REDUCING MALNUTRITION
IN DEVELOPING COUNTRIES:
INCREASING RICE PRODUCTION
IN SOUTH AND SOUTHEAST ASIA

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The Trilateral Commission
A Private North American-European-Japanese
Initiative on Matters of Common Concern

Summary of report on pages XI-XIV
This report was prepared for the Trilateral Commission and is released under its auspices. It was discussed at the Trilateral Commission meeting in Bonn, on October 22-25, 1977. The authors, who are experts from North America, Western Europe and Japan, have been free to present their own views. The Commission will utilize the report in making any proposals or recommendations of its own. It is making this report available for wider distribution as a contribution to informed discussion and handling of the issues treated.

_The Trilateral Commission was formed in 1973 by private citizens of Western Europe, Japan, and North America to foster closer cooperation among these three regions on common problems. It seeks to improve public understanding of such problems, to support proposals for handling them jointly, and to nurture habits and practices of working together among these regions._

THE TRILATERAL COMMISSION

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REDUCING MALNUTRITION
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Report of the
Trilateral North-South Food Task Force
to
The Trilateral Commission

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The Trilateral Process

The report which follows is the joint responsibility of the three authors. The authors owe much to an earlier study undertaken by Saburo Okita and Kunio Takase — *Doubling Rice Production in Asia* (Tokyo: Overseas Economic Cooperation Fund, 1976). The authors also wish to acknowledge the assistance of four special consultants who worked closely with the authors in preparation of this report. Aside from Dr. Okita, now Chairman of the Japan Economic Research Center, and Dr. Takase, who recently moved to the Asian Development Bank as Deputy Director of Projects Department I, this group included Yuijo Hayami, Professor of Economics at Tokyo Metropolitan University, and Kenzo Henmi, Dean of the Faculty of Agriculture at the University of Tokyo.

A full draft of the report was presented by Umberto Colombo, D. Gale Johnson and Saburo Okita to the Trilateral Commission plenary meeting in Bonn in October 1977, where it was recommended that follow-up measures be taken on the recommendations in the report. Subsequently the Commission invited further comments on the report from individuals and organizations involved in this area. Overall, a wide range of experts were consulted by the authors and special consultants either before or after the October 1977 meeting in Bonn. In each case, consultants spoke for themselves as individuals and not as representatives of any institutions with which they are associated. Those consulted include the following:

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Patricia Young, Consultant, National Council of the Churches of Christ, USA

Montague Yudelman, Director of Agriculture and Rural Development, International Bank for Reconstruction and Development
SCHEDULE OF TASK FORCE ACTIVITIES:

March 10, 1976 — Shishido meets with Brzezinski, then Director of the Trilateral Commission, in New York City.

July 19 — Shishido and Japanese consultants meet in Tokyo to consider overall nature of report.

September 22 — Shishido, Hayami, Henmi and Takase meet in Tokyo.

October 31 — Authors meet in Paris to develop task force concerns.


January 31 — Shishido, Hayami, Henmi and Takase meet in Tokyo.

February 25 — Shishido, Hayami, Henmi and Takase meet in Tokyo.

March 18 — Shishido and Japanese consultants meet with Johnson in Tokyo to consider existing draft chapters.

June 6 — Shishido, Hayami, Henmi and Takase meet in Tokyo to consider draft of first four chapters and prepare for Manila meeting.

July 18-19 — Colombo visits experimental rice research stations and meets with James Johnston in Bangkok.

July 21 — Authors, Hayami, Henmi and Takase meet in Manila.

July 22-23 — Authors, Hayami, Henmi and Takase meet in Manila with agricultural experts from South and Southeast Asia to discuss draft of first four chapters.

July 24 — Authors, Hayami, Henmi and Takase meet in Manila to review wider discussions and discuss nature of final chapter.

Early September — Full draft completed for discussion at Bonn meeting.

October 24 — Full draft discussed in Trilateral Commission plenary meeting in Bonn.

January 19, 1978 — Colombo meets with experts at Food and Agriculture Organization headquarters in Rome.

February 25 — Colombo and Okita meet with experts in Paris.


March 20 — Yamamoto meets with Asian Development Bank experts in Manila.

June 13 — Colombo, Johnson and Okita report on follow-up activities to the Trilateral Commission plenary meeting in Washington.

June 13 — Colombo, Johnson, Okita and Henmi meet to review final text in Washington.
SUMMARY OF THE REPORT

Reducing Malnutrition in Developing Countries: Increasing Rice Production in South and Southeast Asia

Over the last hundred years, the extent of starvation and famine in the world, extreme indicators of poor health and nutrition, has diminished considerably. Nevertheless, the extent of malnutrition and hunger is a global problem of the first order. According to the assessment prepared for the 1974 World Food Conference in Rome, at least 460 million human beings are malnourished in developing market economies.

Solid progress in dealing with malnutrition will depend on action on many fronts, in a great variety of national and local situations. Improvements in income distribution and food distribution are of much importance. For the very poorest of the world’s population, increased food production and lower food prices alone will not be sufficient to eliminate malnutrition. Unless their incomes are increased, they will continue to receive less than adequate nutrition, even if commercial demand is being satisfied at reasonable prices. Rapid population growth multiplies problems concerning food and other fundamental human needs; population planning should be an integral part of social and economic development.

While progress on these fronts is necessary, strategies can be most readily implemented and have the most immediate impact in lessening the food deficit in the area of increasing food production, and reducing crop and food wastes. Increasing food production is itself a very complex process, involving more intensive and extensive use of land and water, increased availability of basic agricultural inputs (e.g. fertilizers), appropriate agricultural policies and rural institutions, and expanded agricultural research. The potential for increasing food production in the developing countries is substantial, if the effort is made.

This report focuses on increasing rice production in South and Southeast Asia. About two-thirds of the world’s malnourished live in this area. The 1985 “gap” between projected food demand and extrapolated food production in developing countries is concentrated in rice in Asia. While it is necessary to substantially increase production of all food crops in South and Southeast Asia in the coming years, rice is the staple food of most of Asia (72 percent of foodgrain consumption). Agronomically it is the most suitable crop for a monsoon

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climate such as that found over most of Asia, and it offers the highest yield among food staple cereals per unit of arable land.

The productivity of rice cultivation in Asia remains low, while at the same time the potential for production increases is quite high. Japanese rice yields now average about 6 metric tons per hectare, while the average in South and Southeast Asia is still only about 2 tons per hectare. The history of Japanese agriculture provides the clearest example of what can be seen as a four-stage progression in agricultural development, from primitive rice farming in the first stage to the structural transformation of the rural economy in the fourth. In any attempt to raise significantly overall Asian production of rice, the South and Southeast Asian nations, which have generally not yet completed the first two stages, deserve attention first. The latecomers have advantages in accelerating the development sequence found in Japan and a few other neighboring countries, and it may not be impossible for the tropical Asian countries to double their rice production within fifteen years.

The major factors affecting increased rice productivity include the use of modern high-yield varieties, fertilizer, and agricultural chemicals; irrigation; and the improvement of rural institutions. There is a particularly close correlation between the irrigation rate and mean national productivity of rice cultivation. Such a correlation does not itself establish a causal link. Other factors interact with good water control, such as use of modern varieties and more fertilizer, in lifting yields. Nevertheless, adequate water control can be considered a basic prerequisite for full exploitation of modern rice production practices. Asian experts on rice production generally accept the idea that expansion and improvement of irrigation — adequate water control — is the most important factor in increasing rice production.

In order to find the most economical approach for irrigation development a series of careful and critical cost analyses have been made of several alternatives, based on recent experience in Asia. In general, all methods starting with previously uncultivated land are shown to be not advisable, because they cost more and take more time. The lowest capital costs for increasing paddy production by 1 ton per hectare per year are, first, in improving inadequately-irrigated land to adequately-irrigated land and, second, in improving rainfed cultivated land to adequately-irrigated land. The shift from inadequate to adequate irrigation facilities in most cases requires primarily digging out farm ditches, maintenance of ditches, and good management of water supplies. There is no need for large capital investments. This may be a departure from the traditional idea of "irrigation development," but it has major economic advantages and can be considered an approach
within which “appropriate” technology is suitably applied.

On the basis of this analysis, the report proposes a fifteen year international program for doubling rice production in South and South-east Asia, focused on irrigation improvement as the leading factor in generating production increases. The emphasis is basically on farm ditch construction neglected in the past. The core of the program is the conversion of 30.4 million hectares of rainfed areas and 17.5 million hectares of inadequately-irrigated areas to adequately-irrigated areas in the fifteen years ending in 1993. The total capital cost of this effort is estimated at $52.6 billion in 1975 prices ($7 billion for conversion of inadequately-irrigated land, $45.6 for conversion of rainfed land), plus $1.4 billion in associated costs — a total of $54 billion, or 3.6 billion per year.

Our best guess of current annual budgets for irrigation in South and Southeast Asia is $1.7 billion (in 1975 prices), including foreign exchange granted or loaned from abroad — about one-half of the annual cost of the proposed program. In order to achieve the 1993 target, it is proposed that developed countries and OPEC countries provide increasing levels of capital resources (along the lines presented in Table 5), while the developing countries in the area continue their utmost efforts to share the burden. It may not be unrealistic to catch up with the required annual investment level around 1985. With subsequent increases, the average annual irrigation investment would reach $3.6 billion for the entire period to 1993. It must be stressed that we recognize that these improvements in water control will not automatically and in themselves bring about the desired production increases. A wide range of actions will be needed, including the critical need to develop rural institutions. The difficulty in achieving social change, however, should not lead to defeatism about the prospects for the program proposed here. The institutional innovations would not be likely to emerge unless public investments in irrigation and progress in agricultural technology increase the profitability of making such innovations.

The proposed plan will have the effect of injecting a momentum into rural society for inducing institutional innovations. Today, unless a major effort is made to increase food production in the form of a feasible program, we are bound to lose what is now a dead heat between population and food supply; this will result in greater misery and greater social injustice.

The proposals in this report must take more concrete shape as implementation occurs. But implementation cannot be assumed to result directly from this report or any other report, for that matter. A series of follow-up activities at many levels must be carefully planned and
executed if the proposals are to achieve their potential for reducing malnutrition in the developing countries. Developing countries must take the primary responsibility for preparing plans for expanding and improving irrigation facilities, as well as for modification of domestic policies and programs required to facilitate effective use of the expanded irrigation facilities. Developed countries and international agencies have the responsibility for creating the necessary mechanism for the transfer of resources, and for facilitating the speedy approval of appropriate projects for agricultural growth and improvement in the developing countries.
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I. GENERAL VIEWS ON WORLD FOOD PROBLEMS

The elimination of malnutrition and hunger, with the objective of providing sufficient food of acceptable quality to each individual, is one of the most urgent problems of our time. According to the assessment document for the 1974 World Food Conference, at least 460 million human beings in developing market economies are malnourished. Approximately two-thirds of the malnourished live in South and Southeast Asia. Food shortages at the individual level in industrialized countries are obviously far less severe, although approximately 3 percent of their population is estimated to live below maintenance levels.

A. FOOD SITUATION OF DEVELOPING COUNTRIES

Table A (page 47) projects commercial demand for food and extrapolates food production for various regions and groups of countries through 1985. In developing countries, demand is projected to increase more rapidly than production: 3.4 percent per annum compared to 2.6 percent. To meet commercial demand through 1985, these countries will require an increased rate of growth in food production and/or increased imports. If the entire difference between projected cereals demand and extrapolated cereals production in these countries were to be covered by imports, this would amount to cereals imports by developing market-economy countries of about 85 million tons per year by 1985 (Table 2, page 10), an import total which could certainly exceed their payment capacity. On the other hand, there will be great difficulties in bridging such a gap solely by increasing food production in these countries. Despite overall production increases, per capita food production in developing countries has remained almost static in recent years. In the developing market economies, where the malnutrition problem is most acute, the average annual growth rate of per capita food production declined from 0.7 percent in 1952-62 to 0.2 percent in 1962-72 (Table B, page 48).

A basic distinction must be made between commercial food demand and nutritional requirements. Many of the malnourished have incomes that are not adequate to purchase enough food to meet their nutritional

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requirements. For the very poorest of the world’s population, increased food production and lower food prices alone will not be sufficient to eliminate malnutrition. Unless their incomes are increased, the very poor will continue to receive less than adequate nutrition, even if commercial demand is being satisfied at reasonable prices.

Setting this current picture into a wide historical perspective, we should keep in mind that starvation and famine, extreme indicators of inadequate health and nutrition, are diminishing. During the last quarter of the 19th century, 20 to 25 million persons died from famine, whereas throughout the first three quarters of the 20th century the number of deaths by starvation is estimated in the range of 12 to 15 million. This decline is related to the improvement in per capita food availability. Other important factors are improvements of communication and transportation, as well as general sanitary conditions. As a result of all these developments, life expectancy at birth has increased dramatically in the developing countries.

In the developing countries with market economies, per capita food availability, in caloric terms, has increased from 93 percent of the estimated requirement in 1961 to about 97 percent in 1969-71. This is due to growth in both food production and imports. It is estimated that a further 10 percent increase in the per capita availability of calories and proteins will be achieved by 1985 if projected commercial demand is met. However, taking into account the great disparities in income and food distribution within countries, an extremely large number of persons will remain malnourished in 1985.

Further progress in dealing with malnutrition will depend to a great extent on improvements in income distribution and food distribution, both among income groups and among different regions within a given nation, so that the malnourished may have more food. Changes in income distribution may require political and economic reforms which do not appear imminent in many areas. Nevertheless, since many of the poorest people live in farm areas, increasing farm productivity, which will be stressed in this report, could have favorable effects upon the incomes of many who are malnourished as well as increase production.

The food problem is closely linked with that of the rapid rate of population growth in the developing world, although population growth

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3 Op. Cit., *Assessment of the World Food Situation*, p. 58-60. These are average figures. In some countries, per capita food availability, in caloric terms, was less than 90 percent of the required level, even in 1969-71.
actually multiplies existing problems concerning food and other fundamental human needs rather than being their basic cause. The mere introduction of contraceptive measures in developing countries is not sufficient to decrease the birthrate. Even this step will itself be difficult if women are malnourished and more prone to infections and diseases, or if they are far from medical facilities. More broadly, if infants are without adequate food, medical care, or sanitation, with a resulting higher infant mortality rate, families often seek to have more children, so that at least one child can be educated and survive to take care of the parents when they are old. Population or family planning should thus be considered as an integral part of social and economic development, together with improved nutrition, availability of health services, educational facilities, and welfare provisions for the old.⁴

B. INCREASING FOOD PRODUCTION IN DEVELOPING COUNTRIES

Those areas where strategies can be most readily implemented and can have the most immediate impact in lessening the food deficit are 1) increasing food production in developing countries and 2) reducing crop and food wastes. These areas are stressed in the report.

- Increasing food production is a very complex process, involving both more extensive and more intensive use of land and water, increased availability of basic agricultural inputs (such as fertilizers and pesticides), appropriate agricultural policies and institutions, and strengthened agricultural research. It should be firmly kept in mind that the yields of cereals and other crops throughout the world are far from uniform, reflecting the uneven current distribution of agricultural inputs and skills.

- Reducing the present waste in the entire food system, from production at the farm to final consumption, requires substantial improvements in post-harvest processing, transportation and storage systems, and control of pests. We do not include reliance by developing countries upon international food aid as a suitable long-term measure for reducing the food deficit. While appropriate for problems of instability of production in developing countries, and for partial payment of wages in implementing development support projects, large-scale international food aid on a more or less per-

⁴ This does not mean present population planning in the developing countries is not a necessary measure for solution of the food problem. The development of improved agriculture and population planning must go hand in hand.
manent basis is a problematic solution, since such aid has often discouraged local food production. Another factor to be kept in mind is that food policy in developing countries has to be compatible with other policies of national economic development in these countries. Especially in pursuing policies concerning exchange rates, and foreign and domestic trade and prices, the governments of developing countries have to take into serious consideration the need to reduce their food deficits. At the same time, it would be in rather bad taste to restrict critical policy examination solely to the policies of the developing countries when all the industrial countries have domestic and trade policies that affect export earnings of the developing countries.

1. Higher Yields from Already Cultivated Land

The cultivation of new land is an obvious way to increase food production, but probably not the most effective way. The main cultivated and cultivatable land areas of the world are listed in Table 1. Worldwide, only 60 percent of the potentially arable area is actually cultivated; but one of the regions of severe malnutrition, South Asia, unfortunately has the least amount of unused arable land remaining. The regions capable of the greatest expansion of arable land include the Southern Sudan, the tsetse-infested area of Central Africa, and the basins of the Amazon, Mekong, and Volta.

It is likely that most developing countries will find it more effective for the time being to increase food production through higher yields from already cultivated land, rather than by expanding agriculture into new areas. Land development costs, particularly in areas where investments must be made for extensive resettlement facilities and for irrigation and erosion control, greatly limit the feasible rate of expansion of cultivation into new areas in many developing countries. Moreover, there are many obstacles to the cultivation of new areas in the tropics. Tropical agronomy is still relatively underdeveloped, and it is difficult to adapt agricultural techniques developed in temperate zones to the requirements of tropical land that is easily deteriorated by heavy rainfall and by scorching sunshine. The problem of loss in soil productivity caused by such leaching has not been overcome. In addition, manure in tropical areas is less effective than in temperate zones, and soil in the tropics does not cohere well, making erosion a constant danger. These difficulties contribute to the farmers’ reluctance to depart from the traditional “slash and burn” method of cultivation. Damage by insects and diseases may well be more serious in the tropics than in temperate zones. The maintenance of ecological balance will be a real problem in new tropical agricultural areas.
### TABLE 1
Potential Cultivable Land Compared with Present Cultivated Land

<table>
<thead>
<tr>
<th>Region (popul. in millions)</th>
<th>Cultivated Land,* 1970 (mil. ha)**</th>
<th>Cultivable Land (mil. ha)</th>
<th>Percentage Cultivated</th>
<th>Cultivated Land Per Capita (ha)</th>
<th>Cultivable Land Per Capita (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Asia</td>
<td>(716)</td>
<td>197</td>
<td>195</td>
<td>101.0***</td>
<td>0.27</td>
</tr>
<tr>
<td>East and Southeast Asia</td>
<td>(317)</td>
<td>72</td>
<td>115</td>
<td>62.6</td>
<td>0.22</td>
</tr>
<tr>
<td>China (PRC)</td>
<td>(760)</td>
<td>111</td>
<td>113</td>
<td>98.2</td>
<td>0.15</td>
</tr>
<tr>
<td>Other Asian centrally planned countries</td>
<td>(36)</td>
<td>5</td>
<td>11</td>
<td>45.4</td>
<td>0.13</td>
</tr>
<tr>
<td>Near East</td>
<td>(171)</td>
<td>85</td>
<td>88</td>
<td>96.6</td>
<td>0.49</td>
</tr>
<tr>
<td>North Africa</td>
<td>(36)</td>
<td>19</td>
<td>39</td>
<td>48.7</td>
<td>0.53</td>
</tr>
<tr>
<td>East and West Africa</td>
<td>(199)</td>
<td>135</td>
<td>228</td>
<td>59.2</td>
<td>0.68</td>
</tr>
<tr>
<td>Central Africa</td>
<td>(186)</td>
<td>29</td>
<td>169</td>
<td>17.1</td>
<td>0.80</td>
</tr>
<tr>
<td>South America</td>
<td>(190)</td>
<td>87</td>
<td>540</td>
<td>16.1</td>
<td>0.45</td>
</tr>
<tr>
<td>Central America and Caribbean</td>
<td>(93)</td>
<td>38</td>
<td>52</td>
<td>73.0</td>
<td>0.40</td>
</tr>
<tr>
<td>North America</td>
<td>(227)</td>
<td>236</td>
<td>274</td>
<td>86.1</td>
<td>1.03</td>
</tr>
<tr>
<td>Europe</td>
<td>(462)</td>
<td>144</td>
<td>180</td>
<td>80.0</td>
<td>0.31</td>
</tr>
<tr>
<td>Oceania</td>
<td>(15)</td>
<td>45</td>
<td>70</td>
<td>64.3</td>
<td>3.00</td>
</tr>
<tr>
<td>Other developed market economies</td>
<td>(127)</td>
<td>18</td>
<td>28</td>
<td>64.3</td>
<td>0.14</td>
</tr>
<tr>
<td>USSR</td>
<td>(243)</td>
<td>233</td>
<td>352</td>
<td>66.1</td>
<td>0.95</td>
</tr>
<tr>
<td>TOTAL</td>
<td>(3628)</td>
<td>1454</td>
<td>2454</td>
<td>59.2</td>
<td>0.40</td>
</tr>
</tbody>
</table>


* Cultivated land is measured in terms of crop area, and may exceed the physical area in cases of multiple cropping.
** 1 hectare (ha) = 2.471 acres.
*** South Asia is an area of extensive multiple cropping, and the ratio of cultivated to cultivatable land exceeds one.

### 2. Importance of Good Water Management

Doubling the yield of staple crops such as cereals with the modern high-yielding varieties (MVs) is possible on existing agricultural land with improved water management and adequate provision of fertilizers and other supplies — the essence of the "green revolution." The new high-yielding varieties of crops are very responsive to good water management in particular. The total amount of irrigated area in developing countries in 1975 was 92 million hectares, about 14 percent of the total cultivated area in these countries (Table C, page 49). According to FAO, many irrigation systems are operating at less than 50 percent efficiency.

The expansion and improvement of irrigation and drainage systems require much capital, though generally less than development of new agricultural land with such systems. Renovating one half of the existing
irrigated area in the developing market-economy countries (45.0 million hectares) was estimated in 1975 to cost $22.6 billion (500/ha), while $61.6 billion is the estimated cost for creating irrigation systems on 22.2 million hectares of non-irrigated cultivated land ($2,500/ha). The cost of drainage improvement for 78.1 million additional hectares is estimated at $13.7 billion ($175/ha). These drainage improvements relate to flooding deltas, on which tens of millions of Asians are living and where wide variations in water depth block introduction of the new high-yielding varieties. A total of almost $100 billion (1975 prices) would therefore be necessary, FAO has estimated, for improvement or expansion of irrigation and drainage to meet the increasing demand for food in the period to 1990.5

The present rapid depletion of groundwater resources may soon lead to widespread local shortages in many developing countries. In fact, the water potential for these countries is not well known and there is an urgent need to perform water resource surveys, covering underground water systems as well. Such surveys are essential for regional planning and development, as they would indicate areas amenable to irrigation and intensive agriculture.

3. Increased Fertilizer Use and Integrated Pest Control

Only about 15 percent of the world production of nitrogen, phosphate and potash fertilizers in 1972/73 was consumed in the developing world. According to a conservative estimate, fertilizer consumption (nitrogen and phosphates) must at least be doubled in developing areas from 1972/73 to 1980/81, if food production is to continue to increase slightly faster than population growth.6 In many developing countries the price of fertilizer is too high relative to the price of farm products, and there is no incentive for farmers to use more fertilizer.

Although it is difficult to assess crop losses, it is generally agreed that more effective control of pests could result in a measurable increase in the food supply of the developing countries, with only a moderate increase in cost. The use of pesticides and herbicides can be effective in reducing the losses due to pests. However, their use involves problems of various kinds, arising from their toxicity and from the progressive genetic adaptation of pests to existing products, and it would

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be a mistake to assume that the short-run or immediate benefits derived from the use of presently available pesticides and herbicides would continue indefinitely. A more enduring approach to the problems of pest control is given by integrated methods that combine biological, chemical, crop manipulation and pest surveillance techniques. Large-area management may prove desirable for the introduction of these methods.

4. Increased Agricultural Research in Developing Countries

In the developing countries research remains one of the weakest links in the agricultural process. Less than 0.25 percent of the agricultural GNP is currently spent on agricultural research in the developing nations, compared to 1-2 percent in the industrialized countries. This is obviously unfortunate, because it is in the developing countries that the benefit of research could now be most important. Agricultural research and development must be built up in, and on behalf of, such countries.

The necessity of developing technology for specific socio-economic environments is illustrated in the use of modern, high-yielding varieties (MVs). In some cases, MVs developed elsewhere were particularly susceptible to local pests or not suited to other local conditions. To overcome some of these limitations, crossing of the original MVs with local, more resistant varieties is required.

5. Appropriate Agricultural Policies and Rural Institutions

Agricultural policies and reform should be viewed from the perspective of general economic and social development, particularly in terms of their potential for reducing malnutrition through increasing production and incomes, and for creating conditions that will result in a more uniform distribution of resources, both human and non-human, income and food.

The control of land is important in this process, because the tenure systems in agrarian societies have much to do with perpetuating the economic and social relationships associated with the vicious circle of continuing poverty, low incomes and low productivity. In fact, in poor agrarian societies, land is the main source of wealth. As a result, the control over land largely determines the distribution of income, wealth and power in backward agricultural areas. Obviously, income from land cannot be realized without labor, and thus the distribution of property rights in land is necessarily accompanied by a system of interpersonal and intergroup relationships, associated with the power
to make others follow one's will. These local social systems establish the penalties or incentives and rewards that producers receive for changing farming methods. They set the limits on the peasant farmer laborer's participation in the development process.

Therefore, the concept of agricultural development which underlies this report includes more than just per capita growth in output. Agricultural development may be viewed as widening the economic opportunities for the mass of people in the agricultural sector, reducing poverty and elevating the conditions of life among rural populations.

Land reform alone has no necessarily positive effect on raising production per unit area, particularly if the appropriate inputs are not made available to the new landowners. Governments should additionally provide a political and economic setting in which the basic material inputs to agriculture are made available at reasonable prices. Governments often protect domestic industries, such as those providing fertilizer and farm tools and equipment, resulting in higher prices being paid by farmers for these inputs. In addition, many developing countries have price policies that discourage agricultural production by permitting wide variations in crop prices and by interfering with the market to depress the prices received by farmers.

Where farms are small and the families engaged in agriculture are poor, the modernization of agriculture often requires positive steps to assist those who are at the greatest disadvantage. Particular attention should be given to the availability of credit on reasonable terms, not just for the most prosperous farmers, but for those with small farms and limited incomes. Extension programs should be designed to serve the small farmers so that they will have ready access to information concerning improvement of crop yields and efficient use of new inputs. In many countries, small farms are operated under share-leasing arrangements that may inhibit the use of purchased inputs such as chemical fertilizers and insecticides. Through educational efforts and, if necessary, legislative actions, the sharing of such expenses between the tenant and landlord should be encouraged. As the technology of agriculture changes, as is happening in many developing areas and as must happen in all if nutrition is to be significantly improved, many existing institutions and arrangements need to be changed and modified to meet new conditions.

Effective systems for marketing and processing of crops and food products are necessary for increasing food availability, in addition to limiting losses from other causes. Government action to reduce losses in these marketing and post-harvest processing systems must be taken, in addition to measures for consumer education in nutrition and for continued improvement of sanitary conditions.
On the part of industrial countries, there has been a reluctance to reduce trade barriers to imported agricultural products from the developing nations. This attitude must change if the developing countries are to be in a position to obtain more of the necessary agricultural supplies, and in some cases food, through the international trading system rather than through aid.

C. SUMMARY

There are a variety of means for reducing the food deficit in developing countries: slowing the rate of population growth; achieving a more equal distribution of food and income; increasing food production; and reducing waste. Strategies to increase food production and reduce waste can be most readily implemented and are the ones that are stressed in this report.

The potential for increasing food production in the developing countries is substantial, if the effort is made. In some areas more land can be cultivated. In other areas there are major opportunities for increasing production by expanding and improving water control systems. In all areas, increased research, improved supplies of modern farm inputs, and modifications of agricultural policies and institutions can contribute to a significantly more rapid rate of growth of food production than has been achieved in the past.

In the rest of this report we narrow our emphasis from world food problems to the particular problems of Asia and, more specifically, the possibilities of achieving a large increase in rice production in South and Southeast Asia in the next fifteen years. We believe that this is the most fruitful way to indicate that a positive and feasible program can make a significant contribution to the improvement of nutrition and incomes in the developing countries. We are confident that similar programs could be devised for other regions of the world.
II. WHY FOCUS ON ASIA, ESPECIALLY RICE PRODUCTION IN ASIA?

A. WHY FOCUS ON ASIA?

In this report we feel that we should not simply warn the world about the gravity of food problems. We should also come up with concrete proposals on ways to tackle these problems. We propose that our efforts be focused on the production of rice in South and Southeast Asia. As mentioned at the outset, approximately two-thirds of the world’s malnourished live in South and Southeast Asia. At the same time, there is great potential for quantitative increases in food production. Moreover, as Table 2 indicates, the projected cereals deficit in developing market economies is particularly concentrated in Asia and in rice. The postwar trend of increasing imports of grains into Asia supports this position.

Some Asian nations have overemphasized industrialization at the expense of agricultural development. This, in an attempt to improve income levels, in turn forced heavy reliance on foreign food aid. Here we must stress the contradiction in the idea of industrialization without the support of increased purchasing power of the agrarian population. Increases in food production in Asia will increase the rural income level, which should, in turn, contribute to the broadening of markets.

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**TABLE 2**

Cereals Deficits in Developing Market Economies, 1969-71 and Projection to 1985  
(million metric tons)

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Africa</td>
<td>-2</td>
<td>-3</td>
<td>-1</td>
<td>-1</td>
<td>-1</td>
<td>-17</td>
<td>-4</td>
<td>-21</td>
</tr>
<tr>
<td>Latin America</td>
<td>-4</td>
<td>-13</td>
<td>0</td>
<td>+1</td>
<td>+8</td>
<td>+17</td>
<td>+4</td>
<td>+5</td>
</tr>
<tr>
<td>Near East</td>
<td>-6</td>
<td>-6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>-14</td>
<td>-6</td>
<td>-20</td>
</tr>
<tr>
<td>Asia &amp; Far East</td>
<td>-8</td>
<td>+3</td>
<td>-2</td>
<td>-39</td>
<td>0</td>
<td>-13</td>
<td>-10</td>
<td>-49</td>
</tr>
<tr>
<td>TOTAL</td>
<td>-20</td>
<td>-19</td>
<td>-3</td>
<td>-39</td>
<td>+7</td>
<td>-27</td>
<td>-16</td>
<td>-85</td>
</tr>
</tbody>
</table>

for industrial products in Asia, as well as improve the local supply-demand balance for food.

Improvement of rural income levels through increased food production can be anticipated to exert a positive influence on the birthrate. In Asia, where many governments are promoting family planning as their national policy, it is becoming increasingly apparent that improvements in income levels, nutritional levels and agricultural productivity will contribute to constructive effects of planned parenthood programs. In most of the developing countries of Asia, increases in food production, if indeed they have occurred, have been so slow as to be largely offset by population growth. This has not allowed increases in per capita income, which, in turn, has contributed to the maintenance of high birthrates; in other words, a vicious circle has prevented progress. And it is only after an increase in food production that will raise peasant income and consequently lower birthrates that this circle can be broken. Food production in Asia thus acquires implications far beyond mere fulfillment of demand.

Some Asian governments believe that an increase in regional self-sufficiency in food is a necessity. The Association of Southeast Asian Nations (ASEAN) is a principal feature of regional cooperation among Asian nations — including the Philippines, Indonesia, Singapore, Malaysia and Thailand. ASEAN has gradually come to realize its own significance as a basis for economic self-reliance on the regional level. In specific regard to the food issue, it is hoped that ASEAN will initiate a collective self-reliance policy by such means as encouragement of production increases of promising crops.

There is a large gap between current food production in Asia and potential output from the same land. Furthermore, existing human resources should enable the process of introducing more sophisticated technology to be smoother in Asia than elsewhere. In Latin America, Africa, and the Middle East, overall production can be boosted by the expansion of cultivated land, whereas in Asia fuller utilization of existing farmland must be emphasized, through input-intensive methods. As illustrated in Table 1 (page 5) Asia has the smallest hectarage of cultivated land per capita in the world, and will remain in that position into the 21st century.

B. WHY FOCUS ON RICE PRODUCTION?

Among the three most important grains in the world (wheat, rice and corn), rice has not yet shown any revolutionary production development comparable to the other two: the revolution in corn production in the United States from 1935 to 1965, and the revolution in wheat
production in Asia in the 1960s. World rice production is heavily
centricated in Asia, and represents the staple food of Asians. About
72 percent of foodgrain consumption in Asia is rice, whereas it is 55
percent and only 13 percent in the developing world and the developed
world, respectively, including Asia (Table D, page 50). Rice is, agro-
nomically speaking, the most suitable crop for a monsoon climate such
as that found over most of Asia. It is, in fact, one of the most promis-
ing crops for production increases.

1. Other Food Crops

Here we should make it clear that by no means do we intend to neglect
the importance of production increases of other crops such as wheat,
sweet potatoes, cassava, maize and so forth in Asia. Tens of millions of
the poorest people of Asia are not rice eaters and are unlikely to become
so in the foreseeable future. There are large numbers of people who
depend to a major extent upon grains other than rice, or even wheat,
namely the sorghums and millets and related grains. As of the mid-
1970s in the Asian area under consideration, rice production (in terms
of milled rice) represented approximately 60 percent of total grain
production. While it is necessary to achieve a substantial increase in
the production of all food crops in South and Southeast Asia during
the remainder of this century, the problems of achieving significant
increases vary from crop to crop. The new high-yielding varieties of
wheat have contributed more to increased grain production in South
Asia than have the new high-yielding varieties of rice. This greater
contribution is due, at least in part, to the greater ease and lower cost
of expanding irrigation suitable for wheat rather than for rice. Un-
fortunately, there has been little success in expanding yields and produc-
tion of the grains grown under limited rainfall conditions and where
irrigation is not feasible. Increased production of the sorghums and
millets, if it can be achieved, will depend upon research to develop
new varieties and new cultural methods to improve the utilization of the
available moisture. It is our view that such crops as the sorghums and
millets should receive a great deal of attention from research institutions
in the hope that yields can be increased from their current low levels in
much of Asia. We do not want to leave the impression that large
increases in production of grains and food crops other than rice will be
easy to achieve. However, the capital requirements for expanding rice
production are much greater than for the other food crops.

1 Rice production in Japan, Taiwan and South Korea has shown revolutionary
development, as discussed at the end of this chapter. However, this has not
substantially changed the food situation in Asia.
2. Advantages of Focus on Rice

While recognizing the importance of other cereals, we nevertheless feel that we should concentrate our attention on the production of rice in view of the following factors:

First, the overall projected 1985 cereals deficit of 85 million tons in Table 2 (page 10) hides some important regional and commodity differences which have implications for policies and actions. The rice deficit will emerge as the biggest problem globally, and appears to be a problem almost solely confined to the Asian region. (The extent of this deficit is based on current consumption patterns which can change, of course, under pressure of shortage and high prices.) Furthermore, the rice deficit does not seem to be amenable to correction through imports of this commodity. There is an urgent need for further work to achieve a breakthrough in rice production in Asia.

Second, for the vast lowland areas in monsoon Asia, rice offers the highest yield among food-staple cereals from a fixed measure of arable land. Worldwide patterns of dependence on rice and/or wheat are the result of a long history of choice and selection; they reflect both consumer preference and costs of production. It seems safe enough to predict that patterns of reliance on these two crops will persist. In Asia, concentration on rice has enabled the region with the smallest cultivated land per capita to supply most of the nutritional needs of an enormous population. Moreover, since rice is superior in its protein quality to wheat, dietetic standards can be maintained with less need for supplementary foods.

The improvement of income levels leads toward higher dependence on animal protein, but peoples living on rice increase their consumption of animal protein much slower than peoples living on wheat. Except for those who depend for their meat consumption entirely on grass-fed livestock, meat-eating nations, in order to maintain their level of calorie intake, have to produce substantial amounts of cereals for animal feed, quite aside from those for human food. When compared on the primary calorie level, i.e., total caloric intake including that of animal feed, an American consumes roughly 10,000 calories a day, while a Japanese who lives primarily on rice uses only 5,000 calories. By the same token, an Indian perhaps consumes as little as 3,000 calories per day. It must therefore be remembered that not only does rice yield higher quantities per unit of arable land, but that it will maximize the number of human beings maintained per unit of arable land.

3. Potential for Increasing Rice Yield

The productivity of rice cultivation in Asia remains low, while at the
same time, the potential for production increases is quite high. Japan and a few neighboring countries already enjoy the advantages of a fairly highly developed rural economy; the need now is for a large investment in the rest of the region in a transformation of the entire rural production system, so that the entire rural sector can be geared up to the demands of high-productivity agriculture. This structural transformation is the last stage in what can be seen as a four-stage progression in agricultural development. The first and longest stage is that of primitive farming, with reliance on traditional implements and practices and on rainfall for water. In the second stage, the productivity of the land is improved by irrigation, by the enhancement of soil nutrients through systematic incorporation of organic materials, by the more accurate timing of crop production, and by improved implements for cultivation. The third stage is marked by the introduction of scientifically developed techniques. Cultivation of high-yielding varieties on irrigated land with chemical fertilizer and pesticides is a typical development of this stage. Another is the introduction of vaccines and dips to control livestock disease. The fourth stage is the structural transformation of the rural economy, which involves establishing the full range of institutions needed to support a high-productivity agriculture.

The history of Japanese agriculture provides the clearest example of the four stages. Traditional rice farming relying on rainfall-retumed paddy yields\(^8\) of less than 1 metric ton per hectare (t/ha). The extension of irrigation between A.D. 645\(^9\) and 1850 raised yields (paddy) to the 2.5 ton level. The Meiji Restoration in the 1870s ushered in a long period of scientific innovation in which improved varieties, fertilizers and other chemicals, improved implements and better agronomic practices were investigated by scientists, tested by a network of prefectural research stations, and then demonstrated to farmers. Moreover, many of the inadequately-irrigated rice fields were changed to adequately-irrigated ones. Between the late 19th century and World War II, yields rose from 2.5 tons per hectare to 4 tons. The postwar reorganization of Japan's farmland, the strengthening of farm-supply and marketing industries and trading channels, very favorable price support policies, the establishment of farmer organizations and the opening of more agricultural schools and colleges — in brief, the structural transformation into a complex modern rural economy — pushed paddy yields to the present level of about 6 tons per hectare, and many observers believe 8 tons will be reached in the not too distant future.

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\(^8\) 1 ton of *rice* is equivalent roughly to 1.5 tons of *paddy*.

\(^9\) The year in which rice cultivation in Japan was established.
CHART 1
Correlation of Intensification of Farming and Yield of Rice
(based on historical progress of rice production in Japan)


Chart 1 contrasts the historical progress of rice yields in Japan and the present level in other Asian nations. Most of the other nations in the Far East are only now making the transition from the first to the second stage, from traditional farming to an agriculture based on
increased land productivity. Except in Peninsular Malaysia, where the irrigation potential is fairly developed, yields in South and Southeast Asia are still below 3 tons per hectare.

The extension of irrigation, essential to high productivity rice cultivation, is being laboriously pursued throughout the Far East. The introduction of scientific production techniques and the new dwarf, high-yielding varieties in these nations has been mainly limited to areas served by adequate irrigation. Indeed, the present evidence strongly suggests that entry into the stage of successful technological innovation in the developing countries of Asia depends on a prior capital investment in the productivity of the land. That is, the second stage must precede the third. And it is clear that in any attempt to significantly raise overall Asian production of rice, the South and Southeast Asian nations which have not yet completed these two stages deserve attention first. Japan took more than 300 years to increase paddy yield from 2.0 tons per hectare to 4.0 tons per hectare. But it is encouraging to know that Taiwan doubled its paddy yield within 40 years from 1.9 t/ha in the 1920s to 3.7 t/ha in the 1960s, by introducing MVs (Ponlai varieties first and the improved Indica variety later), with substantial irrigation investment and technological and institutional innovation. The same seems to have occurred in South Korea. We can see the great potential for rice production increases in Asian developing countries. Our efforts should be concentrated on catching up to the level of productivity of a developed rural economy, pursuing the same process as already developed Asian countries, but shortening the learning process as much as possible. The latecomers have advantages in accelerating the development sequence, and it may not be impossible for the tropical Asian countries to double their paddy yield within fifteen years.
III. REVIEW OF RICE PRODUCTION IN ASIA

A. RECENT DEVELOPMENT OF RICE PRODUCTION IN ASIA

As mentioned in Chapter II, rice production yields in Asia have the potential to more than double as this region successfully introduces technical innovations. Modern varieties (MVs), the high-yielding varieties (including improved local varieties) developed by the International Rice Research Institute (IRRI) and other agencies since 1966, had spread throughout this region to 21.2 million hectares by 1974-75, which is about one-fourth of the total harvested rice area and about two-thirds of the irrigated rice area. These proportions have increased somewhat further in more recent years.

As shown in Chart 2, paddy production in 16 Asian countries or areas (excluding China and Japan)\textsuperscript{10} rose about 43 percent in the fifteen years from 1960 to 1975. Total population grew by 42 percent during the same period, however, so per capita paddy production, though fluctuating from year to year, remained almost constant between 143 and 145 kilograms. In brief, for the region as a whole rice production has barely kept pace with population growth; and in South and Southeast Asia, despite the introduction of the new foodgrain technology, per capita rice production has actually fallen over the past decade. Asian countries have made considerable efforts to produce foodgrain and to introduce high-yielding varieties. Further increases in paddy production will be difficult to sustain at recent rates, and even more difficult at rates that would bring substantial per capita increases, assuming the continuation of the population growth rates of recent decades.

Let us examine more closely the performance of food production in India,\textsuperscript{11} which is by far the largest rice-producing country in the region, with about 40 percent of the total paddy production in 1974 (excluding China and Japan). Since the rapid rise in foodgrain production in India after its severe drought in the mid-1960s, India’s grain

\textsuperscript{10} Afghanistan, Bangladesh, Burma, Taiwan, India, Indonesia, Kampuchea (Cambodia), South Korea, Laos, West Malaysia, Nepal, Pakistan, Philippines, Sri Lanka, Thailand and South Vietnam.

\textsuperscript{11} The present discussion is drawn largely from Food Trends and Prospects in India by Shyamal Roy and Fred H. Sanderson (Washington: The Brookings Institution, 1978).
production has suffered alternating periods of stagnation and growth. Foodgrain production,\textsuperscript{12} which had fallen to 72.4 million tons in the 1965/66 crop year, reached a peak of 108.4 million tons in 1970/71. After stagnating around 100 million tons for the next three crop years, it soared in 1975/76 to an unsurpassed 120.8 million tons. After slipping to 111.0 million tons in 1976/77, grain production is projected to rise to 125 million tons in the crop year now ending (mid-1978).

\textsuperscript{12} All cereals and pulses. Of the total cereals output, rice accounts for roughly 45 percent, and wheat for about 30 percent.
However, while production in the past several years has been increasing at an average annual rate of 2.6 percent — commensurate with production increases in the developed countries — per capita foodgrain production has risen only 0.5 percent, due in particular to continued population growth. The sharp rises in foodgrain production are attributable to several factors: improved water supplies; the introduction of commercial fertilizers; the introduction of high-yielding varieties; and favorable weather conditions.

Statistics reveal that the yields of both wheat and rice correspond closely to usage of fertilizer and MVs, which are limited to irrigated areas (Chart A, page 52). Wheat is grown in the dry season, usually with water obtained from groundwater sources or from reservoirs. The supply of water from these sources can generally be controlled and regulated to meet the specific requirements of the crop though water supplies may be inadequate at times. The sudden drop in wheat yields by about 10 percent from 1971/72 to 1974/75 is attributed in part to insufficient rainfall. In many of the rice-growing regions, supplies of water are derived solely from diversion of unregulated rivers or from rainfall (without irrigation facilities), as in Central and Peninsular India. Not only are the MVs extremely sensitive to water shortage; they also are more vulnerable than traditional varieties to flood conditions in the wet seasons.

Wheat yields in India increased by 64.5 percent in the span of only five years, from 0.89 t/ha in 1966/67 to 1.38 t/ha in 1971/72, largely due to the introduction of MVs and increased use of fertilizer in the late 1960s. However, wheat cultivation suffered a setback from 1971/72 to 1974/75, as mentioned above; in addition to the restricted water supplies, a levelling off of fertilized used in 1971/72 and the susceptibility of the MVs to disease, as well as poor seed quality, are generally held responsible for the lag. Since 1975, yields have begun to recover, as a result of the resumed increase in fertilizer consumption, and on a lesser scale, to the introduction in some regions of new disease-resistant, high-yielding seeds.

Rice production in India, on the other hand, has responded less dramatically than wheat to modern inputs, although yields have increased fairly regularly by about 1 percent annually. Fertilizer use and the acreage under MVs have not increased as rapidly for rice as for wheat. One problem with many rice MVs developed so far is that these varieties are better adapted to the dry season rather than the monsoon season, during which 95 percent of the rice crop is cultivated. In addition, less than 40 percent of the rice area is irrigated, and the existing irrigation systems in India are terribly overextended, proving inadequate for the modern varieties which demand a reliable and regulated
supply of water. Increased yields over the past few years may be explained by increased fertilizer usage, and more importantly, by favorable weather conditions which have provided adequate rainfall, well distributed over the monsoon season.

Indonesia is another case of success in the "green revolution." This country achieved a 66 percent increase in paddy production between 1965 and 1974. The major part of this increment was derived from a yield increase of about 46 percent, compared with 14 percent due to growth in area cultivated. As expected from their obvious interdependence, there is a high degree of correlation between cultivation of modern varieties, use of fertilizers and other agricultural chemicals, and irrigation facilities. Such interdependence is not so obvious in the case of more modern farm implements and machinery, which act as substitutes for traditional methods of cultivation with the help of draft animals. The rapid yield increase in Indonesia during the 1965-74 period can be attributed to a massive irrigation rehabilitation program throughout the country, in combination with the introduction of new varieties, and the rapid expansion of the rice intensification program including credit and extension services — the BIMAS (Bimbingan Massal, or mass guidance) and INMAS (Intensifikasi Massal, or mass intensification) program. By the 1973/74 crop year, almost all existing irrigated paddy was covered by the program; and thus the high national growth rate in rice production is unlikely to continue for long, unless the pace of irrigation development is drastically accelerated.

The Philippines expanded irrigation rates from 30 percent to 45 percent in the 1965-74 period. In response to the government's request for technical assistance in 1968, the Asian Development Bank (ADB) has pioneered in the field of water management. The government designated eight pilot schemes selected on a geographical basis from the 85 national irrigation systems. The Angat pilot scheme was the principal one, and was intended to apply the most modern technology for increasing rice production at the lowest costs and within the shortest time. Before the scheme started, there were only a few farm ditches in the 140 hectare pilot area, which could not provide water directly to each individual farm. With a construction cost of less than $100 per hectare, the density of farm ditches was increased from 16 to 62 meters per hectare (Chart B, page 53). A series of demonstration and reeducation campaigns were also conducted in this pilot area. A year after the project began, systematic water application became effective. Subsequently, farmers in the scheme willingly adopted MVs and fertilizers, given confidence in assured water supplies. Yields jumped from 2.3 t/ha in 1968 to 3.1 t/ha in 1969 in the pilot scheme. This is a typical example of the improvements arising out of the shift from inadequate
to adequate irrigation.\textsuperscript{13}

The Philippines attained rice self-sufficiency in 1969 for the first time in its history, thanks to favorable weather and rapid diffusion of modern varieties. Shortly thereafter, however, there were severe setbacks in food production due to tungro disease\textsuperscript{14} in 1971 and heavy floods in 1972. On account of this and to have greater assurance of self-sufficiency in rice even in times of disaster, the government decided to accelerate further its irrigation development program. In expanding the pilot schemes into full-scale operating irrigation systems, however, various institutional problems have been encountered. These include: 1) the need for land reform; 2) unequal water distribution within the main systems; 3) inadequately supervised credit and agricultural extension services; and 4) scattered individual holdings, rather than compact farm organizations operating as a single production unit sharing one farm ditch. The government mounted a nationwide campaign to tackle these problems with “Masagana 99” and a ten-year irrigation program initiated in 1973. The Angat-Magat Integrated Agricultural Development Project, the successor to the pilot scheme discussed above, is one of the pioneer projects. This project covers 70,000 hectares and is soon to be successfully completed.

\textbf{B. WATER CONTROL MOST CRUCIAL FACTOR IN INCREASING RICE PRODUCTION}

As already demonstrated by the above examples, the major factors affecting increased rice productivity include the use of modern varieties, fertilizer, and agricultural chemicals; irrigation; and the improvement of rural institutions. There is a particularly close correlation between the irrigation rate\textsuperscript{15} and mean national productivity of rice cultivation,

\textsuperscript{13} Inadequate irrigation results from insufficient or poorly distributed canal water. A rigorous breakdown of areas adequately or inadequately irrigated is not available, so we simply take as adequately irrigated those systems with more than 50 meters of farm ditches per hectare of cropped area. Greater length of farm ditches does not necessarily guarantee sufficient water, but it is usually accompanied by other improvements which, taken together, provide a rough estimate of well and poorly irrigated areas.

\textsuperscript{14} Tungro is a rice disease caused by a virus carried by the green leafhopper. It is widespread in tropical Asia, from the Philippines to India. When affected, the rice leaf becomes dwarf-sized and yellow-orange, resulting in low yields.

\textsuperscript{15} Irrigation Rate = \frac{\text{Total irrigated rice area (harvested)}}{\text{Total rice area (harvested)}}

“Total irrigated area” includes both adequate irrigation and inadequate irrigation, and may exceed the physical area in cases where more than one crop is harvested annually from the same field.
as shown in Chart 3. The countries in Asia can be divided into three groups on this chart. The first group contains only Japan, with an irrigation rate of 98 percent and paddy yields of 6 t/ha. The second group includes only South Korea and Taiwan with irrigation rates of about 80 percent and yields of about 4 t/ha. The third group includes the remaining thirteen countries, with a mean irrigation rate of 35 percent and yields of about 2 t/ha in 1974-76. Chart 3 also shows comparable statistics for 1965-67, 1970-72 and 1974-76. Some countries, such as South Korea, Indonesia and Pakistan, increased their yields by about 1 t/ha over the nine years. In most countries, however, there

**CHART 3**

Relationship Between Irrigation Rate and Paddy Yield

![Chart 3: Relationship Between Irrigation Rate and Paddy Yield](image)

**Note:** The correlation indicated in the chart does not in itself, of course, establish a solid causal link. Improved irrigation appears to be a necessary but not sufficient condition for higher paddy yields.

**Source:** Yield figures based on estimates from FAO; irrigation rates based on estimates from AOB. This chart was prepared by Kunio Takase, and is an updated version of Figure 3 in Saburo Okita and Kunio Takase's paper, *Doubling Rice Production in Asia* (Tokyo: Overseas Economic Cooperation Fund, 1976), p. 23.
were smaller increases, with an average rise of less than 0.3 t/ha between 1965-67 and 1974-76. It should be recognized that the high correlation between irrigation rate and mean yield is brought about in part by other factors which interact with irrigation, such as the use of modern varieties and more fertilizer. Thus the extent of irrigation can be considered a basic prerequisite\textsuperscript{16} for the full exploitation of modern rice production practices, but not the sole reason for higher yields.

Irrigation contributes as well to increased stability of the rice yield. There is considerable year-to-year fluctuation in traditional paddy production due primarily to variable weather conditions. As noted in the earlier discussion of Chart 2 (page 18), per capita rice production remained roughly constant for the 16 countries covered during the 1960-75 period. Year-to-year fluctuations were mainly due to weather conditions. The stability index\textsuperscript{17} of total paddy production per capita in the 16 countries between 1960 and 1975 was 0.74, which means that the lowest paddy production per capita in that period was 74 percent of the highest paddy production per capita. The stability index was 0.87 for the same period in Japan, where adequate irrigation facilities on almost all cultivated land minimized the adverse effects of weather. In other words, inadequate water supplies in particular years may seriously limit yields even in areas where MVs and the application of fertilizers are being introduced. This is, however, not fully appreciated by policy-makers and planners. When good harvests continue for two or three years and international rice prices drop, policy-makers and planners have often allowed the pace of irrigation development to slow down. It should be noted that two or three consecutive years of bumper crops do not necessarily mean achievement of self-sufficiency in view of the low stability index.

Another major benefit from improvement of existing irrigation facilities is that such an improvement often allows the harvesting of a second rice crop from the same fields (multiple cropping). Adequate irrigation facilities combined with adequate drainage systems will be able to provide substantial opportunities for multiple cropping in Asian rural areas.

In multiple cropping, a greater amount of agricultural inputs (labor, fuels, fertilizers, pesticides, farm equipment, storage facilities and so

\textsuperscript{16} In recent years, the IRRI has been studying drought-resistant and flood-resistant varieties in an attempt to minimize the adverse effects of inability to control water supplies. This does not mean, however, that there are any varieties which can achieve yields as high as those usable in areas with adequate irrigation.

\textsuperscript{17} Stability Index = \frac{\text{Production per capita (yearly minimum)}}{\text{Production per capita (yearly maximum)}}
forth) and better control of such inputs are required. For example, with two or three cropings annually, pest outbreaks are more likely, and there are increased needs for pest control supplies and management. Likewise, more organic matter is removed from the soil with resulting degradation and with the concomitant need for greater quantities of fertilizers (both organic and inorganic) and perhaps of soil conditioners. With multiple cropping, however, there are greater opportunities for crop rotation. Legumes might be rotated so as to add nitrogen to the soil. Likewise, the farmers could occasionally plant a higher value-added crop as a means of income diversification, and as a hedge against low rice prices or possible crop failures. Multiple cropping including rice and other crops is in general more labor-intensive, and therefore quite suitable for many developing countries.

Among the different winter crops grown experimentally in association with double cropping of rice are potatoes, oats and wheat. An interesting development is the cultivation of azolla, an aquatic fern which grows in symbiosis with blue-green algae capable of fixing atmospheric nitrogen. The purpose of this cultivation is not to produce a commercial crop, but to provide an input of nitrogen fertilizer by plowing into the soil, at the end of the winter period, the naturally dried algae-fern mixture. Extension of this concept of cultivation of fertilizer-substitution crops (or algae) should be studied, given their value particularly for poor farmers. Similarly, the experiments underway in several Asian countries (where heated rice nurseries have been developed at the village level, thus permitting earlier harvesting, better utilization of the available water and rapid diffusion of modern rice varieties) should be followed and extended wherever convenient.

The fundamental differences between Asian agriculture and agriculture in other parts of the world are generally considered to be as follows: Asian agriculture takes place in areas of monsoon rainfall; rice is the main crop; and subsistence-level family farming prevails. Agriculture in other parts of the world is predominantly in areas with much less rainfall; the main crop is not rice; and large-scale farming is generally practiced. In the case of paddy, controlled supply of water is an absolute prerequisite; and modern varieties and fertilizer have effects only when there is sufficient water. It should be clearly recognized that good water control is the single most important factor in increasing paddy yield in Asia at this time.

In 1975, the total harvested rice area in the sixteen Asian countries covered here was approximately 80 million hectares. Of this, about 65 percent depends completely on rainfall; 33 percent is inadequately irrigated; and only 2 percent is adequately irrigated. More efforts should be devoted to improvement of irrigation systems in Asia than to ex-
pansion of arable land. In the period 1965-74, total rice production in the sixteen countries increased by 31 percent (Table E, page 51). Harvested area increased by 18 percent, and yields by 11 percent. Of the increase in harvested area, that due to land reclamation accounted for 16 percent, while increased harvested area due to double cropping was only 2 percent. Several studies have demonstrated that growth of production through increased yields is more economical than expanding into new areas, at least since the 1960s, as expansion of arable land is possible only by including less productive areas. From this point of view, there is serious doubt whether scarce agricultural development resources in Asia have been invested most wisely in the last decade.

C. ECONOMICAL IMPROVEMENT OF WATER CONTROL

Asian experts on rice production generally accept the idea that irrigation is the most important factor in increasing rice production. However, problems remain as to how best to go about improving irrigation facilities within the constraint of limited financial resources.

Irrigation improvement does not necessarily mean building big dams which control floods or making huge reservoirs which give farmers sufficient water during drought seasons. In order to find the most economical approach, a series of careful and critical cost analyses have been made of several alternatives for land and water development, based on recent experiences in the region. Chart 4 presents a comparison of capital costs for a standard increase in production through six alternatives:

A) change uncultivated land into adequately-irrigated land;
B) change rainfed cultivated land to adequately-irrigated land;
C) change inadequately-irrigated land to adequately-irrigated land;
D) change uncultivated land into inadequately-irrigated land;
E) change rainfed cultivated land into inadequately-irrigated land;
F) change uncultivated land into rainfed cultivated land.

According to this comparison, the lowest capital cost to increase paddy production by 1 t/ha/year is (C) at $200 per ton, followed by (B), at $300 per ton. These estimates are in 1975 constant dollars, and are based on ten irrigation projects assisted by the ADB. In general, all methods starting with previously uncultivated land [(A), (D), and (F)] are not advisable, because they cost more and also take more time than the others, which further erodes their economic returns. For example, (F) costs as much as $1,500 per ton, or 7.5 times more than (C). Suitable
### Note:
- Obtained from irrigation projects managed by the Minn. Development Bank during 1969-72.

<table>
<thead>
<tr>
<th>Alternative (A)</th>
<th>Alternative (B)</th>
<th>Alternative (C)</th>
<th>Alternative (D)</th>
<th>Alternative (E)</th>
<th>Alternative (F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$0.00</td>
<td>$0.00</td>
<td>$0.00</td>
<td>$0.00</td>
<td>$0.00</td>
<td>$0.00</td>
</tr>
</tbody>
</table>

#### Chart 4

<table>
<thead>
<tr>
<th>Investment Priority (ranking of costs per ton)</th>
<th>Cost per Ton</th>
<th>Rice Yield</th>
<th>Cost per Hectare</th>
<th>Annual Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adequate</td>
<td>$0.00</td>
<td>0.6</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Inadequate</td>
<td>$0.00</td>
<td>0.4</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Field not affected</td>
<td>$0.00</td>
<td>1.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Uncultivated</td>
<td>$0.00</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

To increase production of paddy by 1 ton/ha/acre/year: Illustrative Model Indicating Capital Investment for Six Alternatives.
land for rice cultivation is also getting scarce in Asia, given topographical and soil characteristics. Moreover, land reclamation involves resettlement on new land, which can raise social problems.\textsuperscript{18}

Some may doubt that alternative (C), the favored alternative, requires only $200 per ton of increased paddy production. However, the shift from inadequate to adequate irrigation facilities in most cases requires only digging out farm ditches, maintenance of ditches, and good management of water supplies, as already demonstrated in the Angat pilot scheme in the Philippines, discussed above. There is no need for large capital investments. This may be a departure from the traditional idea of “irrigation development,” but it has major economic advantages and can be considered an approach within which so-called appropriate technology is suitably applied.

When capital is the scarcest factor of production, an important consideration in choosing technologies should be the ratio of output to capital required. If some approaches can achieve high output-capital ratios and at the same time use more of an abundant resource in Asia, namely labor, then these will be the most appropriate technologies. Both higher growth and more widespread benefits from growth will accrue from the use of such technologies. Whether one is concerned with building of dams, excavation of canals, the processing of agricultural products, the making of agricultural implements, or with the training of rural populations in various vocations, it would seem that considerable possibilities exist for innovative and adaptive technology. For example, farm ditches dug and compacted by manual labor are of poor quality and subject to deterioration after one or two years of operation. Also, little or no payment for manual labor delays the work. On the other hand, excavation and compaction by bulldozer is not practical for farm ditches less than 3.5 meters in width. In view of the fact that on-farm development has scarcely begun in most countries of the region, one urgent requirement is the provision of a small-scale farm ditch trencher which could greatly accelerate the massive construction of farm ditches envisaged in the development of irrigation facilities over many years to come. In parallel with this, abundant manual labor has to be mobilized and effectively utilized with reasonable wages, which would

\textsuperscript{18} World Bank recent experience indicates that costs for improvement and rehabilitation of existing systems and for development of new irrigation systems are $800/ha and $2,500/ha respectively, as gross averages for the area involved, with some projects requiring up to $6,000/ha for new land. Recent FAO estimates for improvement of irrigation in the region range from $300 to $700 per hectare, with costs of new irrigation approaching $3,000. The range of the figures in both the World Bank and FAO estimates can be accounted for by price escalation and differences in the classification of the irrigation data.
greatly contribute to the solution of serious employment problems in rural Asia. Appendix II (pages 55-56) sets forth a three-step approach which appears essential for the successful adoption of appropriate technology for rice cultivation.

D. DEVELOPMENT OF RURAL INSTITUTIONS

A critical impediment to the effective development of irrigated agriculture is the lack of organizational capacity in rural communities to mobilize local resources for the construction, maintenance, and operation of irrigation systems. It is well known that the effective mobilization of local resources, especially of labor in agriculturally idle seasons (for which the opportunity cost is low), is most effective in saving external resources and foreign exchange in the development of irrigation facilities. Also, there is no better substitute for farmers themselves in monitoring the operation and maintenance of water control systems. It is a common observation that water resources provided by a major irrigation project were inefficiently utilized because lateral canals and farm ditches were not properly constructed and maintained. Often farmers located upstream of major canals abused their position by stealing water through illegal holes or pumps, resulting in a water shortage in downstream areas. Such inefficiency cannot be removed unless leadership and discipline are developed in the rural community to organize its members for the protection of their common good and reconciliation of conflicting interests.

Such organizational capacity and habits are not, however, something which can be developed quickly when the need arises. In Japan, for example, the organizational capacity of rural people had developed for generations and centuries in response to gradual population pressure on available land, before modern economic growth began with the Meiji Restoration (1868). Most parts of Southeast Asia (except Java) have traditionally been characterized, in contrast, by an abundant supply of unused land resources. It was only recently, primarily due to the population explosion since World War II, that the critical need arose in this region to increase the productivity of existing cultivated land. Time has simply not yet been sufficient for rural communities to adapt to the development of irrigated agriculture. Serious extension efforts to organize farmers into such groups as irrigators’ associations and compact farms should accompany the construction of irrigation facilities. Programs should be promoted to encourage communal activities for the maintenance and rehabilitation of rural infrastructure through subsidies and technical assistance (such as the Subsidi Desa program in Indonesia). Delivery of institutional credit and inputs should
also be designed to enhance the group actions of irrigators.

More basic is the problem of agrarian structure and land tenure. It has often been reported that community work programs are difficult to organize for irrigation projects that primarily benefit larger farmers and landlords. A recent study at the International Rice Research Institute suggests that the participation of community members in communal irrigation projects is greater and more uniform in a village where farmers are more homogeneous in terms of tenure and farm size. If this is the case, redistributive land reform is critical not only for equity considerations, but also for the mobilization of local resources for the sustained increase in food output under the severe constraint of limited land resources.
IV. A PROGRAM FOR DOUBLING RICE PRODUCTION

A. IRRIGATION DEVELOPMENT

Even though the importance of irrigation for rice production has generally been accepted, a program for irrigation improvement in Asia has not been contemplated until now. One of the major reasons for this may be a prevailing misconception that the cost involved for irrigation development would be astronomically high. This misconception has been caused by a lack of critical study of appropriate technology and of cost analysis. The foregoing analysis, however, enables us to propose an urgent and feasible program for doubling rice production in Asia focused on irrigation improvement as the leading factor in generating production increases.

Serious efforts have already been initiated by developing countries in the region and by various international agencies concerned with food production, including the Food and Agriculture Organization (FAO), World Bank (IBRD), Asian Development Bank (ADB), Consultative Group on Food Production and Investment in Developing Countries (CGFPI), Economic and Social Council for Asia and the Pacific (ESCAP), and the International Fund for Agricultural Development (IFAD). In this sense, the preparatory work for the program has already been completed. The program proposed here would set a clear target for this crucial effort and appeal to donors as well as developing countries for sustained efforts and substantial contributions. We propose a fifteen-year program, from 1978 to 1993.

The 1970 harvest will be taken as the reference year of approximate self-sufficiency in Asia (excluding China and Japan). As can be seen in Chart 2 (page 18), the population of the countries covered was about one billion in 1970 and paddy production in the region that year was 150 million tons. On the assumption that the demand for rice will increase by 3.4 percent annually19 (2.4 percent attributable to popula-

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19 FAO has recently completed econometric studies of food demand, and they show a 2.7 percent annual increase in commercial demand for rice in Asia through 1985, compared to 3.4 percent, our assumption. With this lower target, there would be lower resource requirements and lower costs. From a nutritional point of view, however, a higher target may be desired. If the rate of population growth could be lowered appreciably before 1993, the increase in demand for rice would be accordingly smaller. For FAO projections see Rice, Demand and Trade Projections to 1985 (FAO Doc. ESC/Proj. 78/6, June 1978).
tion growth plus 1.0 percent for per capita consumption increases), it will be necessary to produce 321 million tons of paddy by 1993 for a population of 1.72 billion. This requires doubling rice production from the 1974 level (156 million tons).

In order to meet this 1993 target, the irrigation rate in the Group III countries (Chart 3, page 22) should be raised from 38 percent in 1974 (associated with yields of about 2.0 t/ha/year) to 79 percent (4.4 t/ha/year), using the lowest cost approach [Alternatives (C) and (B) in Chart 4 on page 26], which is basically farm ditch construction neglected in the past. It will be necessary that 30.4 million hectares of rainfed areas and 17.5 million hectares of inadequately-irrigated areas be converted to adequately-irrigated areas in the fifteen years between 1978 and 1993 throughout Asia. The total capital cost of this effort is estimated at $52.6 billion at 1975 constant prices, with the following breakdown:

Conversion of 17.5 million hectares at $400 per hectare from inadequately-irrigated to adequately-irrigated: ............................................ $ 7.0 billion

Conversion of 30.4 million hectares at $1,500 per hectare from rainfed to adequately-irrigated: .................. $ 45.6 billion

TOTAL CAPITAL COST: ................. $ 52.6 billion

ANNUAL CAPITAL COST: ............... $ 3.5 billion

The 1993 targets for irrigation development, crop area and paddy production are summarized in Table 3.

To carry out the expansion and improvement of irrigation as recommended will require hundreds of individual projects, each designed for the particular local situation. Each project requires a general survey of resources (land and water), a feasibility study (costs and benefits) and design of the project. For such a major expansion in irrigation construction and improvement it would be essential that each of the countries have a general plan for irrigation improvement and development. Meanwhile, a series of technical studies could be carried out with the aim of assembling available data and analyzing the different aspects involved in the project.

The general criteria for selecting priority irrigation projects should be as follows:

1) Top priority should be given to projects for which effects can be achieved quickly and cheaply, including improvement of existing irrigation projects and pump irrigation, on a small or medium scale. Most of these projects fall under Alternative
### TABLE 3
1993 Targets for Irrigation Development and Effects on Crop Area, Paddy Production and Overall Average Yield

<table>
<thead>
<tr>
<th>Land Status</th>
<th>1974</th>
<th>1993</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Value</td>
<td>(%)</td>
</tr>
<tr>
<td>Physical Area(^{a})</td>
<td></td>
<td></td>
</tr>
<tr>
<td>rainfed</td>
<td>53.3</td>
<td>70%</td>
</tr>
<tr>
<td>inad. irrigated</td>
<td>21.5</td>
<td>29%</td>
</tr>
<tr>
<td>adeq. irrigated</td>
<td>1.0</td>
<td>1%</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>75.8(^{b})</td>
<td>(100%)</td>
</tr>
<tr>
<td>Crop Area(^{a})</td>
<td></td>
<td></td>
</tr>
<tr>
<td>rainfed</td>
<td>53.3</td>
<td>62%</td>
</tr>
<tr>
<td>inad. irrigated</td>
<td>31.0</td>
<td>36%</td>
</tr>
<tr>
<td>adeq. irrigated</td>
<td>1.7</td>
<td>2%</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>86.0</td>
<td>(100%)</td>
</tr>
<tr>
<td>Paddy Production</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(in million tons)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>rainfed</td>
<td>53.3</td>
<td></td>
</tr>
<tr>
<td>inad. irrigated</td>
<td>93.0</td>
<td></td>
</tr>
<tr>
<td>adeq. irrigated</td>
<td>6.1</td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>152.4</td>
<td></td>
</tr>
<tr>
<td>Yield(^{c})</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(t/ha)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>rainfed</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>inad. irrigated</td>
<td>3.0</td>
<td></td>
</tr>
<tr>
<td>adeq. irrigated</td>
<td>3.6</td>
<td></td>
</tr>
<tr>
<td><strong>OVERALL AVERAGE</strong></td>
<td>1.8(^{d})</td>
<td></td>
</tr>
</tbody>
</table>

---

a. Crop area exceeds physical area in cases of multiple cropping.
b. There is no intention of bringing any new land under cultivation.
c. Yield for same category of riceland is assumed to remain constant. The reasons for this assumption are discussed on page 37.
d. Average yield per crop from a hectare of land.
e. Average yield per year from a hectare of land.

(C) on Chart 4 (page 26), converting inadequately-irrigated to adequately-irrigated land. Full participation of local farmers is considered a great advantage in view of employment effects and other positive results of their involvement.

2) Medium-scale multi-purpose dams with provision for irrigation, hydropower, and flood control may require a considerable amount of construction machinery, cement, iron and steel, contractors' work and consultants' services, which in turn would stimulate the economies of developed countries which export these goods and services. These projects would normally belong to Alternative (B) on Chart 4, converting rainfed, cultivated land to adequately-irrigated land.

32
3) Large-scale projects under consideration would be difficult to complete by 1993 as they require at least five years for surveying and designing plus another ten to twenty years for construction. These include the Mekong River Basin Project (requiring a total investment of $20 billion up to the year 2000 according to the Indicative Basin Plan compiled by the Mekong Committee of ECAFE in 1970), and plans for the Indus (Pakistan), the Ganges (Bangladesh and India), and the Kalimantan (Indonesia), which fall under Alternative (A) on Chart 4. Such projects are not included in our proposal.

It appears that the nations of Asia possess most of the skills and capacities required to carry out the irrigation proposal. Due to the substantial expansion of effort and the lead times involved, there may well be temporary shortages of engineers for designing projects and irrigation specialists for conducting feasibility studies. It is likely the developing countries would have difficulty in financing a major increase in project preparation.

We recommend that aid, in the form of grants, be provided for the training of additional personnel required for the development of irrigation projects and that part of the costs of surveys, feasibility studies and detailed designs be covered by grants and the remainder financed on a liberal basis.

B. MODERN FARMING INPUTS

Fertilizer requirements will increase rapidly as irrigation facilities are completed. Based on the assumption that 60 kg/ha of nitrogen (N), 75 kg/ha of phosphate (P₂O₅) and 30 kg/ha of potash (K₂O) are required for the production of 3 t/ha/crop of paddy, the current amount of fertilizers used in Asia (17 kg/ha of nitrogen, 7 kg/ha of phosphate and 3 kg/ha of potash) will have to be increased by 12 million tons²⁰ by 1993 for an estimated rice area of 87 million hectares. When irrigation facilities are completed and the area of double cropping with heavy application for fertilizers is increased, agricultural chemicals will be required to cope with insects, pests and weeds. Since seasonal

²⁰ Nitrogen (kg/ha): 60 - 17 = 43  
Phosphate (kg/ha): 75 - 7 = 68  
Potash (kg/ha): 30 - 3 = 27  
TOTAL: 138 kg/ha x 87 mil ha = 12 million metric tons
cultivation must be completed in a short time, agricultural machinery modified for Asian agriculture (such as small tractors, power tillers, sprayers, rice planters, harvesters, rice mills and storage facilities) will be necessary. Both the developing and developed countries should make serious efforts to provide an assured supply of modern farm inputs at reasonable and relatively stable prices to farmers of the developing countries.\textsuperscript{21}

The capital costs of our program, presented above, do not include expenditures for agricultural chemicals and mechanization. These are current costs, which would be covered by agricultural credit for each crop season and repaid out of farmers' higher income derived from increased production.\textsuperscript{22} This financing can be left to the private sector to undertake, therefore, and it need not be accounted for among the capital costs for this program.

It is important to note that more advanced rice cultivation technology is more labor-intensive per hectare cultivated. One estimate is that labor inputs change from 40-80 man-days/year/ha for primitive cultivation to 300 man-days/year/ha for modern cultivation, even with the application of apparently labor-saving farm machinery. The intensification of cultivation techniques in Asia today thus will not reduce employment, contrary to some popular conceptions.

C. CAPITAL RESOURCES AND AID PROCEDURES

It is extremely difficult to obtain reliable data on government expenditures (GE) or government development expenditures (GDE) in the countries of South and Southeast Asia. Assuming that irrigation budgets are about 10 percent of GDE in the 16 Asian countries covered here, our best guess of annual budgets for irrigation through 1980 is $1.7 billion (at 1975 prices), including foreign exchange to be granted or loaned from abroad. Our estimation of the capital requirements for our

\textsuperscript{21} Environmental concerns, especially in the developed countries, have substantially increased the costs of developing new insecticides, herbicides, and chemicals for treating diseases of plants and animals. It is important that there be continuing evaluation of the costs, in terms of reduced production and increased malnutrition, as well as the benefits of environmental controls. Integrated pest control should be encouraged both as a means of reducing costs (using chemical methods only when and to the extent necessary) and as a means of keeping environmental damage to a minimum.

\textsuperscript{22} In an economic evaluation of irrigation projects, these costs are normally estimated as "production costs," which are deducted from gross benefits for the year. By using the World Bank's projected international price for rice in 1985, most irrigation projects under this program have an internal economic rate of return of 18.5 percent.
program ($3.5 billion annually) is thus more than double the presently available resources.

On the other hand, multilateral and bilateral foreign aid commitments, including OPEC assistance, to the agricultural sector amounted to nearly $2.5 billion in 1973, and increased sharply to over $5.7 billion by 1975, as shown in Table 4. This sharp increase reflects a renewed awareness of rural needs and the agricultural sector's importance in overall national development, following the World Bank's Nairobi Declaration of 1973 outlining a comprehensive rural development program focused on the need to increase the productivity of small farms in developing countries as a means to alleviate absolute poverty. The Asian region was allocated only 36.6 percent of the total amount of aid commitments in 1973-75, although the region contains more than 52 percent of the world's population. Excluding the allocations to non-irrigation categories within agriculture (50 percent) and assuming a ratio of disbursements to commitments in the same year of 0.80, total net disbursements to the irrigation sector in Asia at 1975 aid levels amounted to $5.7 \times 36.6\% \times 50\% \times 0.80 = $0.8\ billion. Nearly equal amounts were apparently provided by developing countries in the region, which brings the total annual investment in Asian irrigation to

<table>
<thead>
<tr>
<th>Aid Source</th>
<th>Total (1)</th>
<th>Agriculture (2)</th>
<th>2/1 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bilateral (DAC &amp; EEC)</td>
<td>13.153</td>
<td>1.637</td>
<td>12.4</td>
</tr>
<tr>
<td>World Bank</td>
<td>5.679</td>
<td>2.243</td>
<td>38.1</td>
</tr>
<tr>
<td>Regional Banks</td>
<td>2.232</td>
<td>626</td>
<td>28.1</td>
</tr>
<tr>
<td>UNDP</td>
<td>311</td>
<td>60</td>
<td>19.2</td>
</tr>
<tr>
<td>WFP</td>
<td>347</td>
<td>199</td>
<td>57.4</td>
</tr>
<tr>
<td>Sub-total</td>
<td>21.822</td>
<td>4,767</td>
<td>21.8</td>
</tr>
<tr>
<td>OPEC</td>
<td></td>
<td></td>
<td>958</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td></td>
<td>5,725</td>
</tr>
</tbody>
</table>

$1.7 billion, the estimate presented above. The balance between this figure and the irrigation requirement for our program ($3.5 billion) is, therefore, about $1.8 billion annually.

In order to fill this gap and achieve the 1993 target, it is proposed that the developed countries and OPEC countries provide capital resources along the lines presented in Table 5, while the developing countries continue their utmost efforts to share the burden. It may not be unrealistic to catch up with the required annual investment level ($3.5 billion) around 1985. With subsequent increases, the average annual irrigation investment would reach $3.6 billion for the entire 1978-1993 period, and the accumulated irrigation investment would

| TABLE 5 |
| Disbursement Schedule of Capital Resources |
| for the Program, 1978-93 |
| (billion dollars, 1975 prices) |

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Annual Disbursement</td>
<td>1.7</td>
<td>2.1</td>
<td>2.8</td>
<td>4.0</td>
<td>5.8</td>
<td>54.0</td>
</tr>
<tr>
<td>Sources of Capital Resources</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DAC Countries</td>
<td>0.7</td>
<td>1.0</td>
<td>1.5</td>
<td>2.5</td>
<td>3.9</td>
<td>32.5</td>
</tr>
<tr>
<td>OPEC Countries</td>
<td>0.1</td>
<td>0.2</td>
<td>0.3</td>
<td>0.5</td>
<td>0.8</td>
<td>6.5</td>
</tr>
<tr>
<td>(about 20% of DAC contribution)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Developing Countries</td>
<td>0.9</td>
<td>0.9</td>
<td>1.0</td>
<td>1.0</td>
<td>1.1</td>
<td>15.0</td>
</tr>
<tr>
<td>(contribution increases 1% annually)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1) The figures of DAC countries' contribution are based on the following criteria:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. GNP index (4% annual growth)</td>
<td>100</td>
<td>113</td>
<td>137</td>
<td>166</td>
<td>202</td>
<td>151</td>
</tr>
<tr>
<td>2. net disbursement of ODA (% of GNP)</td>
<td>35%</td>
<td>40%</td>
<td>48%</td>
<td>50%</td>
<td>55%</td>
<td>48%</td>
</tr>
<tr>
<td>3. share of South and Southeast Asia</td>
<td>36%</td>
<td>38%</td>
<td>40%</td>
<td>42%</td>
<td>45%</td>
<td>42%</td>
</tr>
<tr>
<td>4. share of irrigation sector</td>
<td>10%</td>
<td>11%</td>
<td>12%</td>
<td>13%</td>
<td>14%</td>
<td>12%</td>
</tr>
<tr>
<td>5. compound index (1x2x3x4)</td>
<td>126</td>
<td>189</td>
<td>296</td>
<td>453</td>
<td>700</td>
<td>445</td>
</tr>
</tbody>
</table>

It is extremely difficult to estimate the accurate amount invested in irrigation. Another estimate claims that this amount could be only 70 percent of the above figure.
reach $54 billion by 1993, which meets the total estimated above for the projected irrigation development ($52.6 billion) plus other expenditures necessary for the program ($1.4 billion). This fifteen-year total is less than one-fifth the annual total of world military expenditures ($300 billion).

If the irrigation program is to be carried out in a timely manner, it requires that the various aid and lending agencies be in a position to evaluate projects and reach decisions on financing in a relatively short period of time. The program that we have recommended will require both a change in emphasis in the types of projects financed and in the evaluation procedures used.

A common complaint of officials of developing countries is that current procedures for evaluation and approval of irrigation projects take too long — often as much as two years — and that financing has been difficult to obtain for small projects not requiring major structures.

It is recommended that project evaluation and approval procedures be modified, where necessary, to permit prompt decisions and that the criteria used for approval be consistent with a large variety of projects and not be biased toward particular types of projects.

D. DEVELOPMENT OF APPROPRIATE TECHNOLOGY AND RURAL INSTITUTIONS

Meeting the requirements for irrigation facilities and modern agricultural inputs does not guarantee the success of the program for doubling rice production, unless rice production technology and rural institutions are developed so as to exploit the full potential of irrigated agriculture. It may appear that, with the semi-dwarf varieties of rice developed by the International Rice Research Institute (IRRI) and the several national breeding programs, the technology is now readily available for irrigated rice farming in South and Southeast Asia. Likewise it might be argued that the plan for doubling rice production has been based on very conservative assumptions since no increases of rice yields per unit area have been projected for any one of the types of land for rice cultivation — rainfed, inadequately-irrigated, and adequately-irrigated. However, unless there is a major increase in research on rice it may be difficult to maintain existing yields. As the intensity of rice cultivation increases, disease and insect problems become more serious. It will be necessary to continuously develop new rice varieties that are more resistant to major diseases and insects just to maintain yields. Since relatively little rice is grown in the developed countries, except Japan, much less has been invested in rice research than in the major crops grown in the developed countries.
It is true that national research programs have been strengthened to a stage where they can produce modern varieties for their own needs according to the prototype of IRRI. It is still common, however, to find a single technology-input package recommended for a nationwide extension program (e.g., Masagana 99 in the Philippines and BIMAS in Indonesia), which does not recognize the great diversity of conditions even within single countries.

In fact, rice farming in monsoon Asia is characterized by extremely varied environmental conditions, such as differences in soil type, rainfall and sunlight. Appropriate cultural practices and input applications are quite different among regions, and even among villages. A national standard package tends to result either in non-acceptance by farmers or in inefficient resource use.

What is really lacking is the local network of agricultural experiment stations needed to supply highly location-specific information to each of numerous micro-climatic zones. As yet, countries in South and Southeast Asia seem to be grossly under-investing in agricultural research. Agricultural research expenditures as a percentage of the value of agricultural production for South and Southeast Asia were only 0.31 and 0.49, respectively, in 1974; only about one-third of the levels of North America and Northern Europe and only about one-tenth that of East Asia (Table 6). There is not so large a difference among the regions in extension expenditures. Correction of such under-investment in agricultural research through the building of intensive networks of experiment stations is a critical prerequisite for the exploitation of the potential of irrigated rice farming.

### TABLE 6
Public Research and Extension Expenditures as a Percentage of the Value of Agricultural Product, 1974

<table>
<thead>
<tr>
<th>Region</th>
<th>Research</th>
<th>Extension</th>
</tr>
</thead>
<tbody>
<tr>
<td>North America</td>
<td>1.27</td>
<td>0.86</td>
</tr>
<tr>
<td>Northern Europe</td>
<td>1.32</td>
<td>0.55</td>
</tr>
<tr>
<td>East Asia¹</td>
<td>3.10</td>
<td>1.17</td>
</tr>
<tr>
<td>South Asia</td>
<td>0.31</td>
<td>0.38</td>
</tr>
<tr>
<td>Southeast Asia</td>
<td>0.49</td>
<td>0.60</td>
</tr>
</tbody>
</table>

¹ China excluded


In the expansion and encouragement of research related to rice, we urge particular attention to the following points:
• While the support of research on rice and other tropical and semitropical products at the international agricultural research centers should be fully supported, it is essential that national agricultural research systems be expanded and strengthened. Research to combat diseases and insects and to develop varieties best suited to local conditions under which rice is grown must be carried out in the rice-growing regions — not just in a few such regions, but in many. Local research on combined production of rice and fish, improved soil management and integrated pest control should be encouraged.

• Multiple cropping offers substantial opportunities for more intensive use of land and increased employment of labor. The irrigation program will substantially increase the opportunities for obtaining two or more crops per year from a given area of land. Research will be required to assist farmers to take full advantage of the opportunities. Rice varieties with shorter growing seasons, other crops to be used in rotation with rice, and the development of simple or improved tools to reduce the time required for land preparation between crops are examples of problems that can and should be solved by research. Particular attention should be given to the development of farming systems that can be used profitably on small farms.

• Biological fixation of nitrogen is an alternative to nitrogen from commercial fertilizer. There have been some promising developments in recent years in tropical areas — particularly the growing of azolla, an aquatic fern, in conjunction with blue-green algae, which is capable of fixing nitrogen which is made available for an economic crop by plowing under the azolla. In addition, there is the need for more R&D on suitable chemical fertilizers, with particular attention to the design of fertilizers for the tropics.

There are many other types of research, including social and economic research, that should be pursued. We are pleased to refer those who are interested to an excellent report recently issued by the National Research Council of the U.S. National Academy of Sciences, World Food and Nutrition Study, The Potential Contribution of Research, in which 22 high priority research areas are elaborated and promising lines of research within each of the priority areas are described.24

The role of education and training of skilled farmers and technicians is just as important as technology development and research in

the developing countries. Extension services are extremely important to this end, not only for training and for advisory activities, but because they also provide the necessary link between research and development and diffusion of the new technology in the field.

Marketing institutions and systems should be expanded and modernized to efficiently market and process additional production. It is not implied by this recommendation that the agricultural marketing systems in the developing countries are high cost and inefficient. In fact, where governmental constraints are minimal, several studies indicate that marketing of cereals and other staple farm products is achieved at very low cost compared to similar marketing systems in the industrial countries. But if the object of the rice doubling program is achieved, marketing facilities of all types will have to be expanded greatly. Since the share of output marketed would increase substantially, the capacity of the rice marketing system would have to be more than doubled. In the construction of new facilities for processing and storage, particular attention should be given to the reduction of waste and losses. Research is required to find lower cost means of preserving perishable products and to minimize the cost of preventing losses from insects and rodents. Private firms can make a significant contribution to the development of new technologies to reduce waste and losses and to lower costs of processing under the conditions prevailing in the developing countries.

These points concerning extension services and marketing systems are part of the general critical need to develop rural institutions, as discussed earlier. The importance of strengthening the organizational capacity of rural communities to administer irrigation systems requires no further explanation. Also, the need for programs to strengthen this capacity by combining extension, credit and marketing resources has already been emphasized. Here a cautionary note must be added: Such programs should begin on a pilot scale and be expanded very gradually. In the past, the success of such programs has been limited to cases where high-quality extension agents were generously mobilized with a backup of equally generous arrangements in credit and other services. Often, successful pilot programs were expanded onto a national or regional scale ending in miserable failure because extension resources were diluted so thinly.

An even greater caveat should be added on the issues of agrarian reform. As stated earlier, there should be little disagreement on the desirability of redistributive land reform on the grounds of both social justice and economic efficiency. However, in view of present power structures, it is unrealistic to expect that such land reform will be implemented effectively within the time horizon of this program for doubling rice production. It is even more unrealistic to expect that foreign
agents, either bilaterally or multilaterally, can design and implement effectively such politically sensitive programs.

In any case, we should base our decisions on hard reality: What is desirable and what is feasible? Strengthening the organizational capacity of rural people and reforming agrarian society into more egalitarian forms are much to be desired. But it is not certain that these goals will be achieved in the short or medium run.

The difficulty in achieving social change, however, should not lead to defeatism about the prospects for the program proposed here. We should not conclude that the program should not be implemented until we know how to reform rural society. We should realize that it is neither the scholars nor the policy-makers but rather the people in the village communities themselves who can innovate rural institutions, if anyone can. The institutional innovations would not be likely to emerge unless public investments in irrigation and progress in agricultural technology increase the profitability of making such innovations. Thus, our plan will have the effect of injecting a momentum into rural society for inducing institutional innovations. Of course, there is a danger that the momentum may result in some undesirable social consequences, such as unequal income distribution or polarization of the rural community. We therefore support necessary socio-economic changes and the development of rural institutions and social interaction within rural communities which are vital for the long-run achievement of desirable social objectives.

Today, unless a major effort is made to increase food production in the form of a feasible program, we are bound to lose what is now a dead heat between population and food supply; this will result in greater misery of poor people and greater social injustice. In such a situation, it is criminal not to undertake feasible programs, even though the social consequences are somewhat unpredictable.

E. GOVERNMENTAL POLICIES

Our final set of recommendations concerns governmental policies of both developed and developing nations. Irrigation investments, research, modern inputs and expansion of marketing systems can all be carried out or made available but to little avail if inappropriate governmental policies are followed. Farmers in the developing countries must have assurance of adequate incentives to make full and effective use of available resources. Many developing countries have policies that adversely affect agricultural production, such as rigid controls on the introduction of new crop varieties, price controls or procurement prices designed to lower prices to consumers (with the adverse consequence of
reducing profitability of producers), and protection of one or more industries that produce modern farm inputs such as fertilizers.

The developing countries must have a reasonable expectation that export outlets will be available on favorable terms for any exportable surplus of agricultural products that may be created and for processed and manufactured products, to provide the foreign exchange required for the flow of imports of modern farm inputs, energy, and capital goods required for the expansion of agricultural output. The trade policies of most, if not all, of the Trilateral Commission nations make it difficult for the developing countries to export semi-processed or processed farm products and to expand their exports of labor-intensive manufactured products.
V. CONCLUDING COMMENTS

The rapid decline in the prices of cereals on international markets in recent years should not be the basis for relaxing efforts to expand food production and increase incomes in the developing countries. The low international prices for many farm products do not mean that the people of the developing countries, especially the poorer people, are significantly better fed now than they were in 1974 when prices were at peak levels. The gap between what it is possible to do to improve the nutrition and incomes of the people of the developing countries of Asia (and in the rest of the developing world) and what will be achieved if nothing more than current efforts and policies are maintained is as large today as was the gap in 1974 or any other recent year.

World food problems are continuing ones and require significant and long-term commitments if there is to be substantial improvement in nutrition and incomes of the world’s poorer people. The potential exists for a substantial improvement in nutrition and incomes. If significant actions are not begun now, it is highly likely that there will be, at best, a very modest improvement in diets in the developing countries by the end of this century; and there is a small probability that should not be ignored that there could be a deterioration in diets with an accompanying increase in human suffering.
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**TABLE A**  
Projections of Food Demand\(^1\) and Extrapolations of Food Production to 1985

<table>
<thead>
<tr>
<th></th>
<th>Volume Growth Rates (percent per annum)</th>
<th>Overall Volume Increases (1969-71 = 100)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Demand</td>
<td>Production</td>
</tr>
<tr>
<td>DEVELOPED COUNTRIES</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Market economies</td>
<td>1.5</td>
<td>2.8</td>
</tr>
<tr>
<td>Eastern Europe and USSR</td>
<td>1.7</td>
<td>3.5</td>
</tr>
<tr>
<td>DEVELOPING MARKET ECONOMIES</td>
<td>3.6</td>
<td>2.6</td>
</tr>
<tr>
<td>Africa</td>
<td>3.8</td>
<td>2.5</td>
</tr>
<tr>
<td>Far East(^2)</td>
<td>3.4</td>
<td>2.4</td>
</tr>
<tr>
<td>Latin America</td>
<td>3.6</td>
<td>2.9</td>
</tr>
<tr>
<td>Near East</td>
<td>4.0</td>
<td>3.1</td>
</tr>
<tr>
<td>ASIAN CENTRALLY PLANNED ECONOMIES</td>
<td>3.1</td>
<td>2.6</td>
</tr>
<tr>
<td>ALL DEVELOPING COUNTRIES</td>
<td>3.4</td>
<td>2.6</td>
</tr>
<tr>
<td>WORLD</td>
<td>2.4</td>
<td>2.7</td>
</tr>
</tbody>
</table>

---

2. Includes South and Southeast Asia.

TABLE B
Growth Rates of Food Production and Population Worldwide
and in Main Regions, 1952-62 and 1962-72†
(percent per year)

<table>
<thead>
<tr>
<th>Region or Type of Economy</th>
<th>1952-62</th>
<th>1962-72</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Population</td>
<td>Food Production</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>Per Capita</td>
</tr>
<tr>
<td>Developed market economies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Western Europe</td>
<td>1.2</td>
<td>2.5</td>
</tr>
<tr>
<td>North America</td>
<td>1.8</td>
<td>1.9</td>
</tr>
<tr>
<td>Oceania</td>
<td>2.2</td>
<td>3.1</td>
</tr>
<tr>
<td>Eastern Europe and USSR</td>
<td>1.5</td>
<td>4.5</td>
</tr>
<tr>
<td>All developed countries</td>
<td>1.3</td>
<td>3.1</td>
</tr>
<tr>
<td>Developing market economies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Africa</td>
<td>2.4</td>
<td>3.1</td>
</tr>
<tr>
<td>Far East</td>
<td>2.9</td>
<td>3.1</td>
</tr>
<tr>
<td>Latin America</td>
<td>2.8</td>
<td>3.2</td>
</tr>
<tr>
<td>Near East</td>
<td>2.6</td>
<td>3.4</td>
</tr>
<tr>
<td>Asian centrally planned economies</td>
<td>1.8</td>
<td>3.2</td>
</tr>
<tr>
<td>All developing countries</td>
<td>2.4</td>
<td>3.1</td>
</tr>
<tr>
<td>World</td>
<td>2.0</td>
<td>3.1</td>
</tr>
</tbody>
</table>

† Trend rate of growth of food production; compounded.
2 Including countries in other regions not specified.

<table>
<thead>
<tr>
<th>Region</th>
<th>1965</th>
<th>1975</th>
<th>1990 est.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Africa (excluding Northeast Africa)</td>
<td>1,882</td>
<td>2,610</td>
<td>3,570</td>
</tr>
<tr>
<td>North of Sahara</td>
<td>609</td>
<td>740</td>
<td>980</td>
</tr>
<tr>
<td>South of Sahara</td>
<td>1,273</td>
<td>1,870</td>
<td>2,590</td>
</tr>
<tr>
<td>Latin America</td>
<td>9,623</td>
<td>11,749</td>
<td>14,850</td>
</tr>
<tr>
<td>Central America and Mexico</td>
<td>3,352</td>
<td>4,000</td>
<td>5,000</td>
</tr>
<tr>
<td>Caribbean</td>
<td>606</td>
<td>810</td>
<td>1,050</td>
</tr>
<tr>
<td>South America</td>
<td>5,665</td>
<td>6,939</td>
<td>8,800</td>
</tr>
<tr>
<td>Near East</td>
<td>13,329</td>
<td>17,105</td>
<td>21,400</td>
</tr>
<tr>
<td>Northeast Africa</td>
<td>3,680</td>
<td>4,740</td>
<td>6,300</td>
</tr>
<tr>
<td>Middle East</td>
<td>9,649</td>
<td>12,365</td>
<td>15,100</td>
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<tr>
<td>Asia</td>
<td>45,691</td>
<td>60,522</td>
<td>74,370</td>
</tr>
<tr>
<td>Southeast Asia</td>
<td>37,238</td>
<td>49,666</td>
<td>59,560</td>
</tr>
<tr>
<td>Southeast Asia and Far East</td>
<td>8,453</td>
<td>10,856</td>
<td>14,810</td>
</tr>
<tr>
<td>Subtotal</td>
<td>70,525</td>
<td>91,986</td>
<td>114,190</td>
</tr>
<tr>
<td>World Total</td>
<td>149,862</td>
<td>223,085</td>
<td>273,369</td>
</tr>
</tbody>
</table>

### TABLE D
Per Capita Grain Consumption\(^1\) in 1970\(^2\)

(kilograms/year)

<table>
<thead>
<tr>
<th></th>
<th>Total Grains (A)</th>
<th>Food-grains (B)</th>
<th>Rice (C)</th>
<th>Wheat</th>
<th>C/A (%)</th>
<th>C/B (%)</th>
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<tr>
<td>World</td>
<td>310</td>
<td>144</td>
<td>53</td>
<td>91</td>
<td>171</td>
<td>36.8</td>
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<tr>
<td>Developed Countries</td>
<td>533</td>
<td>138</td>
<td>18</td>
<td>120</td>
<td>3.4</td>
<td>13.0</td>
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<tr>
<td>Developing Countries</td>
<td>186</td>
<td>114</td>
<td>63</td>
<td>51</td>
<td>33.9</td>
<td>55.3</td>
</tr>
<tr>
<td>Asia(^3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>India</td>
<td>167</td>
<td>131</td>
<td>94</td>
<td>37</td>
<td>56.0</td>
<td>71.8</td>
</tr>
<tr>
<td>Indonesia</td>
<td>124</td>
<td>103</td>
<td>99</td>
<td>4</td>
<td>79.8</td>
<td>96.1</td>
</tr>
<tr>
<td>Japan</td>
<td>255</td>
<td>152</td>
<td>102</td>
<td>50</td>
<td>40.0</td>
<td>67.1</td>
</tr>
<tr>
<td>S. Korea Taiwan</td>
<td>241</td>
<td>175</td>
<td>126</td>
<td>49</td>
<td>52.2</td>
<td>72.0</td>
</tr>
<tr>
<td>Hong Kong, Singapore</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pakistan</td>
<td>163</td>
<td>152</td>
<td>91</td>
<td>61</td>
<td>55.8</td>
<td>59.9</td>
</tr>
<tr>
<td>Thailand</td>
<td>195</td>
<td>190</td>
<td>189</td>
<td>2</td>
<td>95.9</td>
<td>99.5</td>
</tr>
<tr>
<td>China (PRC)</td>
<td>220</td>
<td>128</td>
<td>81</td>
<td>46</td>
<td>36.8</td>
<td>63.3</td>
</tr>
</tbody>
</table>

---

1. Calculated on the assumption that consumption = production + imports - exports. Therefore, increases in stocks, non-food use and waste are all included in consumption.

2. 1968-72 average

3. Excludes Middle East and the centrally planned Asian countries

<table>
<thead>
<tr>
<th></th>
<th>1965 (A)</th>
<th></th>
<th></th>
<th>1974 (B)</th>
<th></th>
<th></th>
<th>B/A (%)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Paddy production (thousand tons)</td>
<td>Harvested area (thousand ha)</td>
<td>Irrigated area (thousand ha)</td>
<td>Paddy Yield (ton/ha)</td>
<td>Irrigation rate (%)</td>
<td>Paddy production (thousand tons)</td>
<td>Harvested area (thousand ha)</td>
</tr>
<tr>
<td>Afghanistan</td>
<td>380</td>
<td>249</td>
<td>13</td>
<td>1.52</td>
<td>5</td>
<td>480</td>
<td>266</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>15,751</td>
<td>9,186</td>
<td>460</td>
<td>1.72</td>
<td>5</td>
<td>17,879</td>
<td>9,904</td>
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<tr>
<td>Burma</td>
<td>8,055</td>
<td>4,750</td>
<td>710</td>
<td>1.70</td>
<td>15</td>
<td>8,582</td>
<td>4,974</td>
</tr>
<tr>
<td>Kampuchea</td>
<td>2,500</td>
<td>2,290</td>
<td>62</td>
<td>1.09</td>
<td>3</td>
<td>635</td>
<td>555</td>
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<tr>
<td>India</td>
<td>45,983</td>
<td>29,300</td>
<td>11,700</td>
<td>1.57</td>
<td>40</td>
<td>60,000</td>
<td>37,500</td>
</tr>
<tr>
<td>Indonesia</td>
<td>13,660</td>
<td>7,500</td>
<td>4,000</td>
<td>1.82</td>
<td>53</td>
<td>22,732</td>
<td>8,537</td>
</tr>
<tr>
<td>S. Korea</td>
<td>4,731</td>
<td>1,137</td>
<td>910</td>
<td>4.16</td>
<td>80</td>
<td>6,178</td>
<td>1,205</td>
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<tr>
<td>Laos</td>
<td>740</td>
<td>914</td>
<td>22</td>
<td>0.81</td>
<td>2</td>
<td>905</td>
<td>686</td>
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<tr>
<td>W. Malaysia</td>
<td>892</td>
<td>339</td>
<td>141</td>
<td>2.63</td>
<td>42</td>
<td>1,813</td>
<td>597</td>
</tr>
<tr>
<td>Nepal</td>
<td>2,207</td>
<td>1,108</td>
<td>78</td>
<td>1.99</td>
<td>7</td>
<td>2,453</td>
<td>1,239</td>
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<tr>
<td>Pakistan</td>
<td>1,975</td>
<td>1,147</td>
<td>860</td>
<td>1.72</td>
<td>75</td>
<td>3,470</td>
<td>1,604</td>
</tr>
<tr>
<td>Philippines</td>
<td>4,073</td>
<td>3,140</td>
<td>938</td>
<td>1.30</td>
<td>30</td>
<td>5,660</td>
<td>3,539</td>
</tr>
<tr>
<td>Sri Lanka</td>
<td>756</td>
<td>401</td>
<td>236</td>
<td>1.89</td>
<td>59</td>
<td>1,803</td>
<td>690</td>
</tr>
<tr>
<td>Taiwan</td>
<td>3,081</td>
<td>773</td>
<td>681</td>
<td>3.99</td>
<td>88</td>
<td>3,218</td>
<td>778</td>
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<tr>
<td>Thailand</td>
<td>9,199</td>
<td>5,511</td>
<td>1,650</td>
<td>1.67</td>
<td>30</td>
<td>13,175</td>
<td>7,734</td>
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<tr>
<td>S. Vietnam</td>
<td>4,822</td>
<td>2,432</td>
<td>262</td>
<td>1.97</td>
<td>11</td>
<td>7,200</td>
<td>2,900</td>
</tr>
<tr>
<td><strong>TOTAL:</strong></td>
<td>118,806</td>
<td>70,177</td>
<td>22,507</td>
<td>1.68</td>
<td>32</td>
<td>155,783</td>
<td>82,698</td>
</tr>
</tbody>
</table>

Sources: This table combines data obtained from FAO Monthly Bulletin of Agricultural Economics and Statistics; Asian Agricultural Survey II, Asian Development Bank (November 1978); FAO Bangkok Regional Office; and estimates by Kunio Takase.
CHART A
Green Revolution in India
(comparing wheat and rice)

CHART B
Irrigation Improvement in the Angat Pilot Program, Philippines
(140 hectares)

(A) Before Improvement
(April, 1968)

Inadequately Irrigated

- irrigation canal
  \[(2,240 \text{ m} \div 140 \text{ ha} = 16 \text{ m/ha})\]

- drainage canal
  \[(1,200 \text{ m} \div 140 \text{ ha} = 9 \text{ m/ha})\]

- non-uniform water distribution

Paddy Yield = 2.3 t/ha

(B) After Improvement
(June, 1969)

Adequately Irrigated

- irrigated canal
  \[(8,700 \text{ m} \div 140 \text{ ha} = 62 \text{ m/ha})\]

- drainage canal
  \[(3,200 \text{ m} \div 140 \text{ ha} = 23 \text{ m/ha})\]

- uniform water distribution

Paddy Yield = 3.1 t/ha

APPENDIX II

Technical Appendix

Based on the ADB’s experience described in the text, pilot schemes have become a regular practice in many irrigation projects. This concept has been applied not only to ADB-assisted pioneer projects such as the Nong-Wai Pioneer Project in Thailand and the Teluk Lada Area Development Project in Indonesia, but also the IBRD-assisted Irrigation Rehabilitation Projects in Indonesia and the Upper Pampanga River Project (UPRP) of 100,000 hectares in the Philippines.¹

The Philippine Government has expanded this idea and established a water management training center in the UPRP, with possible extension elsewhere in the country. As experience has accumulated, the following three elements now appear to be essential for the successful adoption of appropriate rice technology in irrigated areas:

1. *Experimental farms* to conduct scientific research and experiments in modern agricultural techniques, including studies of physical and biological relationships among varieties of crops, soils, fertilizers, and water. Experimental farms usually have an area of 5-10 hectares.

2. *Pilot schemes* to demonstrate applied techniques obtained from the experimental farm combined with irrigation water management operations and training farmers. A pilot scheme usually requires 100-200 hectares of land. The irrigation facilities of this scheme should be constructed according to the same design as other parts of the project.

3. *Pioneer projects.* Various activities such as those of marketing, credit, and farmers’ cooperatives should be established in a pioneer project, as a minimum economic and social unit (1,000-5,000 hectares) within a full-fledged irrigation project.

The second Asian Agricultural Survey conducted by the ADB in 1976 confirmed that the methodology and legitimacy of the above-mentioned experimental farms and pilot schemes are well accepted. However, the idea of pioneer projects with complete management and services is not yet widely accepted, which is an important reason for failure in reaching rice production targets in the region.

¹ These projects have confirmed that the average yield of paddy can reach 3.5 t/ha within several years of completion of systems having adequate infrastructure management, on-farm facilities, and modern agricultural practices.
Three-Step Approach to Irrigation Development

Experimental farm (5-10 ha)
Technical experiment (correlation of crop variety, soil, fertilizer and water)

Pioneer project (1,000-5,000 ha)
Minimum economic unit (marketing, credit, farmers' cooperatives, land reform and rural development)

Pilot scheme (100-200 ha)
Applied techniques (extension of cultivation techniques and water control with farmers' group actions)

The Industrialized Democratic Regions in a Changing International System

Inaugurated in July 1973, the Trilateral Commission is a policy-oriented organization. Based on analysis of major issues facing the trilateral regions, the Commission has sought to develop practicable proposals for joint action. The Commission's members are about two hundred distinguished citizens from the three regions, drawn from a variety of backgrounds.

The historical roots of the Commission can be traced to serious strains early in the 1970s in relations among Japan, North America and Western Europe. As the decade has proceeded, however, it has become increasingly clear that the strains and shifts in the international system are global as well as trilateral in scope. The renovation of the international system is a task of global as well as trilateral dimensions, and the work of the Commission has moved accordingly.

In this global effort, the industrialized democratic regions remain an identifiable community and a vital core. Their focus, however, must not be on the preservation of the status quo, but on arrangements which increasingly embrace the Third and Fourth Worlds in a cooperative endeavor to secure a more equitable world order.

The renovation of the international system will be a very prolonged process. The system created after World War II was created through an act of will and human initiative in a relatively restricted period of time. One power had overwhelming might and influence, and others were closely associated with it. In contrast, a renovated international system will now require a process of creation — much longer and more complex — a process in which prolonged negotiations will have to be engaged and developed. In nurturing habits and practices of working together among the trilateral regions, the Commission should help set the context for these necessary efforts.
Reports of Task Forces to The Trilateral Commission

1. *Towards a Renovated World Monetary System* (1973)
   Authors: Richard N. Cooper, Motoo Kaji, Claudio Segré

   Authors: François Duchêne, Kinhide Mushakoji, Henry D. Owen

   Authors: Richard N. Gardner, Saburo Okita, B. J. Udink

   Authors: Guido Colonna di Paliano, Philip H. Trezise, Nobuhiko Ushiba

   Authors: John C. Campbell, Guy de Carmoy, Shinichi Kondo

   Authors: John C. Campbell, Guy de Carmoy, Shinichi Kondo

   Authors: Richard N. Gardner, Saburo Okita, B. J. Udink

   Authors: Michel Crozier, Samuel P. Huntington, Joji Watanuki

   Authors: Michael Hardy, Ann L. Hollick, Johan Jorgen Holst, Douglas M. Johnston, Shigeru Oda

    Authors: Carl E. Beigie, Wolfgang Hager, Sueo Sekiguchi

    Authors: C. Fred Bergsten, Georges Berthoin, Kinhide Mushakoji

    Authors: Egidio Ortona, J. Robert Schaezkel, Nobuhiko Ushiba

    Authors: Chihiro Hosoya, Henry Owen, Andrew Shonfield

    Authors: Richard N. Cooper, Karl Kaiser, Masataka Kosaka

    Authors: Jeremy R. Azrael, Richard Lüventhal, Tohru Nakagawa

16. *Reducing Malnutrition in Developing Countries: Increasing Rice Production in South and Southeast Asia* (1978)
    Authors: Umberto Colombo, D. Gale Johnson, Toshio Shishido

    Authors: Hanns W. Maull, Keichi Oshima, John C. Sawhill