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IRRI RESEARCH PAPER SERIES

RAINFED LOWLAND RICE AS A RESEARCH PROBLEM: AN ECONOMIST'S VIEW

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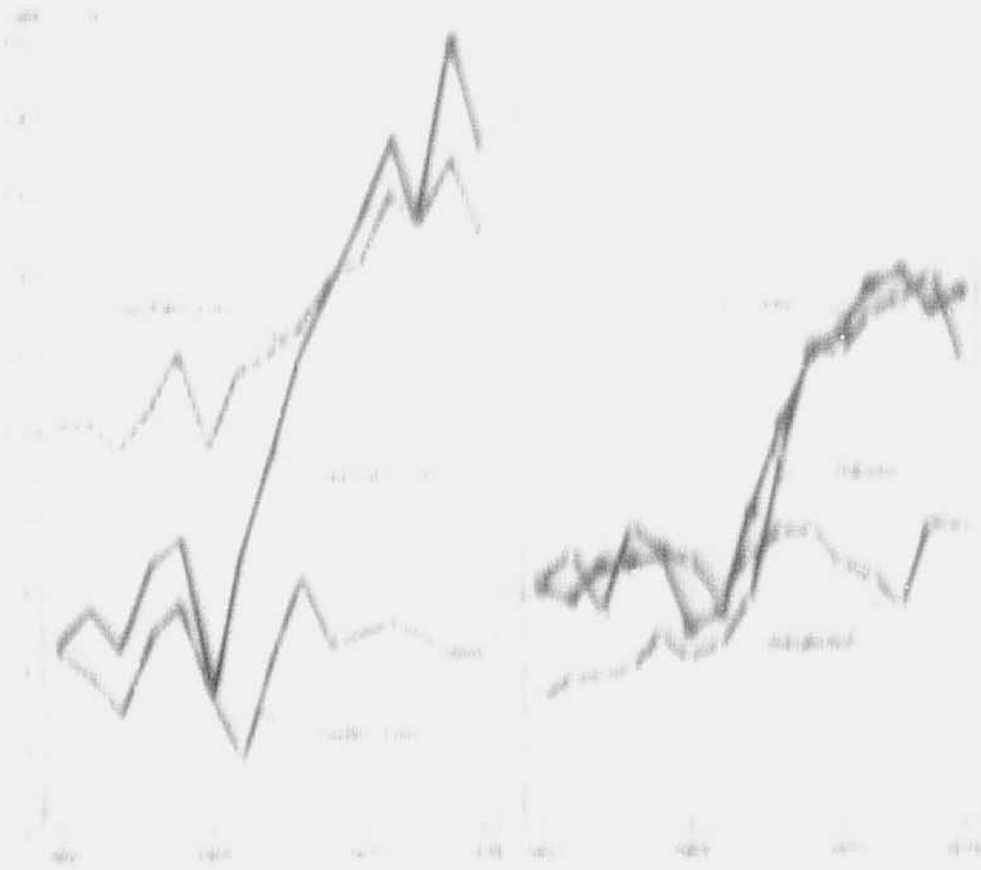


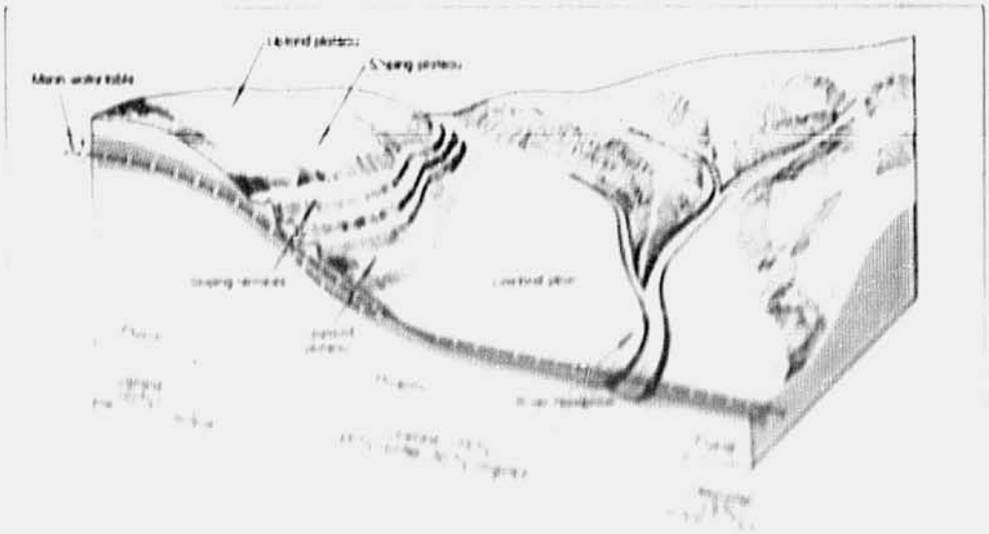
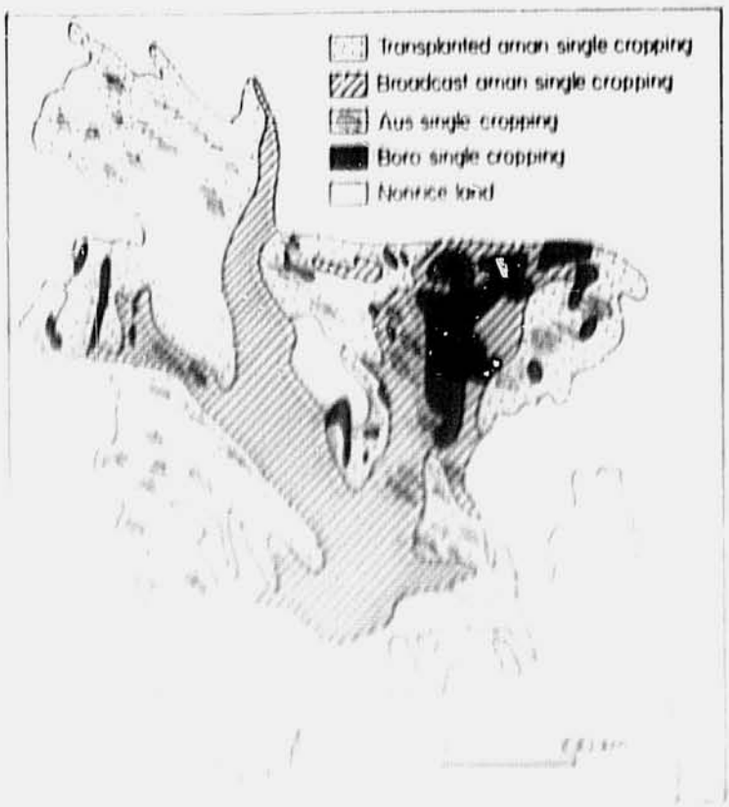


Table 5. Land categories and size cultivated in Indian states 1977

Land categories (topographic)	Size area (ha)	[illegible] (place)	[illegible]	[illegible]	Sowing	Ripening
[illegible]					[illegible]	[illegible] September
[illegible]					[illegible]	[illegible] September
[illegible]					[illegible]	[illegible] September
[illegible]					[illegible]	[illegible] October
[illegible]					[illegible]	[illegible]
					[illegible]	[illegible]
[illegible]					[illegible]	[illegible]
[illegible]					[illegible]	[illegible]
[illegible]					[illegible]	[illegible]
[illegible]					[illegible]	[illegible]
[illegible]					[illegible]	[illegible]
[illegible]					[illegible]	[illegible]
[illegible]					[illegible]	[illegible]


Transplanted aman single cropping
Broadcast aman single cropping
Aus single cropping
Boro single cropping
Nonrice land

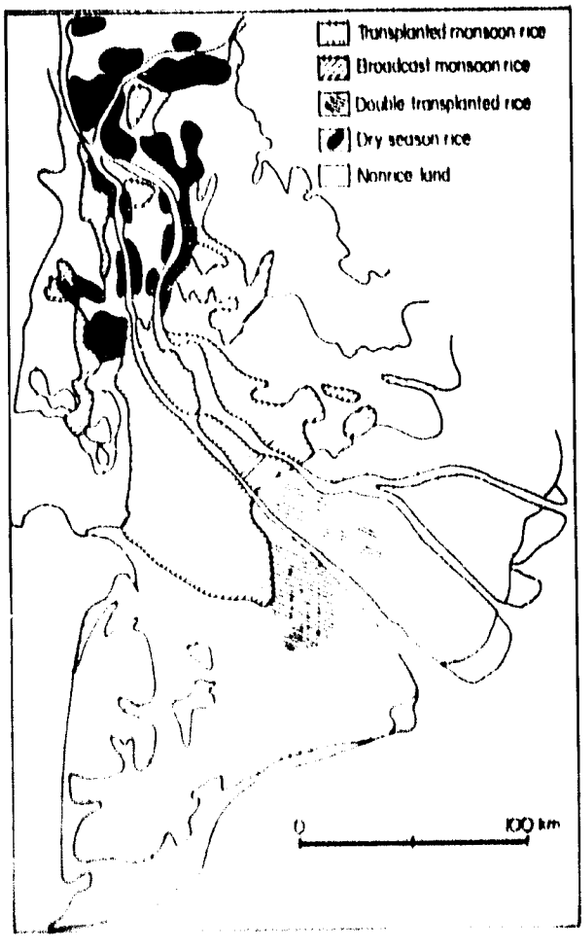
6. Rice cropping patterns in the Chao Phraya delta, Thailand (Takaya 1976)

yields frequently are lower than those for transplanted rice. Much of the transplanted area is subject to flooding, but the margins of the delta contain a fan-terrace complex of foothills where water deficiency can be a critical crop growth factor.

Most of the rice grown in the rainfed delta areas is photoperiod sensitive, i.e. flowering is triggered and hence harvest date determined by day length. If we define the period having monthly rainfall of more than 200 mm as the monsoonal season, the earlier onset of the monsoon in Bangladesh and eastern India permits a photoperiod-insensitive *boro* crop to be grown. There are more than 2 million ha of *boro* in Bangladesh in some of the deeper flooded areas of the Ganges-Brahmaputra, Irrawaddy, and Mekong deltas, a single crop of photoperiod-insensitive rice is planted as the floodwaters recede (Takaya 1975).

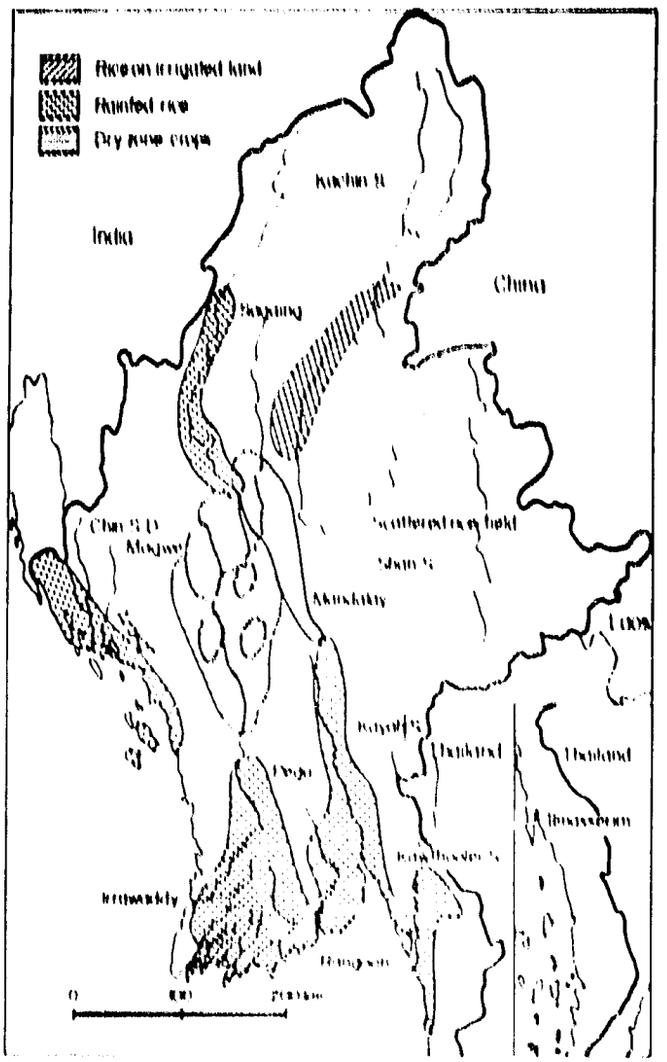
Major soil problems exist in the delta areas. About 700,000 ha of acid sulfate soils in South and Southeast Asia are found in the deltas. Some of these soils can be utilized for rice production if tolerant varieties can be developed (IRRI 1977). Salinity is also a problem on more than 4 million ha in the Ganges-Brahmaputra and Irrawaddy deltas (Ponnamperuma 1977).

Cropping patterns in the deltas are also closely related to soils. The heavy clay soils severely limit the potential for



8 Rice cropping patterns in the Mekong delta of Vietnam
based on the Netherlands delta development team report
1974 (Tatano 1978)

growing a second crop in combination with rice. However, second cropping is common in the sandier soils and shallow water table area of the Ganges-Brahmaputra delta, and is practical on from one-third to one-half of the area. The detailed description of the Chao Phraya River Basin by Tokui (1978) illustrates the relationship between physiography, water conditions, soil fertility, planting practice, farm size, and paddy production (Table 9). Generally speaking, farm size was larger in the broadcast seeded than in the transplanted area, but yields are higher in the latter. The notable exception was the water-deficient lowlands where production was highly variable. In all these regions, the paddy production per farm family was uniformly



7. Irrigated and rainfed rice growing areas of Burma (Richter 1977)

high, with a sizable marketable surplus. (A typical family requires about 1.5 to 2 t of paddy rice per year for home consumption)

Rainfed terraces and plateaus

Much rainfed rice is grown on gentle to steeply sloping terraces in areas that are difficult to irrigate. The position of the paddy on the terrace affects the soil and water conditions and,

therefore, the cultural practices and cropping patterns. Farmers are highly conscious of these differences. Many areas have local systems for classification of paddy position that depict, in microcosm, the system described in Figure 2. For example, in the terraced areas of the Chotanagpur hilly region of eastern India (covering parts of Bihar, Orissa, and West Bengal) the rainfed terraces are in four categories: upland (coarse-textured, light, badly eroded soils), medium upland, medium lowland, and lowland (with intermittent flooding and drainage). Jora paddy is grown on the uplands and can be harvested in about 85 days, but yields are typically less than 1 t/ha. It generally is argued that crops other than rice would perform better in these areas. Soils are more fertile and yields higher in the medium lowlands and lowlands and sparse plantings of high yielding varieties are found in the more fertile areas.

There is a general tendency for yields to be lower in the higher elevation bunded terraces. A series of experiments in farmers' fields at two rainfed sites in Central Luzon, Philippines, showed a yield decline of more than 700 kg/ha for every 1 m increase in elevation (IRRI 1971).

Rainfed farms with poor soil and water resources are sometimes larger than farms with better land quality or in irrigated areas (Table 5). However, this is not always the case. Many hill areas were settled by farmers migrating from the lowlands and in areas of intense population pressure, as in eastern India, farms on less fertile upland terraces may be smaller than farms in the neighboring lowlands.

The single largest plateau area extensively planted to rice is the Korat Plateau in northeastern Thailand. More than 3 million ha in this plateau grow rice -- about 40% of Thailand's total rice area. Only about 100,000 ha are irrigated. The Korat Plateau soils are infertile and average rice yield is about 1.5 t/ha, compared with more than 2 t/ha for the rest of Thailand.

Rainfed vs. irrigated rice farms

Socioeconomic studies of farming in the rainfed rice-growing areas are relatively few. The major research interest over the past decade centered on the modern varieties and on the irrigated areas where the major changes in rice production were taking place. The introduction of the new rice technology widened the yield gap between the rainfed and irrigated areas. With the exception of the Philippines, where 70% of the rainfed area is

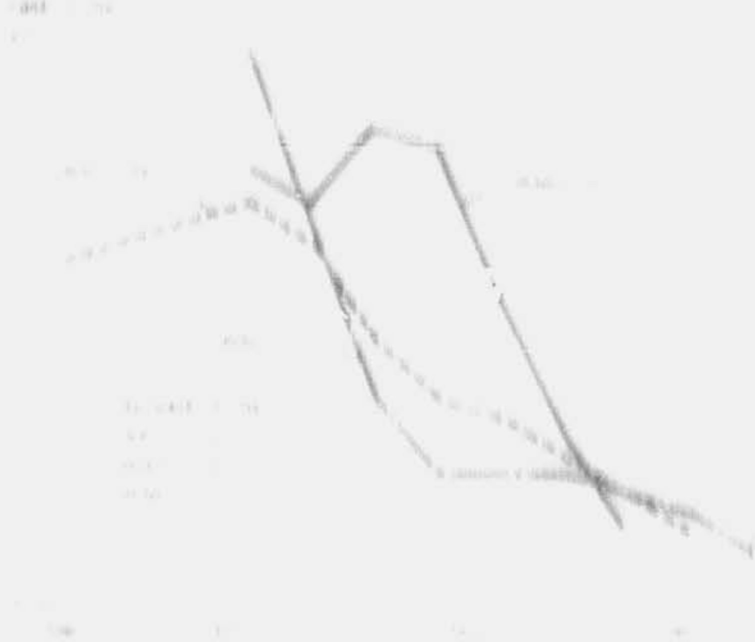
planted to modern varieties, the rainfed areas are planted almost exclusively to traditional varieties.

Input use and returns above variable cost are compared for a sample of rainfed and irrigated farms in three Philippine studies: Nueva Ecija (Table 6), Camarines Sur (Table 7), and Iloilo (Table 8). Similar data are shown for Suphan Buri, Thailand, which is on the western edge of the Chao Phraya delta (Table 9). In each case, the rainfed and irrigated areas represented neighboring farms or villages. In all cases, yields, input levels, and returns per hectare on the rainfed farms were substantially lower.

[illegible]

[illegible]

[illegible]



4. [illegible]
[illegible]

in the first week of November. About [illegible] of the harvest on the [illegible] farms was completed [illegible] for the farms harvested after the first week of November. However, the yield decline was [illegible] compared with that for [illegible] (Fig. 4).

In 1977, early maturing modern varieties, including IR36, yielded [illegible] t/ha, medium maturing modern varieties [illegible] t/ha, and medium late maturing varieties [illegible] t/ha. All three varieties performed well. The principal medium late variety C4-63 was grown primarily in the [illegible] of the 12 barrios surveyed where soil and moisture were more favorable. Under ideal conditions the medium late maturing varieties, such as C4-63 or [illegible], gave higher yields than IR36. It is recognized that a decrease in yield may occur as the maturity date is shortened, but there is no precise information on the probable magnitude of decline.

Information on the relationships between age of seedlings, length of maturity, and yield are also inadequate. For modern varieties, the recommended practice has been to transplant seedlings at 21 days of age. It was argued that yields decline as seedling age extends beyond 30 days. Farmers in the survey area typically transplant [illegible] to [illegible] day-old seedlings, which may help explain the short growth duration of 80-85 days for IR36 (Fig. 4).

per 1000 ha research investment for selected countries. Both in absolute level and by unit of cultivated rice area, the research investment generally was lower in those countries with a high proportion of rainfed area. IRRI research to date has been of greater benefit to countries with a high proportion of irrigated area. Only in the Philippines is a significant portion of the rainfed area planted to modern varieties.

This analysis assumed that the probability of success, the direct cost of technology for each area, and the time required to achieve success were the same for all environments. This may not be a reasonable assumption. In fact, it seems more reasonable to expect that developing technology for an expanding irrigation base has a greater probability of success, but a higher cost.

In Table 20, we budgeted the annual returns and costs for expansion of production in the irrigated and in the rainfed

Table 20. Annual [illegible] for [illegible] in the irrigated and [illegible] rainfed environments, [illegible]

Item	[illegible]	[illegible]	[illegible]	[illegible]	Annual additional [illegible]	Annual [illegible]
					[illegible]	[illegible]
Irrigation[a]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
Fertilizer[b]	[illegible]	[illegible] million [illegible]	[illegible]	[illegible]	[illegible]	
Research-extension[d]		[illegible]				
Labor[e]	[illegible] million man-days		[illegible]		[illegible]	
Paddy[f]	[illegible]		[illegible]			[illegible]
Total				[illegible]	[illegible]	[illegible]
Fertilizer[b]	[illegible]	[illegible] million [illegible]	[illegible]	[illegible]	[illegible]	
Research-extension[d]		[illegible] million		[illegible]		
Labor[e]	[illegible] million man-days		[illegible] days		[illegible]	
Paddy[f]	[illegible]		[illegible]			[illegible]
Total					[illegible]	[illegible]

[a]Irrigation grows at [illegible] annum, [illegible] = [illegible] million ha = [illegible] ha.
[b]Fertilizer use will grow at [illegible]/annum in irrigated land. It [illegible] from [illegible] million t [illegible] million t nutrients, an assumed increase of [illegible] million t nutrients. Converted [illegible] urea and TSP, assuming 1/4 of fertilizer is urea and [illegible] TSP, the tonnage is [illegible]. The rainfed area is assumed to require about 40% as much total fertilizer as the irrigated area: [illegible] = [illegible] t. [illegible] the fertilizer produced domestically, one plant is assumed to cost $[illegible] million and produce 495,000 t urea/year. The annual investment requirement is computed assuming that 50% of the fertilizer will be produced domestically. Domestic fertilizers will be [illegible] at $100/t and imported fertilizer will cost $200/t.
[c]Fertilizer cost multiplied by 1.5 to account for cost of other cash inputs excluding labor.
[d]$100,000 is allocated annually to research-extension for irrigated and rainfed areas.
[e]It is assumed that producing an additional ton of paddy requires 10 man-days or $80.
[f]Increased paddy production per annum in the 1990s is based on the implicit rate of growth from Tables 14-16. Irrigated output will increase from 81 million t in the 1970s to 197 million t in the 1990s or 4.5%/annum (197 x 0.045 = 8.87 million t). Rainfed output will increase from 65 million t in the 1970s to 125 million t in the 1990s or 4.5% (125 x 0.1[illegible] = 12 million t).

[illegible] The annual change in yield, production, and land [illegible] Some of the assumptions about investment costs and [illegible] are based on Herdt et al (1974). For this set of calculations we assume that by the mid 1990s US$100 million will be spent on research and extension to irrigated rice and another US$100 million on research to rainfed rice. The expenditure in 1974 was US$50 million (Evenson and Flores 1978) and in these calculations it is, therefore, estimated to grow at 5% during the next 20 years, close to the rate of growth in fertilizer use.

These data show the investment requirement not only for research and extension but also for fertilizer and irrigation. While the returns from the irrigated area are almost double, the capital investment required to create 1 irrigated hectare is more than 4 times as great. Therefore, the return on investment is much larger for the rainfed than for the irrigated area.

[illegible] Asian economies participate in the rice importing countries. At times it emphasizes irrigation as a fairly safe but costly means of increasing rice production and achieving price and political stability. However, if the estimates of the potential for yield increase in rainfed rice are correct, the total benefits for the Asian economies may be greater if more emphasis is placed on research on rainfed rice problems.

Unlike wheat technology, the new rice technology has not lowered the cost of rice production to any significant degree. As a result, world rice prices continue to remain at twice the level of world wheat prices. Part of the reason lies in the fact that the technology has been suitable for only about one-fourth of the rice area with better water control. Raising yields in the rainfed areas that have been largely bypassed by the new technology will have important social as well as economic benefits.

BARRIERS TO EFFECTIVE RESEARCH

The potential benefits for research in rainfed rice were discussed in the previous section. Whether or not these benefits are realized in the next two decades will depend upon the ability to:

- develop a suitable technology for the rainfed areas
- put the technology into the hands of farmers, and
- provide the proper incentives to encourage farmers to utilize the technology.

[illegible]

[illegible]

[illegible]

[illegible] farmers should be given the choice of raising varieties that [illegible] level of yield every year [illegible] higher yields under ideal conditions, but lower yields under unfavorable conditions. The international rainfed rice trials may help to identify varieties with these different traits.

Cultural practices, as well as varieties, will differ for the rainfed areas. For example, the wide variability in cropping patterns from one location to another, and even within a given area, reflects the extreme heterogeneity of conditions and the attempt of farmers to stabilize production by providing contingencies for variable weather conditions. Cropping patterns generally vary according to topography, but are adjusted also to annual variation in weather. The implications of these types of adjustments are important for technology development. Researchers can provide technology components, such as short season varieties, that can be used to adjust cropping patterns and increase production. But because of the extreme heterogeneity of the environmental conditions and the limited capacity of the research-extension network, it normally must be left to farmers to work out the most appropriate cropping patterns.

[illegible] Technology into the Hands of Farmers

The input delivery system for rainfed areas is, in general, not as well developed as for the irrigated areas. Land mechanization and delivery are a major problem in some areas. For example, we were told recently in eastern India that it takes about 12 years from the time of the first trial to the release of a new strain of rice. Among the varieties released, there is no assurance that seed will be made available to farmers in quantity, [illegible] farmers to the [illegible] within 3 years. [illegible] The only modern varieties [illegible] are [illegible] IR8, Cauvery, and Jaya. [illegible] were released more than a decade ago. These varieties are genetically unsuitable to the rainfed areas. Jaya and IR8 are [illegible] and Cauvery and Mahsuri are the wet season.

[illegible] suggests that the problem begins with the breeding objectives. Breeders in India will recently have [illegible] the genetic characteristics required for the [illegible] and [illegible] in eastern India. The [illegible] with research. We saw varieties in eastern India that seemed to be more suitable than what farmers are using now. And the mechanism for testing promising new rice and assuring their release and wide dissemination is not adequate.

[illegible] the distribution system in the rainfed areas is [illegible] that farmers have to travel several kilometers to purchase inputs or obtain institutional credit. [illegible] most progressive of the 12 rainfed villages surveyed in the ARDP in central India received a significant amount of Hasagana 20 credit and extension support in 1975. The government surmised, perhaps correctly, that given the potential of existing technology in the rainfed area at that time, the irrigated areas would provide a higher return on investment.

Incentives to Farmers

Many observers associate farmer incentives with prices. Low rice prices and high input cost will discourage production. However, the disincentives for rainfed rice producers extend well beyond the pricing mechanism. Land fragmentation, small size of farms, lack of credit, inappropriate technology, and lack of knowledge on how to use inputs are often noted. A

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

Modern rice technology has [illegible] bypassed the rainfed areas with two notable exceptions. Almost 10% of the Mekong Delta had been planted to modern varieties by 1971, and in the Philippines modern varieties were on 10% of the rainfed area in 1977. The Philippine situation demonstrates the potential of short season varieties in rainfed areas.

Analysis of the potential benefits from research-extension over the next two decades indicates that for South and Southeast Asia as a whole, about 17% of the benefits can be realized through increases in rainfed rice production. Not countries tend to fall into two very distinct groups. In Bangladesh,

Burma, Nepal, Thailand, central and eastern India, and Vietnam 70% of the benefits from research extension are likely to come from productivity increases in the rainfed rice area. For Indonesia, Malaysia, Philippines, Sri Lanka, northern and southern India, the benefits will come largely from the irrigated rice areas.

In the past decade, there has been a substantially greater investment in rice research and development of new technology for the irrigated areas. However, if we include the cost of irrigation development, the economic benefits of [illegible] through investment in rainfed rice may have a [illegible] irrigated rice.

Attention to rainfed rice research is increasing in most of the major rainfed rice growing countries and regions — Bangladesh, Burma, Nepal, Thailand, and eastern India — supported by external funds, [illegible] the United Nations Development Program, [illegible] international donor agencies.[1]

The [illegible] and dissemination of rainfed rice technology [illegible] already [illegible] research [illegible].

[1] See for example the report by the Rice Division of the Department of Agriculture of Thailand, "Rainfed Rice Improvement Pioneer Project. Review of Annual Action Program for 1978", or Government of India — International Rice Research Institute "Production Oriented Survey on Rice in Problem Areas of Bihar, Orissa and West Bengal." 1977 (mimeo). In October 1977, the Bangladesh Rice Research Institute sponsored a workshop devoted to the problems of rainfed rice production (BRRI 1978).

[illegible]

[illegible]

[illegible]

[illegible]

- [illegible]
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- [illegible]
- [illegible]
- [illegible]
- [illegible]

[illegible]

system to be used to aggregate the scores. It proved impossible to achieve a consensus on either the interpretation of the criteria or on the scores to be assigned to each problem area. It also proved difficult to get relevant data to score research problems with which they were not directly associated.

The productivity approach

An alternative approach based on productivity concepts was used to develop an appropriate resource allocation rule. Theoretically, in order to maximize the productivity of research resources, expenditures should be allocated so the *increase in productivity* from an additional amount of funds spent on research for each problem is equated. This rule requires the definition of research problems, the estimation of research productivity and related time lags, and the measurement of the extent of the area affected by a technology. To facilitate discussion a one to one correspondence between a *research project* and a *new rice farm technology* (RFT) is assumed. Success in a research project implies the development of a new RFT. A model taking account of time required to solve the problem, expected benefits, probability of success, area affected, direct costs of using the technology, and intensity changes was formulated.

Consider initially only research activities aimed at increasing rice yield per hectare. Suppose there is a probability of P_1 that successful completion of a project will result in Y_1 yield increase, a P_2 chance that the yield increase will be Y_2 and so forth over n yields. The expected yield increase then is:

$$E(\Delta Y) = \sum_{k=1}^{n} P_k Y_k \qquad (1)$$

If the project has a life of t years and the social rate of time discount is r, the present value of such an increase is:

$$PV(Q_j) = (1+r)^{-t} (E \Delta Y) \qquad (2)$$

Generalizing by letting the j subscript represent projects and ΔY_{jk} the yield increase expected with probability P_k, the present value of the yield increase per hectare is:

$$PV(Q_j) = (1+r)^{-t} \sum_k (\Delta Y_{jk} \cdot P_k) \qquad (3)$$

Recognizing that certain RFT are more productive in one season (wet, dry) than in another, this present value must be calculated on a per-hectare per-year basis.

Projects that can be confidently expected to give a stated yield increase but which will succeed in an uncertain number of years can be evaluated by letting the probability term represent the probability of success in a given number of years. Then

$$PV(Y_{ij}) = \sum_k (1+r)^{-t} (\Delta Y_{ijk} \cdot P_k) \qquad (4)$$

If both yield and years for success are uncertain, the two can be combined. For simplicity, the first formulation is subsequently used.

A RFT applicable in an environment which has a very large hectarage of rice will have a bigger impact than a technology applicable to a small area. This is reflected by multiplying the present value of the yield effect of the technology by the area affected to get the present value of the technology for, say, the area j

$$PV(P_{ij}) = (1+r)^{-t} \sum_k (\Delta Y_{ijk} \cdot P_k) \cdot A_j$$

Some research is directed at expanding the area on which crops are grown during a year. Cropping systems research, and work to find cultivars suited to adverse conditions fall in this category. In this case, the appropriate formulation would be:

$$PV(P_{ij}) = (1+r)^{-t} / \sum_k (\Delta Y_{ijk} \cdot P_k \cdot A_j) +$$

$$\sum_m (\Delta A_{ijm} \cdot P_m \cdot Y_j) / \qquad (5)$$

This formulation is suitable for evaluating yield and area increasing technologies that are continuous in use, but many new technologies entail some additional direct costs to the users, for example, fertilizer responsive varieties require the purchase of fertilizer. The benefit of such new RFT must be calculated net of the direct costs involved in their use. Once the possibility of costs is recognized, the benefits of the new RFT must be measured in monetary terms — a simple transformation of yield. Then, the net present value of technology i for area j is:

$$NPV(T_{ij}) = (1 + r)^{-t} \left[\sum_{k} (\Delta Q_{ijk} P_k A_i - C_j) + \sum_{m} (\Delta A_{ijm} P_m Q_i - C_j) \right] \quad (6)$$

where ΔQ_{ijk} equals ΔY_{ijk} times price, Q_i equals Y_i times price, and C_j equals the additional per-hectare cost involved in attaining the increased productivity of the jth technology in the ith environment.

With this formulation, the relative value of RFT that do not raise rice yields can be evaluated. For example, a RFT that reduces costs reduces the C_j term and can be directly evaluated using equation (6). The net present value, being measured per hectare per year, will reflect the productivity increase.

APPENDIX D

Notes on Sources of basic data for Appendix A, Table 1

Proceedings refers to *Proceedings of the International Seminar on Deepwater Rice*, August 1974, BRRI; *Upland to Major Research in Upland Rice*, IRRI, 1975.

India: See Appendix A Table 1 for sources and assumption, dry season area equals "summer rice."

Bangladesh: 20% in Deepwater, *Proceedings*, p. 7, irrigated area equal to irrigated aus + boro (11%) as given in *Bangladesh Economic Survey* 1974-75, Ministry of Finance, *Upland* p. 4, etc. 23% as upland, but description on p. 4 shows much of it is dry seeded lowland. That assumption 21% upland. Allocation made in table assumes difference between total rice and deepwater plus irrigated is equally allocated to three other categories. Dry season area is equal to boro area reported in *Bangladesh Economic Survey*.

Laos: 20% is upland, according to 1974 estimate by USAID. Yield estimates of same source area: upland 2.8t/ha, lowland 3.8t/ha, with provision that upland rice yields were well above long term average and the normal. Balance of total upland divided equally to irrigated, DRR and MDRR. Source: USAID A-569, February 14, 1975, USAID.

Malaysia: Source: *A Review of Current Status of Rice Production, Imports, Consumption in Malaysia*, MARDI Review Paper, August 1977. Assumed 90% irrigated area is 1/3 of dry season rice area, so total irrigated = 2/3 x dry season area; balance assumed shallow rainfed. For Sarawak same source gives upland area; balance assumed shallow lowland. Sabah assumed same as Sarawak.

China: Allocation indicated by recent statements on China, "90% irrigated," *Upland* reports 3% in 1961, in 1981, assumed constant %.

Korea: *Yearbook of Agriculture and Forestry Statistics*, Ministry of Agriculture & Fisheries, Republic of Korea, 1974. DRR assumed same.

Indonesia: Allocation to upland, deepwater, dry season estimated by R. A. Morris (personal communication, 5/19/81), based on data accumulated by World Bank. Difference between total and above three types allocated half to irrigated and 1/4 each to DRR, MDRR, Rel Lambar. Informed estimate opinion accumulated by J. Wimberly (personal communication, May 1981). Data from published

statistics of Department of Agriculture are not as complete, but very similar. Dry season area from official statistics (Yala).

Japan: "Rice Statistics in Japan," by Hayami and Kikuchi, from offered statistics.

Burma: Deepwater area reported in 1965 in Irrawaddy Division = 84,546 acres, the "main deepwater area of Burma;" other areas total 10,000 acres, according to [illegible], Aug.-Sept. 1977, 94,546 acres = 38,256 ha. Total, irrigated and dry ("winter") acreage from [illegible], 1974-75, 1975-76 and 1975-76, Burma, Ministry of National Planning, refer to 1972/73 and 1973/74 average.

Burma: Upland area derived from M. Y. Nuttonson, *The Physical Environment and Agriculture of Burma* by HIK, 1951/55. Balance allocated to SRF and MDRF in the same proportion as irrigated and deepwater.

Thailand: Y. Goonwan, A. Stamwalla, and D. Welsch, *Rice Production and Consumption Data* [illegible], Kasetsart University, Department of Agric. Econ., Staff Paper 14, June 1974 gives broadcast and transplanted areas. All broadcast assumed to "Central" region and assumed to be deepwater. Balance of "Central" assumed MDRF. South assumed MDRF, North and Northeast Thailand assumed SRF. Regional data from Div. Agric. Econ., Ministry of Agric. quoted in [illegible], [illegible] irrigated area of all crops from same source. Seventy five percent of irrigated area attributed to rice, 5% of irrigated rice area assumed to carry dry season crop, giving 6% of total rice as dry season, which agrees with conventional "guesstimate." Upland estimated at 10% total. MDRF and SRF allocated to remaining area in same proportion as DW and IRRIG.

Philippines: BAEcon data provide irrigated, semi-irrigated, and upland areas. Retained semi-irrigated (upland). Dry season is taken as second crop lowland area, which is given in BAEcon data. Source is [illegible], Philippines.

Vietnam: Allocation among types based on reply of L. P. Nhon to questionnaire on basis of his informed estimate of situation about N. Vietnam. Both given same allocation, though likely overstatement deepwater, understatement irrigated area.

Pakistan: All assumed to be irrigated, equivalent to dry season culture in NE Asia.

Nepal: Breakdown based on GSK's field trip report Oct. 9-13, 1973. All rainfed area assumed to be shallow rainfed, 128,000 ha in hills with temperate climate, rest in Tarai.

Brazil: *Upland* shows 77% in upland rice, balance assumed equally distributed to irrigated and MDRF.

Colombia: Grant Scobie, *Costs and Returns to Rice Research*, Consequences Discussion Paper No. 11 1976 shows yield and production data that result in this allocation.

USA: Assumed.

Egypt: Assumed.

Sierra Leone: *Upland* shows 60% upland, balance equally allocated to irrigated BRF, MDRF.

Guinea, Ivory Coast: Same as for Sierra Leone.

Madagascar: Upland area given in *World Rice Statistics* for 1961 balance allocated equally to other types.

Iran and Afghanistan: Judgment of WRC.

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