". These functions run the spectrum from the determination of a favorable macroeconomic environment, through to the allocation of resources to the agricultural sector, to the generation and transfer of technology, finishing with the creation of support policies for the adoption of the technology. The method attempts to study the role of the key actors and the ways they participate in each of the major functions.

If a policy is persistently bad, it is almost axiomatic that it serves the interest of some group which is influential in policy-making. In analyzing the resource allocation decisions that are made, we must keep in mind the structure and processes that produced those decisions. The question is whether changes in procedures and/or changes in structures are necessary to change the policy and hence effect an improvement in the functioning of the system.

4. The Types of Allocative Decisions to be Made

In this section I would like to discuss the different types of allocative decisions that have to be made and comment on the different attempts that have been made to deal with them in more scientific/rigorous fashion.

For convenience we look at three levels of decision making in the ATM system. At the highest level is the Inter-Ministerial level at which the decision on the amount of resources allocated to the Agricultural Sector is made. It is not always the case that the Minister of Agriculture or the Minister of Scientific Research is strong relative to other ministries. One of the concerns of the economist working in the research system is to provide him with the information and justifications he needs to increase the political commitment to agricultural research.

At ISNAR, we do not attempt to be leaders in the policy field, but we do want to understand the basis on which broad allocations of funds to agriculture are made. Direct comparison of the levels of investment in research countries and analysis of the determinants of the level of research investment are two approaches we are currently using at ISNAR to deal with this issue.

At the second level is the level of strategic planning within the Ministry of Agriculture or other coordinating body to which a block of resources will have been given. This is the process by which national deveopment objectives and client needs are translated into a set of research objectives and priorities based on carefully delineated programs by commodity, region, factor, or research area. This leads to a broad allocation of present and intended future resources to these programs. This decision making usually takes place in the Ministry of Agriculture, the Agricultural Research Council, or Ministry of Scientific Research.

It is at these two levels that formal economic approaches to priority setting and resource allocation can contribute the most. We will discuss below some of the work that has been done.

Finally, there is a level at which the tactical decisions are taken with respect to research programs and projects. This process of program formulation usually takes place at Institute level. The programming of agricultural research is then the process by which program priorities and resource allocations are translated into operational programs and projects. The economist has less to contribute at this stage; but need not be totally absent. In this paper we will be concerned primarily with the first two levels of resource allocation.

5. The Difficulty of Improving Priority Setting Procedures

It is true that there are many limitations on the use of approaches that have been developed for use in advanced market economies. However, it is precisely because resources are so limited, and the impact of wrong choices are so great, that an effort must be made to develop or adapt instruments of policy analysis for use in developing countries.

A small, poorly financed system cannot afford to carry out research on all commodities and in all regions, particulary where systems and agroecologies may be complex. Thus priority-setting for small systems under budget restrictions is a common problem. The choices that are made are likely to make major impacts on the course of agricultural development.

In such a system, the role of the researcher in the priority setting process is likely to be greater and his task more difficult for several reasons :

* First, client groups are less able to identify what they need from the research system and, even if their needs are identified, they are often powerless to express them. This contrasts with a system such as the land-grant system of the U.S. where farmers set the agenda for the research system and, in some cases, pay for the research through voluntary taxes on fertilizer and other inputs. A state research station which is not responsive to the State's farmers is soon out of business as it loses political support.

* Second, this burden of identification of need falls on the researcher in systems where there is a shortage of experienced research entrepeneurs able to transform the needs into projects.

* Third there is often indaquate information on which to base judgments.

* Fourth, it is difficult to estimate the probability of success of research at the level of the farmer because success depends on accommodation by many other components of the ATM System, and

* Finally, the priority setting, resource allocation, and long-term planning in developing countries must take account of the strong influence of donor policies. Questions of sustainability, uncertainty, and basic direction of the program must be treated within a policy environment that includes donors.

6. The Contribution of Economic Analysis at the National Planning Level

The productivity of agricultural research is often poorly understood at the national planning level. Research is necessarily of a long term nature and uncertain outcome. Moreover, the output of research is a potential for production increases; the chain of intervening policies between sucess at the research level and success in production make it difficult to ensure that there will be an impact on production. In such a case, politicians may be excused if they prefer activities with an immediate payoff.

Economists have attempted to provide policy makers with two ways of judging the adequacy of their investment in research. One is an input measure and the other is a measure of the productivity of agricultural research.

6.1 Comparison of the Research Effort ("Research Intensity")

The World Bank Sectory Policy Paper (1981) establishes a target level of investment in 1990 as follows :

> In a number of countries, national research program are weak and, therefore, not able to adapt fully and utilize technologies being developed by international research community. A rational allocation of financial resources for research on a global basis requires substantial increases in funds to strengthen national programs and to complement any further expansion of the international system. A desirable investment target for research for many countries with poorly developed agricultural research systems would be an annual expenditure (recurrent, plus capital) equivalent to about 2 percent of agricultural gross domestic product (AGDP). The Bank qualifies this target by noting, however, that the rate at which annual research expenditures can be increased and effectively utilized will depend on several factors, including the absolute size of the existing system, the availability of qualified technical staff, and the financial capability of a country to support a larger research effort.

Table 1. below shows the expenditure for a sample of 67 market economy countries. The measurement of a country's effort relative to other "similar" countries (or relative to the Bank's "target") may provide some policymakers with reason for concern that they are not up to the "norm". It is not, howeever, a very powerful indicator. A high expenditure may indicate a temporary inflow of donor funding which has distorted the picture or, conversely, describe a describe a system bloated with unproductive functionaries. Therefore, any input measure should be supplemented with other measures such as the ratio of scientists with advanced degrees relative to total university-level personnel, or the level of operating funds per scientist.

ISNAR and AOAD have undertaken a survey of the National Agricultural Research Systems in AOAD member states which parallels a worldwide survey undertaken by ISNAR in association with IFARD. One of our objectives is to obtain comparable information on staffing and current expenditures on agricultural research in order to establish such norms on a region by region basis.

67 DEVELOPING MARKET ECONOMY COUNTRIES CLASSIFIED IN ORDER OF 1980 EXPENDITURES ON AGRICULTURAL RESEARCH AS A PERCENTAGE OF THEIR AGRICULTURAL GDP

COUNTRY	GNP PER CAPITA US$	AGRICULTURAL RESEARCH EXPENDITURE 1980 '000 US$	% OF AGR. GDP
EXPENDITURE OVER 1% OF AGRICULTURAL GDP			
PANAMA	1,730	3,200	5.33
ZIMBABWE	630	10,560	2.42
GUYANA	570	2,428	1.85
ARGENTINA	2,390	166,340	1.64
MEXICO	2,090	172,402	1.36
BARBADOS	1,620	767	1.35
VENEZUELA	3,630	39,172	1.32
MALI	190	7,354	1.24
SENEGAL	450	9,797	1.21
KENYA	420	24,052	1.19
BRAZIL	2,050	245,000	1.15
CYPRUS	1,520	2,411	1.12
TOTAL		683,483	
EXPENDITURE BETWEEN 0.5 AND 1% OF AGRICULTURAL GDP			
FIJI	1,150	2,349	0.88
MALAYSIA	1,620	46,334	0.82
CHILE	2,150	10,353	0.81
BURUNDI	200	3,610	0.81
ZAMBIA	560	5,205	0.80
IVORY COAST	1,150	24,370	0.78
TOGO	410	1,892	0.76
MALAWI	230	4,562	0.75
NIGERIA	1,010	134,964	0.74
COLOMBIA	1,180	38,572	0.64
MOROCCO	900	19,981	0.62
LESOTHO	420	465	0.60
PAPUA NEW GUINEA	780	5,052	0.59
BENIN	310	2,403	0.59
URUGUAY	2,810	4,174	0.59
SUDAN	410	14,636	0.57
CHAD	120	1,602	0.56
TUNISIA	1,310	6,764	0.55
EL SALVADOR	660	4,974	0.50
TOTAL		332,262	
EXPENDITURE BETWEEN 0.25 AND 0.49% OF AGRICULTURAL GDP			
BANGLADESH	130	26,616	0.48
EGYPT	580	23,717	0.45
JORDAN	1,420	850	0.44
LIBYA	8,640	2,793	0.44
PAKISTAN	300	25,277	0.41
SRI LANKA	270	4,342	0.41
GUATEMALA	1,080	4,700	0.39
MADAGASCAR	350	4,801	0.39
TANZANIA	280	7,219	0.35
ECUADOR	1,270	6,436	0.35
BOLIVIA	570	2,808	0.34
INDIA	240	154,781	0.33
PERU	930	8,912	0.33
TURKEY	1,470	34,426	0.28
BURKINA FASO	274	1,105	0.28
PARAGUAY	1,300	3,100	0.28
NICARAGUA	740	1,999	0.27
THAILAND	670	23,276	0.26
INDONESIA	430	44,485	0.26
TOTAL		381,743	
EXPENDITURE UNDER 0.25 OF AGRICULTURAL GDP			
COSTA RICA	1,730	2,082	0.24
SYRIA	1,340	5,293	0.24
KOREA (REP)	1,520	29,031	0.23
JAMAICA	1,040	772	0.23
MAURITANIA	440	284	0.22
SIERRA LEONE	280	698	0.21
NEPAL	141	2,797	0.20
CAMEROON	670	3,788	0.20
DOMINICAN REP.	1,160	2,515	0.20
PHILIPPINES	690	16,254	0.20
ZAIRE	220	5,098	0.20
RWANDA	200	945	0.18
ETHIOPIA	140	3,400	0.18
GHANA	420	10,095	0.17
HONDURAS	560	978	0.16
LIBERIA	530	394	0.11
UGANDA	300	7,452	0.08
TOTAL		91,876	

SOURCE: P. ORAM, IFPRI, 1986.

In addition, data from such surveys may be used to increase our understanding of the determinants of a government's commitment to agricultural research. Eventually, we hope to identify a set of macro variables which are systematically related to the level and orientation of agricultural expenditures. From among the parameters which appear to influence agricultural development efforts, we can concentrate our attention to those that are subject to action which will modify the "policy environment" for agricultural research. Preliminary work at ISNAR suggests that low income countries give agricultural research approximately the same level of commitment as high income countries within the constraints imposed by their overall spending on agriculture, assisted by various donors. However, their total spending on agriculture as a percentage of agricultural GDP is lower. Of more concern is the fact that investment in agricultural research appears to be slowing down after a period of growth in the 1970's.

6.2 Measuring the Ex-Post Profitability of Research Investment

There are two approaches to measuring the ex-post profitability of investment in agricultural research : the rate of return approach and the production function approach. Both methods have been used to demonstrate that the rate of return on invesment in agriculture is higher than alternative public or even private sector investments and that, consequently, there is a presumption of underinvestment in agricultural research. Let us describe each briefly.

6.2.1 The Rate of Return Approach

Many studies have been done which attempt to measure the rate of return on past investments in agricultural research. Expenditures incurred in the past are presumed to have been made in expectation of future gains in productivity, either in increased output from the same factor inputs, or in the form of cost reductions to produce the same level of output.

In Table 2 below we reproduce a table from the World Bank's Agricultural Research Sector Policy Paper showing the consistently high internal rates of return that have been found in studies of particular research projects.

The usual study measures the reduction in unit costs that come about as a result of the technological innovation and compares them with the costs of achieving that cost reduction.

Summary of Selected Studies of Agricultural Research Productivit

Study	Country	Commodity	Time period	Annual internal rate of return (%)
Sources of Growth Type Studies				
Tang (1963)	Japan	Aggregate	1880-1938	35
Griliches (1964)	U.S.A.	Aggregate	1949-59	35-40
Latimer (1964)	U.S.A.	Aggregate	1949-59	Not significant
Peterson (1966)	U.S.A.	Poultry	1915-60	21
Evenson (1968)	U.S.A.	Aggregate	1949-59	47
Evenson (1969)	South Africa	Sugarcane	1945-58	40
Evenson (1969)	Australia	Sugarcane	1954-58	50
Evenson (1969)	India	Sugarcane	1945-58	60
Ardito Barletta (1970)	Mexico	Crops	1943-63	45-93
Evenson & Jha (1973)	India	Aggregate	1953-71	40
Kahlon, Saxena, Bal, & Jha (1975)	India	Aggregate	1960/61-1972/73	63
Direct Cost-Benefit Type Studies				
Griliches (1958)	U.S.A.	Hybrid corn	1940-55	35-40
Griliches (1958)	U.S.A.	Hybrid sorghum	1940-57	20
Peterson (1966)	U.S.A.	Poultry	1915-60	21-25
Evenson (1969)	South Africa	Sugarcane	1945-62	40
Ardito Barletta (1970)	Mexico	Wheat	1943-63	90
Ardito Barletta (1970)	Mexico	Maize	1943-63	35
Ayer (1970)	Brazil	Cotton	1924-67	77+
Schmitz & Seckler (1970)	U.S.A.	Tomato harvester: with no compensation to displaced workers.	1958-69	37-46
Schmitz & Seckler (1970)	U.S.A.	Assuming compensation of displaced workers for 50% of earnings loss.	1958-69	16-28
Hines (1972)	Peru	Maize	1954-67	35-40[1] 50-55[2]
Hayami & Akino (1975)	Japan	Rice	1915-50	25-27
Hayami & Akino (1975)	Japan	Rice	1930-61	73-75
Hertford, Ardila, Rocha, & Trujillo (1975)	Colombia	Rice	1957-72	60-82
	Colombia	Soybeans	1960-71	79-96
	Colombia	Wheat	1953-73	11-12
	Colombia	Cotton	1953-72	None
Peterson & Fitzharris (1975)	U.S.A.	Aggregate	1937-42	50
			1947-52	51
			1957-62	49

Sources: Reported in *Resource Allocation and Productivity in National and International Agricultural Research*, T. Arndt, D. Dalrymple, V. Ruttan eds., pp. 5-6. A compendium of papers presented at an ADC/RIN Conference on this topic held at Airlie House, Virginia, January 26-29, 1975. References to individual estimates are:

Ardito Barletta, N. "Costs and Social Benefits of Agricultural Research in Mexico," Ph.D. dissertation. (Chicago: University of Chicago, 1970).

Ayer, H. "The Costs, Returns and Effects of Agricultural Research in a Developing Country: The Case of Cotton Seed Research in Sao Paulo, Brazil," Ph. D. dissertation. (Lafayette: Purdue University, 1970).

Evenson, R. "International Transmission of Technology in Sugarcane Production," Mimeograph. (New Haven: Yale University, 1969).

Evenson, R. "The Contribution of Agricultural Research and Extension to Agricultural Production," Ph.D. dissertation. (Chicago: University of Chicago, 1968).

Evenson, R. and D. Jha. "The Contribution of Agricultural Research Systems to Agricultural Production in India," *Indian Journal of Agricultural Economics*, 28 (1973), 212-230.

Griliches, Z. "Research Costs and Social Returns: Hybrid Corn and Related Innovations," *Journal of Political Economy*, 66 (1958), 419-431.

Griliches, Z. "Research Expenditures, Education and the Aggregate Agricultural Production Function," *American Economic Review*, 54.6 (1964), 961-974.

Hayami, Y. and M. Akino. "Organization and the Productivity of Agricultural Research Systems in Japan," ADC/RIN Conference, *op. cit.*

Hertford, R., J. Ardila, A. Rocha and C. Trujillo. "Productivity of Agricultural Research in Colombia," ADC/RIN Conference, *op. cit.*

Hines, J. "The Utilization of Research for Development: Two Case Studies in Rural Modernization and Agriculture in Peru," Ph.D. dissertation (Princeton: Princeton University, 1972).

Kahlon, A.S., P.N. Saxena, H.K. Bal, and D. Jha. "Returns to Investment in Agricultural Research in India," ADC/RIN Conference, *op. cit.*

Latimer, R. "Some Economic Aspects of Agricultural Research and Extension in the U.S.," Ph.D. dissertation. (Lafayette: Purdue University, 1964).

Peterson, W.L. "Returns to Poultry Research in the United States," *Journal of Farm Economics*, 49 (1967), 656-669.

Peterson, W.L. and J.C. Fitzharris. "The Organization and Productivity of the Federal-State Research System in the United States," ADC/RIN Conference, *op. cit.*

Schmitz, A. and D. Seckler. "Mechanized Agriculture and Social Welfare: The Case of the Tomato Harvester," *American Journal of Agricultural Economics*, 52.4 (1970), 569-577.

Tang, A. "Research and Education in Japanese Agricultural Development," *Economic Studies Quarterly*, 13 (1963) 27-41; 91-99.

One of the advantages of the rate of return approach is its ability to estimate the share of benefits which accrue to producers and consumers separately. From there it is a simple matter to introduce distributional considerations into planning. Technological change in basic foodstuffs will usually have the effect on lowering food prices and lower income groups will benefit more than proportionately. Scobie, (1984), illustrates this with the case of two consuming groups, one very rich and one very poor, with known expenditures on wheat as shown in Table 3 below.

Table 3 Distribution of Gains from Cost Reduction in Production of Wheat

	Poor Group	Rich Group
Number of people	100	100
Income per capita	5	50
Total income	500	5000
Amount spent on wheat	400	1000
Original price of wheat	10	10
New price of wheat	9	9
Cost of buying original quantity of wheat	360	900
Gain in income	40	100
Gain in income as percentage of original income	8%	2%

Even though the richer group captures the largest amount of total benefits, the poorer group enjoys a larger percentage increase in its real income because of the larger percentage of their income that previously went to consumption of this commodity. Thus the goal of equity is served by selecting basic foods as a target of research and maximizing the net economic benefit from the use of scarce research resources.

The rate of economic return studies have been criticized on several accounts :

* They have been carried out at too high a level of aggregation (eg. hybrid maize in the US; rice in Japan, etc.) to provide a guide to future investment.

* They have been biased in favor of successful research projects and do not look at the agricultural research system as a whole.

* They have problems with data and do not separate out other important productivity increasing factors or the effect of price distortions.

* Past productivity is not an indication that future investment will lead to the same high gains.

However, the rate of return approach remains attractive because :

* its treament of agricultural research as an investment is something that can be intuitively understood by planners and businessmen who are used to making finanancial calculations, and

* it can incorporate many of the other goals of society (employment generation, income distributional effects, and foreign exchange value) by the use of shadow prices which reflect the true scarcity of the factors or social value of gains to different groups.

The need for a method which is able to separate the contribution of research from the contribution of other factors, however, led to the use of production functions which include research expenditure as one of the inputs to production.

6.2.2 The Production Function Approach

The production function approach uses multiple regression analysis to separate the impact of research expenditure on production after accounting for increases or improvements in the quality of other factors. In this formulation, the impact at the farm level is estimated as function of conventional inputs and research/extension expenditure lagged several years.

Production = f (Labor, Land, Capital, Education, Climate, Research Expenditure, Extension Expenditure, Research / Extension Interaction)

Studies in the United States show that the coefficient on research expenditure is consistently high and stable. In early studies this coefficient did not change very much with different lag structures. Experimentation with different lags suggested that research may take 6-8 years before its impact is felt at the production level. More recent studies, using longer data series and improved techniques are showing that the lag may be much longer (in the 20-30 year range). This has important implications for policy makers in the sense that there are no "quick fix" solutions that research offers.

Nevertheless, the studies show a marginal productivity of research which can be converted into a rate of return figure that compares very favorably with rates of return on alternative investments in the economy.

The production function approach also allows us to analyze the interaction between research and extension expenditure. Studies of returns to investment in research generally report higher returns to research investment than to extension investment. However, low income countries tend to over invest in extension relative to research, even though they may lack a product to extend. More study is needed of the degree to which research and extension expenditures are substitutes in the production function.

Both of the ex post approaches provide strong evidence that the rate of return to research is high and quite stable. However, the presumption of underinvestment does not tell us how rapidly investment in research should be increased. The high rate of return was calculated with respect to a given cost situation. A rapid acceleration of research investment, with inadequate human resources, physical infrastructure, and operating budgets could lead to a rapid inflation of the real cost of doing research and bring down the returns rapidly. Moreover, such studies have usually concentrated on particular commodities and neither of the methods gives guidance as to how much expenditure should go into basic research as distinct from applied or adaptive research on commodities.

7. Economic Analysis in Strategic Planning for Research

The preceding discussion has concentrated on the use of economic analysis to help research leaders justify agricultural research to policy makers on the basis of past performance. Once policy makers have determined the global level of resources that will go into agricultural research, the establishment of priorities at the commodity and regional levels becomes the task of the Ministry of Agriculture, a research council or similar body.

Unfortunately, the procedures for doing this are often poorly developed. A frequent scenario found in many systems might be presented as follows :

* There is limited ex ante evaluation for strategic planning purposes and few "top-down" guidelines.

* There is general aversion to utilizing quantitive data and techniques.

* Ex ante evaluation is informal, mainly undertaken by individual scientists, and is thus a "bottom-up" activity.

* There is limited collegiality in undertaking evaluations. Annual planned meetings are essentially "show and tell" events. Scientists are reluctant to criticize the work of their fellows.

* Most research problems are considered to be "obvious" with one problem leading naturally to another. There is no need for much evaluation of probable impact.

* Programming in general is regarded as a bureaucratic exercise. Station directors and institute directors aggregate the proporals of their scientists and transmit them to a planning office. The "plan" is an aggregation of these "bottom-up" requests.

Where this is the case, the allocation of resources among institutes, and even among commodities within institutes, may be based primarily on precedent, i.e. the previous year's budget plus some percentage rate of growth applied to the entire system. Such a procedure is simple to administer, responds to pressures from established client groups and in-house interests, and avoids having to make costly political decisions about closing out old programs or even established centers. It also means that priorities change slowly over time. Studies in several African countries show that in many resource allocation has not changed significantly since Independence.

The "precedence criterion" may also be responsible for pressures that many poorer systems face on their operating budgets. The attempt to maintain a large network of research stations dating from colonial days diverts funds from actual research and the system fails to concentrate a critical mass of researchers in the stations that are important. Several ISNAR reviews have led to measures to close out unnecessary stations and concentrate the staff in productive locations. Certain production function studies have provided (in a more general way) support for concentration. Using research publications as a measure of output, economists have demonstrated that the more concentrated systems and larger stations have higher productivity. This goes along with what scientists have known : that the large number of stations scattered throughout the country during colonial times was a sophisticated form of multilocational trials which can be replaced by more advanced techniques on central stations today.

It is generally agreed that most systems could improve their priority setting and resource allocation procedures by introducing greater objectivity into the process. While excessive reliance on quantitive evaluation models is not practical, and subjective judgments will continue to play a major role, the attempt to introduce greater rigor into the process will provide at a minimum better information on which informed judgments can be based. By establishing a framework for ex ante evaluation proposed investments can be checked for compatibility with other efforts. Quantification of the process will allow the expected benefits of one research investment to be compared with another.

In the economist's terminology, a good research plan aims at three qualities :

* "Consistency" (or "feasibility"). It can be carried out with the resources that are available; the various components of the program do not compete for the same resource simultaneously.

* "Efficiency". The output of the program is the maximum that can be obtained from the resources available; there are no idle resources that could be reallocated to achieve a greater output.

* "Optimality". The pattern of expected output of an efficient research plan matches the goals that society has fixed for the agricultural research sector.

The program budgeting approach, to be discussed later in this workshop, is one method of striving for optimality in the allocation of resources at a technical level once society's priorities have been clearly established at the commodity level.

7.1 Congruence Indices

The starting point of many ex ante resource allocation exercises is "congruence" between expenditures on research and the importance of the commodity or group of commodities in total production (imports, exports, or other strategic variable).

The formula is :

$$C = 1 - \sum_{i=1}^{n} (A_i - S_i)^2$$

Where A_i = the share of commodity "i" in the research budget, and
S_i = the share of commodity "i" in total agricultural production.

If there is perfect congruence, C = 1.

The congruence measure is a useful starting point. Its rationale is that if the probability of success and size of productivity gains from research are equal across all commodities, then the payoffs will be proportionate to the relative values of the commodities in production. In its simple form it provides a useful overview of the research allocation process that is easy to develop; with some additional effort it can be extended to cover the lively future growth of consumer demand for specific commodities. However, in terms of our earlier analogy of the bowl with molasses, the congruence criterion represents the simple case of the system at rest.

Table 4 below is intended to be only illustrative of the way in which congruence ratios can be used as a starting point for discussion. For three commodities, one basic food crop (rice), one industrial crop and potential export crop (oilpalm), and one pure export crop (coffee) we show the ratio between research expenditures and the share of the commodity in the total production of the country (Oram, 1984, unpublished). The commodities are grouped into broad classes showing the importance of that commodity in the economy.

Table 4. Congruence of Research Expenditures to Commodity Values

	Rice		Coffee		Oilpalm	
Over 20%	Bangladesh	.32	Costa Rica	.22	Malaysia	.28
	Nepal	.82	Kenya	.41		
	Thailand	.62				
10-20%	Philippines	.19	Colombia	.27		
					Ivory Coast	.60
5-10%	Brazil	.59	Peru	.02		
	Colombia	.27				
	Peru	.93				
	Malaysia	2.56				
	Ivory Coast	.54				
2-5%	Costa Rica	.83	Sri Lanka	2.26		
	Guatemela	.62				
0-2%	Zambia	47.00			Ivory Coast	6.25
	Sudan	12.00			Nigeria	3.13

Without going into the problems associated with the data themselves, we can see that there is great divergence from congruence. Much of it can be explained by reference to the situation of particular crops within given countries. By looking at coffee we can see that research must be largely at a maintenance level among the large producers and there are no new countries investing in research to try to break into a regulated market. In oilpalm, a dominant producer such as Malaysia is at a maintenance level while the Ivory Coast is investing in research to gain a share in the world market. Nigeria, historically one of the largest producers, lost its share of the world market but palm oil is still a major product for the internal market. The congruence index would lead us to investigate whether the relatively high expenditure on oilpalm research reflects the maintenance of an infrastructure of a bygone era or a reinvestment. It is in this sense that congruence is only the starting point of the analysis.

7.2 Relevance Factors in Priority Setting

7.2.1 The Use of Scoring Models

A resource allocation rule which aims at congruence efffectively looks upon the current value of production as the only relevant factor and assumes that benefits will be proportionate to the current value of production.

There are a large number of other "relevance factors" which may be taken into account in assessing priorities to a given crop. Generally, these are associated with "scoring models". Some of the more frequent factors are shown below with their suggested measures :

Importance of the commodity in aggregate terms

- value of production in national or regional terms
- area harvested
- agroecological suitability
- trends in total production
- yield trends

Relevance to target producer and employment groups

- numbers of producers directly and indirectly involved
- nutritional factors (protein, calorie contributions)
- on-farm consumption and monetary income
- food security
- regional balance
- numbers of consumers
- consumption (percent of household budget)
- future consumption patterns (demand elasticities)

Relevance to the nation's foreign exchange position

- current and potential export earnings
- current and potential expenditures on imports

Relevance to national food self-sufficency

- current import dependence
- future growth in national consumption

A government may seek more than the maximization of net economic benefit from its investments in agricultural research. High among its goals may be regional balance or improved nutritional status of disfavored groups. In this case, the government may want to allocate its resources to regions and commodities that contribute in different degrees to these goals.

A good example of the mixing of equity and efficiency criteria in allocating resources across regions is the procedure used by ICRISAT. ICRISAT used a total of 10 criteria, summarized in Table 7, to take account of the two objectives.

Table 5. Allocation Criteria of ICRISAT

Criterion	Highest Priority	Justification	
		Efficiency	Equity
1. Income	Lowest income		x
2. Income growth/income	Lowest ratio		x
3 Population	Highest population	x	x
4. Population growth	Highest growth		x
5. Crop production growth trend	Lowest growth		x
6. Current food status (calories, protein, fat)	Lowest intake		x
7. Crop contribution to food status	Highest contribution		x
8. Regional contribution to SAT crop production	Highest contribution		x
	Lowest stability	x	x
9. Yield stability (R^2 of trend lines)	Lowest stability	x	x
10.Man/land ratio	Highest	x	x

An index was created for each criterion in which the highest priority region was given the value of 100 and the lowest 0 with the other regions expressed as a percentage of the highest priority region. Various weighting schemes were applied to test the sensitivity of the composite index to changes in weights. The congruence of ICRISAT's actual allocation of scientist manyears to the various regions was very close to the allocation suggested by the composite index.

The ICRISAT approach is useful because it obliges research administrators to analyze the criteria they are using in allocating research resources and eventually lead to an allocation which serves the combined goals of equity and efficiency.

ISNAR has begun to accumulate experience on the use of scoring models in Latin America. In the Dominican Republic and Ecuador ISNAR consultants have used the scoring method effectively, (Norton, 1985).

The procedure basically followed the following four steps:

1) Elicit the national goals and establish criteria relating to these goals.

2) Separate the criteria developed for commodity and research areas.

3) Elicit weights from decision makers to establish the relative importance of the criteria.

4) Rank commodity and research areas according to each criterion and multiply by their weights to arrive at research priorities.

The goals of the countries studied generally include the following : 1) to raise national income; 2) to improve the well-being of low income groups; and 3) to reduce income variability of farmers. The latter goal is not always stressed but the first two are usually highlighted.

The criteria for the particular commodities include : 1) importance of the product; 2) probability of research success; 3) efficiency in research; and 4) distribution of impact.

The method involves a great deal of subjective judgement but the weights are made explicit.

The advantages of scoring models as used in these Latin American experiences are :

1) They incorporate both quantitive and qualititve information in analyzing multiple goals.

2) They are easy for research administrators and local analysts to understand.

3) They force decision makers to consiously identify and trade-off goals and criteria; and

4) They result in relatively explicit assessments of priorities because individuals were not allowed to rank commodities and research areas directly but had to weight the criteria.

Nevertheless, the method remains subjective; it is hard to specify criteria with no overlap; and it requires more time than simply asking respondents to rank commodities and research areas.

The conclusion was that the scoring model was a useful priority setting tool where multiple goals used to be considered and major reassessment of priorities is contemplated.

In many countries it is possible to improve upon the scoring model approach through the incorporation of many of the relevance factors in an ex ante rate of return calculation. The advantages and disadvantages of this approach are discussed below.

7.3 Ex ante Rate of Return : A Consumer/Producer Surplus Approach

The advantages of scoring models in dealing with multiple objectives have been described above. The use of subjective weights may be very helpful in reducing a large number of possible priorities to a more restricted group for which more detailed analysis is desirable. This leads to ex ante rate of return studies using a consumer/producer surplus approach.

Ex-ante benefit-cost analysis also depends in part on subjective judgments to determine projected research impacts. It requires one to know, or to make estimates of :

* the impact of research on productivity (the nature of the shift in the supply curve);
* the probability of success of the research;
* the expected rate of adoption of the research results;
* expected research costs;
* the appropriate discount rate;
* any price distortions that need to be considered; and
* supply and demand conditions for the commodity.

All of the above variables can be expressed in probabilistic terms and the economist can build them into his estimate of expected net benefits.

The method may be applied to the case of research which leads to a reduction in unit cost of production and through time is adopted by increasing numbers of farmers. Then the benefit in time "t" will be :

$$b_t = V_o . A_t . R^t$$

where
V_o= the value of output in year O
A_t= the adoption level in year t
R_t= the reduction in unit costs due to research

Using Scobie's example (1984), let the value of crop production be $ 300 million and assume the combined investments in research and extension would produce results applicable to 75% of the crop. Further, assume that unit costs are reduced by 15% (i.e. with current input levels output would rise 15%). As a result, by the time the full benefits are achieved in year 10, we would have :

$$b_t = 300 \times 0.75 \times 0.15 = \$ 33.75 \text{ million}$$

Assume the research program is being funded at $5 million per year produces results only after a five-year lag, and a further five years are required until full adoption. The stream of costs and benefits will be as shown in Table 6.:

Table 6. DCF Analysis of Net Benefits Adjusted for Adoption

Year	Benefits	Cost
1-4	0	5
5	6.75	5
6	13.50	5
7	20.25	5
8	27.00	5
9	33.75	5
10-20	33.75	2

This example implies an internal rate of return of 42%. The magnitude of benefits depends on both the economic size of the base to which gains are applied and the reduction in unit cost. One could also assume that the base V_o would be growing even in the absence of research, in which case the benefits would be even greater since the cost reduction applies to the growing base.

The attempt to integrate the relevance indicators mentioned above into an ex ante economic surplus model to obtain rates of return brings several advantages :

1) It allows us to analyze the distribution of benefits between producers and consumers;

2) it incorporates regional considerations into the analysis, and

3) it can handle the interactions between agricultural research policy and other policy decisions taken by the government.

The approach does not eliminate the subjective element in priority setting but it does allow us to make the analysis as rigorous as possible of those issues which can be made objective.

Norton and Ganoza (1986) applied a consumer and producer surplus model to five major commodity programs in Peru. Through a questionnaire, administered to 40 extension workers and 45 researchers, they obtained information on the timing of adoption, geographic spread of new technology, and expected impact. Data was obtained from published sources for the quantity of production, area under differenct crops, imports, exports, and prices at different levels. The cost of research and extension were available from INIPA records, while estimates of income elasticity of demand for different crops were derived from expenditure elasticities estimated by other researchers.

The approach enabled them to integrate research and other policy decisions. They found that producers were the primary beneficiaries of research on commodities traded in international markets. However, the domestic market was constrained and if a crop such as rice were prohibited for export, price would fall so much that all the benefits would accrue to consumers. The consumers are already the beneficiaries of potato and bean research. There are substantial returns to both research and extension expenditure. A final observation is that government policies appear to have a greater effect on the distribution than on the level of research benefits.

7.4 Comparative Advantage Using Domestic Resource Cost Estimates

CIMMYT has been a leader in applying a variant of economic return analayses based on the concept of comparative advantage. The analysis is aimed at both research resource managers and ploicy makers. It provides a framework for assessing how the comparative advantage a region might have in the production of a given crop changes with changes in selected policy variables or with the introduction of new technologies. In particular, it permits the assessment of private profit ability versus profitiability to the nation and an analysis of the distrotions introduced by taxes and subsidies.

The method attempts to identify the crops in which a country should be investing. The measure of comparative advantage is the domestic resource cost (DRC) of earning (or saving) one unit of foreign exchange through production of the commodity. In order to make DRC calculations, we need to know the foreign exchange value of the product, foreign exchange input costs, the domestic currency cost of production, and the opportunity cost of capital.

Applied to the case of Ecuador, the CIMMYT analysis elucidates an important dilemma faced by the research manager. A brief account of the case is in order.

During the oil boom in the mid 1970's Ecuador experienced a rapid domestic inflation due to inflow of resources with fixed exchange rates. This inflation made the cost of imported wheat to consumers fall in relation to the price of domestic wheat production and alternative domestic goods. The linking of the guaranteed producer price for wheat to the price of wheat imports at official (overvalued) exchange rates, created a disincentive for local producers. Consequently, Ecuador became 90% dependent on imported wheat. Land previously under wheat was put into cattle for beef and dairying since prices of domestic animal products were rising due to restrictions on imports of these commodities. The question CIMMYT needed to answer was "Would it be economic to produce wheat locally and, if so, what policy incentives would be needed?"

The method involved the following steps :

1) value locally produced wheat at the equivalent price of imported wheat;

2) value imported inputs at their import cost plus internal transport and marketing margins;

3) value labor and capital at their opportunity cost (return to alternative uses) in Ecuador;

4) make similar calculations for competing crop and livestock enterprises;

5) compare returns to the nation of land used in wheat versus other uses; and

6) establish whether the net inpact of policy on the different products was positive or negative

Applying the DRC criterion, they found :

1) Wheat offered the highest returns to land after potatoes, while extensive dairying offered the lowest;

2) Wheat offered the highest increase in economic returns per hectare due to the use of improved technology; and

3) The net policy effect was negative for wheat and positive for dairying.

The dilemma for the research director is the following : under current policy arrangements there is little demand for research on wheat and new technology alone cannot overcome the unfavorable policy environment. However, in terms of true national profitability, wheat offers interesting returns in the long run, the research leader might be vindicated if he maintains a strong research program anticipating the end of easy wheat imports and a return to emphasis on domestic production. However, in the short run, he does bot strengthen his institute by appearing to work on crops of low priority to both policy makers and clients.

The preceding case clearly brings us back to the need to have appropriate tools for setting priorities with in the framework of the larger policy environment of the agricultural technology management system. The information, formal priority setting methodologies, and channels of communication might exist which enable research leaders to identify and be allowed to work on programs which maximize the expected contribution to society's goals.

8. Conclusion

We have attempted to present several issues associated with resource allocation and priority setting as part of the functioning of the overall agricultural technology management system. The goals of the system determine the questions which must be addressed adn thereby the most appropriate methodology to be used. There is an underlying presumption, however, that in most systems the process of resource allocation can be improved, and the costs of such improvement will be more than offset by the gains from more efficient use of resources.

BIBLIOGRAPHY

Barker, R — "Establishing Priorities for Allocating Funds to Rice Research" Paper presented to the International Agricultural Economic Association Meetings, Banff, 1977. p.40.8

Byerlee, Derek — "Comparative Advantage and Policy Incentives for Wheat Production in Ecuador". CIMMYT Economics Program. Working Paper No. 01.85.

Elliott, Howard; Reed, Hertford; Snow, Judy; Trigo, Eduardo — "Identifying Opportunities to Improve Agricultural Technology Management Systems in Latin America : A Methodology Test Case". ISNAR and Rutgers University, December 1985.

Evenson, R.E. — "IARC Investment, National Research and Extension Investment and Field Crop Productivity" New Haven, Yale University. 1984

FAO — "Quantitive Indications for Priorities in International Agricultural Research". Rome : FAO 1984

Judd, Ann; Boyce, James K; Evenson, Robert E — Investing in Agricultural Supply : The Determinants of Agricultural Research and Extension Investment" (Mineo)

Norton, G — "Priority Setting Mechanisms for National Agricultural Research Systems : Recent Experience and Future Needs". ISNAR : Nov 1986 (Draft for discussion)

Norton, G; Ganoza, Victor — "Guidelines for Allocations of Resources to Agricultural Research and Extension in Peru". North Carolina State University, Feb 1986

Norton, G; Ganoza, Victor; Pomareda, Carlos — "Potential Benefits of Agricultural Research in Peru" Report to USAID under Contract 527-0166

von Oppen, M; Ryan, James G — "Research Resource Allocation Defining Regional Priorities". Food Policy Vol 10 (3) : 253-264 August 1985

Oram, Peter — Unpublished data; (IFPRI 1984)

Pardey, P.G.; Norton, G — "Strategy for Strengthening ISNAR's Capability to Provide Assistance with the Resource Allocation -- Priority Setting Problems of NARS in Developing Countries. May 1986.

Pardey, P.G.; Craig, Barbara — Unpublished data from study of expenditures in the State Agriculture Experiment System : University of Minnesota, ISNAR and Virginia Tech. Oct. 1986

Ruttan, V — Agricultural Research Policy Minneapplis : University of Minnesota Press 1982

Scobie, G "Investment in Agricultural Research : Some Economic Principles". Mexico : CIMMYT Working Paper, Aug 1984

Simon, H.A. "Theories of Decision-Making in Economics and Behavioural Science" Surveys of Economic Theory, American Economic Association and Royal Economic Society London : Macmillan 1966

ANNEX 1

Suggestions for Discussion Groups

A. The Concept of the Agricultural Technology Management System

1) Is it possible to identifiy the key organizations in each component of the ATM system and describe their principal mandates and objectives?

2) Have the objectives of the ATM system changed recently?

3) For what individual organizations have the objectives changed recently?

4) What are the means (budgetary or other) which are available to implement the change?

5) How complex is decision making at each of the three levels and who are the participants?

B) Decision to Allocate Resources to Agricultural Sector

1. What Ministries are involved at Cabinet level?

2. What factors determine
   a) The share of the budget going to agriculture
   b) The share of the agriculture budget going to research

3. How does Syria's research intensity ratio (expenditure on research relative to Agricultural G.D.P.) compare with other similar countries?
   Is there an explanation for its ratios being different?

4. What studies have been done to demonstrate the economic profitablity of research?
   - Have such studies been of the net economic benefit type of production function type?

5. Have the economic studies taken income distribution, employment generation and other factors into account? How?

C. The Priority Setting Mechanism

1. Have national objectives for the agriculture been made explicit in a way that permits the research sector to translate them into researchable problems?

2. Have there been any changes in priorities or "shocks" to the system recently?

3. Have these forces for change been external or internal?

4. Has the allocation of resources among institutes changed significantly in relation to historical shares? (precedence criterion)

5. How do universities and other agricultural research centers receive their funding? Are their priorities included separately in the NARP or included in ARC?

D. Congruence Across Commodities

1. How congruent is the allocation of research resources across commodities?
2. What are the explanations for any divergence from congruence?
   a. Dynamic considerations
   b. Scale factors
   c. Change in priorities
   d. Probability of success

E. Scoring Model

1. What key factors are taken into account when assessing the priority to be given to a commodity (or region)?

2. What indicators are used to represent these factors? How many of these are objectively measurable and how many are subjective? Are they overlapping in some way? Can they be included in a more formal ex-ante benefit cost approach?

3. What process is used to involve researchers and administrators in establishing the weights attached to research areas and individual factors?

4. What corrections are made for distortions due to policy?

5. Is there an attempt to have congruence by region?

6. What criteria should be used in assessing the share of resources that go into a geographic region?

7. What weight should be given to equity efficiency?

F. Use of Benefit-Cost Analysis for Ex-ante Evaluation

1. What studies have been done?

2. How have they dealt with price distortions, subsidies, and quotas?

3. What does a research director do when his perception of need differ from that of the policy makers?

4. Have any domestic resource cost studies been done?

5. How do the economists fit into the decision-making process at the Institute level? Are they integrated into commodity programs or separated into an economics program? How can they be brought more closely into the commodity programs?

6. In what organization should analysis of research priorities be carried out? Are the universities a source of assistance in such efforts?