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Establishing Priorities for Allocating Funds to Rice Research

There has been an increasing interest in recent years in the problems and procedures related to establishing priorities in agricultural research programmes. In developed countries this is a reflection of tighter budgets for research. In the developing countries the interest arises out of a growing recognition of the critical role played by research in the development process, as the severe limitations imposed by the lack of trained manpower as well as funds for research.

Agricultural research, particularly in the biological sciences, has the characteristic of a "public good" in that it is: (i) equally available to all, and (ii) it is impossible to exclude from utilization those who have not paid for it. The result is that investment in agricultural research is undertaken largely by the government rather than by the private sector. A number of recent studies have shown clear evidence of an under investment of public funds in research in the developing countries. This explains in part the rapid development of the network of international agricultural research centres. The creation of these centres has brought to the fore a number of important issues with respect to the allocation of research funds for agriculture. How much in total could or should the developed country donor agencies contribute to agricultural research? What types of research centres and activities should be supported? What should be the balance of support between national and international programmes; between focus on basic science and development of technology; between focus on current research problems and development of research capacity? How can national governments be encouraged to provide more support for research activities and for training research workers? The above questions are of concern to the international centres themselves who obtain their financial support from the Consultative Group on International Agricultural Research (CGIAR) and who have the dual role of engaging in research and facilitating the development of indigenous research capacity. Furthermore, the CGIAR, which is composed of representatives from the donor agencies, is warning of the

* Read by Robert Herdt in Professor Barker's absence.

possibility of a sharp slowdown in the growth of its own contribution (which now exceeds $100 million annually). Pressure is being brought on the individual research centres to improve their procedures for establishing priorities in the allocation of funds. In achieving this objective, an understanding of the interrelationship between the research in the international centres and in national programmes is of paramount importance.

In this paper we report the results of an exercise undertaken by one of the international centres, the International Rice Research Institute (IRRI), in an effort to clarify its own research priorities. Both the procedures followed and the results obtained should be of general interest to professional economists, research administrators and others concerned with agricultural policy.

The paper is divided into three sections. The first examines the structure of the research system. Methodologies for establishing priorities among rice research programmes are discussed in the second section. The third section presents the results of the analysis. This is followed by concluding remarks on the implication of these results for rice research in Asia.

THE ORGANIZATION OF RICE RESEARCH

A typology of rice research systems can be drawn which relates research skills and institutional organization to the stage of development of the system.[1] A research system passes through three stages of development: (i) *the low skilled system* dependent primarily on technical and engineering skills and characterized by widely diffused commodity oriented experiment stations, (ii) *the intermediate hierarchal system* with appreciable scientific skills and substantially economies to be gained by the concentration of these skills in leading institutions, (iii) *advanced scientific-based systems* characterized by a large supply of conceptual scientific skills and emphasis of the most highly regarded centres on research which does not have a direct technological objective.

Japan is perhaps the only country in Asia where the rice research system has passed through all three stages and can today be characterized as *advanced scientific-based*. The shift from the first to the second stage occurred in 1926 when the build-up of technical and scientific skills resulted in a major reorganization of agricultural research. The intermediate hierarchal system that emerged allowed Japan to capitalize on the development and dissemination of crossbred varieties.

Although the same scientific knowledge was potentially available to the experiment stations established throughout the tropics in the early part of the century, the scientific manpower needed to translate this knowledge into new technology did not emerge. Neither the pressures of population nor the priorities of the colonial administrations dictated the need for a major research effort to increase rice yields. Rice yields remained static. By mid-century an emerging food problem was becoming evident, but the belief was widespread that the *indica* varieties would not respond, like the *japonicas*, to conditions of intensive cultivation and heavy fertilization. The potential for altering the *indica* plant type through breeding was yet to be recognized.

The virtual disappearance of the arable land frontier in South and Southeast Asia after World War II hastened by the "population explosion" obviated the need for the development of modern technology to enable rice production to keep pace with rapidly growing demand. The dismantling of the colonial research network as the developing countries gained independence left tropical Asia with virtually no legacy of trained research manpower.

In the decade after World War II efforts to encourage agricultural development in the tropics still tended to ignore the potential of research in food crops. Extension received priority over research in part because it was felt that higher production could be achieved with existing technology, and in part because the benefits promised to be more immediate.

Beginning in 1954 the *extension model* was superseded and incorporated into a more comprehensive organizational structure for agricultural development patterned after the land grant universities in the United States.[2] The adoption and promotion of the *land grant model* was reflected in international aid agency funding of developing country research. This represented 40 to 50 per cent of the total investment in the 1950s and about one-third of the total in the mid-1960s. In research, export crops continued to be favoured over food grains. With one or two exceptions, such as India, the national research programmes of tropical Asia could continue to be categorized as *low skilled systems*. This lag in the development of research organization and scientific skills set the stage for the technological breakthrough that was to follow. The establishment of the International Rice Research Institute (IRRI) in 1962 as the "main station" in an international hierarchal system can be viewed as a temporary departure from the basic developing country research process.

The creation of IRRI and the other international centres for biological research has been referred to as the *"big science" model*.[3] After 1965 international aid funding for national research agencies declined as more and more funds were diverted to the establishment of the international agricultural research centres. The main criticism of this approach is that the new varieties tend to be limited primarily to farmers who can replicate the favourable environmental conditions (e.g. irrigation) and afford the costly inputs. Furthermore, analysis of returns on investment shows that returns in national programmes are very high. There is an observable high degree of complementarity between the work of the national institutions and international centres. A strong national programme can facilitate the spread of new technology by adapting the exotic materials to local conditions. This capacity becomes increasingly important as the easy gain in productivity in the more favourable environments is fully exploited. The establishment of the International Agricultural Development Service (IADS) in 1975, International Service for National Agricultural

Research (ISNAR) in 1978, whose main focus is on the strengthening of national research systems, reflects a growing recognition of the need to achieve an appropriate balance of international aid support between international and national programmes.

ALTERNATIVE METHODS OF ESTABLISHING RESEARCH PRIORITIES

Although the issue can be debated, there was undoubtedly more agreement among rice research workers in the early 1960s as to the best research strategy for increasing rice production than exists today. The lag in technology development created a gap, but experience with small grains elsewhere suggested the potential to be gained from developing a short-strawed fertilizer responsive variety. This objective having been achieved, however, the subsequent steps to increase production were less obvious. Thus, a little more than a decade after the establishment of IRRI, the appropriate allocation of research resources was a matter of considerable debate. Scientific and management staff alike showed increasing concern for the need to develop a clearer perception of research priorities.

Methods and procedures for evaluating agricultural research can be usefully divided into *ex post* studies and *ex ante* models.[4] We will discuss only the *ex ante* approaches. In degree of methodological sophistication, the *ex ante* models range from the simple scoring schemes to highly complex mathematical programming models. To a greater or lesser degree all such models depend upon the judgement of either the research or of knowledgeable individuals concerning the outcome of future events. While the results may be sensitive to these judgements, some of the most important findings are likely to hold under a wide range of sensitivity tests. Three *ex ante* approaches have been utilized by IRRI.

A wide range of models has been developed which attempts to examine the results of research in terms of expected impact on production and income distribution. One such approach employed by IRRI is closely related to the "gap and trend analysis" undertaken by the International Food Policy Research Institute (IFPRI).[5] The growing gap between projected demand for food and projected trend in supply reflects the need to achieve more rapid increase in production. A preliminary study was undertaken to determine the investments required in irrigation, fertilizer, and research to increase Asian rice supplies at a pace in keeping with projected demand.[6] A joint project is now being initiated by the ASEAN rice growing countries (Indonesia, Malaysia, Philippines and Thailand) in co-operation with IFPRI, IRRI, and the International Fertilizer Development Centre (IFDC) to investigate the supply, consumption, and trade dimensions of this problem in greater detail. This investigation looks on research as one alternative for shifting the supply function. It is concerned with the total research needs for rice, but not specifically with the allocation or research priorities within rice.

A number of studies have focused on the productivity and income distribution effects of the allocation of research funds among alternative problem areas or commodities. The scoring model has been employed to determine the relative research emphasis that should be given to specific problem areas.[7] Senior scientists were asked to rank the Institute's nine problem areas separately on the basis of twelve questions relating to research expectations. The results were weighed into a single ranking of problem areas. These rankings turned out to be highly comparable to the ranking according to budget allocation. The only significant discrepancy is in the lower rating by scientists of "machinery development and testing" and the higher rank by scientists given to "soil and crop management". The results are, of course, sensitive to the weightings given to the various questions (e.g. will the research increase the yield of rice?) A further difficulty is that even in an institute as small and homogeneous as IRRI, the average scientist is not and should not be expected to be concerned with the priorities of the entire institute.

In the analysis presented in this paper we have used a productivity approach to examine the benefits to be derived from research in different rice-growing environments – irrigated, rainfed, upland, and deep-water rice – in the main rice growing countries of South and Southeast Asia. Scientists believe that in large measure the research findings are environmental specific, and this is borne out by the fact that the new varieties have been adopted principally in the irrigated areas. Thus, we can assume that the four types of rice defined by the different environmental conditions are, from a production perspective, essentially different commodities.

This analysis of production potential in different rice growing environments has implicit implications for income distribution. Many of the rural poor in Asia are located in the unirrigated rice producing regions, particularly in Eastern India and Bangladesh. The initial success of the new rice technology in the irrigated environment has tended to widen the disparity between the irrigated and non-irrigated regions.

Theoretically, in order to maximize the productivity of research resources, expenditures should be allocated so that the increase in productivity from an additional amount of funds spent on research for each rice environment is equated. The analysis should take into account the hectares in the environment over which the new technology is suitable, the expected productivity gain, the farmer's cost involved in using the new technology or the reductions in costs achieved by the technology, the probability of success, and the time period from the start of research until the productivity gain is achieved. Given this information one may calculate the net present value of research for the ith type of rice environment as:

$$NVP_i = \sum_{t=t'}^{T} (1 + r)^{-t} \left\{ \sum_{m=m'}^{M} P(m)[(\Delta Q_{m,t} - \Delta C_{p,t})A_i] + \right.$$

$$\left[\sum_{n=n'}^{N} P(n)\Delta A_{n,t}(Q_i - C_i)\right] - \sum_{t=0}^{T'} (1+r)^{-t} K_{i,t}$$

NVP_i r t M $P(m)$ $\Delta Q_{m,t}$ $\Delta C_{p,t}$ A_i

$\Delta A_{n,t}$ n $P(n)$ Q_i C_i $K_{i,t}$

where:

NVP_i	=	net present value of potential new technology for environment i
r	=	social rate of time discount (interest rate)
t	=	time period
M	=	yield level
$P(m)$	=	probability of success in achieving the production or yield increase
$\Delta Q_{m,t}$	=	change in value of output made possible by the research in time period t
$\Delta C_{p,t}$	=	cost to the farmer of using the technology in time period t
A_i	=	area over which the technology is successful
$\Delta A_{n,t}$	=	new production area suitable for production made possible by research
n	=	cropping intensity level
$P(n)$	=	probability of success in achieving the area change
Q_i	=	value of output per hectare in environment i
C_i	=	cost to the farmer of extending production to the new area in environment i
$K_{i,t}$	=	capital investment for new technology environment i in time period t

Given this data for each type of environment, it would be optimal to allocate research resources to equate the net present value of potential new technology for each environment. This model has been used in carrying on the analyses in the following section.

ALLOCATION OF RESEARCH INPUTS TO RICE ENVIRONMENTS

The analysis in this section includes the benefits derived from research in four rice growing environments – irrigated, rainfed, deep-water, and upland – in the main rice growing countries of South and Southeast Asia (see definitions of environments in footnotes of Table 1). We assume that the four types of rice defined by different environmental conditions are, from a production perspective, essentially different commodities. The analyses and results are discussed under three headings: (i) gross benefits, (ii) net benefits for irrigated vs. rainfed rice, (iii) contribution of research by country.

Gross benefits

A group of IRRI scientists estimated the anticipated increase in rice yield and cropping intensity that would be possible from "reasonable" research and extension inputs directed at each environment for South and Southeast Asia. It was assumed that these yields could be realized over a 20-year period. The probability of success, the direct cost of technology for each area, and the time required to achieve success were initially assumed to be identical for all environments. Thus, the objective of the exercise was to estimate the value of the potential increase in production in each area.

Increase in total production was assumed to be attributed to the gain in production from yield, cropping intensity, and new irrigation develop-

TABLE 1 *Estimated changes in yield and cropping intensity attainable in 20 years from reasonable research and extension efforts on rice and its cropping systems for specified rice environmental complexes in South and Southeast Asia, 1970s and 1990s*

Environmental[a] complexes	Yield (t/ha)			Rice cropping intensity			Upland cropping intensity		
	1970s (1)	1990s (2)	Change (3)	1970s (1)	1990s (2)	Change (3)	1970s (1)	1990s (2)	Change (3)
Irrigated	3.0	4.1	1.1	1.2	1.6	0.4	0.3	0.5	0.2
Shallow rainfed	1.8	2.6	0.8	0.7	1.0	0.3	0.4	0.5	0.1
Medium deep rainfed	1.0	1.8	0.8	0.8	0.9	0.1	0.3	0.5	0.2
Deep-water	1.0	1.5	0.5	0.9	1.0	0.1	0.3	0.4	0.1
Upland	1.0	1.5	0.5	0.8	0.8	0	0.5	0.8	0.3

a For irrigated rice, water is added to the fields from canals, river diversions, pumps or tanks. For unirrigated rice the maximum water depths, tillering to flowering, are 5 to 15 cm for shallow rainfed, 15 to 100 cm for medium deep rainfed, 1 meter or more for deep-water. Most rainfed rice is grown in bunded paddy fields, but for upland rice, water is not impounded in paddy fields.

ment. Gains in yield and cropping intensity are shown in Table 1. Irrigated area was assumed to grow at 1.5 per cent per year. The gross area in rice increased by 3 million hectares due to the increase in the area double-cropped, but the area in rainfed rice declined by 6 million as land was converted from rainfed to irrigated area. Irrigated area thus grew by 9 million hectares.

The value of discounted benefits over the 20-year period are summarized in Table 2. The largest share of benefits, 56 per cent, is in the irrigated area, both because the area is expanding and because the absolute yield gain is larger for irrigated than for rainfed rice. The potential for increasing yields on shallow and medium rainfed areas was assumed to be equal (0.8 t/ha), but the shallow rainfed area is considerably larger than the medium deep rainfed. Rainfed rice accounts for 37 per cent of the total increase in benefits. Upland and deep-water rice account for only 3 and 4 per cent of the total benefits, both because the area is small and the potential for increase in yield is low.

Net benefits for irrigated vs. rainfed rice

We now take into account the cost of increasing production in the irrigated and in the rainfed land in order to compute a benefit–cost ratio and an internal rate of return on investment. The return to increased production in irrigated rice is divided between return on newly irrigated land and on land already irrigated (Table 3). Assumptions with respect to capital investment and annual costs for new irrigation, research and extension, fertilizer, and labour are shown in the paragraphs that follow.

Beginning in 1976 irrigation expands in South and Southeast Asia at a

TABLE 2 *Summary of discounted added benefits from research and extension due to yield increase and cropping intensity for specified environmental complexes in South and Southeast Asia, discounted to present value at 12% interest, 1970s to 1990s*

	Benefits (billion $) from				
Environmental Complexes	Increase	Rice cropping intensity	Upland cropping intensity	Total benefits	(%)
Irrigation	10.4	12.9	4.7	28.2	56
Shallow rainfed	5.2	7.4	1.8	14.4	29
Medium deep rainfed	2.3	0.6	1.0	3.9	8
Deep-water	0.9	0.3	0.2	1.4	3
Upland	1.1	0	1.0	2.1	4
Total	19.9	21.2	8.9	50.0	100

rate of 450,000 hectares annually for 20 years at which time there are 9 million hectares of newly irrigated land. The capital cost per hectare of irrigation is $1500 and the annual maintenance fee is $11. The stream of benefits from new irrigation begins 5 years after the investment and benefits are discounted up to the year 2010.

In the year 1976 the annual investment in research and extension on irrigated rice is assumed to be $40 million. It increases at a rate of approximately $3 million per year reaching $100 million in 1995. The investment in rainfed rice research is assumed to be $10 million in 1976 and to increase at approximately $5 million per year reaching $100 million in 1995. Beginning in 1981 yields increase by 55 kgs per year in irrigated land or a total of 1.1 tons/ha by 2000 and by 40 kgs per year on rainfed land or a total of 0.8 tons/ha by 2000. The stream of net benefits (return to rice less fertilizer and labour costs) remain constant after 2000 and is discounted to the year 2010.

Shifting from rainfed to irrigated rice raises the fertilizer nutrient (NPK) input by 60 kg/ha on the 9 million hectares of newly irrigated land by 1985. An additional 120 kg/ha NPK is required on all 36 million hectare of irrigated land, while 40 kg/ha NPK is added to 36 million hectare of rainfed land. The fertilizer costs approximately $150 per ton or $0.33/kg of NPK. Paddy is $0.10/kilo and the NPK to paddy price ratio is 3.3 Approximately half of the fertilizer is produced domestically in 12 new urea plants producing 500,000 tons of urea per year and costing $300 million per plant. One of the plants is charged to new irrigation, 8 to the

TABLE 3 *Annual discounted investment costs and net benefits, benefit–cost ratio and internal rate of return for alternative rice investments, 1970s to 1990s in South and Southeast Asia*

	New irrigation[a]	Research and Extension Irrigated rice	Research and Extension Rainfed rice
Discounted investment costs	5800	2000	850
Discounted net benefits			
equal probability	5600	13500	11000
unequal probability[b]	5000	10100	5500
Benefit–cost ratio (12% interest)			
equal probability	1.0	6.7	12.9
unequal probability	1.9	5.0	6.5
Internal rate of return (%)			
equal probability	12	40	85
unequal probability	11	35	40

a Benefits from new irrigation include the yield increase due to research on new irrigated area.

b Assumed probability of achieving production gain from new irrigation = 100 per cent; from research/extension on irrigated rice = 75 per cent; from research/extension on rainfed rice = 50 per cent.

irrigated, and 3 to the rainfed area. The schedule for construction is 2 plants in 1980, 4 in 1985, 3 each in 1990 and 1995.

In both rainfed and irrigated areas labour is the main cost associated with increased production. Thirty days are required to produce an additional ton of paddy and labour is valued at $1 per day.

The results in Table 3 suggest that the benefit–cost ratio and internal rate of return is high for investment in research and extension on existing irrigated land, seemingly even higher on rainfed land. Why then do we find in the plans of many developing Asian economies increasing emphasis on irrigation investment and relatively little interest in research on rainfed rice? The answer is, in part, related to the fact that secondary benefits including employment impact are not incorporated in the benefit–cost analysis. Another important factor is the probability of success, the element that we have not yet incorporated in our model. Although the payoff is low, the greatest certainty is associated with increased productivity due to expansion of irrigated land. We assumed that the probability of success in achieving returns on a hectare of new irrigation comparable to that for existing is 100 per cent; the probability of achieving a 1.1 ton yield increase from investment in research for the irrigated environment is 75 per cent; the probability of achieving a 0.8 ton yield increase from investment in research on the rainfed environment is 50 per cent. Using these probabilities, we recalculate the benefits and costs and internal rates of return (Table 3). While the order of priority remains the same, the difference among alternatives is understandably much smaller.

Given these new calculations one might argue that with scarce scientific manpower, it makes better sense to concentrate these limited resources in irrigated rice. In the early 1960s, when the potential for increasing rice production even in the favourable tropical environments was uncertain, the argument seemed valid. However, to see this issue more clearly in the light of the situation existing today, we need to examine the potential benefits from irrigated and rainfed rice research and extension on a country by country bias.

Contribution of research by country

We sent questionnaires to a delegation of rice scientists from each country asking them for the information on the present area in irrigated, upland, deep-water, and rainfed rice (shallow, and medium deep) and for the present and potential yields in each of these categories. This unofficial data received from each of the countries was used to compute the potential benefits from research extension in each country following the procedure used previously. (Benefits due to cropping intensity were not considered.) The percentage share of the benefits attributable to each rice crop environment are summarized in Table 4.

The results indicate that the countries in Asia fall into two categories: those with high potential benefits from investment in rainfed rice research and those with high potential benefits from investment in irrigated rice research. Bangladesh, Burma, Thailand, and Nepal fall into the first category; Indonesia, Philippines, and Sri Lanka into the second. The exception is India, which shows a distribution of benefits similar to that for South and Southeast Asia. But if we were to divide India, which accounts for almost half of the total rice area, into regions we probably would observe the same biomodal distribution. Hence, the global priorities as seen by IRRI differ markedly from the priorities as seen by individual countries or regions.

IMPLICATIONS FOR RICE RESEARCH

The evolution of rice research systems in South and Southeast Asia has been accompanied by an extreme shortage of manpower and a chronic underinvestment in research funds. Developed countries have played an important role in establishing the system that exists today. However, this has involved an extended learning process as efforts to transfer first technology and then institutions to the developing countries did not solve the production problem. IRRIs initial success in increasing rice production has been criticized on the grounds that it failed to give adequate attention to the distribution problem.

The potential for increasing production on the non-irrigated areas is still in question. However, it now seems appropriate for social as well as economic reasons to concentrate more research resources on the more promising of the shallow rainfed areas. The success of such a research endeavour will depend much more than in the past on an understanding of the clientele that the research is designed to serve. To design appropri-

TABLE 4 *Estimated percentage contribution of research–extension to growth in rice production by specified environmental complexes for selected countries in South and Southeast Asia, 1970s to 1990s*

	SA	N	T	B	Bu	In	Ph	I	SL
Irrigated	52	20	22	23	25	45	75	76	79
Shallow rainfed	26	67	49		10	11	10	8	
Medium deep rainfed	12		24	22	72	26	1.5		9
Deep-water	5	–	4	4		4	0.5	6	–
Upland	5	13	1	10	3	15	12	8	4
Total	100	100	100	100	100	100	100	100	100
Implied annual growth in rice production	2.4	3.0	4.1	1.9	3.2	3.6	2.9	4.2	2.4

a Benefits are due to yield increase only.
Key: SA = South and Southeast Asia; N = Nepal; T = Thailand; B = Bangladesh; Bu = Burma; In = India; Ph = Philippines; I = Indonesia; SL = Sri Lanka.

ate research for rainfed farmers, it is necessary to understand their present farming system, and the factors that constrain their production. There are already attempts to experiment with this new *interactive model*. However, increasing rice production in the rainfed areas will require a major research investment and a new philosophy in place of the drive for high yield that pervades most experiment stations.

NOTES

[1] This typology is due to Evenson, developed in the context of developing country research generally, and not with specific reference to rice in Asia. Robert E. Evenson "Comparative Evidence on Returns to Investment in National and International Research Institutions", in *Resource Allocation and Productivity in National and International Research*, edited by Thomas M. Arndt, Dana G. Dalrymple, and Vernon W. Ruttan, pp. 237–64, Minneapolis, University of Minnesota Press, 1977.

[2] Esman discusses the postwar research and development phase in terms of four models, reflecting the particular emphasis of the period. These include: (i) the *extension model*, (ii) the *land grant model*, (iii) the *big science model*, and (iv) an *interactive model*, as yet in the formative stage in which the attempt is to provide appropriate technology to those farmers by-passed by the "green revolution," by strengthening the link between the farmer and the research worker. Milton J. Esman "Research and Development Organization", mimeo, International Studies, Cornell University, Ithaca, New York 1978.

[3] Ibid.

[4] Two useful review documents on this subject have been prepared at the request of the Technical Advisory Committee (TAC) of the Consultative Group on International Agricultural Research (CGIAR): (i) G. Edward Schuh and Helio Tollini "Cost and Benefits of Agricultural Research: State of the Art, and Implications for CGIAR", mimeo, Consultative Group on International Agricultural Research, Oct. 1978, and (ii) International Food Policy Research Institute "Criteria and Approaches to the Analysis of Priorities for International Agricultural Research," mimeo, Working Paper No. 1, Washington, DC Nov. 1978.

[5] International Food Policy Research Institute "Food Needs in the Developing Countries: Projections of Production and Consumption to 1990", Research Paper No. 3, Washington, DC Dec. 1977.

[6] Robert W. Herdt, Amanda Te, and Randolph Barker "The Prospects for Asian Rice Production," *Food Research Institute Studies* 16 (1977).

[7] The procedure and the productivity approach presented subsequently are described in detail in "IRRI Long Range Planning Committee Report," mimeo, Draft V, International Rice Research Institute, Los Baños, Philippines Sept. 1978.

GENERAL DISCUSSION – RAPPORTEUR: EARL D. KELLOGG

Since the indirect effects of increasing irrigated rice production are different from the indirect effects of increasing rainfed rice, the estimating procedure accounted for these differences through cropping intensity levels. The different adoption rates and equity impacts of increasing irrigated versus rainfed rice production were not included in the estimation procedures but could be incorporated when better data is available on which to base the estimates of the parameters. One reason for emphasizing the differences among countries was to encourage scientists in those countries to increase their own efforts to measure the probable returns to alternative investments in research on the various rice environments.

One question involved the reasons for a lack of communication between staff of International Agricultural Centres and National Research programmes. It was pointed out that, in some cases, individuals in both institutions did not *want* to communicate. In some cases, national research programmes decreased investments in some research areas because they were being emphasized by the international centre.

Participants in the discussion included Uma Lele and Indra Jit Singh.