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# REPORT TO THE PRESIDENT OF THE INTERNATIONAL BANK FOR RECONSTRUCTION AND DEVELOPMENT AS ADMINISTRATOR OF THE INDUS BASIN DEVELOPMENT FUND

## STUDY OF THE WATER AND POWER RESOURCES OF WEST PAKISTAN

## VOLUME II

### Program for the Development of Irrigation and Agriculture

Prepared by a Group of the World Bank Staff

Headed by

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July 28, 1967

## CURRENCY EQUIVALENTS

| | | |
|---|---|---|
| 4.76 rupees | = | U.S. $1.00 |
| 1 rupee | = | U.S. $0.21 |
| 1 million rupees | = | U.S. $210,000 |

Program for the Development of
Irrigation and Agriculture in West Pakistan

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## Program for the Development of Irrigation and Agriculture in West Pakistan

## INTRODUCTION

i. This volume of the Bank Group's Report deals with the development of irrigation and agriculture in West Pakistan. Over a period of two years the Bank Group's consultants 1/ made a detailed study of the basic resources, the farming conditions and prospects, the existing and potential water resources, and the most practical means of developing agricultural production in keeping with the needs of the economy. Their findings together with a vast amount of data, supporting information, reasoning, conclusions and recommendations are contained in a Comprehensive Report 2/ supported by 22 volumes of annexures and a map supplement.

ii. At the beginning of the Study the general lines of procedure, terms of reference and the principle of full cooperation between the Bank Group, its consultants and the Government of Pakistan (GOP), including its agencies and consultants, was established. This cooperation has been maintained formally through a coordinating committee which met on eight occasions and, within the excellent atmosphere which has prevailed, to a much greater extent informally through the exchange of views and information between all concerned.

iii. This Bank Group's Report is based on the consultants' work and findings. It does not attempt to reproduce supporting data beyond what is necessary for an understanding of the Bank Group's conclusions and recommendations. In reviewing the consultants' report, the Bank Group has been influenced by the views expressed by the GOP on the consultants' findings, by their own experience in Pakistan and to some extent by developments and information which has become available since the consultants completed their field work early in 1966 and their report in October 1966. In a study of this complexity, where judgment must play such an important part in the interpretation of data and analyses, it is not surprising that - while there is a great measure of general agreement - the Bank Group's conclusions differ in some important respects from those of its consultants.

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1/ In the field of irrigation and agriculture the Bank Group obtained the services of the following consultant firms: Sir Alexander Gibb and Partners, London; International Land Development Consultants N.V. (ILACO), Arnhem, Holland; and Hunting Technical Services Limited, London. For the duration of the Indus Special Study these consultants formed the "Irrigation and Agriculture Consultants Association" (IACA) under the general coordination of Sir Alexander Gibb and Partners.

2/ International Bank for Reconstruction and Development; Program for the Development of Irrigation and Agriculture in West Pakistan. Comprehensive Report, Sir Alexander Gibb and Partners, International Land Development Consultants, N.V., Hunting Technical Services Limited; London and Arnhem, May 1966.

iv. The Bank Group's report, in accordance with the objective of the Indus Special Study, concentrates on the determination of a feasible Action Program capable of achieving levels of agricultural production commensurate with the resources and needs of the economy within the decade, 1965 to 1975. To this end the report evaluates some 14 major water development projects to be undertaken in the Third and Fourth Plan periods in addition to the on-going projects. These include the Tarbela Dam, 12 groundwater development projects formulated by IACA and one drainage project. Such a program, however, must be evolved within the context of longer term planning and its implications for future resource development have also been assessed in this report.

v. Attention has been concentrated on the canal commanded areas of the Indus Basin since these produce over 80 percent of present agricultural gross production and also offer the greatest scope for rapid further water and agricultural development. A detailed study of the irrigated land and the irrigation system by IACA preceded the establishment of priorities which make up the Action Program for 1965-75 referred to above. The Bank Group's report is not intended to provide a master plan for water and agricultural development in West Pakistan. However, the Bank Group considers that the Action Program outlined in this report is consistent with the resources likely to be available, the immediate needs of the country and sound future development. Also, the extensive studies carried out by IACA provide useful guidance for long term planning of water resource development.

vi. Having regard to West Pakistan's basic resources, the Bank Group is in no doubt that higher levels of production than are predicted in this report are technically feasible. Throughout, but particularly for the period 1965-75, the Bank Group has been concerned with what is practically achievable within the constraints that are likely to be operative, rather than with the technical potential. It has been assumed that the development of irrigation and agriculture would receive the high priority in the allocation of resources, which its importance deserves, and that these would be efficiently and effectively deployed. Water development and agricultural development are essentially interdependent, and both must receive appropriate emphasis. The level of agricultural production projected for 1975 would only be achieved as the result of a major effort of an emergency character and spectacular improvement in performance in all sectors. Its attainment should go far towards meeting West Pakistan's most pressing needs in food and exports of agriculturally based commodities and would reflect great credit on those concerned.

# I. PAST AND PRESENT PERFORMANCE OF AGRICULTURAL SECTOR

## A. Agriculture in West Pakistan

1.01 West Pakistan covers a land area nearly equal to that of France and Germany combined, but over three-fourths of this large expanse remains agriculturally unproductive. According to the 1960 Census of Agriculture, out of a total of nearly 200 million acres, only 37 million acres were actually under cultivation. Making allowance for sparce grazing over large additional areas, the agricultural sector thus rests on a much smaller land base than the vast size of the Province may at first imply.

1.02 A major characteristic of agriculture is the role played by irrigation. Being a semi-arid area, the availability of water is of critical import to West Pakistan's agriculture. Most of the water used for irrigation is supplied through canals fed by the Indus River and its tributaries, and this elaborate canal system currently commands about 33.5 million acres. Only about 25 million of these acres actually receive irrigation, but this area comprises nearly 70 percent of the cultivated acreage, supplies approximately 80 percent of the foodstuffs produced in West Pakistan and nearly all the cash crops. Over the years the reliance on the major rivers as a source of water for irrigation has led to a high concentration of population, irrigation investment, infrastructure, and markets in the Basin of the Indus River. Further extension of the canal system is constrained, however, by salinity and topography, and is also governed by limitations to the future supplies of irrigation water. In these circumstances, the more intensive use of the land already under irrigation is a strategic objective of the efforts to bring about future increases in agricultural production.

1.03 Within the constraints imposed by the natural resource base and the investment in agricultural infrastructure, the farmers of West Pakistan cultivate their fields under a two-season cycle -- kharif crops are grown during mid-April to mid-October, and rabi crops are grown during mid-October to mid-April. The major crops grown in the kharif season are cotton, rice, sorghum and millets. The major rabi crops are wheat and fodder. Gram, pulses, oilseeds, and fodder are grown in both seasons. Both sugarcane and fruits have been assuming greater importance as perennial crops. Since the relative importance of different crops varies greatly with the regions of West Pakistan, these generalizations hold true only in the broadest sense. Livestock provide the main source of draft power in farm operations, and West Pakistan supports a large livestock population for this purpose. Milk, milk products, meat, and animal by-products also make a considerable contribution to total agricultural production.1/

1/ A more detailed description of West Pakistan's agricultural resource and development features is presented in Chapter II below.

## B. Growth of Agricultural Production

### 1. Pattern and Magnitude of Growth

1.04 A brief review of the past performance by the agricultural sector in West Pakistan gives some indication of the patterns which agriculture has followed to date. From the time of Independence in 1947 to the start of the Second Five-Year Plan in 1960, the sector as a whole failed to exhibit any signs of sustained growth. There were year-to-year fluctuations in output owing to weather conditions, but the gross value added by agricultural production 1/ rose at an annual average rate of only 1.6 percent between 1949/50 and 1959/60. This trend continued into the first year of the Second Plan period, but changed markedly thereafter. Over the five years of the Second Plan period (1959/60 to 1964/65) the growth rate was at 3.8 percent per annum on average, or substantially higher than for any other comparable period since Independence.

1.05 The increased production of crops was particularly striking during these most recent years. Their gross value added grew at an annual rate of 4.7 percent over the Second Plan period. In contrast to this, the remaining components in the agricultural sector (livestock, forestry, and fishing) had a growth rate of 2.1 percent. It should be added, however, that the data concerning livestock are particularly uncertain, and are possibly subject to rather wide margins of error. Forestry and fishing did register sizeable increases during the Second Plan period, but they constitute small shares of the sectoral total, and are completely dominated in comparisons such as this by the livestock component.

1.06 Expressing the most recent level of output in monetary terms at 1959/60 prices, the official estimate of gross value added of agricultural production was Rs. 9,276 million in 1964/65. 2/ This, in turn, consisted of Rs. 6,018 million from crops (about 65 percent of the total) and Rs. 3,258 million from livestock, forestry, and fishing combined (about 35 percent of the total). Forestry and fishing, however, accounted for less than 1.5 percent of total value added. The orders of magnitude and rates of growth over the period 1949/50 and 1964/65 were as follows:

1/ Data cited here on value added in production are taken from official Government of Pakistan sources, and are expressed in constant (1959/60) prices.

2/ These and other official estimates of value added magnitudes differ from IACA's estimates of Gross Production Value (GPV) and value added because IACA has used its own assumptions for farm costs, farm prices, livestock production, acreage cropped and volume of production. In analyzing the implications of the IACA Comprehensive Report, the Bank Group has worked mainly from IACA estimates.

Growth of West Pakistan Agricultural Sector and Contribution to Gross Provincial Production 1949/50 to 1964/65
(Rs. million at constant 1959/60 prices)

| | 1949/50 | 1954/55 | Average Annual Rate of Growth 1950-55 | 1959/60 | Average Annual Rate of Growth 1955-60 | 1964/65 1/ | Average Annual Rate of Growth 1960/65 |
|---|---|---|---|---|---|---|---|
| Crops | 4,250 | 4,320 | 0.3 | 4,775 | 2.0 | 6,018 | 4.7 |
| Others | 2,345 | 2,628 | 2.3 | 2,936 | 2.2 | 3,258 | 2.1 |
| Total Agriculture | 6,595 | 6,948 | 1.0 | 7,711 | 2.1 | 9,276 | 3.8 |
| Agriculture's Percentage of GPP | 54.4 | 48.8 | | 46.3 | | 42.4 | |

1/ These and other official estimates of value added magnitudes differ from IACA's estimates of Gross Production Value (GPV) and value added because IACA has used its own assumptions for farm costs, farm prices, livestock production, acreage cropped and volume of production. In analyzing the implications of the IACA Comprehensive Report, the Bank Group has worked mainly from IACA estimates.
Source: Central Statistical Office.

1.07 The small amount of growth which occurred up to the 1960's came primarily as a result of sustained increases in the acreage under cultivation. The combined acreage under the major crops of wheat, cotton, rice, sugarcane, gram, oilseeds, and maize rose at an annual rate of about two percent over the decade 1949/50 to 1959/60, although rice and sugarcane acreage actually expanded at faster rates. Growth of crop yields was more disappointing and for most crops, yields either fell or remained relatively static during the same period. Continuous land and water development supported this acreage trend and this was also a time when refugees were being resettled in the aftermath of Partition and when land reforms were being initiated. These factors, plus natural population increase, undoubtedly had some impact on the area being cropped.

1.08 The experience since 1959/60 reveals a different set of forces at work. The shift to higher levels of production and more rapid growth which characterized most of the Second Plan period came about as a result of both increases in the acreage cropped and improved yields. For example, six of the seven major crops cited above showed some increase in acreage over the period 1959/60 and 1964/65, but they also showed greater proportionate increases in production in most of those same years. Climatic factors in different years caused some variation in yields, but the sizeable increase in production during the Second Plan period, which is not explained by acreage increase, suggests that factors other than weather had begun to exercise a significant influence on West Pakistan's agriculture. Recent acreage and production indices for major crops in all West Pakistan are shown below:

Acreage and Production Trends
(1959/60 = 100)

| | Cotton | | Wheat | | Rice | | Sugarcane | | Gram | | Oilseeds[1] | | Maize | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Acreage | Prod. | Acreage | Prod. | Acreage | Prod. | Acreage | Prod. | Acreage | Prod. | Acreage | Prod. | Acreage | Prod. |
| 1947/48 - 1952/53 Av. | 91 | 80 | 84 | 88 | 74 | 78 | 52 | 61 | 84 | 92 | 80 | 74 | 80 | 79 |
| 1959/60 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 1960/61 | 96 | 103 | 95 | 98 | 98 | 104 | 98 | 109 | 97 | 100 | 98 | 91 | 99 | 91 |
| 1961/62 | 104 | 111 | 101 | 103 | 101 | 113 | 112 | 135 | 105 | 102 | 80 | 87 | 98 | 102 |
| 1962/63 | 102 | 126 | 103 | 107 | 99 | 110 | 134 | 173 | 107 | 112 | 89 | 113 | 95 | 102 |
| 1963/64 | 110 | 141 | 103 | 107 | 107 | 120 | 120 | 151 | 98 | 100 | 84 | 91 | 104 | 111 |
| 1964/65 | 109 | 127 | 109 | 118 | 113 | 136 | 127 | 175 | 106 | 110 | 86 | 91 | 101 | 111 |

1/ Rape and Mustard Seed only.

Source: Computed from acreage and production date given in "Handbook of Agricultural Statistics", Planning Commission (1959/60 - 1962/63) and "Statistical Bulletin", February 1966 (1963/64 and 1964/65).

1.09 The recent yield trends for four of the most important crops in West Pakistan show the order of magnitude of some of the yield increases, as well as the variation in yield improvement as between different crops. Performance in wheat, for example, has lagged behind yield growth in cotton, rice, and sugarcane. Despite the favorable picture of yield improvement, which the following table illustrates, it should be borne in mind that yields in 1959/60 were generally at about the levels of the 1947/48-1952/53 averages, or below. Sugarcane, for example, did not exhibit significant yield increases beyond the earlier levels until mid-way in the Second Plan period, and 1964/65 wheat yields were still at about the level of the 1947/48-1952/53 average.

Yield Trends during the Period 1959/60-1964/65
(1959/60 = 100)

| Crop Year | Cotton | Rice | Sugarcane | Wheat |
|---|---|---|---|---|
| Average 1947/48-1952/53 | 88 | 106 | 117 | 105 |
| 1959/60 | 100 | 100 | 100 | 100 |
| 1960/61 | 107 | 105 | 112 | 103 |
| 1961/62 | 107 | 112 | 120 | 102 |
| 1962/63 | 123 | 112 | 129 | 104 |
| 1963/64 | 129 | 112 | 126 | 103 |
| 1964/65 | 116 | 121 | 138 | 108 |

Sources: Handbook of Agricultural Statistics, June 1964;
Statistical Bulletin, February 1966.

1.10 The next table provides a more comprehensive view of the performance by major crops in terms of acreage, production, and yields for selected intervals between 1947/48 and 1964/65, and the implicit annual growth rates. Comparison of the growth rates for the latest period (1957/58-1962/63 to 1964/65) with those for an earlier period, or over a longer period, indicates that a break of some kind has been made with the past. Increases in production seem less dependent on expansion of acreage than previously, again leaving the inference that yield improvements have begun to play a more important part in agricultural growth than before.

## Growth of Production of Major Crops (excluding Fodder) 1947/48 - 1952/53 to 1964/65

| | Wheat | Gram | Rice | Sugar | Cotton | Maize | Millet | Oilseeds |
|---|---|---|---|---|---|---|---|---|
| **Quantities:** | | | | | | | | |
| 1947/48 - 1952/53. Average Acreage (mill. acres cropped) | 10.2 | 2.4 | 2.2 | 0.5 | 3.1 | 1.0 | 3.4 | 1.1 |
| Production (mill. tons) | 3.5 | 0.6 | 0.8 | 0.6 | 1.3 1/ | 0.4 | 0.6 | 0.2 |
| Yield (mds. per acre) | 9.20 | 6.70 | 9.74 | 32.16 | 2.00 | 10.72 | 4.73 | 4.87 |
| 1957/58 - 1962/63. Average Acreage (mill. acres cropped) | 11.9 | 2.9 | 2.9 | 1.1 | 3.4 | 1.1 | 3.1 | 1.3 |
| Production (mill. tons) | 3.8 | 0.6 | 1.0 | 1.3 | 1.8 1/ | 0.5 | 0.6 | 0.2 |
| Yield (mds. per acre) | 8.75 | 5.85 | 9.43 | 32.78 | 2.43 | 11.03 | 4.92 | 4.87 |
| 1964/65. Average Acreage (mill. acres cropped) | 13.1 | 3.0 | 3.4 | 1.2 | 3.6 | 1.2 | 3.7 | 1.2 |
| Production (mill tons) | 4.5 | 0.7 | 1.3 | 1.8 | 2.1 1/ | 0.5 | 0.7 | 0.2 |
| Yield (mds. per acre) | 9.15 | 6.25 | 10.25 | 40.20 | 2.78 | 11.17 | 5.07 | 4.47 |
| **Growth Rates (percent per annum):** | | | | | | | | |
| 1947/48 - 1952/53 to 1957/58 - 1962/63 | | | | | | | | |
| (a) acreage | 1.6 | 1.9 | 2.8 | 8.2 | 0.9 | 1.0 | (-) 0.9 | 1.7 |
| (b) production | 0.8 | - | 2.3 | 8.0 | 3.3 | 2.3 | - | - |
| (c) yields | (-) 0.5 | (-) 0.5 | (-) 0.4 | 0.2 | 2.0 | 0.3 | 0.4 | - |
| 1947/48 - 1952/53 to 1964/65 | | | | | | | | |
| (a) acreage | 1.5 | 1.5 | 3.0 | 6.2 | 1.1 | 1.2 | 0.6 | 0.6 |
| (b) production | 1.5 | 1.0 | 3.3 | 7.8 | 1.1 | 1.5 | 1.1 | - |
| (c) yields | - | (-) 0.5 | 0.3 | 1.6 | 3.3 | 0.3 | 0.5 | (-) 0.6 |
| 1957/58 - 1962/63 to 1964/65 | | | | | | | | |
| (a) acreage | 2.4 | 0.8 | 4.1 | 2.2 | 1.4 | 2.2 | 4.5 | (-) 2.0 |
| (b) production | 4.3 | 3.9 | 6.7 | 8.5 | 3.9 | - | 3.9 | - |
| (c) yields | 1.1 | 1.7 | 2.1 | 5.2 | 3.4 | 0.3 | 0.8 | (-) 2.2 |

Source: Handbook of Agricultural Statistics, June 1964; Statistical Bulletin, February 1966.

1/ In million bales.

1.11 The two kinds of trend data given above show that sugarcane, a high value crop, had the largest proportionate acreage and yield increases among the major crops since 1959/60. On these counts it therefore made a substantial contribution to overall growth in the agricultural sector, probably accounting for nearly 40 percent of the increase in gross production value of major crops between 1959/60 and 1964/65. Wheat accounted for about one-third of the increase in gross production value. This was due mainly to the fact that wheat is the largest single crop in terms of both acreage sown and gross value. Although neither wheat yields nor wheat acreage increased very greatly, its dominant position in the cropping pattern gives it an important weight in the total increase in production. Rice was the third largest influence among major crops, and recorded increases in both yields and acreage in the most recent years. Cotton yield improvements were among the highest, but cotton production increases contributed less to total production than the other three crops. Altogether, sugarcane, wheat, and rice probably provided over 85 percent of the increased gross production value over the Second Plan period. Viewed in this perspective, another aspect of the pattern of recent agricultural growth was that producton increases in a very small number of major crops provided the bulk of the production on which growth is measured.

2. Sources of Growth

1.12 Efforts to identify the specific contribution of individual productive inputs to agriculture have not been convincing, but the increase in production has been accompanied by a general increase in the use of inputs of several kinds. One major influence has certainly been the impact of additional water supplies from public and private sources. The Government of West Pakistan has followed an investment policy in water resource development designed to expand the water supplies available to farmers, and about 5.5 million acre feet (MAF) were added to existing supplies during the Second Plan period. Approximately 3.0 MAF of this resulted from improvements in surface water supplies and the balance of 2.5 MAF came from public tubewell installations. The striking element, however, was the surprising surge in private investment in tubewells and the sustained momentum of this investment throughout the Second Plan period. The probable additional contribution of private tubewells was nearly 6.0 MAF, or a volume of water about the same as provided by the public programs. Available data indicate that the number of private tubewells has increased at a rate of about 15 percent per annum during the Second Plan period. Over the past two years the annual increase has averaged above 30 percent. The numbers of wells installed in the most recent years are shown below:

Estimate of Private Tubewells in Operation

| | 1963 | | 1964 | | 1965 | |
|---|---|---|---|---|---|---|
| | Number | MAF | Number | MAF | Number | MAF |
| Private Tubewells | 17,390 | 3.47 | 23,700 | 4,74 | 26,650 | 4.7 |
| Private Tubewells supported by Department of Agriculture | 1,109 | 0.22 | 1,475 | 0.29 | 7,350 1/ | 1.3 |
| TOTAL | 18,499 | 3.69 | 25,175 | 5.03 | 34,000 2/ | 6.0 |
| Rate of Growth | | | 36% | | 35% | |

1/ Source: Agriculture in Pakistan, USAID, Karachi, 1966.
2/ Exceeds IACA's estimate by about 2,000 wells allowing for recent findings of survey in the Northern Zone.

An important factor in spreading private tubewell development has been the Department of Agriculture's drilling activity on behalf of farmers.

1.13 A second important input was chemical fertilizers. Use of these, and particularly nitrogenous fertilizers, began to grow rapidly during the Second Plan period. The increase during the First Plan period (1954/55-1959/60) was a modest one of only 5,000 nutrient tons. Thereafter, the rise was more spectacular, as shown in the following table:

Fertilizer Use during the Second Plan Period

| Year | Nitrogen (N) | Phosphate ($P_2O_5$) | Total | Annual Increase (%) |
|---|---|---|---|---|
| | ---- (tons of nutrient) ---- | | | |
| 1959/60 | 19,300 | 100 | 19,400 | 0.8 |
| 1960/61 | 31,100 | 400 | 31,500 | 62.7 |
| 1961/62 | 37,200 | 500 | 37,700 | 19.7 |
| 1962/63 | 42,900 | 1,400 | 44,300 | 17.5 |
| 1963/64 | 62,400 | 1,100 | 63,500 | 43.3 |
| 1964/65 | 84,000 | 2,000 | 86,000 | 35.4 |

Source: Planning Commission

This increase in fertilizer use was supported by a Government subsidy. The drop in growth of offtake in 1961-1963 coincided with a decrease in the rate of subsidy. After reinstatement of full subsidy, offtake again grew rapidly.

Shortages in supply probably limited use in the final year of the Second Plan to the quantities shown, for there have been pervasive reports of sales of fertilizers at black market prices since 1964/65. The availability of additional water must have been an important stimulus to fertilizer sales because the geographical distribution of the largest increase in fertilizer use tended to coincide with the areas where rapid growth in private tubewell installation took place, i.e. the northern parts of the Indus Plains. Though still small in absolute terms, the rapid rise in fertilizer use must have made an important contribution to the growth of cash crops on which applications have been concentrated.

1.14 An increase in the use of other inputs may have made some marginal contribution to growth, but these effects are difficult to trace and do not begin to rank with water and fertilizer in importance. Plant protection measures were carried out on an additional four to five million acres during the Second Plan period, but results are uncertain. This is because the effectiveness of plant protection activities depends on the timeliness of their application and other factors as much, or more, than the acreage covered, and no comprehensive assessment of the program in these qualitative terms has yet been made. The distribution of improved seed has been hampered by administrative difficulties and a lack of good foundation stock. Probably only in the case of cotton has there been any widespread supply of improved varieties to farmers, and the significance of this improvement is open to doubt since controls on seed selection and protection against adulteration have not been equally effective in all areas. Major efforts have now been launched to produce and distribute improved wheat varieties, but these started too late to have an impact on production during the Second Plan period.

1.15 Better farming methods, e.g. proper seed bed preparation, effective weeding, row planting, and the like, depend in part on the institutions responsible for the dissemination of relevant information, and the agricultural supporting services in West Pakistan suffer from a variety of deficiencies which limit their capacity to perform this function. Operators of some of the larger farms have begun to express keen interest in new ways to improve husbandry practices, and the watercourse studies carried out by IACA have shown that the most progressive farmers are already achieving excellent yields under existing conditions. The average farmer, however, seems little affected thus far by the efforts of the research and extension services, and continues to cultivate his land in the traditional manner and with generally poor results.

1.16 The varied experience with respect to crop production and the use of inputs which has been outlined above does not detract from the fact that many farmers have begun to make positive, albeit selective, efforts to improve their yields and to adopt a more commercial type of agriculture. This implies that economic incentives were present and important in the stimulation of investment in new inputs, and led to a higher proportion of cash crops. Examination of the domestic terms of trade confirms that such incentives did, in fact, prevail. The terms of trade were unfavorable toward agriculture in the early and mid-1950's as a result of a range of Government policies designed to stimulate industrial growth, but this situation underwent substantial change starting in the early 1960's. More favorable price policies toward agriculture (for both exported and domestically consumed commodities), and a rapid growth in supplies of manufactured goods from the expanding Pakistan industrial sector combined to improve the situation of agriculture. This shift is illustrated by the movement in the terms of trade indices shown below:

Summary of Domestic Terms of Trade 1/ for the Manufacturing and Agricultural Sectors

| Year | Manufacturing Sector | Agricultural Sector |
|---|---|---|
| 1951-1954 | 108.6 | 97.4 |
| 1954-57 | 112.0 | 91.4 |
| 1957-60 | 102.6 | 99.4 |
| 1958-61 | 98.1 | 103.1 |
| 1959-62 | 95.3 | 106.4 |
| 1960-63 | 94.8 | 108.3 |
| 1961-64 | 96.1 | 107.8 |

1/ Based on three-year moving averages. The indices measure the wholesale prices of goods that a sector sells relative to the wholesale prices of goods it buys. The weights for manufacturing are the values added in each industry in 1959/60, and the weights for agriculture are the estimated purchases of agricultural goods by the non-agricultural sector in 1959/60. Stephen R. Lewis, Jr. and S. Mushtaq Hussain, "Relative Price Changes and Industrialization in Pakistan, 1951-64", Memorandum No.5, Center for International Affairs, Harvard University, Cambridge, Mass.

The changes shown, starting in 1958-61, should have provided incentives for farmers to increase their production, and also made it more possible to invest in the kinds of inputs which promote growth in production.

1.17 A final element affecting growth was the level of resources invested in agricultural and water development. Government planning has been directed toward a structural transformation of the economy to reduce its dependence on agriculture and increase the proportionate shares of the non-agricultural sectors, but it has not intended to curtail the contribution which agriculture can make to economic growth. The West Pakistan allocations to public sector expenditures on agriculture and water in the Second Plan period were 16.9 and 15.1 percent of the total Provincial allocation respectively, or a total of Rs. 2,527 million. Weakness in the administrative organization resulted in a failure to utilize more than two-thirds of the allocation to agriculture. Public investment in water development exceeded the Plan allocation by nearly 20 percent, although physical targets were not always achieved. There was thus a net shortfall in expenditures, amounting to about nine percent of the total, for the agriculture and water sectors combined, but in comparison with the First Plan and earlier periods there was still a substantial increase in both the volume of resources invested and the proportion of the total allocation actually utilized by agriculture and water.

Public Sector Expenditure on Agriculture in West Pakistan During the Second Five-Year Plan (1959/60-1964/65)

| Sector | Allocation (Rs. mill) | Allocation (Percent) | Actual Expenditure (Rs. mill.) | Shortfall (Percent) |
|---|---|---|---|---|
| Agriculture | 1,336 | 16.9 | 890 | - 33.3 |
| Water | 1,191 | 15.1 | 1,413 | + 19.1 |
| Total Agriculture | 2,527 | 32.0 | 2,303 | - 9.0 |
| Total Plan | 7,878 | 100.0 | | |

Source: IACA Comprehensive Report, Volume 1, page 7.

Allowance should be made for the fact that much of this expenditure would not be productive during the Second Plan period but would be significant to growth during the Third Plan period. In addition to the above figures, Rs. 2,185 million were spent in the Second Plan period on the Indus Basin Plan Works.

## C. Contribution of Agriculture

### 1. Contribution to the National Economy

1.18 The agricultural sector in West Pakistan, although still the single most important sector in the Provincial economy in terms of value added, has been providing a declining share of Gross Provincial Product since 1949/50, from 54.4 percent in 1949/50 the proportion had been reduced to 42.4 percent by 1964/65. Even the recent improvement in agriculture's growth rate during the Second Plan period failed to alter this trend, for other sectors of the Provincial economy continued to develop at a faster pace than agriculture.

1.19 When considered in the context of the national economy, the agricultural sector for the whole of Pakistan has been contributing about half the Gross National Product. The sector also exhibits a similar tendency to decline as a proportion of Gross National Product, although the drop is less pronounced than in the case of West Pakistan alone. The structural transformation of the economy from agriculture toward a more diversified industrial base, which has been an objective of Pakistan's economic planning, has thus gone much farther in West Pakistan than for the national economy as a whole. Even so, West Pakistan agriculture is still contributing more than one-fifth of Pakistan's Gross National Product. It may also be noted that although the sectoral contribution of West Pakistan's agriculture has declined in the above sense, West Pakistan's share in the total agricultural sector for all Pakistan has increased slightly. This reflects the fact that West Pakistan's agricultural growth has been more vigorous than East Pakistan's during the Second Plan period. The following table summarizes these different relationships:

Agriculture's Contribution to Gross National Product
(constant 1959/60 prices)

| | 1959/60 | 1960/61 | 1961/62 | 1962/63 | 1963/64 | 1964/65 1/ |
|---|---|---|---|---|---|---|
| Gross National Product (Rs. mill.) | 31,439 | 32,992 | 34,884 | 36,062 | 38,881 | 40,679 |
| Agricultural Sector (Rs. mill.) | 16,753 | 17,285 | 18,183 | 18,272 | 19,405 | 19,753 |
| Agricultural Sector as percentage of GNP (%) | 53.3 | 52.4 | 52.1 | 50.7 | 49.9 | 48.6 |
| West Pakistan Agricultural Sector (Rs. mill.) | 7,711 | 7,695 | 8,171 | 8,597 | 8,813 | 9,276 |
| West Pakistan Agricultural Sector as percentage of GNP(%) | 24.5 | 23.3 | 23.4 | 23.8 | 22.7 | 22.8 |
| West Pakistan Agricultural Sector as percentage of all Pakistan Agriculture (%) | 46.0 | 44.5 | 44.9 | 47.1 | 45.4 | 47.0 |

Source: Planning Commission.
1/ Provisional.

The table indicates that over the five year period of the Second Plan GNP grew at about 4.3 percent per annum while the all Pakistan agricultural sector grew at about 2.7 percent per annum only. The agricultural growth in

West Pakistan at 3.8 percent per annum was thus considerably above that of the total sector and fairly close to that of total GNP.

2. Employment and Per Capita Income

1.20 Agriculture's most direct contribution is the livelihood it provides to the people engaged in it, and this still involves a large majority of the population of West Pakistan. Out of a total population estimated to be 51.2 million in 1965, about 35 million or roughly 70 percent are directly dependent on agriculture. An additional three million people live in rural areas, but are only indirectly dependent on agriculture in the sense they are employed as traders, artisans, in transport, or in other service occupations. Assuming the rural population was 38.1 million persons in 1964/65, and using only the agricultural sector total as a base, per capita Gross Provincial Product in that year for this population segment was Rs. 243. This compares with Rs. 962 per capita if the non-rural population is assumed to share in all sectors of the Gross Provincial Product exclusive of agriculture, and Rs. 428 for the total population and the West Pakistan economy as a whole. A similar disparity would be evident if the comparisons were made on the basis of Gross Provincial Product per worker employed in agriculture as against other sectors. Admitting the imprecision of the data on which such measures of per capita production rest, it nevertheless seems clear that the much larger agricultural population receives disproportionately small rewards.

1.21 Current estimates of population growth in West Pakistan assume a growth rate of about 2.6 percent per annum, and this rate has also been used to estimate the population in prior years back to 1959/60. Comparison of this rate with the growth rate for agriculture, and particularly for crops, over the period 1949/50 and 1959/60 indicates that agriculture failed to keep pace with an expanding population. This has been most evident in the case of wheat, the major food grain for the Province. West Pakistan had been a marginal exporter of wheat in years prior to 1950, but since that time the Province has absorbed increasing quantities of imported wheat. IACA has estimated that during the period 1950-54 average annual imports of wheat were 330 thousand tons, equal to around ten percent of Provincial production. This quantity and proportion had risen to an annual average of over one million tons, or 22 percent of Provincial production, by the period 1960-64. Wheat imports were brought in under concessional terms available through the P.L. 480 program and therefore did not constitute a heavy foreign exchange expenditure, but their growing size does serve as one measure of performance during recent years. Other foodstuffs have not been imported to a similar extent, but IACA estimates of apparent consumption from domestically produced supplies point to a conclusion that the typical diet in West Pakistan is deficient in calories and protein, does not include sufficient fruit and vegetables, and is unusually dependent on milk as a source of animal protein and calories.

1.22 This general picture can be shown in another way. Per capita foodgrain production, computed for four reference years between 1949/50 and 1964/65, was at its highest level in 1949/50. It declined quite seriously by the mid-1950's and had not fully recovered the 1949/50 level by 1964/65, in spite of the growth which took place during the Second Plan period. The same pattern emerges from per capita estimates of income for the agricultural population, again relating the rural population to the agricultural sector of the Gross Provincial Product. An important part of the most recent growth has, therefore, been devoted to regaining lost ground, and it appears that at present the rural population as a whole is probably little better off than it was fifteen years ago. Looked at from this perspective of a longer time period, agriculture's contribution to the people engaged in it has not provided the basis for much, if any, improvement in economic status. Estimates for per capita income and production are summarized in the following table:

Per Capita Production and Income
(at constant 1959/60 prices)

| | 1949/50 | 1954/55 | 1959/60 | 1964/65 |
|---|---|---|---|---|
| Per capita-total population | | | | |
| Income 1/ (Rs.) | 342 | 354 | 366 | 428 |
| Foodgrains production (kgs) 2/ | 188 | 144 | 151 | 153 |
| Total agricultural production 3/ (Rs.) | 187 | 174 | 171 | 181 |
| Per capita-rural population | | | | |
| Income 3/ | 238 | 222 | 215 | 243 |
| Foodgrains production (kgs) 2/ | 239 | 182 | 189 | 206 |
| Population (millions) | | | | |
| Total | 25.3 | 39.9 | 45.0 | 51.2 |
| Rural | 27.7 | 31.5 | 35.8 | 38.1 |

1/ Gross Provincial Product at factor cost.
2/ Taken from Pakistan Handbook of Agricultural Statistics, with same allowance for under counting used by IACA
3/ Agricultural sector of Gross Provincial Product.

The maintenance of an acceptable per capita income in agriculture carries important implications for the economy at large. Economic growth involves movement of labor from agriculture into other sectors provided these have sufficient capacity to absorb additional labor. Absorption of labor by non-agricultural sectors, however, is largely dependent on agriculture as a market for industrial production. The maintenance of socially acceptable incomes in agriculture is thus important from two points of view: a) it should prevent excessive movement of labor, and b) it should generate sufficient purchasing power to create adequate markets to support domestic industrial growth. The disparity between per capita income in agriculture and other sectors shown above would suggest that this balance has not yet been reached.

## 3. Export and Import of Agricultural Products

1.23 Despite the fact that agricultural production has not grown as rapidly as the population during much of the period since 1949/50, agriculture has continued to be the major source of foreign exchange earnings. Furthermore, increases in output achieved during the Second Plan period, and changes in the composition of the crops which are grown, have raised the foreign exchange contribution in absolute terms. Agriculture, as measured by raw commodities and manufactures from cotton and animal products, provided about 74 percent of all exports from West Pakistan in 1964/65, and nearly Rs. 850 million in foreign exchange. This may be seen from the following table:

Agriculture's Share of Foreign Exchange Earnings During the Second Plan Period 1/

| | 1959/60 | 1960/61 | 1961/62 | 1962/63 | 1963/64 | 1964/65 2/ |
|---|---|---|---|---|---|---|
| | ----- (Rs. million: f.o.b.) ----- | | | | | |
| Total Exports West Pakistan | 763 | 540 | 543 | 998 | 1,075 | 1,152 |
| Agricultural Exports West Pakistan | 593 | 431 | 392 | 792 | 781 | 849 |
| Agricultural Exports West Pakistan as percent of West Pakistan Exports | 78% | 80% | 72% | 79% | 73% | 74% |
| Rate of Growth of Agricultural Exports from West Pakistan | -- | (-) 27% | (-) 9% | (+)102% | (-) 1% | (+) 9% |

1/ Compiled on the basis of Pakistan Statistical Yearbook 1964 Karachi 1966, pages 194 to 201 and Preliminary Evaluation of Progress during Second Five-Year Plan, Karachi 1965, page 117; IBRD Report No. AS-112 and Annexure 1 of IACA Report.
2/ Estimates.

The major components in this export performance were cotton and fine rice, both of which have shown their largest growth during the Second Plan period. There has been an import substitution effect because West Pakistan textile manufacturers using domestic fibers now supply the bulk of cotton textiles used in Pakistan, but there have been direct effects as well now that textile exports have begun to increase. Raw cotton exports declined somewhat during the early 1960's as the expansion of Pakistan's manufacturing capacity took place and local demand for the fiber grew, but raw cotton exports have again risen to the levels of previous years. Fine rice varieties from West Pakistan have been well received in Middle East markets, and export earnings from this source have increased more than three-fold since 1954/55. Quantities and values of other agricultural exports, however, have changed less.

1.24 In the context of earlier observations concerning the need to import wheat for domestic consumption, it should be noted that West Pakistan's agriculture, as a sector, has contributed more to export earnings than has been required for the import of agricultural commodities (either as raw material or as manufactured goods based on agricultural commodities). It has, therefore, been more than self-sufficient on this basis and, in fact, has made a net contribution toward the importation of goods and services into Pakistan for consumption or investment in new development activities. The following table illustrates this aspect of agriculture's performance:

Exports and Imports of Agricultural Commodities, 1956-1963
(Rs. mill.)

| | 1956 | 1957 | 1958 | 1959 | 1960 | 1961 | 1962 | 1963 |
|---|---|---|---|---|---|---|---|---|
| Exports (raw materials and manufactures based on agricultural commodities) | 548.2 | 557.9 | 332.3 | 419.6 | 581.0 | 411.8 | 499.1 | 620.2 |
| Imports (raw materials and manufactures based on agricultural commodities) | 218.9 | 375.3 | 310.3 | 349.3 | 525.5 | 375.7 | 335.3 | 477.5 |
| Export Balance | 329.3 | 182.6 | 22.0 | 70.3 | 55.5 | 36.1 | 163.8 | 142.7 |

Source: Computed from data provided in Statistical Handbook of West Pakistan, 1964, pages 408-411.

Figures in the previous table showing foreign exchange earnings were compiled on a fiscal year basis, and therefore differ from the calendar year figures shown in the table above.

## D. Main Aspects of Production Policies toward Agriculture

### 1. Policy Framework and Application

1.25 The foregoing brief review has attempted to describe the pattern of agricultural growth in West Pakistan and the factors most directly related to it. Behind these factors, however, lies a background of policy actions and policy attitudes which combine to stimulate or discourage responses in the agricultural sector. Some of the important parts of this background can be broadly outlined here, although the account will be necessarily incomplete and lacking in detail.

1.26 Government development strategy has been to provide the agricultural sector with adequate resources to achieve the agriculture production targets, while the non-agricultural sectors have been regarded as the major sources of long term economic growth. Within agriculture, an important share of the resources allocated have gone to provide physical inputs such as fertilizers and plant protection materials, while the supporting services have generally operated under some financial stringency in their efforts to improve the quality and quantity of such services. Because West Pakistan agriculture depends so heavily on irrigation, and because the implementing agency for water development has demonstrated a greater capacity to absorb the investment resources allocated to it, an increasing share of the resources for agriculture has been diverted to the water sector.

1.27 Within Pakistan's comprehensive planning effort, however, and a public investment program which still dominates Pakistan's development activities, there is increasing evidence of a pragmatic willingness to afford wide opportunity for private initiative and private investment in all fields, especially since the start of the Second Plan period. This must be credited as an important environmental factor influencing the significant volume of private investment which has recently been going into tubewells. Although Government did relatively little consciously to stimulate such private investment, aside from a certain amount of contract drilling by the Department of Agriculture and electrification of some rural areas, the general attitude of Government did not impose obstacles which discouraged or dampened the vigor of the private sector. Now that the private tubewells' contribution to agriculture has been clearly demonstrated, Government has moved to provide more positive support. The Agricultural Development Bank (ADB), operating with an International Development Association (IDA) credit, has been increasing its loans for tubewell installation and mechanization since the latter part of 1965. The Government of West Pakistan has also adopted a formal policy position that public tubewell programs should not be carried out in areas where substantial private tubewell development is in progress, except in those places where public programs have already begun. Further indication of Government's recognition of the importance of private investment, including tubewells, is the projection that 31 percent of Third Plan expenditures on agriculture will come from the private sector - a proportion more than double the projection made for the Second Plan.

1.28 Policies affecting prices have shaped the favorable movements in the domestic terms of trade, cited earlier. Government has used its imports of wheat under P.L. 480 to stabilize the price of this staple foodgrain. Maintaining favorable prices in the urban areas was a part of Government efforts to stimulate the industrial sector, but at the same time the maintenance of relatively stable prices throughout the year may have also encouraged farmers to emphasize cash crops in place of subsistence production. Procurement prices for fine rice, reflecting to some degree the premium received for its export, have apparently had a promotional affect on this crop, and sugarcane production has increased under the combined incentives of a high procurement price for cane and heavy duties on imported sugar. These policies are in marked contrast to those which prevailed prior to 1960, at which time rationing of foodgrains and Government control over the intra-Provincial movement of foodgrains generated disincentives to farmers and disorganized normal marketing channels.

1.29 Prices of some farm inputs, notably fertilizers and plant protection have been set at levels which provide incentives to use them. Fertilizers were sold to farmers at fixed retail prices which reflected a subsidy of about one-half the supply cost. When a reduction of this subsidy (accompanied by a corresponding increase in the price to farmers) coincided with a drop in the rate of fertilizer sales expansion in 1961-63, the original subsidy level was reinstated and fertilizer sales rose briskly in subsequent years. The subsidy has recently been again reduced, but the prices paid by farmers are still below costs of procurement, transportation and handling. Plant protection materials and service are provided without charge to the farmers. While the value of the current plant protection program is uncertain, for reasons briefly touched upon earlier, the intention is clearly to provide the strongest possible price incentive (i.e. a free good) during a time when plant protection is being introduced to farmers. Subsidies have also been present to some extent in the charges for rental of tractor services and for Agriculture Department well-drilling, and charges for canal irrigation water have not been raised commensurately with the increase in farmers' incomes and in operation and maintenance costs on the canals.

1.30 Production of certain crops, e.g. fine rice, dried and fresh fruits, oilcakes and oilseeds, has been stimulated by the issuance of bonus vouchers against their export. The bonus improves their competitive position in world markets, and domestic procurement prices are strengthened by the increased demand from foreign buyers. Cotton, however, has been subject to an export tax, designed originally as a revenue-producing levy. Government became increasingly aware that the export tax had the unfortunate side effect of depressing the price to farmers, and from 1958 the tax on cotton has been steadily reduced until it is now only a nominal amount. This has strengthened the prices farmers receive and has undoubtedly been a factor in the recent growth of cotton production.

1.31 Government has also made an attempt to alter the land tenure system in favor of the small landowner and the farm tenant. Land in West Pakistan is very unevenly distributed - IACA estimates that 49 percent of the farms are of five acres or less and account for ten percent of the culturable area, while eight percent of the farms are 25 acres or more and account for 40 percent of the culturable area. The average farm size is about ten acres and therefore relatively small. Land reform legislation has sought to reverse this situation in two ways: one limits the right to sub-divide land below a minimum size designated as an "economic holding", and the second requires the largest landowners (those with more than 500 acres of irrigated land or 1,000 acres of unirrigated land) to divest themselves of land in excess of the legal limits. Both kinds of measures have had only limited success in achieving their objectives, but the former strong bargaining position of the larger landlords may have been partially weakened in the process. Efforts to consolidate land holdings which are fragmented have proceeded very slowly, although IACA finds that consolidation schemes are more favored by the large commercial farmers than the smallholders. It is difficult to relate any of the recent increase in production directly to the effects of land reform programs, in part because land reform has had so little measurable impact on the size distribution of land holdings. On the other hand, land reform may be a factor in changing the attitudes of large landowners, and awakening a more active interest in improving the productivity of their lands through increased investments, including tubewells and mechanization of farm operations.

1.32 There has been limited improvement in the agricultural marketing system in the Province. Market places have been established at convenient points, but malpractices persist and the farmer is generally at a disadvantage in his dealings with market middlemen. It seems probable, therefore, that marketing arrangements have had little positive influence on recent trends in agriculture and in their present form may create disincentives to increased production, particularly for the small farmer. Transportation is closely related to marketing and here Government has allocated resources under the Rural Works Program to stimulate local participation in the creation of rural infrastructure. In recognition of the importance of rural farm-to-market roads, Government stipulated that one-half the funds earmarked for Rural Works in 1964/65 had to be spent on local roads construction, but actual performance fell short of this. Aside from this, however, Government investment in transportation under the Plans has been for major highways and railway improvements. Weaknesses in both these respects emerged during the Second Plan period when transport facilities were severely taxed by the increased movement of both agricultural and non-agricultural commodities. Improvement in these major arteries of transport, though not a direct link for much of the rural area, will nevertheless provide the basic transport capacity on which an expanding agricultural sector will depend for the movement of the goods it requires and the goods it produces.

## 2. Institutional Support

1.33 In addition to the general policies affecting agriculture, briefly sketched above, Government has sought to improve the efficiency of the direct flow of investment and services to agriculturists through a variety of institutional arrangements. Some of these are well-established, such as the Departments of Agriculture (responsible for agricultural research and extension) and Irrigation, and the Board of Revenue (responsible for land reform, colonization, land utilization, and revenue collection). Other agencies have been organized more recently to carry out certain development activities not generally provided for within the framework of the traditional administrative structure. Included in this latter group would be the Water and Power Development Authority (WAPDA), The Agricultural Development Corporation (ADC), The Land and Water Development Board (LWDB), The Agricultural Development Bank (ADB), and the Cooperative Development Board. Responsibility for overall planning and coordination (agricultural and non-agricultural sectors) rests with the Planning and Development Department of the Government of West Pakistan.1/ More recently, as further evidence of the priority Government attaches to the agricultural sector, a high level Agriculture Committee has been established, with the Governor of West Pakistan as Chairman. This listing of the organizations indicates the range of activities and the Government's willingness to support administrative innovations where development needs seem to require them.

1.34 The effectiveness of these institutional arrangements has not been uniform, however, although broad generalizations are both inadequate and probably unfair in some respects. Nevertheless, some comments can be made on the basis of experience to date. The most pervasive problem has arisen from the fact that institutions dealing with agriculture have frequently had overlapping responsibilities, or at a minimum have had jurisdictional limits which were sufficiently vague to permit differing interpretations by different Government bodies. Strong and purposive coordination is essential in such situations, but this has been difficult to attain at times in West Pakistan. Problems have arisen in efforts to relate research to extension, development of water resources to water distribution and utilization, project implementation to project management, and input supplies to credit availability, to cite some examples. Where coordination has been weak, there has been some tendency to protect or expand narrowly construed institutional interests, rather than to focus efforts on the main task of promoting agricultural development. An outcome of this nature may be inevitable whenever new institutions are created since it takes time for any new organization to fall into a workable relationship with the already existing administrative structure. The point remains, however, that there is presently need for better coordination and careful delineation of areas of responsibility. Further, the difficulties encountered in providing coordination in the past should receive heavy weight when considering proposals to increase further the number of institutions to be coordinated.

1.35 A second area affecting institutional performance concerns the quality of the available staff in the various agencies. Lack of skilled and experienced personnel is, of course, a constraining factor in any large and rapid development effort, and its elimination is one of the objectives.

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1/ A description of the status, function, and composition of these Departments and agencies is given in IACA's Comprehensive Report, Volume 8, Annexure 11.

Personnel deficiencies with respect to skill and experience retard the capacities of development-oriented agencies to fulfill their functions adequately. Agricultural institutions in West Pakistan have been subject to this weakness, and all could benefit substantially from significant additions of well-qualified staff in a wide range of specialities. The availability of such personnel depends, in part, on improvement in the education facilities at all levels. It also requires pay scales and career opportunities (in fields related to agriculture) that are attractive to promising young people at the secondary levels of education.

1.36 To illustrate something of the magnitude of this problem the institutions concerned with water development programs (WAPDA and the Irrigation Department) will require large numbers of graduate engineers. Current estimates indicate that against Third Plan total requirements in all fields for about 7,000 new engineers, only 3,800 new graduates are expected to come from the engineering colleges. The IACA water development program alone will need about 1,000 engineers for planning and construction and 300 for supervision and operation of tubewell projects. The number of graduates of agricultural colleges may be more adequate when compared with expected needs, but it is difficult to predict whether they will be adequate in terms of the quality of training received, or whether certain critical fields of specialization (e.g. in research) can be sufficiently staffed. The shortage of field assistants, to work with farmers in extension activities, is particularly severe. IACA has estimated that the agricultural institutions will require about double their present field staff by 1975, and nearly three times as many by 1985. Present training facilities cannot produce these numbers and, at the same time, the process of providing qualitative and quantitative staff improvement for agricultural institutions requires support and planning from levels of Government outside the institutions themselves.

1.37 In addition to these problems, which are somewhat specific to the situation in West Pakistan, there are the types of problems which usually arise in any institution. For example, there are problems of intra-agency coordination, allocation of funds for equipment and services to supply staff members in field assignments, turnover among key personnel, and general administrative procedures. These are affected to some extent by the inter-agency coordination difficulties and personnel problems singled out above, but are not solely the result of them.

1.38 On balance, it appears that institutional arrangements have been made in West Pakistan which provide an administrative machanism to carry out a full program of agricultural development. The results to date have been disappointing both in actual achievement and relative to expectations. This may be due partly to unduly optimistic expectations. Success in mounting and carrying out an expanded future program of development depends a great deal on the institutional base and Government's ability to make improvements in it. The Bank Group feels that the latter will come less from additions to, or major modifications in, the institutional arrangements which already exist than it will from better planning and coordination of the activities of all organizations concerned and a steady improvement in the caliber of their personnel.

# II. AGRICULTURAL DEVELOPMENT POTENTIAL

## A. Land, Soils, Climate, and People

### 1. Land

2.01 The Province of West Pakistan is bordered on the west and north by mountain ranges, with desert areas lying inside the mountains along much of the lower western portion. The common boundary with India on the east also consists of desert over roughly its southern half. The major agricultural areas lie within the basin formed by the Indus River and its tributaries, which run in a general northeast/southwest direction from the points where the rivers enter Pakistan to the mouth of the Indus at the Arabian Sea east of Karachi, and which extends into the northwest to include the Peshawar Vale.

2.02 The most productive agricultural area in West Pakistan is the Punjab -- the northeast region watered by the four important tributaries, the Jhelum, Chenab, Ravi and Sutlej Rivers. Some of the most developed irrigated agriculture is found here, on land situated in what are known locally as "doabs" (see Maps 6 and 7).1/ These areas were the sites of some of the earliest large-scale investments in irrigation facilities. The Sind, which stretches south below the confluence of the Indus and its major tributaries, is an area of more recent irrigation development. Three major barrages on the Indus -- Sukkur (1932), Ghulam Mohammed (1955) and Gudu (1962) -- supply the water for agriculture, but the first of these was not completed until some fifty years after the first weirs of the Punjab. This fact, plus the precipitation pattern and other factors, have kept agriculture in the Sind at a lower level of development than in the Punjab. A third region, the Peshawar Vale, is much smaller in size than these two major areas, and somewhat removed from them. It benefits, however, from more plentiful supplies of annual rainfall, as well as from the addition of an irrigation system. Its more northern location brings greater annual fluctuations in temperature, but in terms of relative levels of agricultural development the Peshawar Vale equals, or may even exceed, the Punjab but it is of less significance because of its smaller area.

2.03 Approximately half of the 199 million acres comprising the total land area of West Pakistan consists of mountains and deserts. Slightly over a further quarter of the total land area is accounted for by towns, roads, water area, and other similar categories which preclude agricultural exploitation, plus forests and culturable waste outside the canal commands. Less than one-quarter thus remains as either under cultivation or within the culturable commanded area of the canal irrigation system, and this constitutes the present land base utilized for agricultural production. If forests (which are included in the agricultural sector) and culturable waste

1/ The term "doab" refers to land which lies within the boundaries provided by two rivers.

outside the canal commands are added to this present land base, the maximum agricultural land potential rises to 73 million acres, or about 37 percent of the total area of West Pakistan. The distribution among different categories of land is shown in the following table:

Land Area and Present Land Use

| | Land Area (mill. acres) | Land Area (percent) |
|---|---|---|
| **Culturable Commanded Area (CCA)** | | |
| Designated for perennial irrigation | 20.3 | |
| Designated for non-perennial irrigation | 13.2 | |
| Subtotal | 33.5 1/ | 16.8 |
| **Other Cultivated Area** | | |
| Irrigated from wells, streams, tanks, etc. | 1.6 | |
| Rainfed (barani) | 8.0 | |
| Riverain | 2.9 | |
| Subtotal | 12.5 | 6.3 |
| **Culturable Waste and Forest** | | |
| Culturable waste | 24.0 | |
| Estimated forest area | 3.0 | |
| Subtotal | 27.0 | 13.6 |
| Total suitable for agriculture and forestry | 73.0 | 36.7 |
| **Unsuitable for Agriculture and Forestry** | | |
| Mountains and deserts | 100.0 | |
| Unrecorded, towns, water area, etc. | 26.0 | |
| Total unsuitable for agriculture and forestry | 126.0 | 63.3 |
| TOTAL AREA - West Pakistan | 199.0 | 100.0 |

1/ Out of a culturable commanded area of 33.5 million acres, only 25.0 million acres currently receive surface water supplies. The balance of 8.5 million acres is classified as culturable commanded waste.

2.04 Although the Indus Plains are well suited to irrigated agriculture and can be productive, a lack of water for proper crop growth has imposed a rather rigorous obstacle to increased intensification of cropping by West

Pakistan's farmers. Current estimates are that about 39 million 1/ acres are being cropped annually, of which 26.5 million 1/ acres are within the canal commanded areas. Despite an apparent land base for agriculture much larger than this, the shortage of past and current surface water supplies relative to the total culturable area commanded by the canal system has been an important factor inhibiting the grcwth in cropped acreage.

2.05 Distinct regional differences between the agriculturally important parts of West Pakistan have led to different cropping emphases based on prevailing climate, soil, and rainfall characteristics, as well as the pace and extent of past and present investments in irrigation facilities. IACA has adopted a breakdown which identifies nine such regional distinctions, using a classification system which groups together areas with similar crop distributions.2/ The boundaries of these nine agricultural zones have been drawn across canal commands where necessary because the basis of classification is agricultural similarity, rather than the particular canal command which provides water for irrigation. Since an important part of the acreage cropped during the rabi season is devoted to wheat and fodder in all zones, with the exception of those located in the Ghulam Mohammed Barrage area, these crops do not afford a basis on which to distinguish one zone from another. IACA has chosen instead to use the important kharif and perennial crops as identifying features for the nine zones. These zones, together with the CCA and present cropping intensity in each, are listed in the table below and in Map 2. It will be noted that the CCA totals 29.3 million acres, which is the area IACA has recommended for further development (see para 3.44). The higher intensities achieved in some non-perennial zones reflect the cultivation of crops using residual water from the kharif season (dubari cropping), a single watering at the start of autumn (bosi cropping), or the growing influence of private tubewell installations.

1/ Perennial crops counted once only.
2/ See Annex 2.2 and Map 2.

Agricultural Zones Within Canal Commanded Areas as Designated by IACA and Non-Commanded Areas for West Pakistan Total

| Region | | Agricultural Zones | Approximate Acres in Millions CCA | Cropped | Present Cropping Intensity 1/ |
|---|---|---|---|---|---|
| Peshawar | I | Peshawar Vale | 0.7 | 0.9 | 135 |
| Punjab | II | Punjab Rice Area | 3.1 | 3.3 | 107 |
| | III | Punjab Cotton Area | 13.0 | 13.2 | 102 |
| | IV | Punjab Development Area | 3.6 | 2.3 | 64 |
| | | Punjab Regional Totals | 19.7 | 18.8 | 96 |
| Sind | V | Sind Cotton Area | 5.2 | 4.5 | 87 |
| | VI | Gudu and Sukkur (Perennial rice area) | 1.0 | 1.1 | 106 |
| | VII | Gudu and Sukkur (Non-perennial rice area) | 1.4 | 1.9 | 138 |
| | VIII | Ghulam Mohammed (Non-perennial rice area) | 1.0 | 1.1 | 104 |
| | IX | Ghulam Mohammed (Perennial rice area) | 0.3 | 0.1 | 54 |
| | | Sind Regional Totals | 8.9 | 8.7 | 98 |
| (A) | | All Regions - Canal Commanded | 29.3 | 28.4 | 97 |
| (B) | | Non-Commanded (outside areas) | - | 12.4 | - |
| | | Total Cropped Area of West Pakistan | | 40.8 2/ | |

1/ Cropping intensity is defined as the sum of the areas under kharif and rabi crops plus twice the area under perennial crops expressed as a percentage of the CCA.
2/ Perennial crops counted twice.

2.06 Rice and cotton are the distinguishing kharif crops in seven of the nine agricultural zones, and are important sources of cash income to farmers. Sugarcane is another important cash crop, although the area devoted to it is smaller than the areas covered by the other two. This is mainly a reflection of demand but it is also because sugarcane is more dependent on regularity in the perennial water supplies, and cane exercises a high demand on available water because of greater water requirements. Further perspective on the acreage devoted to different crops may be gained from summary figures for all of West Pakistan, which are presented in the following table. The weight accorded to the production of food crops emerges clearly, for they occupy nearly three-quarters of the cropped acreage. Wheat alone accounts for nearly one-third of the cropped acreage. The disproportionately greater Gross Production Value (GPV) for sugarcane and cotton, and to some extent for rice, reflects their role as cash crops. Taking both acreage and value into account, the dominant crops in West Pakistan are thus wheat, fodder,1/ cotton, rice, and sugarcane which together contributed more than 70 percent of the 1964/65 GPV.

Present Area and GPV of Crops (1964/65)

| Food Crops | Area (mill. acres) | Percent of cropped Area | GPV (Rs. mill.) | Percent of GPV |
|---|---|---|---|---|
| Wheat | 12.71 | 32.5 | 1,635 | 30.4 |
| Coarse Grains | 3.01 | 7.7 | 205 | 3.8 |
| Pulses, Oilseed | 3.02 | 7.7 | 390 | 7.3 |
| Rice | 3.52 | 9.0 | 589 | 11.0 |
| Maize | 2.16 | 5.6 | 251 | 4.7 |
| Gram | 2.93 | 7.5 | 277 | 5.1 |
| Sugar | 1.21 | 3.1 | 721 | 13.4 |
| Fruit, Vegetables | 0.41 | 1.0 | 391 | 7.3 |
| Others (including Tobacco) | 0.25 | 0.6 | 34 | 0.6 |
| | 29.22 | 74.7 | 4,493 | 83.6 |
| Non-Food Crops | | | | |
| Fodder | 6.19 | 15.8 | - | - |
| Cotton | 3.71 | 9.5 | 880 | 16.4 |
| Grand Total Cropped | 39.12 | 100.0 | 5,373 | 100.0 |

Source: IACA Comprehensive Report, Volume 7, page 106.

## 2. Soils

2.07 Two general conclusions emerge from studying the findings of the several soil surveys carried out in West Pakistan. These are that soils of the irrigated plains provide a satisfactory medium for plant growth, and that soils, as such, do not impose a serious constraint on future development of agriculture. Soils were surveyed under a Colombo Plan Cooperative Project in 1954/55 and by the Waterand Soil Investigation Division (WASID)

1/ Fodder is the most important crop after wheat in terms of acreage, but in the IACA analysis it does not receive any valuation in calculating the GPV of crops. Fodder, grazing, and crop residues consumed by work-animals are accounted for as negative cost elements in the farm production costs. Fodder consumed by production animals is reflected in the GPV for livestock from milk, meat, and animal products.

under assistance from the U.S. International Cooperation Administration, also in 1954. The Lower Indus Project (LIP) carried out soil surveys at a later stage, concentrating on the Sind and former Khairpur State. A U.N. Special Fund Soil Survey project has been under way since 1964, but will not be completed until 1968 or later. Finally, IACA has done some further soil investigation in connection with the study of 20 individual watercourses and a semi-detailed soil survey of two of the sample areas amounting to 240,000 acres. Although strict comparison of the results of these studies has not been possible for a variety of reasons some generalizations about the soils appear valid and relevant to development planning.

2.08 The physical properties of the soils, though generally favorable, do create some problems. The majority of the soils have favorable textures and a high potential productivity. Over most of the area they have characteristics favorable for irrigated farming, and even the lighter textured soils have relatively good moisture retention capacity. Soil texture tends to vary from loams to silty clays, with the heavier textured soils becoming more evident in the downstream areas of the doabs. Heavier textured soils are also more common in the Sind than in the Punjab. Where fine silts are present, weakly developed soil structure in the top layer (due to a lack of organic material in the soil) results in the formation of a crust which interferes with water infiltration, and therefore with seedling emergence. Proper preparation of the seed bed thus becomes extremely important for future plant growth and this would require more attention to the necessary cultural practices than most farmers in the Indus Basin typically devote to such activities at present. Failure in this regard appears to be one reason for the observed low plant populations and associated low yields in many areas, and particularly in the Sind.

2.09 With respect to the fertility aspects determined by mineralogical and chemical composition, the soils of the Indus Plains are characteristically deficient in nitrogen and organic matter, and many are also deficient in phosphate. There seems no widespread evidence of primary deficiency of trace elements. There is considerable information on the response to fertilizers, one important source being the Rapid Soil Fertility Survey carried out under FAO guidance between 1958 and 1963. Although the results varied from crop to crop and region to region, nitrogen applications on current varieties in the irrigated areas of the Punjab and the Sind appear to give satisfactory response at the level of 30 to 40 pounds per acre. Requirements in some parts of the Punjab, however, are twice this much. Phosphate application at the level of 30 to 40 pounds per acre in the Punjab also gives satisfactory response when used in combination with nitrogen, but smaller applications seem to be required in the Sind. The need for potash is less clearly established, although some areas (e.g. Sialkot) did show economic response to its application. The available evidence thus suggests there is great scope for increased and continuing use of nitrogenous and phosphatic fertilizers to raise and maintain the high fertility necessary for high crop yields. The more widespread use of new, higher yielding varieties, such as those derived from the introduction of Mexican short-stemmed wheats, would require higher levels of application than present varieties. This factor also supports the belief that there would be high demand for fertilizers in the years ahead.

2.10 Salinity in the soil has been a major concern in West Pakistan. This condition arises from the upward capillary action of moisture which contains salts, and the evaporation of this moisture at or near the soil surface. Capillary action of this type is most likely to occur in areas where the groundwater level is high. The common practice of underwatering, or spreading the available surface irrigation supplies over too wide an area, further aggravates the situation because the soil does not receive enough water to leach out the accumulating salts. The use of unirrigated fallow periods also promotes salinity because it permits more rapid evaporation and precludes the leaching action of added irrigation water. Although some crops are more sensitive to salinity than others, or are more sensitive at some stages of plant growth than others, wherever salinity occurs it has adverse effects on the output of major crops grown in West Pakistan.

2.11 Current assessments of the full extent of salinity largely rest on annual surveys undertaken by the Directorate of Land Reclamation, Irrigation and Power Department, when each canal patwari is required to estimate the extent of visible salinity in his irrigation unit. This survey methodology results in findings which reflect the subjective judgment of those making the reports, but it does provide some rough measure of the extent of the salinity problem. WASID salinity investigations are more restricted, and relate only to the Punjab and the former Bahawalpur State. The various salinity surveys suggest that about 15 percent of the area surveyed is visibly affected. Since the area included in the surveys is not identical with areas used in other contexts (i.e. the total CCA of the canal commands or the total cultivated acreage), it is difficult to translate survey results into more meaningful terms. Under these circumstances, the most significant information provided by the surveys relates to the changes which appear to be occurring from year to year. During the recent period of 1961/62 to 1963/64, the percentage of saline area appears to have remained relatively unchanged at about the 15 percent level noted above. Moreover, about one-third of the area classified as saline has never been under cultivation, and nearly half of it is still under cultivation. The balance is made up by land which has gone out of cultivation due to excessive salinity.

2.12 While salinity thus constitutes an important problem for agriculture, there is little evidence that it is a growing threat, and it should be susceptible to control. Current reclamation efforts may be already restoring as much land to productive use as is annually lost to agriculture because of salinity.1/ Future efforts to reduce the groundwater level should serve to reduce the capillary action which is responsible for the deposit of salts, and an increase in irrigation supplies should provide farmers with the water needed to leach out the past accumulations. Less land would be left in fallow if more irrigation water is available, because it would permit a more intensive use of the land than at present. This view is not intended to imply that the task would be easy, or that

1/ See IACA Comprehensive Report, Volume 1: Comparative study of aerial photographs taken in 1954 and in 1964/65.

there would be few complications. In some areas, for example, the groundwater is too saline for use as irrigation water (over 3,000 ppm TDS), even when mixed with fresh surface water, and any lowering of the groundwater level would require costly special drainage facilities. Nevertheless, the presence of salinity in West Pakistan does represent a soluble problem. The means to achieve a solution are known, and to a great extent could be feasibly employed. From the point of view of bringing about rapid agricultural growth, salinity does not appear to warrant the high priority previously accorded to it.

2.13 A problem related to salinity, which may become more important in the future and requires special attention, concerns the continuing presence of alkalinity in the soils after soluble salts have been leached away.1/ There has been relatively little attention given to this possibility, although recent monitoring of reclamation procedures provides an indication that "non-saline alkalinity", or "residual alkalinity", is a more important factor than previously thought in Pakistan. The presence of residual alkalinity causes physical soil conditions to deteriorate with reduction in permeability which impedes the reclamation process. High sodium levels in the soils also adversely affect plant growth and development. Further careful monitoring and continuing research is needed to identify the full extent of alkalinity as a residual problem following simple leaching. IACA has concluded that it is a fairly common occurrence in the Punjab, but had insufficient data on which to base any firm opinion about the incidence in the Sind. It is generally believed, however, that alkalinity is relatively rare in the Sind.

2.14 IACA has recommended the application of gypsum to reduce the hazard of alkalinity during the reclamation process. Specific recommendations would differ under various circumstances and in different areas, but IACA proposes a general level of application of about two tons of gypsum per acre every five years. 2/ The Bank Group does not question the technical validity of this suggestion, but does feel that the transport and application of the volume of gypsum required to implement this recommendation would create major organizational problems were this to be adopted as a widespread reclamation measure under West Pakistan conditions. Localized initiative may be able to implement these reclamation practices on a limited scale however, and such efforts should receive every encouragement.

2.15 The productive capacity of West Pakistan's soils has been summarized by IACA as being a function of many factors. Although soils are basic to agriculture's performance, the availability of irrigation water and drainage facilities, the skill of the farmer, the preparation given the land, and the quality of seed used, to cite some of the important influences, can upset expectations based on analysis of soil quality alone.

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1/ For further discussion of the alkalinity problem, see IACA's Comprehensive Report, Volume 4, Annexure 5.

2/ Details of these recommendations are given in IACA's Comprehensive Report, Volume 4, Annexure 6.

3. Climate

2.16 Three principal climatic factors in West Pakistan -- day length, temperature, and evaporation -- are consistent with the temperate tropical climate generally found in the latitudinal range of 24-34 degrees North. The exception to this generalization is with respect to rainfall, for the precipitation pattern provides a more arid climate than is found in many areas at comparable latitudes. Altitude also modifies the climate in the north and northwest parts of the Province, where climatic characteristics more closely approach those associated with the sub-tropics.

2.17 Day length tends to vary from ten hours in January to 14 hours in June, but because most of the crops grown in West Pakistan are neutral with respect to photo-periodicity this factor exercises little critical influence. This is not necessarily true for all varieties of these crops, however, and it is therefore important that the sensitivity to day length of new varieties be carefully examined before they are widely introduced.

2.18 Temperatures in the Indus Plains range from mean monthly minima of 40 degrees (Fahrenheit) during December and January to mean monthly maxima in excess of 100 degrees during June and July. While it is generally true that this range of temperature per se does not hamper agriculture and, in fact, the range permits year-round cropping over the entire Province, temperature does exercise an influence on the cropping patterns. For example, the lower winter temperatures in the north slow down early crop growth and, despite its widespread distribution there, are not favorable for the cultivation of sugarcane. Temperature also comes into play with respect to wheat grown at higher altitudes, because low temperatures arrive earlier in those locations and the best wheat yields are obtained when wheat is sown before the minimum temperatures occur. The diurnal temperature range, or the variation within a single day, is important for cotton production. The best boll development of cotton takes place when the diurnal range is greatest, which is usually during October and November. To meet this condition, it is necessary to sow cotton no later than June.

2.19 The factor of evaporation is strongly related to the water requirements of crops. Its measurement is extremely complex, and any evaluation of evaporation in connection with irrigation requirements must take into consideration both the irrigation water and probable precipitation. Some of the substantial differences in evaporation which take place in different parts of the Indus Basin may be seen in the following table and in Map 1. The data there show the range of variation on the basis of both geographical location and season of the year.

Computed Evaporation and Rainfall, by Region and Season of the Year
(Rainfall in parentheses)

| | North | South |
|---|---|---|
| | ---- (in inches) ---- | |
| Winter (October to March) | 18 ( 3.6) | 27 (0.8) |
| Summer (April to September) | 41 (15.6) | 49 (2.6) |
| Annual Total | 59 (19.2) | 76 (3.4) |

2.20 The significance of the relationship of rainfall to evaporation is demonstrated by the figures given in the following table. The higher irrigation requirements, including a modest addition to permit leaching of accumulated salts and to offset seepage losses, in the southern Punjab and the Sind reflect the combined effect of higher evaporation and lower rainfall although for the purpose of this comparison all areas selected were assumed to be under cultivation at a cropping intensity of 150 percent. Allowance has been made for the portion of rainfall making an effective contribution to plant growth.

Irrigation Requirements at Watercourse Head
For Cropping Intensity of 150 Percent

| | Acre Feet Per Acre of CCA |
|---|---|
| Northern Punjab | 3.9 |
| Southern Punjab | 4.7 |
| Sind | 5.6 |

The implications of evaporation and rainfall factors for development thus stand out clearly, for the higher irrigation requirements at watercourse head in the Sind mean larger water supplies than in northern areas to achieve a comparable cropping intensity on a given CCA.

2.21 The pattern of rainfall in West Pakistan is highly variable, both with respect to its distribution over the Province and its timing. The southeast monsoon moves up the Indo-Gangetic plain in July to September, but is quite unpredictable in terms of rain it produces because it is nearing the end of its travel when it reaches the Punjab Plains. The southwest monsoon is more reliable in this sense, but is weaker at its source and produces less rain for the lower parts of the Indus Basin which it touches. The range of mean annual rainfall extends from less than four inches in the Sind to more than 30 inches in the foothills of the northern mountains. Although the latter amount is apparently quite adequate for agriculture, most of this comes during the monsoon period, and then frequently in torrential showers. Much of the summer rain may therefore not be available for agriculture because of rapid run-off and is not effective in meeting the crop water requirements. Moreover, the intensity of the rainstorms in the northern catchment areas of the rivers of West Pakistan results in sudden rises in the river discharges, with consequent breaching and/or overtopping of protective bunds. This is most likely to occur at the time of heaviest rainfall in the Indus Basin itself, when inadequate drainage prolongs the period of inundation and increases the probability of serious damage. 1/ At other times, showers may be so light that the precipitation evaporates before the water can penetrate to the root zone of the crops. In general terms, therefore, over large areas rainfall is either so meager, or so unreliable, or some combination of these characteristics, that it constitutes a distinct constraint on agricultural production in the absence of assured irrigation supplies.

4. People

2.22 Reference has been made earlier to the size and rapid rate of growth of population in West Pakistan. It should also be noted that this population is predominantly rural, largely dependent on the land for direct subsistence, and concentrated in its geographical distribution. The following table shows that over three-quarters of West Pakistan's people live in the Peshawar and Punjab regions, and that this proportion is not expected to change significantly by 1985. This reflects, in turn, the attraction of areas where the climate and conditions are more favorable and where irrigation was installed earlier, with the result that irrigated agriculture has become more advanced.

IACA Population Estimates

| | 1965 | | 1985 | |
|---|---|---|---|---|
| Region | Millions | Percent | Millions | Percent |
| Peshawar | 14 | 27 | 22 | 25 |
| Punjab | 26 | 50 | 43 | 50 |
| Sind and Karachi | 10 | 20 | 19 | 22 |
| Rest of Province | 1 | 3 | 3 | 3 |
| Total West Pakistan | 51 | 100 | 87 | 100 |
| Rural | 38 | 74 | 50 | 57 |
| Urban | 13 | 26 | 37 | 43 |

Source: IACA's Comprehensive Report, Volume 1, page 5.

2.23 Estimates of the size of the labor force available to the agricultural sector generally assume that it consists of about one-third of the rural population dependent on agriculture. This would total between 11 and 12 million people in 1965, using an estimate of 35 million people as the rural population dependent on agriculture. On the other hand, the Planning Commission estimates that a labor force of only 8.1 million man-years

1/ For drainage and flood control priorities, see Chapter III, D 2.

is required for the agricultural sector. Direct comparison of these two estimates indicates a likelihood that there is considerable under-employment in the sector. While this is a somewhat tenuous basis for generalization, especially in the absence of widespread mechanization, there is undoubtedly a certain amount of seasonal unemployment. There are, however, also times of the year when labor requirements may equal, or exceed, the number of persons available to work, as, for example, when the harvesting of one crop and the preparation for planting another must be completed within a very short time interval. At such periods there may be localized labor shortages. This is not to deny the possibility of generalized under-employment, but it does argue for caution against easy acceptance of the view that abundant labor is always available. Although the rural population proportion is likely to decline, present projections show an increase in absolute numbers up to 1985 and beyond. Further, IACA projections anticipate that the rural labor force and the cropped acreage will increase at about the same rates up to 1985. To the extent that under-employment, and particularly seasonal under-employment exists at present, it may continue in the future. On this basis the factor of labor does not appear to pose a serious development constraint. With a larger cropped acreage and increased output of commodities, however, seasonal labor shortages may become increasingly critical. IACA's projection of greater mechanization of farming -- to cover about 25 percent of the irrigated farm area by 1985 -- therefore seems realistic, and could be consistent with the expectation that a sizeable portion of the agricultural labor force may be under-employed for several months out of the year.

2.24 Although the typical farm size in West Pakistan is generally categorized as "small", and the land as equally divided between owner-operators and tenants, this tends to obscure the variation which exists in land tenure arrangements throughout the Province. The average farm holding, for example, is 10.1 acres (with an average cultivated area of 7.7 acres), but the range extends from an average of 5.5 acres in Peshawar Division to a high of 35.9 acres in Kalat Division. The 1960 Pakistan Census of Agriculture shows that 49 percent of the farms are under five acres, but these only contain some ten percent of the culturable farm area. By contrast, eight percent of the farms which are over 25 acres contain 40 percent of the culturable farm area. 1/ Land ownership patterns, shown in the following table, indicate that nearly two-thirds of all ownership units are smaller than five acres, but that these small units account for only 15 percent of the farm area. It also shows that over 30 percent of the total area owned falls within the limits of large scale units above 100 acres in size. This suggests there may be considerable scope for private investment in agriculture by operators of commercial-scale farm units.

1/ IACA's Comprehensive Report, Volume 7, Annexure 9, page 13.

Land Ownership Pattern

| | Up to 5 acres | 5-25 acres | 25-100 acres | More than 100 acres | Total |
|---|---|---|---|---|---|
| Number of owners (thousands) | 3,266 | 1,452 | 286 | 63 | 5,067 |
| Percent of owners | 64 | 29 | 6 | 1 | 100 |
| Area owned (thousand acres) | 7,427 | 15,438 | 10,616 | 15,161 | 48,641 |
| Percent of area owned | 15 | 32 | 22 | 31 | 100 |

Source: IACA's Comprehensive Report, Volume 8, page 8.

In general terms, farms are smaller in the more productive, irrigated areas of the Punjab and Peshawar Vale than elsewhere. There is also variation in the proportion of land which is owner-operated. Owner-operated farms account for nearly half the acreage in three Divisions of the Punjab, but the proportion drops to about one-third in Khairpur Division in the Sind. This reflects the fact that tenancy is more prevalent in the less developed parts of the Province, where large acreages are owned by absentee landowners.

2.25 In its watercourse studies, IACA has attempted to assess the prospects for innovation and the exercise of initiative among the farmers in relation to the land tenure system. These studies found evidence of willingness amongst farmers to accept new ideas and new methods in examples such as the widespread use of improved sowing material and the increasing demand for chemical fertilizers, though these are more apparent on larger farms than smaller ones. In general, however, IACA has found no significant differences in farm productivity between tenant farmers and the owner-operators of small farms, indicating that tenant status apparently does not generate additional productivity-depressing influences at the level of smallest farm size. The large investment made in private tubewells during the Second Plan period is further evidence of the exercise of initiative at the farm level, but the costs involved have tended to restrict this development mainly to owner-operators of the medium and larger farm units.

2.26 Experience such as this supports the generalization that conservatism and resistance to change should not prove to be insurmountable obstacles to future development efforts. It is nevertheless probable that adoption of new methods and ideas will be more rapid among the owner-operators of the larger farms than among tenants or the smallest owner-operators. Not only would the owner-operators of larger farms be in a better economic position to make investments to increase productivity, but there would be greater incentives for them to do so than in the case of tenants who retain a much smaller share of total output. This would mean a somewhat uneven pattern of improvement, with a slower rate of increase in real living standards among the majority of farmers who fall in the smallest farm-size categories. An uneven pattern need not imply any greater innate unwillingness to accept change on the part of those who would, by force of past circumstances, be in a less advantageous position to adopt the means of change, nor may it necessarily curtail the rate of growth in production if the required support and incentive is provided.

## B. Principal Features of Development

2.27 The above description indicates that West Pakistan's agriculture is endowed with the basic resources sufficient to realize production levels many times greater than the level achieved at the present time. In planning for this development, however, there tends to be a preoccupation with material inputs of various kinds which sustain a production effort -- a preoccupation that, at times, may obscure the fundamental importance of the farmers themselves. It is essential to remain aware that farmers are involved and that they will determine what is done on the land. They must be assisted to acquire the knowledge and equipment necessary to employ material inputs and farming skills in a manner which results in increased production. There must also be assurance they would be rewarded adequately for the additional effort, risk, skill, and investment involved. This underlying frame of reference should be borne in mind when considering the succeeding sections of this report, which necessarily devotes considerable attention to the material input element and its relevance to development planning.

2.28 To obtain detailed information on all aspects of production at the farm level field studies were carried out on 20 watercourses in the Punjab by IACA and on 60 watercourses in the Sind by the Lower Indus Project (LIP), consultants for WAPDA. The areas chosen for these watercourse studies were intended to represent all the main geographical features of the irrigated areas and the major canal commands. Data of agricultural activities, land use, costs, cropping, and other statistics were recorded over a period of four seasons in the Sind and one complete summer and two partial winter seasons in the Punjab. The comprehensive and detailed information emerging from these important studies has influenced IACA's assumptions and projections over the whole field of irrigation and agriculture and undoubtedly will be of great value to the Government of West Pakistan in future planning. A full account of the watercourse studies is given in IACA's Comprehensive Report and supporting documents 1/ and is briefly summarized in Annex 2.1.

1/ IACA's Comprehensive Report, Volume 10, Annexure 14 and supporting documents to Annexure 14.

2.29 The need to increase agricultural production in Pakistan is a basic one for the foreseeable future. An attempt is made in Chapter VIII B to determine the demand for agricultural commodities, and these estimates show the large and widening gap which has to be closed between the present level of production and future demand. There is no doubt that it is technically feasible to meet the anticipated demand, but achievement of this goal will require much higher standards of farming than presently prevail, and a high rate of growth in agricultural production which has seldom been attained over a sustained period except in relatively small countries. Data for agricultural production of a number of countries were used to estimate compound annual growth over the eight-year period ending 1964/65, and are shown below:

Growth in Volume of Agricultural Production For
Selected Countries, With Arable Area and Total Population
(Base for 1952/53 to 1956/57 = 100) 1/

| | Arable Area (Millions ha.) | Population (In Millions) | Compound Growth of Agricultural Production Over 8 Years to 1964/65 2/ |
|---|---|---|---|
| India | 163 | 472 | 3.0 |
| Pakistan | 26 | 101 | 3.5 |
| Japan | 6 | 97 | 2.8 |
| Brazil | 19 | 79 | 3.7 |
| France | 21 | 48 | 4.0 |
| Mexico | 24 | 40 | 6.0 |
| Thailand | 11 | 30 | 7.4 |
| Australia | 33 | 11 | 4.7 |
| Israel | 1/2 | 2-1/2 | 11.0 |
| U.S.A. | 185 | 192 | 2.1 |

1/ Source of Data: FAO Production Year Book 1965.
2/ Compound Growth from regression coefficient.

To achieve a breakthrough in the growth of agricultural production there must be a major effort to provide the incentives, the physical resources, with technology to develop the necessary farming skills, and a judicious employment of the market mechanism.

2.30 The IACA Comprehensive Report attempts to provide guidance for West Pakistan's agricultural development. It proposes large public and private investments to supplement the irrigation supplies, examines the need for complementary efforts (such as drainage works and canal remodelling), estimates the scope for applying other agricultural inputs, and discusses the role to be played by agricultural institutions of various kinds. The Bank Group's review of IACA's development proposals is presented in some detail in the succeeding chapters, but first it is necessary to consider some of the fundamental factors which underlie agricultural development. This section is devoted to such factors. It emphasizes the need for more water and other inputs, but examines their relative importance and interrelationship within a framework of improved farming, higher cropping intensities, higher yields and increased livestock production.

1. Dependence on Irrigation

2.31 The semi-arid conditions which prevail over much of West Pakistan are generally unfavorable for rainfed cropping and where it does occur it tends to be a hazardous undertaking. The parts of the Province which depend on rainfall alone provide an important annual contribution to the agricultural output, but it is also true that climate and the amount and pattern of rainfall impose a severe constraint on efforts to promote a more productive agriculture in such areas. Even in the areas currently receiving irrigation, it is difficult to foresee much increase in the intensity of land use, or significant new additions to the acreage cropped, without further improvements in the irrigation system. Recognition of this dependence on irrigation underlies the priority which has been and continues to be accorded to water resource development.

2.32 To illustrate the degree to which agriculture in West Pakistan depends on irrigation, canal irrigation water is now being provided annually to about 27 million cropped acres. Together with a small, but important, lift-irrigated area of about 1.6 million acres, irrigation covers over 70 percent of the total cropped area. Production of three of the important crops grown in the Province -- rice, cotton and sugarcane -- is virtually confined to the canal irrigated areas, and these account for nearly half the GPV of crops. Three-fourths of the GPV from wheat comes from canal irrigated areas. Fodder is not included in this accounting because its contribution is reflected in the separate valuation of livestock production, but its importance should not be overlooked in assessing the benefits of irrigation. Farmers clearly recognize the need for small water supplements, to minimize crop risk and to ensure the supply of fodder for their livestock, as demonstrated by the popularity of Persian wheels and (more recently) private tubewells for this use.

2.33 The rainfed (barani) areas in contrast to this are both less extensive and less productive. They are located primarily in the Peshawar region, the northern part of the Lahore region, and in Quetta and Kalat, and altogether comprise about ten million cropped acres. Their major contribution to agricultural production is in food grains, of which they provide 25 percent of the wheat, 49 percent of the maize, and 67 percent of the millets currently (1965) produced in West Pakistan. Production in the rainfed areas is characterized at present by low levels of agricultural inputs and correspondingly lower yields than elsewhere. The relative position of the irrigated and rainfed areas, in terms of cropped acreage and contributions to the GPV of crops, is given in the following table:

Cropped Acreage and GPV for Canal Irrigated and Other Areas (1965)

| | Canal Irrigated | | Remainder | | West Pakistan | |
|---|---|---|---|---|---|---|
| | Area in Acres | GPV Rs. | Area in Acres | GPV Rs. | Area in Acres | GPV Rs. |
| | ----- (millions) ----- | | | | | |
| Annual Food Crops | | | | | | |
| Wheat | 7.72 | 1,222.5 | 4.99 | 412.5 | 12.71 | 1,635.0 |
| Millets | 1.02 | 68.2 | 1.99 | 136.8 | 3.01 | 205.0 |
| Maize | 1.09 | 128.6 | 1.07 | 122.4 | 2.16 | 251.0 |
| Others | 3.08 | 412.9 | 3.12 | 288.1 | 6.20 | 701.0 |
| Rice | 3.52 | 589.0 | -- | -- | 3.52 | 589.0 |
| Perennial Crops | 1.62 | 1,112.0 | -- | -- | 1.62 | 1,112.0 |
| Total Food Crops | 18.05 | 3,533.2 | 11.17 | 959.8 | 29.22 | 4,493.0 |
| Cotton | 3.71 | 880.0 | -- | -- | 3.71 | 880.0 |
| Fodder | 4.99 | -- | 1.20 | -- | 6.19 | -- |
| Total Crops | 26.75 | 4,413.2 | 12.37 | 959.8 | 39.12 | 5,373.0 |

Source: Computed from data provided in IACA's Comprehensive Report, Volume 7, Annexure 9, page 106.

On the basis of the figures cited above, the canal irrigated areas now provide 79 percent of the GPV from food crops on 62 percent of the cropped acreage under food crops, which summarizes the relative importance of these areas in terms of extent and productivity. For all crops canal irrigated areas supply 82 percent of the total GPV of crops from 68 percent of the total cropped area.

2.34 The canal system which supplies the bulk of the irrigation water used in West Pakistan was originally designed for a low intensity of cropping. 1/ These design intensities range from a low of 60 percent to a high of 81 percent, but a majority of the canal commands would fall in the upper portions of this range. In actual practice most of the commands are currently being farmed at average cropping intensities above the design level, and only a few development commands have not yet reached the design level. The achievement of average cropping intensities above the design level is partly due to the presence of private tubewells and Persian wheels, but after making a suitable allowance, these intensities are still indicative of widespread underwatering. Whatever the underlying explanation in a given

1/ Cropping intensity is defined as the sum of the acreage cropped in the kharif and rabi seasons plus twice the perennial cropped acreage, all expressed as a percentage of the CCA.

situation, the comparison of actual with design intensities provides evidence that there is considerable scope for effective use of additional water supplies. Future development of agricultural production is thus dependent on irrigation for the extension of acreage as well as for the increase in yields through higher irrigation application per acre cropped.

2. Irrigation Application

2.35 IACA has assessed water requirements and, with minor exceptions before 1975, all yield and intensity projections are made on the basis of "full delta irrigation". "Full delta" is defined as the summation of (a) the net consumptive use of water by crops after making allowance for effective rainfall, (b) an allowance for pre-planting, (c) an allowance for soil moisture retention, and (d) an allowance for seepage loss which also provides for leaching of salts. In computing the full delta requirements at watercourse head, IACA has totalled items (a), (b) and (c) above and adjusted this sum upward by assuming that item (d) involves a general loss of 37 percent, including conveyance losses in the watercourses. It should be noted that full delta, as defined by IACA, provides water in excess of the consumptive use of water by crops at the ultimate (year 2000) stage of development. The irrigation requirements at watercourse head, based on full delta irrigation, are shown in the following table for an assumed cropping intensity of 150 percent, and these water requirements are compared with the current status in various parts of the Indus Basin.

CCA, Cropping Intensities, Watercourse Deliveries 1/ and Water Application

| Region | CCA (mill. of acres) | Cropping Intensity (%) | Current (1965) Status: Annual Watercourse Supplies (MAF) | Current (1965) Status: Acre Feet Per Cropped Acre | For Full Delta At 150% Intensity: Annual Watercourse Supplies (MAF) | For Full Delta At 150% Intensity: Acre Feet Per Cropped Acre |
|---|---|---|---|---|---|---|
| Peshawar and Swat | 0.7 | 135 | 1.7 | 1.8 | 2.8 | 2.3 |
| Bari Doab | 5.8 | 102 | 12.1 | 2.0 | 26.0 | 3.0 |
| Rechna Doab | 4.7 | 106 | 11.2 | 2.3 | 18.0 | 2.6 |
| Chaj Doab | 2.0 | 104 | 3.8 | 1.8 | 8.0 | 2.6 |
| Sutlej/ Panjnad L.B. | 3.5 | 92 | 7.0 | 2.2 | 18.0 | 3.4 |
| Thal/ Indus R.B. | 3.6 | 64 | 6.3 | 2.7 | 15.0 | 2.8 |
| Sind | 13.2 | 67 | 25.6 | 2.9 | 47.0 | 3.5 |
| | 33.5 2/ | | 67.7 | | 134.8 | |

1/ Includes surface and groundwater deliveries.
2/ Only 25 million acres currently receive canal supply.

Variations in agricultural specialization throughout the Province have earlier been expressed in terms of agricultural zones (para 2.05). The above table shows the irrigation pattern in terms of canal commands grouped by regions. This is because data on irrigation flows and cropping intensity are collected on the basis of canal commands and not for agricultural zones. Because the zones, as identified by IACA, can include more than one canal command, any conversion of canal command data to a zonal base would involve some arbitrary allocation of acreages and water supplies. To avoid this, the canal commands have been retained by IACA as the basic units in their analyses.

2.36 The table shows that a gross area of 33.5 million acres CCA (of which 25 million acres are irrigated) now receive 68 million acre feet (MAF) annually. If the same CCA were to be cropped at an intensity of 150 percent with full delta irrigation, the water requirements at watercourse head would rise to 135 million acre feet. The table was drawn on the assumption that the cropping pattern would remain the same, but at a higher intensity of cropping. A comparison of the current water applications (in acre feet per cropped acre) and at full delta gives some indication of the present degrees of underirrigation by comparison with the ultimate level required when new varieties, adequate inputs and full delta irrigation are employed. IACA has estimated that the prevailing overall average degree of underwatering is about 20 percent below ultimate full delta requirement, but this varies considerably between and within canal commands, and between seasons and years.

2.37 While there is no doubt that the average applications of irrigation water per cropped acre are below the full delta requirements, there is evidence that farmers exercise some judgement in scheduling their use of available water. Important crops, and cash crops in particular, probably receive close to present crop water requirements, while other crops are underirrigated to a greater extent than indicated by the overall average estimates of underirrigation. This is important in considering the scope for increasing production under prevailing conditions through the application of better husbandry and agricultural inputs other than irrigation water.

3. The Relationship between Crop Yields, Irrigation Application and Non-Water Inputs

2.38 IACA and the Bank Group have examined available data on crop yields and application of water and other inputs to assess the nature of the relationship which exists among them. Appreciation of this relationship is necessary for evaluation of the probable contribution of agricultural inputs at different levels of water application. One source of information for this review was the Revelle Report, 1/ which contained an extrapolation of expected relationships. A second source was the Watercourse Studies, 2/ which reported the field results for wheat yields under different irrigation applications in the Punjab, and had the advantage of reflecting actual results under West Pakistan conditions.

2.39 The relationship between yields and irrigation applications was strikingly similar in both sets of data (see Figure 2.1). Yields decline as the degree of underirrigation increases, but the rate of decline in yield is disproportionately smaller than the rate of decline in water application. A greater increase in production in the short run would therefore be expected if a given quantity of irrigation water were used to expand cropped acreage, rather than using it on the acreage implied by IACA's full delta requirements. Data to illustrate this point are given in the following table:

Relationship Between Irrigation Application and Wheat Yields

| Irrigation Application 1/ | Yield at Irrigation Application | Cropping Intensity At Respective Irrigation Application | Production From Area and Yield |
|---|---|---|---|
| ------(Percent)------ | | | |
| 100 | 100.0 | 100.0 | 100.0 |
| 90 | 96.0 | 111.1 | 106.7 |
| 80 | 90.8 | 125.0 | 113.5 |
| 70 | 84.2 | 143.0 | 120.4 |
| 60 | 76.3 | 166.7 | 127.2 |

Source: Computed from data presented in Watercourse Studies, IACA's Comprehensive Report, Volume 10, Annexure 14, page 179.

1/ Expressed as percentage of crop water requirement, not IACA's full delta requirement which refers to ultimate state of development and includes an allowance for leaching and losses (see para 2.35).

2.40 The table indicates that under prevailing farming conditions production could be maximized by increasing intensities with proportionate

1/ Report on Land and Water Development in the Indus Plains, The White House, Washington, D.C., January 1964, pages 417-429.

2/ IACA's Comprehensive Report, Volume 10, Annexure 14.

reduction in irrigation application. IACA estimates that the present water availability is on average equivalent to about 80 percent of its full delta requirements. This prevailing level of water availability - subject to the necessary qualifications regarding its timely distribution - exceeds the 80 percent of crop water requirements shown in the table above, since it includes a leaching allowance. Full delta would therefore be adequate to support the 125 percent intensity at the 80 percent level of underwatering. Although yields would be ten percent lower than optimum, the larger acreage would produce 13.5 percent more wheat.

2.41 The relationship described above would hold generally true for all crops, subject to some qualification because of special characteristics associated with certain crops. Cotton, for example, is distinguished by its boll-shedding tendency because of its extreme sensitivity to water strain, and slight water deviations as a result of field conditions would lead to greater crop loss in cotton than in the case of wheat.

2.42 These relationships between irrigation application, yields, acreage cropped, and consequently productivity are of considerable significance in present circumstances and are likely to continue to be of importance for some time to come. Under the prevailing standards of farming and use of inputs, and measured purely in terms of production, the relationships imply a diminishing rate of return to water at the higher levels of application. This implicit relationship supports farmers' present practice and the widespread belief that, in the short term, underwatering is advantageous to the farmer in conditions of scarce water and so long as farming standards and crop yields remain at their current levels.

2.43 As farming standards improve and yield levels increase as the result of better crop husbandry and a greater use of inputs, this bias in favor of underwatering and extended acreage would disappear. At higher yield levels, there is some evidence that the use of a given increment of water to increase delta should, in most circumstances, result in more production than an extension of acreage at the existing degree of underwatering. (These relationships are illustrated in Figure 2.2). The influence on yields and productivity of water and other inputs are thus inextricably linked. Each supports the other and consideration of the effects of one must be set in a frame which includes reference to the related use of the others. All factors must be kept in proper balance to avoid one particular ingredient of the input mix becoming the limiting factor or, alternatively, being applied in excess of requirement.

2.44 As stated in para 2.35 above, all IACA's projections of water requirements, yields, intensity and consequent productivity are based on full delta irrigation commensurate with the ultimate (year 2000) state of development and yields. Such levels of water application would be in excess of the consumptive use of crops even at the stage of full development and much more so at prevailing levels of farming with sub-optimal inputs, plant populations and varieties. In these circumstances, where water is the constraint, to limit increase in intensity and yield response to inputs to the equivalent of the full delta acreage, as IACA does, may well be understating the potentiality (and the probable actual production increase) during the transitional period of development by comparison with what could be obtained with modest underwatering on an extended acreage.

2.45 In the opinion of the Bank Group, if timely availability of water could be assured by improved operation and regulation, the prevailing level of water application (around 80 percent of IACA's full delta requirements) would in many areas be adequate to support as high a level of farm inputs as is likely to be generally available for use in the next few years. If this is the case, the choice between moving to full delta (as IACA does with all water increments) or extending the cropped acreage at a lower level requires very careful consideration and the decision should be properly related to particular circumstances (i.e. a move to full delta should only be made where water is, in fact, the limiting factor). Support for the view that water alone is not universally the principal limiting factor is to be found in IACA's Watercourse Studies. 1/

2.46 In recognition of the fact that farmers in general are not likely to reduce their existing cropped acreage to that which would correspond with water availability at full delta application, IACA has assumed a continuation of some underwatering up to 1975. In IACA's production calculations, however, all cropped acreages have been reduced to "full delta equivalent acreage" and IACA's full delta yield growth has been applied to this reduced acreage. To compensate to some extent for the additional production which would associate with the farmers' actual practice of underwatering (but is eliminated by IACA's process of calculation), IACA has made an addition to the resulting production of something like ten percent in the case of minor crops. 2/ No such addition has been made in respect of major crops. 3/ In the opinion of the Bank Group, this method of projection must tend to understate the probable, and certainly the potential, level of production during the transitional period.

2.47 In the case of major crops, IACA makes the assumption that in conditions where underwatering prevails additional water made available would give the same increase in production whether it was used to increase delta or to expand acreage at underwatering. In keeping with this assumption, in circumstances when additional water becomes available from surface storage, public tubewells or canal enlargement, IACA in their production calculations give an almost instantaneous increase in yield equivalent to the degree of underwatering corrected, e.g. if the additional water is sufficient to raise the irrigation level from 80 percent to full delta this would, on IACA's assumptions, result in an automatic yield increase of 20 percent. In the opinion of the Bank Group, this has the effect of overstating the immediate post-project productivity since in its view it would take considerable time

1/ IACA Comprehensive Report, Volume 10, Annexure 14.
2/ Fodder, maize, millets, oilseed and gram.
3/ Wheat, rice, sugarcane, groundnuts and fruit.

to organize the required higher level of other inputs to match the increase in water. In practice, a growth improvement in all respects, acreage as well as delta and inputs, would be more probable with neither moving up to the optimum except in proper balance. This implies for some time a larger cropped area at a lower level of production per cropped acre but higher overall production.

2.48 While the Bank Group recognizes the need and supports the policy of adequate water application to meet both crop consumptive use and maintain the long term productive capacity of the soil, they are of the opinion that IACA's full delta concept has been too rigidly applied, particularly under the conditions likely to prevail during the early years of development. IACA's assumptions appear to have the effect of:

(i) Understating the probable increase in crop production in the absence of improvement in water availability, by discounting the opportunity for increasing productivity through better farming and greater use of inputs under prevailing conditions of water availability;

(ii) Overstating the rate of agricultural growth of productivity in the immediate post-project period as a result of the instantaneous increase in yield in direct proportion to the additional water provided up to full delta;

(iii) Reducing the production potential, after more water becomes available, by limiting intensity growth to the acreage corresponding to full delta. This level of water application may be excessive in relation to the other ingredients in the production package likely to prevail in the early years of development.

2.49 Existing under-irrigation and unreliability of water supplies undoubtedly have a substantial influence on the low yields presently obtained in West Pakistan, but the separate effects of these and other factors cannot be easily isolated. The IACA Comprehensive Report tends to approach this problem indirectly, largely from the standpoint of the sequential adoption of inputs. According to IACA, increases in water application up to full delta requirements would result in improvements in yields, but much of the full benefit in terms of production would arise because full delta irrigation would stimulate the use of, and increase the response to, other inputs such as fertilizers and improved varieties of seed. 1/ It is important nevertheless to have some indication of the extent to which other inputs can increase yields, with under-irrigation, because this practice is likely to continue for some time and until more adequate water supplies become generally available would represent the main opportunity to increase production. An assessment of the contribution of inputs other than water is also relevant to areas

1/ IACA has provided a wealth of valuable information on the responses to water and other inputs in Volume 10, Annexure 14, but in the absence of carefully designed long term experiments was hesitant to present firm conclusions on the precise effects of inputs other than water.

which depend on rainfall alone, where no additional irrigation supplies are anticipated, to determine the effects of better farming methods on yield improvement.

2.50 The Bank Group has attempted to assess the contribution of fertilizers using data from both the IACA Comprehensive Report and the West Pakistan Department of Agriculture. 1/ IACA used the yield responses to fertilizers for several crops as evaluated and reported by the Rapid Soil Fertility Testing Scheme in the Punjab and the Sind for the years 1960-63. These tests were not laid out as formal replicated experiments but were carried out on relatively large numbers of unreplicated plots. It seems appropriate to conclude, with IACA, that the reported average yields in the presence and absence of nitrogen and phosphate, under better than average irrigation conditions, probably represent yields which the better farmers in West Pakistan might achieve. Average yield response to 30 pounds of nitrogen was between 20 and 30 percent while with the addition of 30 pounds of phosphate the average yield increase was about 45 percent.

2.51 The fertilizer trials conducted by the Department of Agriculture during 1954-57 covered a large number of irrigated plots and a smaller (though sizeable) number of plots cultivated under rainfed conditions. Although precise data are lacking, for purposes of analysis it has been assumed that the irrigated plots received adequate crop water requirements and that the rainfed plots represented a degree of underirrigation equal to the discrepancy between the calculated crop water requirements and the average rainfall. In Peshawar, for example, a crop water requirement of 14 inches coupled with an average rainfall of eight inches would thus represent an equivalent of irrigation at 60 percent of crop water requirements. This method of estimation does not take into account the irregularity of supply inherent in dependence on rainfall, but it does give some indication of the yield improvement resulting from fertilizer application at low levels of water supply. The following table shows the average wheat yields in 131 field trials over a period of several years:

Wheat Yields on Irrigated and Rainfed Plots, With and Without Nitrogen

| | Yields and Percentage Response (Yield without fertilizers = 100 percent) | | | | | |
|---|---|---|---|---|---|---|
| | No Nitrogen | | 30 lbs. Nitrogen/acre | | Increment | |
| | Maunds | % | Maunds | % | Maunds | % |
| Rainfed | 9.8 | 66 | 12.7 | 86 | 2.9 | 30 |
| Irrigated | 14.9 | 100 | 18.5 | 124 | 3.6 | 24 |

2.52 Although these data are an inadequate basis for drawing general conclusions, they are the best available to the Bank Group for providing some evidence of the magnitude of input effects. The rainfed plots (assumed

1/ A. Wahab, "Fertilizer Trials in Farmers' Fields", November 1965.

to represent under-irrigation) show an increase of 2.9 maunds per acre when treated at a rate of 30 pounds of nitrogen per acre. Irrigated plots, with nitrogen, show a greater increase over unfertilized rainfed plots than the additive effects of irrigation alone and nitrogen alone. With the qualifications noted above, the main inferences to be drawn from the table are therefore that nitrogen alone seems capable of raising wheat yields on rainfed lands by about 30 percent, and there is some beneficial interaction between additional water and nitrogen. With all the reservations necessary on such slender evidence, this would tend to support the view that there is a case for additional nitrogen even at relatively low levels of water availability but, due to the interaction effect, the advantage would be greater at higher levels of water application.

2.53 The data from the Rapid Soil Fertility Scheme and the Department of Agriculture trials were all based on results obtained in farmers' fields, and not on experimental farms. From the control yields cited, however, it appears likely that some selectivity was exercised in choosing the sites for the trials. Even so, it would be unrealistic to assume that the selection was done in a manner which avoided situations of underwatering, particularly for the trials on rainfed lands. It therefore still seems plausible to conclude that satisfactory responses to fertilizers can be obtained under conditions approximating the current degree of under-irrigation. On this basis, the increase in yield due to nitrogen on rainfed plots (2.9 maunds per acre) would be equivalent to a conversion rate of eight pounds of wheat grain per pound of nitrogen. This compares with a conversion rate of ten to one when nitrogen is added to irrigated plots. Considering the present limited use of fertilizers, increased applications of nitrogen, even under conditions of underwatering, thus constitute an important potential for agricultural production in West Pakistan in the immediate future. It should be noted, however, that a response factor of 1:8 may not be achieved generally nor with all crops.

2.54 To summarize, the available evidence suggests that at present farming levels there are decided production benefits if farmers spread the available irrigation water over a large cropped acreage, and correspondingly apply less than full delta irrigation (as defined by IACA) to the cropped areas. This is understandable, in part, because full delta irrigation includes allowances for pre-planting, for seepage and leaching out accumulating salts and for run-off losses. Under-irrigation as defined by IACA in comparison with its full delta requirement, may give close to the quantities required by plants alone. The benefits to farmers from underwatering may be short-run benefits, however, because as IACA has rightly stressed continued under-watering brings with it the danger of increasing salinity and its associated depressing effect on yields. The application of either additional water (up to full delta irrigation) or fertilizer appears to bring favorable responses when the starting point is some degree of under-watering, and there are no grounds for asserting that one must precede the other. On balance, as yields begin to rise there appear to be advantages in a shift from under-irrigation of larger acreages to full delta irrigation of smaller acreages. This is in addition to the longer term benefit of preventing undesirable salt accumulations.

## 4. The Choice Between Water and Other Agricultural Inputs

2.55 With considerable development of water resources already accomplished -- 80 percent of full delta, which may be approaching the crop water requirements under prevailing conditions -- the question arises whether future emphasis should be on further water development or on the measures required to get full use of other inputs. Water development has been a major source of agricultural growth in the semi-arid conditions of West Pakistan, and farmers and Government agricultural agencies have come to regard water as the element most strategic to the expansion of agricultural production. There is little reluctance among farmers to accept more water. Rather, the major constriant has been the rate at which additional water resources can be developed with the capacities available. It therefore seems necessary that any development strategy take into account the familiarity with irrigation, and the rate at which additional water can be made available.

2.56 In contrast to irrigation, farmers are less familiar with the advantages from inputs such as fertilizers, improved seeds, plant protection, mechanization, and other supporting services. This is partly due to lack of knowledge about them, but it is also related to the problems of availability in adequate quantities, regularity of supply, and the manner in which these inputs and services have been introduced to farmers. Further, benefits from some inputs may not be attained without more assured water supplies than farmers are currently receiving.

2.57 A strategy which emphasizes the increased use of inputs other than water may therefore be more difficult to implement in West Pakistan than one which offers more irrigation water. It would require a re-orientation of habitual attitudes toward agriculture, and also an expansion and improvement of the institutional base which supplies the new inputs. Both of these would be time-consuming efforts. The difficulties would be further compounded by the risk of uncertain irrigation supplies, the virtual absence of river regulation, and the currently limited development of groundwater resources. Despite practical problems such as these, inputs other than water can make a very important contribution to agricultural growth. In economic terms and without taking account of behavioral patterns, a strategy which emphasizes the non-water inputs might be superior to a strategy of water development alone at this stage. This is, however, too rigid a formulation of the alternatives, for both water and other inputs fill vital gaps in West Pakistan's current agricultural practice. Emphasis should be on balanced provision of these inputs to obtain the added advantages of interaction, and it is important to avoid thinking of development inputs in mutually exclusive terms.

2.58 For purposes of comparison individual canal commands with similar crop distribution have been grouped by IACA into nine specific agricultural zones. Details concerning cropping intensity, yield per cropped acre and total GPV, both for crops and livestock, are given at Annex 2.2 and locations are shown on Map 2. The summary of these data was employed by the Bank Group in an attempt to attribute growth of GPV to water alone, other inputs and the combination.

2.59 Since 1965 prices have been used (with minor exceptions), the increment in GPV between any two reference years reflects increases in acreage plus the increase in yields in the table below:

Estimated Increments of GPV Attributed to Water and Other Inputs
(Totals of GPV in Billions of Rupees)

| Due to | 1965 Present GPV | 1965 - 1975 GPV 1975 | Increment over 1965 | % of Increment | 1975 - 1985 GPV 1985 | Increment over 1975 | % of Increment | 1985 - 2000 GPV 2000 | Increment over 1985 | % of Increment |
|---|---|---|---|---|---|---|---|---|---|---|
| Combined Water & Other Inputs | 6.8 | 10.5 | 3.7 | 100 | 19.0 | 8.4 | 100 | 31.9 | 12.9 | 100 |
| Of Which | | | | | | | | | | |
| (1) Acreage Effect (Water Alone) | 6.8 | 8.0 | 1.2 | 31.7 | 9.6 | 1.6 | 19.0 | 11.7 | 2.2 | 17.0 |
| (2) Input Effect (Yield Alone) | 6.8 | 8.9 | 2.1 | 56.4 | 13.5 | 4.6 | 54.9 | 18.9 | 5.4 | 42.2 |
| Residual or Interaction: | | | 0.4 | 11.9 | | 2.2 | 26.1 | | 5.3 | 40.8 |

(1) Acreage expansion with yield held constant (water alone).
(2) Increased inputs with acreage held constant (effect of inputs).

The estimate of the separate effect of acreage was derived by employing IACA's estimated acreage expansion for the reference years, at the fixed GPV per acre for 1965, i.e. no increase in yield. Similarly, an estimate of yield effect was derived by using IACA's estimate of yield advances, but at fixed 1965 acreage, i.e. no increase in area. Production values are strictly those of IACA. While this method is somewhat arbitrary, since IACA's yield growth incorporates some improvement in delta, this contribution of yield is still indicative of the order of magnitude although it is subject to some margin of error. The acreage effect would be the most directly measurable effect of more irrigation water alone, and would be a first approximation of what would result from a strategy which concentrates on supplying additional water without improving other inputs. The "input effect" is less clearly defined. It consists of the increment in GPV due to increased inputs of all kinds -- i.e. increased delta and more non-water inputs -- on the fixed 1965 cropped acreage. The "input effect" effectively measures what would happen if no water were used to expand acreage, but additional irrigation water, merely to increase delta, were combined with increased application of other inputs as proposed by IACA. This would be a rough approximation of the results of a strategy which concentrated on providing new inputs and only sufficient water to improve the delta on the existing cropped acreage. The "combined effect" is the additional increment in GPV projected under the IACA program when there is sufficient water to increase acreage cropped and apply full delta irrigation to match the level of non-water inputs IACA has assumed in the different reference years. The "residual or interaction" is the difference between the sum of (1) "acreage effect" and (2) "input effect" from the "combined effect", and can only be loosely ascribed to the beneficial interaction between water and inputs not already contained in item (2).

2.60 The table shows that the "acreage effect" is important, but that it accounts for a much smaller proportion of total increment in GPV than the "input effect" would provide. Moreover, the relative importance of the "acreage effect" would decline as cropping intensities approach practical limits. The "input effect" would also decline slightly over time, but less sharply than the "acreage effect". The relative decline in the "input effect" would occur because the potential GPV in any year is based on acreage expansion and additional inputs (water and non-water) over the entire acreage. There would thus be an increasing "residual effect" as the cropped acreage increases because the "input effect" is measured on the 1965 acreage and is thus based on a declining proportion of the increased cropped acreage at successive reference years. The implications of this analysis appear consistent with the views expressed earlier, i.e. that emphasis should be on application of a combination of all inputs and that water resource development and provision of material inputs are not real alternatives.

2.61 In considering further agricultural development, it is important to keep in mind the inter-dependent nature of all measures relating to agricultural production. For instance, the application of fertilizers has reduced effects unless the land is watered properly. Proper water applications would not have the desirable results unless adequate drainage is provided. In saline areas the use of better seeds would have little effect without measures for desalinization of the soil. The full impact of land and water improvement measures would be felt only when followed by the use of better seeds and the application of fertilizers. It thus becomes apparent that few improvement measures can be taken in isolation, and that maximum benefits are obtained only from an integrated approach. Some measures may have to precede others, but there should be an integrated plan that calls upon all to play their proper roles at the appropriate time.

2.62 The development strategy implicit in IACA's program is based on a time horizon of 35 years (1965-2000), and assumes specific scarcities as well as some substitutability. It must therefore be considered in the context of a feasible rate of implementation of either choice, as well as the possibilities for combination. Because of higher risks and the large degree of uncertainty surrounding the possible future use of non-water inputs, it would appear advisable to continue a strategy of accelerated water development in the short run. Because, however, of the large potential contained in further emphasis on non-water inputs, it is of the utmost importance that water development be supplemented by a vigorous program of introduction and supply of non-water inputs. As irrigation supplies become more reliable the emphasis should gradually shift more and more toward non-water inputs in the medium term.run. Thereafter, water development would mainly consist of replacement and additional re-regulation and distribution, while the main source of further agricultural growth would be expected to come from the growth of yields, e.g. better farming practices and increasing use of non-water inputs.

2.63 The main strategy elements arising out of these considerations are thus as follows:

(i) Water development should retain relative priority in the short run, say, up to 1975;

(ii) The relative priority of water development is based on considerations of risk, associated with unreliability of irrigation supplies, as well as the need for additional supplies to act as incentives for the use of non-water inputs;

(iii) Because of "interaction effects", efficient use of existing as well as additional irrigation supplies is dependent upon the complementary use of non-water inputs;

(iv) When assured water supply is established, emphasis should shift increasingly towards the accelerated use of non-water inputs. To accomplish this it is imperative in the immediate future to develop the productive, administrative and organizational capacities for the supply and distribution of such inputs.

The Bank Group thus agrees with IACA that the strategy of agricultural development to be adopted for West Pakistan should take into consideration the practical complementarity between water and other inputs. In the present circumstances, to the extent that the two modes of development are competitive, it appears necessary for water development to have priority in the strategy until such time as the irrigation system offers a degree of reliability which would largely eliminate the risks involved in the full use of non-water inputs. This does not detract from the importance of increasing the use of other inputs without delay up to the level compatible with the prevailing level and reliability of water supply and institutional support.

5. Yields, Cropping Intensities, and Cropping Patterns

2.64 (a) Yields and Yield Growth. Preceding sections of this Chapter have discussed the influence of water and other inputs on crop yields under

West Pakistan conditions. With this background, this section examines yield prospects in more generalized terms. Comparison of average yields of different crops in Pakistan with average yields in other countries shows that Pakistan's are among the lowest in the world. Such averages, however, hide remarkable differences in the range of performance. IACA watercourse studies have shown that the most progressive farmers in West Pakistan obtain average yields for rice, cotton, and wheat as high as the averages in countries specializing in these crops. During the period 1961-63, for example, only Japan and the U.S. had average rice yields higher than the average of the best farmers on the watercourses of West Pakistan. Similarly, only Israel had a higher average for cotton. The U.S., with an average of 15.6 maunds of cotton per acre, was at the lower end of the progressive farmers' range of 15 to 20 maunds per acre. Only the Netherlands, with an average yield of 42 maunds, surpassed these farmers in wheat performance. Even Mexico, where new high yield varieties have been developed in recent years, did not, on average, do as well as the best Pakistani farmers.

2.65 These averages are, of course, national averages and are compared above with the performance of a small sample of very good farmers. Moreover, the national averages include both rainfed and irrigated acreages, whereas the Pakistani farmers in the comparison all benefitted from irrigation. Nevertheless, it is valid to point out that much higher yields than the current average are quite possible in West Pakistan -- in fact, the better farmers are already obtaining them. The most urgent problem is therefore to raise the yield levels of the vast majority of the farmers whose productivity is so far below the leaders and who have been unable to achieve much more than bare subsistence thus far. This serves to emphasize the vital role to be played by extension and farmer services in the development effort.

2.66 Earlier discussion in this chapter has emphasized the importance of irrigation water, in terms of both quantity and regularity of supply, and the yield-depressing effects of inadequacies in these respects. There are, however, many factors not directly associated with the availability of irrigation supplies which singly, and in combination, keep yields low in West Pakistan. Problems of salinity and alkalinity are, of course, related to water supply. Poor farming practices - levelling, seedbed preparation, subsequent cultivations and weed control - affect yields adversely. The absence of effective plant protection measures may be a deterrent to farmers otherwise prepared to introduce inputs such as fertilizers. Improved varieties of seed may be known and actually in circulation, but poor quality basic seed stock as well as inadequate quality control can lead to disappointing yields.

2.67 Yield constraints of these kinds can be reduced by corrective action. There appear to be no technical reasons why, over time, uniformly high yields cannot be obtained in most of the irrigated parts of West Pakistan. The speed with which this can be done would depend in large part on the research and extension services, and the degree to which such services become aware of and are responsive to practical farm problems. It would require more field experimentation oriented toward general improvement in farming methods, rather than basic technical research, and a heavy practical emphasis in the training given to extension personnel. If large numbers of farmers are to take the steps necessary to increase yields, they must be informed of the proper steps, and by people who can demonstrate convincingly the reliability of the information they convey.

2.68 IACA's analysis of yield potential is based on the assumption that unreliable and inadequate water supplies, waterlogging and salinity, limited use of fertilizers and pesticides, and poor quality seed are major constraining factors at present. To overcome these constraints, IACA stresses the importance of using a combination of agricultural inputs. While this would be the most desirable approach, it seems unlikely that it would occur rapidly over wide areas. The more probable sequence of events would be a gradual increase in the use of some inputs, or sporadic enthusiasm for one or two inputs at a time, building up to the full package as farmers become convinced of the advantages. Consequently, the widespread achievement of uniformly high yields would not come about rapidly. Increased irrigation supplies should act as something of a catalyst in the adoption of new inputs, but this again would be a relatively slow process determined by the pace of the water development program.

2.69 According to IACA's estimates of future agricultural production in West Pakistan average crop yields per acre would go up by nearly three times their present levels over the period 1965-2000. IACA assumes that this may take place generally by cumulating contributions of the more important yield-increasing factors. This assumes that each additional factor builds on the yield level obtained from the introduction of preceding factors. The result is a cumulative growth in yield which is greater than the additive effects of the factors if taken separately, and therefore provides the interaction effect due to the combined application of different sources of yield growth. The following table shows IACA's supposition regarding the most important yield-improving factors. This should be regarded as a general indication of the possible cumulative effects rather than as experimentally-based findings of actual contributions.

IACA's Assumptions Regarding Contributions to Yield Growth from Selected Yield-Improving Factors Over the Period 1965-2000

| | Factor Contribution in Isolation (%) | Cumulative Yield (%) | Apparent Contribution in Combination (%) |
|---|---|---|---|
| Present Yield | - | 100 | - |
| Factors: | | | |
| Additional Water Supplies Alone | 10 | 110 | 10 |
| Removal of Waterlogging and Salinity | 10 | 121 | 11 |
| Application of Fertilizers | 40 | 169 | 48 |
| Disease and Pest Control | 15 | 195 | 26 |
| Improved Seedbed Preparation and Cultivation Practices | 20 | 234 | 39 |
| Improved Varieties | 20 | 281 | 47 |

Source: Computed from data presented in IACA's Comprehensive Report, Volume 7, Annexure 9, pages 93 ff.

2.70 This supposition is, of course, a gross over-simplification and in practice there would be wide variation in the response to different factors depending on the circumstances and the composition and balance of the package of inputs. The apparent contributions of factors would change with the sequence in which they were implemented. In practice the yield-improving factors would not be added in the discrete steps set out in the table. Rather, they would be adopted in various combinations and at various rates as development proceeds over the entire 35-year period. Since water is such a familiar input in West Pakistan it is likely that farmers would quickly take advantage of additional water supplies when they become available. Fertilizer is also in increasing demand and may reflect the stimulus which appears to follow added supplies. The sequence in the table above is therefore probably accurate to this extent.

2.71 The nearly three-fold increase in yields over 35 years shown above would constitute an annual compound yield growth rate of three percent, but the growth rates between different periods within this total time span would depend on the actual pace of the water development program, and the speed with which other inputs are available to, and accepted by, farmers.

2.72 IACA has assumed, for instance, that proposed project areas and canal commands would not all receive adequate water supplies for full delta irrigation prior to 1975. The increase in yields would therefore continue at present rates between 1965 and the advent of additional water. As additional water becomes available under the program -- mainly the period 1965-85 -- the most rapid yield improvement is expected to occur. This reflects IACA's assumption that the water/yield relationship is as discussed in para 2.47 above and that elimination of underwatering would bring about an immediate proportionate increase in yields. IACA anticipates a Provincial growth rate in yield per acre of over four percent per annum for the ten-year period 1975-85, but with rates of around four to eight percent in the irrigated areas. Yields are projected to grow at a slower rate thereafter averaging less than three percent per annum from 1985 to 2000 because the major yield improving inputs and farming practices would already have been adopted in the earlier period. Also, at the higher yield levels projected for 1985, IACA assumes that further rapid improvement would become much more difficult to achieve. The total effects of the various IACA assumptions affecting yield are reflected in the yields per acre and rates of growth in the following table:

Derived Average Yields For Important Crops in Three Regions Resulting From the Application of IACA Assumptions and Associated Compound Annual Growth Rates

| | 1965 | 1975 | Growth 1965-1975 | 1985 | Growth 1975-1985 | 2000 | Growth 1985-2000 | Growth Overall |
|---|---|---|---|---|---|---|---|---|
| | (Mds. per acre) | | (Percent per annum) | (Mds. per acre) | (Percent per annum) | (Mds. per acre) | (Percent per annum) | |
| **Punjab (irrigated)** | | | | | | | | |
| Rice | 17.0 | 21.0 | 2.2 | 32.7 | 4.1 | 43.3 | 2.1 | 2.8 |
| Cotton | 8.3 | 10.4 | 2.3 | 16.8 | 5.0 | 21.8 | 1.7 | 2.8 |
| Wheat | 12.7 | 17.2 | 3.1 | 26.9 | 4.6 | 33.8 | 1.5 | 2.8 |
| Sugar | 34.5 | 42.8 | 2.2 | 63.2 | 4.0 | 78.6 | 1.5 | 2.4 |
| Kharif Fodder | 226.8 | 285.9 | 2.3 | 425.0 | 4.1 | 543.5 | 1.7 | 2.5 |
| Rabi Fodder | 522.7 | 596.1 | 1.3 | 800.4 | 3.0 | 957.5 | 1.3 | 1.8 |
| **Sind (irrigated)** | | | | | | | | |
| Rice | 2.2 | 15.3 | 2.3 | 29.2 | 6.7 | 44.9 | 2.9 | 3.8 |
| Cotton | 7.1 | 8.0 | 1.2 | 16.2 | 7.4 | 22.5 | 2.2 | 3.4 |
| Wheat | 10.6 | 13.5 | 2.4 | 24.6 | 6.2 | 34.2 | 2.2 | 3.4 |
| Sugar | 22.7 | 28.6 | 2.3 | 63.2 | 8.2 | 97.0 | 2.9 | 4.2 |
| Kharif Fodder | 172.2 | 218.7 | 2.4 | 365.8 | 5.5 | 513.9 | 2.1 | 3.1 |
| Rabi Fodder | 206.1 | 361.9 | 5.8 | 633.0 | 6.0 | 901.5 | 2.3 | 4.3 |
| **Outside Areas** | | | | | | | | |
| Jowar | 6.0 | 7.7 | 2.5 | 9.0 | 1.6 | 10.9 | 1.3 | 1.7 |
| Gram | 6.0 | 7.6 | 2.4 | 8.8 | 1.5 | 10.6 | 1.3 | 1.6 |
| Wheat | 6.1 | 7.6 | 2.1 | 8.7 | 1.5 | 10.3 | 1.2 | 1.5 |
| Maize | 10.0 | 13.0 | 2.7 | 15.3 | 1.6 | 18.5 | 1.3 | 1.8 |
| Kharif Fodder | 120.1 | 154.6 | 2.6 | 181.7 | 1.6 | 219.1 | 1.3 | 1.7 |
| Rabi Fodder | 115.3 | 145.7 | 2.3 | 167.8 | 1.4 | 196.3 | 1.0 | 1.5 |

Source: Prepared from data given in IACA Comprehensive Report, Volume 7, Annexure 9, pages 106-108, and exclusive of dubari/bosi crops in the Sind.

2.73 The growth rates of yields for the crops included in the above table strongly reflect the dominating influence of additional water supplies on yield levels implied in the IACA projections. This is particularly pronounced in the rapid growth during the 1970's and the early 1980's. Similarly, the projections reflect a less optimistic response to non-water inputs at higher levels of application in those areas not receiving additional water supplies and by the modest yield growth projected for the period 1985 to 2000 (see Figure 2.3).

2.74 These yield levels appear feasible on purely technical grounds, but the Bank Group has some reservations about the practical probability of the sustained high rates of yield growth projected for some crops. This applies particularly during the 1975-85 period and especially to cotton in the Punjab and all crops in the Sind. With respect to cotton yields, experience at the Convillepur Farm in the Punjab can be used as an example. On this large-scale, well-managed commercial farm, which employs irrigation and has continually adopted a variety of improved agricultural inputs over time, cotton yields have been increasing at an annual rate of 2.1 percent over the period 1915 to 1964. Figure 2.4 shows the Convillepur (and Khanewal) 1/ experience and compares these with the IACA and Bank Group projections for twelve project areas. The Convillepur Farm experience thus demonstrates that maintenance of sustained yield growth is quite possible but that about two percent growth per annum represents the best effort of a sophisticated farming enterprise in West Pakistan. Therefore, it would be difficult to sustain average yield growth rates for cotton of the order of five to seven percent per annum as projected by IACA for 1975-85 over the whole cotton area.

2.75 The prospects for wheat also require special consideration since this is a critical crop both as regards acreage devoted to it and the role it plays in domestic consumption. In Pakistan, as elsewhere, great efforts have been made in recent years to raise wheat yields through a Program of Accelerated Wheat Improvement. This Program seeks to achieve widespread distribution and adoption of improved wheat seed derived from dwarf Mexican varieties and crosses with local Pakistani wheat varieties. Results from the first year (1965/66) of extensive testing on both private and Government farms indicate that substantial improvements over present yields are possible. The average yield obtained by 1,500 farmers from plantings on 3,500 acres was 33.7 maunds per acre. The average for Government farms from plantings on 1,200 acres was 26.1 maunds per acre. Since the control plots in these tests averaged 11.6 maunds per acre, compared to the Provincial average of 9.7 maunds for the same year, a downward revision in the same proportion may be appropriate in gauging the potential of the improved varieties under Province-wide conditions. Even with this adjustment, however, an average yield of more than 25 maunds per acre appears feasible. The IACA wheat projections may seem somewhat conservative, in light of this experience, but the problems of large-scale multiplication, distribution, and adoption of the new varieties must not be overlooked.

2.76 The projected growth of yields in the Sind in the 1975-85 period for other crops seem less probable. The Sind is scheduled to receive increments in water supplies, and improved availability and regularity in water supplies would undoubtedly assist yield improvement from the present low base. The Bank Group feels, however, that annual yield growth rates in excess of six percent would be very difficult to maintain over a period of ten years. A more probable growth path would be at levels of the order of four to six percent.

1/ Khanewal is another large farm similar in all respects to Convillepur.

2.77 The Bank Group is in general agreement with the yield levels projected by IACA for the year 2000, but considers that in comparison with IACA's projections, these would come about as the result of somewhat higher growth rates during the 1965-75 period, somewhat lower rates during the 1975-85 period and about the same rates from 1985-2000.

2.78 (b) Cropping Intensities and Cropping Patterns. The impact of additional irrigation water on West Pakistan agriculture would open up a number of opportunities. It could be used: (i) to bring about more extensive use of land, i.e. to develop new areas for irrigation; (ii) to increase the intensity of cropping and/or improve the standard of irrigation farming within the existing irrigated land, i.e. more cropped acres per unit of CCA and/or higher delta associated with better farming practice and a higher level of other inputs; or (iii) to bring about change in the cropping pattern, i.e. change the kharif/rabi ratio and/or within any given cropping pattern change the composition either by changing the proportions of existing crops or introducing new crops.

2.79 In circumstances where, under prevailing conditions, only 25 million acres out of the existing 33.5 million acres of CCA receive irrigation water (and that in inadequate quantity), and where foreseeable future supplies would only be sufficient to increase this to 29.5 million acres at full delta at the desired cropping intensity level, there would have to be very compelling reasons for extending irrigation into new land. The Bank Group would in general endorse IACA's policy of intensification of farming within the existing CCA rather than the extension of the canal system into new land. It would not, however, be as rigid as IACA in limiting the developed CCA to 29.5 million acres at all times. This may well prove to be the desirable acreage at full development under conditions of limited irrigation water supply and a high standard of farming observing optimum levels of cropping intensity and high agricultural inputs. Until this state of development is reached, however, to the extent that it is feasible and advantageous to use any water available on the four million acres of CCA not designated for long term development, this should be done. This would pose a difficult problem of contraction at some future date, but the future conditions cannot be foreseen with sufficient confidence to justify foregoing the production from any suitable areas which are economically viable during the development period.

2.80 The relationship between higher delta and more non-water inputs has been discussed in the preceding section. This section will consider the inter-relation between cropping intensity and cropping pattern, and the prospects for change as they appear at this point in time.

2.81 Since West Pakistan has two agricultural seasons, the theoretical maximum cropping intensity is 200 percent, or full use of the existing CCA in both seasons. There are several reasons why this maximum is not a feasible objective, however, foremost among them being the physical impossibility of growing certain crops in succession. At the current stage of agricultural development in West Pakistan, most farmers are at least partially engaged in subsistence farming, and do not depend on cash crops for all their needs. Part of their cropped acreage must therefore supply food for home consumption and fodder for livestock. The need to grow a variety of crops under these circumstances forces farmers to make decisions between different crops in accordance with their subsistence and other requirements. Putting more acreage into one crop usually means reducing the acreage devoted to some other crop or crops. For reasons such as these, farmers cannot move towards specialization in two or three crops which may fit the seasonal cropping opportunities precisely.

2.82 Several examples of the incompatibility of certain crop successions are of particular importance. The difficulty in fitting wheat or fodder (rabi crops) after cotton (a kharif crop) has already been noted. Gram grown in rabi cannot follow kharif maize because of overlapping growing periods. Coarse rice, grown mainly for domestic consumption, has a shorter growing period than fine rice, which is grown for export. A decision to move into fine rice production as a cash crop thus involves conflict with rabi crops which must be planted before fine rice is harvested.

2.83 The incompatibility of different crop successions is not due to an overlap in the growing seasons alone. The preparation of land for a new crop requires time, and in some cases a pre-irrigation. Shortages of animal power or labor may make it impossible for some farmers to complete the harvesting and marketing of one crop in time to prepare the land for a succeeding one. In other cases, climatic factors impose a time constraint. Wheat, for example, can be planted in December and still yield a crop, but by that date the temperatures in some regions would be low enough to affect emergence, early growth, and therefore yields. Specific examples of cropping intensities in different regions, and patterns affecting efforts to increase intensities, are given in Annex 2.3.

2.84 Increases in cropping intensity in many areas involve expansion into saline areas, or some of the poorest land within present farm boundaries. Many farmers have adjusted to this problem by cropping their best land at higher levels of intensity and leaving saline or poor land uncultivated. Farming intensity, which measures the proportion of cropped area to cultivated area, is therefore frequently higher than cropping intensity based on the CCA. This would arise where the cultivated area is less than the CCA, or the cultivated area includes non-commanded portions. Where farming intensity is already high, any increase in cropping intensity (based on the full CCA) may call for additional managerial skill, labor, and animal power which farmers are not in a position to provide. Reclamation of saline land can also be an expensive process and farmers, particularly those with smallholdings, may not be able to afford the costs of bringing this land under production, even where additional water supplies become available. There is the further fact that some of the CCA may have to be reserved for the use of livestock, so it would not always be practical to consider that all of the CCA would be available for cropping.

2.85 After taking factors such as these into account, IACA has concluded that an overall average cropping intensity of 150 percent is a reasonable indicative target for development in the Indus Basin. Two exceptions to this are: (i) Region I (Peshawar Vale) where maize, wheat and sugarcane occupy 82 percent of the cropped area and ultimate intensity may reach 173 percent, and (ii) Region VIII (Ghulam Mohammed Barrage, non-perennial rice area) where a low rabi cropping associated with dubari/bosi conditions limits expectations to an ultimate cropping intensity of 130 percnet. 1/ IACA projects an ultimate cropping intensity for the 29.5 million acres of CCA of about 145 percent. IACA's projections for intensification assume that the principal controlling physical factors would be the starting intensity and the occurrence of salinity, and current variations in these respects are reflected in the projections. The following table gives the estimated average time required, in years, to raise present cropping intensities to the 150 percent level. To the extent that the occurrence of salinity would influence the growth of intensities, this is further broken down in the table below to show the length of time required under three categories of salinity.

IACA Base for Projection of Growth in Cropping Intensities
Time Required to reach 150 percent

| Starting Intensity (Percent) | Salinity Category 1/ I | II | III |
|---|---|---|---|
| | (years) | | |
| 135 | 5 | - 2/ | - 2/ |
| 120 | 6 | 10 | - 2/ |
| 110 | 7 | 10 | - 2/ |
| 100 | 8 | 11 | 15 |
| 90 | 9 | 11 | 15 |
| 80 | 10 | 12 | 16 |
| 70 | 11 | 13 | 16 |
| 60 | 12 | 14 | 17 |

1/ Salinity Categories are defined as follows:
I - 15 percent of CCA requires reclamation
II - 30 " " "
III - 45 " " "
2/ No cropping intensity this high in the salinity category.
Source: IACA's Comprehensive Report, Volume 7, page 215.

2.86 The time estimates shown above have been applied by IACA to each area as it becomes scheduled to receive sufficient water to provide for expansion of cropped acreage at full delta, and include an allowance for

1/ This is based on the assumed command of the Ghulam Mohammed Barrage of about 1.3 million acres as against the original design of 2.8 million acres with a cropping intensity of about 75 percent.

reclamation. The estimates also include the assumption that intensities may increase fairly rapidly up to about 120 percent, but that advances beyond this point up to 150 percent will be slower because farm management constraints become increasingly operative.

2.87 By applying these generalized time estimates to the conditions prevailing in the major irrigated regions, IACA has provided a view of the cropped acreage, and cropping intensities, which might occur with the proposed water development. This is given in the following table, which shows the cropped acreage in three regions for selected reference years. The table also shows the expected variations, by region, around the ultimate objective of 150 percent cropping intensity for the Indus Basin as a whole.

Growth of Cropped Acreage and Cropping Intensities in Irrigated Zones
(as projected by IACA)

1965

| | 1965 | | 1975 | | 1985 | | 2000 | |
|---|---|---|---|---|---|---|---|---|
| | Cropped Acreage (mill. acres) | Cropping Intensity (Percent) | Cropped Acreage (mill. acres) | Cropping Intensity (percent) | Cropped Acreage (mill. acres) | Cropping Intensity (percent) | Cropped Acreage (mill. acres) | Cropping Intensity (percent) |
| Peshawar | 0.8 | 135 | 0.7 | 132 | 0.9 | 153 | 1.0 | 173 |
| Punjab-Irrigated | 17.5 | 95 | 21.3 | 114 | 24.2 | 131 | 27.7 | 150 |
| Sind-Irrigated + Dubari/Bosi | 8.5 | 90 | 9.3 | 100 | 10.6 | 115 | 12.5 | 137 |
| | 26.8 | | 31.3 | | 35.7 | | 41.2 | |

Source: IACA's Comprehensive Report, Volume 7, Annexure 9, page 106.

The small contraction of cropped acreage in the Peshawar Vale as projected for 1975 is apparently a result of IACA's full delta calculations. In the absence of detailed investigations, IACA has projected no further water development in this region for the period 1965 to 1975. The slower expansion in the Sind reflects the later development there, and the continuation of some non-perennial water supplies up to the year 2000.

2.88 Recent experience with the SCARP I (Salinity Control and Reclamation Project) provides some check on the realism of the IACA projections. SCARP I is situated in an area where salinity was quite severe, and not unlike the conditions postulated for Salinity Category III (about 45 percent of the CCA requiring reclamation). In the first four years of operation in SCARP I, cropping intensity has increased from 89 percent to 110 percent. This compares with IACA's estimated increase, under Category III conditions, from 97 percent to 114 percent over a four year period. The following table illustrates this comparison. The close correspondence between the SCARP I experience and IACA's Category III projection tends to support the view that IACA's estimates represent feasible possibilities.

Cropping Intensity Increases in SCARP I
Compared with IACA Projections

| Time Period | SCARP I | Category III |
|---|---|---|
| | ----- (percent) | ----- |
| Start of Operation | 78 | 80 |
| 1st year (1961/62) | 89 | 97 |
| 2nd year (1962/63) | 100 | 107 |
| 3rd year (1963/64) | 108 | 111 |
| 4th year (1964/65) | 110 | 114 |

2.89 The IACA selection of an overall average of 150 percent intensity at full delta as the ultimate objective was influenced by a desire to provide the means by which small-scale farms could rise above the subsistence level and produce marketable surpluses. IACA concludes that if water supplies were made adequate for an ultimate intensity of only 130 percent (at full delta irrigation), farmers would continue to under-water, and expand their cropping to an operational limit of about 150 percent. Because of IACA's conviction that under-watering must be stopped as rapidly as possible in the interest of eliminating salinity in the long run, it has recommended a program which matches the farmers' desire to increase cropped acreage with a water supply which will enable them to preserve the productivity of their lands. The Bank Group agrees that full delta irrigation is essential to West Pakistan's long term agricultural development. It also recognizes, however, as noted earlier that there are short run advantages to the farmers from under-irrigation at lower yield levels. The increase in intensity, but at less than full delta applications, may thus be more rapid than IACA has projected within the rigid set of assumptions it has used with respect to intensity growth.

2.90 With the overall intensity objectives determined on the grounds which have just been briefly indicated, IACA's estimated water requirements over time (in quantities and seasonal distribution) have been derived from the cropping patterns proposed to fit into an ultimate average intensity of 150 percent. In this context, the kharif/rabi ratio of the cropping pattern exerts considerable influence on the corresponding seasonal water requirements, and changes in this ratio could have quite large effects on the type of water development program which would be needed. In the early years of the development program maximum emphasis is placed on increasing the rabi intensity consistent with the greater efficiency in water use, the importance of wheat, and in keeping with the constraints imposed by the existing system and the availability of resources. As intensities increase over time other considerations, notably land occupation, distribution of the work load and the greater scope for canal remodelling begin to operate with greater force leading towards an equalization of rabi and kharif intensities as 150 percent is approached.

2.91 At the higher intensities the GPV of crops, whether related to total water requirements or to the cropped acreage, is relatively insensitive to changes in the kharif/rabi ratio. This is illustrated in the table below, which contrasts three different crop rotations at the same cropping intensity of 150 percent. The water requirements at watercourse head are those for the Lower Chenab and Sidhnai canal commands, and the GPV of crops has been calculated on the basis of IACA's estimates of ultimate yields and constant farm-gate prices. The alternative use of present yields would not affect the results materially. Changes, however, in price relationships would have a substantial impact.

GPV for Three Rotations at 150% Cropping Intensity
With Different Kharif/Rabi Ratios

| | Rotation 1<br>Lower Chenab | Rotation 2<br>Sidhnai | Rotation 3<br>Sidhnai |
|---|---|---|---|
| Kharif:Rabi Ratio | 75:75 | 81:69 | 71:79 |
| Major Crops | | (percent) | |
| Rice | 11 | Negligible | Negligible |
| Cotton | 23 | 45 | 35 |
| Wheat | 26 | 28 | 38 |
| Fodder | 38 | 32 | 32 |
| Irrigation Requirement at Watercourse Head - acre feet per acre | 4.90 | 4.95 | 4.75 |
| GPV Rupees per acre foot of water | 161 | 156 | 160 |
| Gross Value Crops per cropped acre (rupees) | 787 | 774 | 760 |

Source: Data from Lower Chenab and Sidhnai Canal Commands, IACA's Comprehensive Report, Volume 7, Annexure 9, pages 73 and 80.

While no detailed assessment of the associated on-farm costs have been made, IACA's projections of future on-farm costs under varying conditions would indicate that on-farm expenditures would not materially change the above results.

2.92 In the light of the similarity of returns to land and water from different cropping patterns as seen in the preceding table, the patterns can be expected to change over time in response to new opportunities to increase intensity, change technology, and markets for farm commodities. As farmers increasingly participate in the market economy they are also likely to become more cost conscious. Thus, to promote a sustained efficient utilization of the irrigation system while simultaneously meeting production objectives, the cost-price relationships are likely to assume increasing importance over time.

2.93 Although IACA is aware that there is adequate flexibility to permit changes in cropping patterns and kharif/rabi ratios, the projections of cropping patterns given in the Comprehensive Report show a distribution of crops that is largely unchanged from the present. This results in estimates of foodgrain shortages in future years, and surpluses in fodder, cotton, sugarcane, and some other crops. The demand and supply projections are discussed further in Chapter VIII B below, but it should be noted here that it would be possible on technical grounds to adjust the cropping patterns so that surpluses and deficits are eliminated or greatly reduced, provided appropriate incentives are given to induce farmers to make such changes. This appears feasible without alteration in IACA's estimates of total water availability. For example, acreage could be changed from rabi fodder to wheat which would reduce projected fodder surpluses without serious loss to TDN requirements for the projected livestock production and without major change in the water requirements. Acreage can also be switched easily from gram or oilseeds to wheat. Wheat can be sown later than the final date shown in IACA's cropping calendar (mid-November), which has been used in the projection of cropping patterns and water requirements. This would require water for a pre-irrigation and late sowing would reduce yields, but despite these qualifications it is nonetheless true that additional wheat acreage could be obtained by planting after mid-November. In fact, current experience (1965/66) in perennial canal commands in the Punjab, based on IACA's Watercourse Studies, shows that about 45 percent of the wheat acreage was planted in the second half of November or later. There is a pressing need for the agricultural research and extension services to pursue investigations to determine which new crops can be introduced with advantage in the future and to develop the necessary information on cultural practices, costs, and probable returns.

2.94 As previously explained, IACA's Comprehensive Report and this report tend to focus attention on the canal irrigated portions of the Indus Basin, but the future contribution from the sizeable uncommanded and mainly non-irrigated areas should not be overlooked. Where cropping depends on rainfall, or residual soil moisture from flooding, the concepts of cropping intensity and cropping pattern cannot be applied directly. Since the area involved is not fixed, as in a canal command, and the supply of water is uncertain from one year to the next, without private tubewell development there can be little planned change in land and water use. In those areas not served by private tubewells, farmers will have little choice but to adjust to the cropping opportunities presented by the play of natural forces. IACA's projections therefore indicate little change in the proportional allocation between crops on the non-irrigated land, but they do show a gradual increase in the area cropped. The latter is expected to come about as a result of private tubewell installation, improved technology, increasing pressure of population on the land, and because gradual farm mechanization may make timely sowing possible over a larger area than at present. Soil conservation and grazing protection programs may increase the output from livestock supported on grazing land, and IACA estimates that this would help to double the TDN production from uncommanded lands. The Bank Group believes that farmers in the uncommanded areas could improve production by private tubewell installation where conditions permit, and by better farm practices and increased use of agricultural inputs, but agrees with IACA that there are only limited opportunities to change the combination of crops which are grown on the non-irrigated areas.

## 6. Livestock Production Potential

2.95 The brief review of technical agricultural considerations has thus far omitted direct reference to the role of livestock. At West Pakistan's present stage of development, draft animals are the main source of power for farm operations. While some of the larger farms have begun to employ tractors and other mechanized equipment, they are a very small minority among all farms. The agriculture sector's heavy dependence on animal power means that an important part of the available land, irrigated and non-irrigated, must be reserved for the support of the livestock population. Moreover, development planning must make provision for the animals needed for farm work in years to come. Farm mechanization would continue to spread, but the small size of so many farms in West Pakistan would limit their participation in this development and necessitate a substantial reliance on animal power. Development planning must also take into account the probable change in diet associated with rising per capita income levels in all sectors of the economy -- a change which should bring higher per capita consumption of milk, dairy products, and meat. Whether speaking of work animals or production animals, qualitative improvement in livestock would require increased fodder intake per animal, either to increase draft power or production efficiency, and this aspect must also be included in planning estimates. For reasons such as these, the livestock portion of the agricultural sector would constitute an important component of total production and would absorb a significant portion of resources for development.

2.96 The IACA framework for projecting the livestock component, starts with an estimate of the livestock population in 1965 derived from the Livestock Census of 1960 as adjusted to allow for changes during 1960-65. These data on West Pakistan livestock are admittedly of uncertain quality, but have been used in the absence of any alternative that appeared more reliable. From this benchmark estimate, the size of the bullock herd, which would be the source of draft power on farms, is assumed to decline gradually to one-half its present number by the year 2000. In the early years between 1965-75, however, the herd may increase somewhat. This later declination would reflect a growing mechanization of West Pakistan farming but does not eliminate the current need for draft animals. A breeding herd for bullocks is also retained, but the size is scaled down in proportion to the decline in the number of working bullocks required. On the other hand, the number of cattle and raised for milk production increases substantially, and more than offsets the reduced number of working bullocks. The following table illustrates these changes over the period 1965-2000. The totals are expressed in actual numbers and in terms of Animal Units (AU), a concept used by IACA as a common denominator to permit estimation of food needs for animals of different categories. The base for an AU is the annual fodder consumption of one bullock.

Composition of Projected Livestock Population, in Actual Numbers and Animal Unit Equivalents

| | 1965 | | 1975 | | 1985 | | 2000 | |
|---|---|---|---|---|---|---|---|---|
| | No. of Stock | Animal Units | No. of Stock | Animal Units | No. of Stock | Animal Units | No. of Stock | Animal Units |
| | (in millions) | | | | | | | |
| **Bovines** | | | | | | | | |
| Bulls and Adults | 7.4 | 7.40 | 6.6 | 6.60 | 5.6 | 5.60 | 3.7 | 3.70 |
| Milk Cow Adults | 4.4 | 3.32 | 3.8 | 3.11 | 3.0 | 2.52 | 2.0 | 1.78 |
| Male Followers | 1.8 | 1.39 | 2.3 | 1.77 | 2.0 | 1.54 | 1.4 | 1.08 |
| Female Followers | 1.7 | 1.25 | 2.4 | 1.73 | 1.9 | 1.35 | 1.4 | 0.98 |
| Milk Zebu and Followers | - | - | - | - | 0.7 | 0.58 | 7.6 | 6.76 |
| | 15.3 | 13.36 | 15.1 | 13.21 | 13.2 | 11.59 | 16.1 | 14.30 |
| **Buffalos** | | | | | | | | |
| Bulls & Followers | 3.1 | 3.19 | 6.4 | 6.08 | 10.9 | 19.92 | 8.4 | 7.22 |
| Cows | 5.4 | 6.53 | 6.9 | 9.35 | 9.6 | 12.97 | 7.0 | 10.74 |
| | 8.5 | 9.72 | 13.3 | 15.43 | 20.5 | 22.89 | 15.4 | 17.96 |
| **Other Work Animals** | | | | | | | | |
| Horses, Camels, etc. | 2.4 | 1.20 | 2.1 | 1.05 | 1.8 | 0.90 | 1.0 | 0.50 |
| **Small Animals** | | | | | | | | |
| Sheep and Goats | 17.0 | 2.77 | 20.1 | 3.16 | 24.7 | 3.82 | 27.2 | 4.15 |
| **Poultry** | | | | | | | | |
| Existing Desi Breed | 10.0 | 0.13 | 10.0 | 0.13 | 10.0 | 0.11 | 10.0 | 0.10 |
| Improved Stock | - | - | 2.4 | 0.06 | 7.1 | 0.24 | 20.3 | 0.68 |
| GRAND TOTALS: | | 27.18 | | 33.04 | | 39.55 | | 37.69 |

Source: Prepared from data presented in IACA Comprehensive Report, Volume 7, Annexure 9, page 110.

2.97 The figures in the table imply an increase of nearly 40 percent in the total number of Animal Units over the 35-year period. To feed this larger animal population, and to supply it with a gradually increasing feed intake over time, IACA has provided fcr expansion in the acreage of fodder crops. IACA measures animal feed in terms of Total Digestible Nutrients (TDN), which includes fodder, crop residues, and grazing. Part of the increase in feed requirements would therefore be met by crop residues from the increasing volume of crops raised for other purposes. Anticipated improvements in pasture management and control would also help to supply some of the additional TDN consumed by the larger herds. Nevertheless, the IACA projections show that fodder production would double between 1965 and 2000. The consumption of TDN per AU of production animals would go from 1,035 kg. in 1965 to 1,395 kg. by the year 2000. Included in this would be enough digestible protein to ensure a reasonably balanced diet for the livestock.

2.98 While the method and assumptions employed in arriving at these projections seem appropriate to West Pakistan conditions, the resources employed to produce fodder would generate a surplus of TDN under the IACA demand assumptions. This may be seen from the table below. As discussed in other parts of this report, the Bank Group believes that pressures for foodgrain production would bring about some shift of cropped acreage from fodder to wheat and coarse grains.

IACA Projections of TDN Requirements and Supply

| | 1965 | | 1975 | | 1985 | | 2000 |
|---|---|---|---|---|---|---|---|
| | ----- | | (in million tons) | | | | ----- |
| Estimated Requirement | 28.1 | | 35.7 | | 47.7 | | 52.6 |
| Estimated Availability | 28.1 | | 36.9 | | 48.5 | | 62.8 |
| Annual Growth Rate | | 2.8% | | 2.8% | | 2.1% | |

Source: Computed from data presented in IACA's Comprehensive Report, Volume 7, Annexure 9, pages 110, and 112.

2.99 An important special element in the IACA projections, obscured in the total figures presented above, is the assumed change in the kinds of the cattle to be raised for milk and meat production. Buffalos provide a major part of the milk production up to 1985, and the projections show an increasing herd size to that date, but a decline from 1985 to 2000 would be offset by increases in the number of dairy cattle from Zebu breeds such as the Sahiwal and Red Sindi. Present numbers of these cattle are small and, in fact, are expected to total only 0.7 million head by 1985. Between 1985 and 2000, however, this herd is estimated to grow to 7.6 million, or at an annual rate of 11.7 percent per annum. This is obviously an extremely high rate of growth, and would be a difficult objective to achieve. Experience elsewhere has shown that a dairy herd can be doubled in ten years time, with good management and adequate feed, and this would be a growth rate of 7.2 percent. IACA counts heavily on very widespread use of artificial insemination and expects that the high growth rate can be attained if this is used on about four million cows and followers in the latter part of the 15-year period, 1985-2000. An extract giving a brief summary of IACA's proposals for the organization of Artificial Insemination is given at Annex 6.3. If an artificial insemination program can be organized to this extent, and particularly if it is introduced at an earlier stage than assumed by IACA, there seems to be no biological reason why the ultimate target of 7.6 million head cannot be reached. It normally requires long periods of time to bring about herd build-up to the extent envisaged here, and much would depend on the economic incentives operating in West Pakistan. While change on this scale may be technically feasible, the Bank Group would doubt that its attainment can be realized in practice. Firmer judgement must be based on more detailed study as recommended later.

2.100 IACA has translated its projections of livestock development into value terms by concentrating on the milk and meat from production animals, plus an allowance for hides, skins, wool and other animal by-products. Produce from work animals has not been included in gross production value because it is accounted for as a negative item in farm production costs. The value of fodder produced has also been excluded from crop GPV calculations on the grounds that this is later represented in the value estimates for livestock production. The contribution expected from livestock, which includes the value of fodder and crop residues fed to production animals, is shown in the table below:

IACA Projections of Available TDN, Milk and Meat Production and Resulting GPV from Production Animals (Excluding Draft Livestock)

| | 1965 | 1975 | Growth Rate 1965-1975 (% p.a.) | 1985 | Growth Rate 1975-1985 (% p.a.) | 2000 | Growth Rate 1985-2000 (% p.a.) | Over-all Growth Rate (% p.a.) |
|---|---|---|---|---|---|---|---|---|
| **Available TDN:** | | | | | | | | |
| Amount (millions of tons) | 17.8 | 26.9 | 4.2 | 38.8 | 3.7 | 55.5 | 2.4 | 3.3 |
| Milk (kg) per ton of TDN | 337 | 331 | | 362 | | 413 | | |
| Meat (kg) per ton of TDN | 17.3 | 27.4 | | 33.0 | | 48.6 | | |
| **Livestock Production:** | | | | | | | | |
| Milk (millions of tons) | 6.01 | 8.94 | 4.0 | 14.04 | 4.6 | 22.91 | 3.3 | 3.9 |
| Meat (millions of tons) | 0.40 | 0.84 | 7.6 | 1.39 | 5.6 | 2.79 | 4.7 | 5.7 |
| **Gross Production Value:** | | | | | | | | |
| Milk (billions of rupees) 1/ | 2.66 | 3.95 | 4.0 | 6.20 | 4.6 | 10.13 | 3.3 | 3.9 |
| Meat (billions of rupees) 1/ | 0.65 | 1.82 | 10.9 | 3.51 | 6.8 | 8.33 | 5.9 | 7.5 |
| Total GPV (billions of rupees) 2/ | 3.31 | 5.77 | 5.7 | 9.71 | 5.3 | 18.46 | 4.3 | 5.1 |

1/ IACA at Volume 1, page 27 projects milk prices at 16.5 rupees per maund throughout. Data for GPV for meat, derived from IACA totals less milk, suggest a meat price range of 60 through 110 compared with IACA's stated range of 62 to 94 rupees per maund.

2/ These projections represent the high growth path (Volume 1, page 84) from 1965 to 1975. At the lower path, resulting from 25 percent less TDN production, the 1975 figures would be 5.1 instead of 5.8 billion rupees, and would therefore represent 40 instead of 43 percent of the total GPV to agriculture.

2.101 This table also indicates that conversion of TDN to milk and meat improves from 1965 to the year 2000. One exception to this general picture is the conversion rate for milk in 1975, which is lower than the rate in 1965. This slight drop in quantity of milk per ton of TDN is because IACA assumes the period 1965-75 is a time of herd build-up when there would be a larger proportion of followers than at later stages. Other than this one case, the overall improvement in conversion rates reflects IACA's expectations that increasingly better-fed animals would be more efficient producers of milk and meat, and also that better breeding practices would result in overall up-grading of the basic stock.

2.102 The growth rates projected by IACA would constitute an impressive achievement. To a great extent, the growth of livestock appears to be an adjustment to the large volume of TDN which would be produced under the cropping patterns and cropping intensities assumed for future years, rather than a conscious production policy based on consideration of economic alternatives. Although the livestock projections make allowance for the biological constraints governing production and reproduction, they also depend implicitly on improvements in herd management and selective breeding practices. The latter factors may impose more critical constraints than the availability of TDN. As previously stated, the livestock estimates appear technically feasible, but the Bank Group considers them susceptible to downward adjustment in practice, particularly in light of the importance of managerial factors and if demand and marketing opportunities do not expand in accordance with IACA projections.

2.103 As will be seen in Chapter VIII A, livestock production and the growth projected for livestock production is an extremely important factor amounting to some 47 percent of the total GPV of agriculture by the year 2000. In the course of the Indus Special Study, examination of the problems of livestock development has of necessity been based on inadequate data and has been too general in character to provide more than a broad indication of what may be feasible and the steps required to bring about the performance projected. The Bank Group considers that, in view of its importance and complexity, a special study of the livestock sector is urgently required to establish more accurately its present status, its potential, and to provide a better base for any detailed recommendations regarding the requirements for its development. Such a study should include both production and marketing aspects and make more detailed recommendations on the appropriate measures required to bring about the desired improvement and growth.

# CHAPTER III. DEVELOPMENT OF WATER RESOURCES

## A. The Water Resources

### 1. Introduction

3.01 The total water supplies available to agriculture within the Indus Basin derive from three sources: rainfall which occurs directly on the cropped areas, surface water from the River Indus and its tributaries, and usable groundwater from the aquifers underlying the Indus Plains. Rainfall alone is inadequate to sustain more than a very low level of agricultural production in the semi-arid conditions which prevail over most of West Pakistan. The increases in agricultural production over the past hundred years have been mainly dependent upon the provision and expansion of irrigation supplies which will remain the principal base for future development. This chapter is concerned essentially with the potential development of irrigation by surface water and groundwater within the Indus Plains. The present water budget for the canal commanded areas of the Indus Plains is illustrated diagrammatically in Figure 3.1. 1/

3.02 The supply of irrigation water in the Indus Basin can be increased in three ways:

(i) by the development of the usable groundwater underlying a large proportion of the Plains;

(ii) by surface storage schemes that will store the surplus kharif water which flows into the sea;

(iii) by enlarging the canals to permit greater diversion of kharif river flows.

According to the IACA projections and their water development program discussed in succeeding chapters, the relative use of the three water sources would increase as follows:

Relative Use of Rainfall Surface Water and Groundwater as projected by IACA

(Flows measured at watercourse)
MAF

| | Present | 1975 | 1985 | 2000 | Increase Percent |
|---|---|---|---|---|---|
| Rainfall | 6 | 7 | 9 | 10 | |
| Surface Water | 58 | 63 | 77 | 91 | 50 |
| Groundwater | 10 | 30 | 40 | 44 | 340 |

1/ The figures shown for river inflow and canal head diversions are known fairly accurately but those below canal head are less accurate and below watercourses head they are approximate estimates only.

The comparison shows that the surface water resource is and will remain the dominant contributor to irrigation supplies but that the groundwater resource can provide an increasing proportion of these supplies with the increment for the 1965-75 period exceeding that of surface water.

## 2. Rainfall

3.03 The mean annual rainfall ranges from less than four inches in parts of the Lower Indus Region to more than thirty inches in the northern foothills as shown in Map 3. The effective annual rainfall which forms a useful and fairly reliable supplement to irrigation supplies is much less than the total and ranges from only one inch up to 17 inches. The rainfall not used by crops seeps into the groundwater or is lost to evaporation and surface runoff. Most of the rainfall occurs in the monsoon season between July and September and it is particularly in this period that storm drains are required to prevent damage to crops.

3.04 The present contribution of rain to crops in the canal commanded areas is estimated at about 6 MAF which would rise to about 10 MAF as the cropped area increases in the course of development. Rain also represents the sole source of supply to much of the cultivated land outside the canal commands.

## 3. Surface Water

3.05 The rivers serving the Indus Plains are the Indus and its principal tributaries, the Kabul, Jhelum, Chenab, Ravi and Sutlej, as shown on Map 3. The rivers have individual flow characteristics but they all rise in the spring and early summer with the snowmelt and monsoon rainfall and have a combined peak discharge in July or August. In the winter flows are much lower and during the period November to February the mean monthly flows are only about one-tenth of those in the summer monsoon as illustrated by the hydrographs on Map 3.

3.06 The total annual mean discharge of the rivers entering the Indus Plains of Pakistan and India amounts to 175 MAF a year, of which about 167 MAF a year enters Pakistan. About 79 MAF is diverted into the canal system of West Pakistan and some 76 MAF discharges into the Arabian Sea, with the remainder lost to evaporation and seepage from the rivers. The discharge to the sea is largely concentrated in the summer period of high river flow between about June and September when the canals are already being operated near or at their full capacity levels.

3.07 After full implementation of the Indus Waters Treaty, in the early 1970's, India will be entitled to divert all flows of the eastern rivers, the Ravi and Sutlej, for her own use. As shown in Map 3 these two rivers have a combined average discharge of 33 MAF of which about 25 MAF flows into West Pakistan. By deducting this flow from the present available average flow of 167 MAF the supply for future use in Pakistan will be about 142 MAF made up as follows:

| River | Mean Annual Discharge 1/ (1922-62) |
| --- | --- |
| Indus (including Kabul) | 93 |
| Jhelum | 23 |
| Chenab | 26 |
| TOTAL | 142 MAF |

1/ Measured at rim-stations - points of entry of the rivers to the Plains.

The median combined flow (exceeded in 50 percent of the years) of these three rivers is only slightly less than the mean being 140 MAF a year. The lowest combined flow in the period of record was 116 MAF which occured in 1961/62.

3.08 The flow in the Indus follows a more reliable pattern than that of the Jhelum or Chenab. The variation between the mean annual supply and the supply which would be exceeded in an average of three years out of four is only six percent for the Indus compared to 15 percent for the Jhelum and Chenab. On the same basis, the variation in monthly supplies extends up to 25 percent in the case of the Indus and up to 33 percent on the Jhelum and Chenab. The provision of storage on the Jhelum and later on the Indus would result in a considerable reduction in monthly variations downstream of the storage dams. The annual variability will also be alleviated over time with the expansion of tubewell fields and, at a much later stage of development, by over-year storage in surface reservoirs.

3.09 The storage of summer surplus flows will lead to a more efficient use of surface water resources but it is likely that some flows will still be passed to the sea at all stages of development. However, the principal river flows are supplemented by small tributaries entering the plains and by return flow from drainage effluent. Also the non-beneficial losses from the rivers will eventually be reduced when plant growth is cleared and the river channels become more controlled. The mean discharge to the plains of 142 MAF a year is therefore considered to be a reasonable estimate of the surface water resource which is available for the development of irrigation. Domestic and industrial consumption is likely to remain relatively very small compared to the irrigation uses and has been allowed for by IACA in the calculation of system losses.

3.10 When compared with the present average canal head diversions of 79 MAF a year the combined mean discharge of the Indus, Jhelum and Chenab of 142 MAF indicates the considerable potentiality that exists for future surface water conservation and use in West Pakistan.

3.11 The Indus and its tributaries carry large quantities of silt during the flood season and the average sediment transport is estimated at 700 million short tons a year which would have a deposited volume of about 0.4 MAF. Siltation would thus cause a significant rate of depletion in the volume of future reservoirs particularly on the Indus main stem where the majority of the sediment flow occurs.

4. Groundwater

3.12 The Indus Plains, stretching from the foothills of the Himalayan Mountains to the Arabian Sea over a distance of nearly 1,000 miles, are composed of deep alluvial deposits which form an extensive groundwater aquifer of great potentiality covering a gross area of some 40 million acres. Before systematic irrigation was started, the groundwater table was well below the surface and the aquifer was in a state of hydrological equilibrium. The recharge to the aquifer from rivers and rainfall which probably amounted to some 10 MAF a year mainly in the north was balanced by outflow in various forms. When large-scale canal irrigation was introduced, percolation to the aquifer was greatly increased in the irrigated areas. Today the recharge is three or four-fold that of the natural state with the result that the water table has risen to within ten feet of the surface over almost half the canal commanded land. Furthermore, in about one-sixth of the irrigated areas the groundwater table is estimated to have risen to within about five feet of the surface causing problems of waterlogging and soil salinity in some two million acres in these areas. Despite the problems of waterlogging the development of irrigation on the Plains has in this way created a valuable source of water with large potentialities that are discussed later in this chapter.

3.13 Outside the Indus Plains there are other opportunities for groundwater development, but on a relatively limited scale and at present little information is available. It is, however, clear that tubewell development outside the Plains would have to be restricted to small groups of wells and furthermore the potential yields of the scattered aquifers would be small on account of the arid conditions that exist over so much of the country. Areas of more significant potentialities appear to be the Bannu Basin, the Warsak-Peshawar area and the Potwar Plateau, but no general assessment of their resources has as yet been made.

3.14 Two basic factors in groundwater development are the physical characteristics of the aquifer and water quality. The physical characteristics of the alluvium of the Indus Plains are generally very favorable to tubewell development except in parts of the Lower Indus Region where some deposits of low permeability occur. The quality of the groundwater is more variable as may be seen from Map 3. It is, however, estimated that some 19 million acres of CCA lie over usable groundwater of which 14 million acres contain fresh water that may be used directly on the crops and the remaining five million acres has groundwater of intermediate salinity which requires mixing with fresh surface water to make it suitable for irrigation.

3.15 IACA has given particular attention to the requirements for quality of irrigation supplies in order to establish criteria for groundwater development. 1/ An important conclusion reached was that water containing not more than 1,000 parts per million of total dissolved solids is suitable for direct use on the crops.

3.16 From a study of a large number of individual groundwater analyses, IACA has found that in most cases the 1,000 ppm TDS criterion embraces also an acceptable level for the other criteria and is therefore satisfactory for general planning purposes. Eventually it might be possible for water of higher salinity to be used directly on the crops but that would require an increased application of water and a degree of control which IACA do not regard as feasible at present or in the near future and which would require the assumption of lower yield levels and different cropping patterns.

3.17 IACA has considered the salinity of groundwater at a depth of 300 feet in order to classify the groundwater resource in terms of the following general zones:

(i) Fresh groundwater zones where tubewell water can be applied directly to the crops. Deep groundwater quality is less than 1,000 ppm TDS.

(ii) Mixing zones where tubewell water has to be diluted by surface water before being used for irrigation. Deep groundwater quality is of intermediate salinity being more than 1,000 ppm TDS but less than 3,000 ppm TDS in all areas except the Lower Indus Region where a limit of 2,000 ppm TDS is applied. The lower limit in the Lower Indus Region allows for the more rapid increase of salinity with depth of the aquifer than in the northern plains and for the higher salinity of the river water after it has received drainage effluent.

(iii) Saline groundwater zones where the groundwater would not be used for irrigation. Deep groundwater quality is more than 3,000 ppm TDS in the northern areas and more than 2,000 ppm TDS for the Lower Indus.

It may eventually become feasible to employ skimming techniques in the saline groundwater zones to utilize the upper and less saline layers of

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1/ IACA considered that water with the following properties could be used directly for irrigation:

(i) EC of less than 1.50 mmhos per cm. at 25°C, approximately equivalent to 1,000 ppm TDS. (EC is electrical conductivity which relates to the salinity hazard).

(ii) SAR of less than ten. (SAR is sodium adsorption ratio which defines the alkali hazard).

(iii) RSC of less than 2.5 m.e. per liter. (RSC is residual sodium carbonate and is an expression of the deleterious concentration of carbonates and bicarbonates).

the aquifer. However, this would require further investigations and careful control in actual operation.

3.18 The extent of areas of the different groundwater quality zones are shown below by regions:

Regional Groundwater Quality Zone Areas

| Region | Fresh | Mixing | Saline | Total |
|---|---|---|---|---|
| | (millions acres of development CCA) | | | |
| Vale of Peshawar | 0.58 | 0.10 | -- | 0.68 |
| Thal Doab and Indus Right Bank | 2.03 | 0.99 | 0.60 | 3.62 |
| Chaj Doab | 1.19 | 0.36 | 0.49 | 2.04 |
| Rechna Doab | 3.37 | 0.84 | 0.49 | 4.70 |
| Bari Doab | 3.95 | 1.34 | 0.54 | 5.83 |
| Sutlej and Panjnad Left Bank | 1.29 | 0.47 | 1.75 | 3.51 |
| Lower Indus | 1.81 | 0.45 | 6.72 | 8.98 |
| TOTAL: | 14.22 | 4.55 | 10.59 | 29.36 |

The fresh groundwater and mixing zones together represent the usable groundwater and have a gross area of 18.8 million acres or over half the recorded CCA of the Basin and about two-thirds of the CCA included in IACA's development plan (see Chapter V). The physical characteristics of the aquifer are such that all the usable groundwater zones can be developed by well fields although the capacity of the well would be more restricted in the Lower Indus Region than in the northern plains. Well fields are also feasible for drainage of the saline groundwater zones except in parts of the Lower Indus Region.

3.19 The proposed criteria for use of groundwater for irrigation are summarized below:

Proposed Mixing Ratios for Overall Basin Planning

| Groundwater Quality Zone | All Regions except Lower Indus: Deep Groundwater Quality (ppm TDS) | All Regions except Lower Indus: Average Mixing Requirements (Surface water to groundwater) | Lower Indus Region: Deep Groundwater Quality (ppm TDS) | Lower Indus Region: Average Mixing Requirements (Surface water to groundwater) |
|---|---|---|---|---|
| Fresh | Less than 1,000 | No restriction | Less than 1,000 | No restriction |
| Mixing | 1,000-2,000 | 1 : 1 | 1,000-2,000 1/ | 1 : 1 |
| | 2,000-3,000 | 2-1/2 : 1 | | |
| Saline | More than 3,000 | Not used | More than 2,000 | Not used |

1/ See para 3.17 (ii).

3.20 The uppermost 100 feet of the usable groundwater in the irrigated area of the plains stores about 300 MAF of usable water, equivalent to a latent resource of 400 MAF when re-use of the recharge from pumped groundwater is taken into account. The storage of groundwater is dependent on the inflow or recharge to the aquifer relative to the withdrawals or discharge from it. Recharge is derived from:

(i) losses from rivers, canals and surface drainage channels;

(ii) irrigation losses from watercourses and fields; and

(iii) percolation of rain.

Discharge is affected by:

(i) natural agencies of evaporation, base flow to the rivers and basin discharge downstream; and

(ii) extraction by tubewells, Persian wheels and horizontal drains.

3.21 The recharge to the aquifer represents the main source of groundwater supply since it is being constantly renewed. The usable groundwater recharge is at present estimated at slightly over 30 MAF a year of which about 10 MAF are pumped for irrigation. With full development of surface water resources and of the canal system, the available usable recharge would rise to about 44 MAF a year. A further quantity of about 27 MAF a year would percolate to recharge in the saline groundwater areas and would require tubewells or tile drainage together with disposal works when the water table rises to near ground level.

3.22 The estimated recharge to the aquifer under the IACA projections for development would be as shown below:

Estimated Recharge to the Aquifer[1/]
(MAF)

| | 1975 | 1985 | Full Development |
|---|---|---|---|
| To Usable Groundwater Zones | 34 | 41 | 44 |
| To Saline Groundwater Zones | 15 | 18 | 27 |
| Total Recharge: | 49 | 59 | 71 |

1/ See also Figure 5.2

## B. The Irrigation System

### 1. Present Situation

3.23 The canal system was started in the nineteenth century when weirs and barrages were constructed so that the supply of irrigation water would be no longer so dependent on the natural variations in river level as it was in the old inundation canals. Since Independence in 1947, Pakistan has continued this extension of the canal system and almost all the areas previously served from inundation channels are now served from barrages. While barrages permit a more reliable command of the land they do not provide significant water storage.

3.24 The early weirs and barrages were mainly on the Indus tributaries in the Punjab and in the Peshawar area and more recently emphasis has been placed on the main Indus stem with Jinnah, Taunsa, Gudu and Ghulam Mohammed barrages (see Map 7).

3.25 The canal systems were generally designed to command as much land as possible, particularly crown waste, so that maximum returns would be obtained from the sale of project lands and from subsequent taxation. For this reason, the cropping intensities adopted for the designs were low and were often about half the intensities which the land would be capable of supporting. In the early stages canal systems were developed for perennial or year-round cropping but later, as the limited rabi supplies became fully committed, non-perennial systems were built essentially, though not exclusively, for summer crop production.

3.26 The irrigation system of the Indus Plains commands a gross area of about 38 million acres and comprises some 38 thousand miles of canals. By 1971, after completion of works under construction under the terms of the Indus Waters Treaty, the main and link canal headworks would be served from a major storage dam at Mangla, 16 barrages, three weirs and a hydroelectric power dam at Warsak (see Map 6).

3.27 The total irrigated area is covered essentially by 42 principal canal commands of which four are being partitioned by the link canals now under construction. The total CCA is officially stated to be 33.5 million acres, though in practice no more than about 25 million acres receive surface water supplies; the rest is classified as culturable waste and a large proportion of it is in the Lower Indus Region. About 20.3 million acres of the total CCA are at present designated for year-round perennial supplies of canal water and about 13.2 million acres designated for non-perennial supplies usually from mid-April to mid-October. Non-perennial areas do, however, receive occasional rabi water and some years fairly consistent deliveries reach the farmers, but not as a right and only when river flows are surplus to the requirements of the perennial areas. With these irregular rabi supplies, supplemented by Persian wheel and tubewell water, rabi intensities often reach levels comparable with those in perennial areas.

3.28 The total area now remaining on the old inundation canal system is relatively small, amounting to about 100,000 acres.

3.29 Persian wheels, normally powered by animals, have always made an important contribution to irrigation in rabi, in perennial, non-perennial and uncommanded areas. It is estimated that there are about 200,000 Persian wheels in the Basin, but the discharge of even an efficient one is only about one-tenth of a cusec and on average they are operated for only about 1,000 hours a year. Recently there has also been considerable activity by enterprising farmers in the installation of tubewells as a means of pumping groundwater for irrigation. IACA estimated that about 32,000 private tubewells with an average capacity of about one cusec each had been installed in the Indus Basin by 1965. More recent estimates of the 1965 situation indicate that the number of private tubewells in operation may be as high as 34,000. About one-third of the private tubewells are operated by electric power and the remainder by diesel engines.

3.30 A river barrage feeds one or more main or link canals. Many of the canals are very large indeed and practically all of them are unlined. Fifteen of them have capacities of between 10,000 and 22,000 cusecs. The main canals serve the irrigated areas whereas the links perform bulk transfers of water from the major sources on the western side of the former Punjab to the vast irrigated areas to the east. A main canal and its branches feed a number of distributaries or minor distributaries, with capacities of up to about 200 cusecs, and these in turn serve outlets to the farmers' watercourses. The watercourse area is generally between 150 and 600 acres in extent and the ratio between outlet capacity and watercourse area is determined for a given climatic zone by the originally assumed cropping pattern and intensity.

3.31 A feature of the canal system is the absence of intermediate regulators along the distributaries and minors. The latter are designed to run in a form of hydraulic equilibrium, maintaining sufficient head of water on each outlet to give it an almost constant discharge. For this reason they cannot be run at less than about three-quarters of full capacity without creating a very inequitable distribution to the irrigated lands they command. On the other hand, the main canals themselves have sufficient control structures to permit variations in flow down to about one-third of full capacity.

3.32 Thus, the canal system has been designed to take variable flows from the rivers up to the limit of the canal capacity, yet deliver to the farmer a fairly constant flow. This necessitates a system of rotated closures of the distributaries during periods when less than full supply conditions are in operation owing to either reduced availability or reduced demand. Within the watercourse area a cultivator usually has a fixed time during which he is entitled to the whole of the flow in the watercourse channel.

3.33 The time allotted to a cultivator for the duration of his irrigation supply from a watercourse is directly proportional to the size of his holding in relation to the culturable area commanded by the watercourse. The schedule of cultivators' turn times authorized by the Irrigation Department is known as the "warabandi". When the cultivators decide the turn times themselves by joint agreement, the schedule is known as the "kacha warabandi", and is usually applied to watercourses with a small number of relatively large holdings. As the number of holdings per watercourse is rising and their size decreasing, it is becoming necessary for the number of watercourses operated by the warabandi system to be extended so as to ensure that the smallest land holder receives his proper share of the supply.

3.34 Once a warabandi has been drawn up it will stand indefinitely unless a successful petition for change is made to the District Canal Officer. In order to avoid indefinite night watering by some of the cultivators the warabandi is rephased by 12 hours annually. If, owing to canal closure, turns are missed there is no adjustment to compensate for the loss of water and the unfortunate cultivators must wait for their next established turn.

3.35 The water that is diverted into the canals has a sediment concentration approaching that of the river source, though every effort is made in the design and operation of the headworks to reduce the silt intake.

3.36 The canals are designed and built to such proportions that they would run without undue scouring or silting when operating under normal conditions of discharge but all problems of silting and scouring cannot be eliminated. Silting occurs at localized points, usually in the middle and tail reaches and scouring is mainly experienced in the head reaches. Various devices are applied to the operation of the canals to rectify these occurrences but at times the canal design has to be modified. The farmers' watercourses are particularly subject to siltation and here the sediment is excavated by the farmers as part of the general maintenance.

3.37 Up to the present there has been virtually no development of surface storage to regulate the river flows. The only large dam, at Warsak on the River Kabul, is used primarily as a regulator for hydroelectric generation. The commissioning in 1967 of Mangla Dam on the River Jhelum, with an initial live capacity of 5.2 MAF 1/ would complete the first major storage scheme. The Mangla storage would, however, serve essentially as a replacement for the loss of flows from the Ravi and Sutlej Rivers. The raising of Chasma Barrage will provide additional storage of 0.3 MAF.

3.38 As with many irrigated areas developed in arid and semi-arid zones over the last century, there is very little drainage provided in the Indus Plains, either sub-surface drainage to control the water table or surface drains to remove excessive runoff. The lack of sub-surface drainage has

1/ IACA used a live storage capacity of 4.5 MAF based on a drawdown level of 1,075 feet and the exclusion of the contents of the Jari Arm. Subsequently WAPDA decided to abstract storage from the Jari Arm and to allow for drawdown to 1,040 feet, thus providing 5.2 MAF.

gradually become a serious constraint on crop production and is being combatted by an ambitious series of salinity control and reclamation projects (SCARP's) the first of which was commenced in Rechna Doab in 1959. By 1965 some 2,500 public tubewells with capacities of between two and five cusecs each had been installed over an area of about 1.2 million acres in the whole of SCARP I, covering the central part of Rechna Doab, and the first part of SCARP II in Chaj Doab. These SCARP tubewells have provided a valuable increment to irrigation supplies in the areas they serve.

3.39 The estimated irrigation deliveries to the watercourse from all sources under present (1965) conditions are shown below:

Summary of Watercourse Deliveries - 1965 Conditions
(MAF/Year)

| | | | |
|---|---|---|---|
| Surface Water: | | | |
| | Canals | 58.0 | 58.0 |
| Groundwater: | | | |
| | Public Tubewells | 2.7 | |
| | Private Tubewells | 5.3 | |
| | Persian Wheels | 1.7 | 9.7 |
| Total Watercourse Deliveries: | | | 67.7 MAF/Year |

A further quantity of about one MAF a year is estimated to be pumped by private tubewells and Persian wheels to cultivate land outside the canal commanded areas of the Indus Plains. The division of the present watercourse deliveries by regions is shown below:

Summary of Watercourse Deliveries by Regions - 1965 Conditions
(MAF/Year)

| Region | Canal 1/ | Public Tubewells | Private 2/ Tubewells | Total | Feet Per Acre CCA |
|---|---|---|---|---|---|
| Vale of Peshawar | 1.7 | 0.0 | 0.0 | 1.7 | 2.9 |
| Thal Doab and Indus Right Bank | 5.6 | 0.0 | 0.7 | 6.3 | 1.7 |
| Chaj Doab | 3.2 | 0.2 | 0.4 | 3.8 | 1.9 |
| Rechna Doab | 6.6 | 2.5 | 2.1 | 11.2 | 2.4 |
| Bari Doab | 9.0 | 0.0 | 3.1 | 12.1 | 2.1 |
| Sutlej and Panjnad Left Bank | 6.4 | 0.0 | 0.6 | 7.0 | 2.0 |
| Lower Indus | 25.5 | 0.0 | 0.1 | 25.6 | 2.9 |
| Total Canal Commands | 58.0 | 2.7 | 7.0 | 67.7 | |

1/ Based on recent average deliveries.
2/ Including Persian wheels

The Rechna and Bari Doabs accounting for 32 percent of the total designated CCA of the Plains, receive nearly 80 percent of all groundwater supplies, 27 percent of surface supplies and 35 percent of all present watercourse deliveries. Since crop water requirements are slightly below average in these less arid regions, they thus receive a favorable proportion of the present water supplies. The Lower Indus Region receives a share of water which is proportionate to its designated CCA but in this case more than one-quarter of the CCA is in fact unused.

3.40 The practice of under-watering crops, as stated in Chapter II, is widespread and IACA estimate that most crops receive on average about 80 percent of full delta requirements. Exceptions occur in the developing commands on the Indus main stem where the intensities have not yet reached the design levels. This includes parts of the Lower Indus Region and the Thal. As would be expected, under-watering is most severely applied to crops grown in rabi in the non-perennial areas when some element of hazard must inevitably be accepted by the farmers.

## 2. Main Characteristics and Constraints of the Present Irrigation System

3.41 The principal characteristics of the present Indus Basin irrigation system may be summarized as follows:

(i) Canal irrigation is dependent on natural river flows until major storage reservoirs come into operation.

(ii) A large part of the irrigable land of the Punjab is on the eastern side whereas the preponderating water supplies are on the west.

(iii) Almost throughout the Basin, the canal system has been designed for much lower cropping intensities than are presently required.

(iv) The system is designed to deliver an almost fixed flow into the farmers' watercourses from distributaries that flow in hydraulic equilibrium without intermediate regulators. Flows below about three-quarters of full supply cannot be delivered through the system except by the rotation of distributary supplies.

(v) In many parts of the system a rapid advance is now being made towards the exploitation of the vast groundwater aquifer underlying the Plains.

3.42 Cropped acreage has almost everywhere expanded up to the limits of the present irrigation system, except in some of the still developing commands of the Indus served by Jinnah, Taunsa, Gudu and Ghulam Mohammed barrages. Over vast areas covered by the older parts of the system, the area cropped has gone beyond the water supplies based on the originally designed intensities, resulting in widespread underwatering.

3.43 The main deficiencies of the present system as they relate to present and future needs were found by IACA to be the following:

(i) The amounts of water available to the cultivators in rabi and late and early kharif are too unreliable and are inadequate to sustain optimum crop production.

(ii) In some areas, the canal capacities are inadequate to achieve optimum kharif intensities and this constraint will have an increasing impact as intensities rise.

(iii) In the longer term, distributary and watercourse flows will prove too inflexible for proper water economy.

(iv) Lack of sub-surface drainage causes, directly or indirectly, adverse effects on crop growth.

(v) Lack of surface drainage causes crop losses and yield reductions in the upper northern and lower southern regions.

These constraints and the works required to remove them over time are discussed in the following parts of this chapter and in Chapter V.

## C. Potential Development of Water Resources

### 1. Introduction

3.44 In the next two decades there is no likely shortage of water resources, and it is the feasible rate at which the water potential can be further exploited that will largely govern the rate at which irrigated agriculture can be intensified and extended. Subsequently, as cropping intensities rise, further development of irrigated agriculture in the Indus Basin will be increasingly constrained by water rather than land. IACA have demonstrated in the analyses of their projections, discussed in Chapter V, that even with full development of the total groundwater and surface water potentialities there is unlikely to be sufficient water to meet the crop water requirements at the estimated attainable cropping intensities over the whole of the presently designated CCA. As explained in Chapter V IACA has, for this and other reasons, advocated a policy of intensification of existing irrigation rather than extension into new areas. Under the IACA proposals the present canal irrigated area of 25 million acres would be expanded to 29.5 million acres and brought to full intensity and full farming efficiency. This would leave some 4 million acres of the presently designated but partly uncultivated CCA of 33.5 million acres undeveloped. This is in accordance with the recommendation of the LIP consultants who maintain that there is about 3.5 million acres of designated (but not developed) CCA in the Sind which is of very inferior quality and has been abandoned or is basically unsuitable for development in conditions of water shortage.

A further 0.5 million acres will be required for roads, canals, dam sites, etc. Alternatively, if the full 33.5 million acres are to be developed it would have to be at a correspondingly lower cropping intensity with water used on inferior lands.

3.45 The rate at which water resources can be further exploited depends largely on the sources and mode of development. The most rapid progress can clearly be made with tubewell construction by both private and public undertakings because this method of supply can be applied progressively over the usable groundwater zones of the Plains and is not initially dependent upon other major works which might take time to build, thus hindering the early realization of benefits.

3.46 Enlargement of the irrigation canals, on the other hand, is not only a slow process in itself, owing to the complex land acquisition and other administrative and technical problems that it gives rise to, but little can be achieved without the associated enlargement of the feeder or link canals and, furthermore, most areas require drainage before the additional water from larger canals can be served onto the land. In general therefore canal enlargement would follow after tubewell installations and represents a longer term means of using more of the available surface water resources. Surface water storage in the Indus Basin again involves a long term measure solely for the reason that it can be effected only through the construction of very large dams such as Tarbela and Mangla which take many years to plan and construct.

2. Groundwater

(a) Objectives of Tubewell Development

3.47 The traditional function of Persian wheels and the recent trend to install private tubewells demonstrate that the concept of using groundwater for irrigation has long been accepted in West Pakistan and that the farmers are moving rapidly to the more advanced method of abstraction provided by the modern tubewell.

3.48 The main objectives of groundwater development are to increase agricultural production by:

(i) Provision of additional irrigation supplies. With more tubewells and with higher recharge to the aquifer from enlarged canals but without depletion of the natural groundwater reservoir, IACA estimates that about 44 MAF of usable groundwater could be made available for irrigation each year, compared to the present total groundwater abstraction of about 10 MAF a year.

(ii) Control of the water table. In order to remove the ill effects of high groundwater on crop production, it is necessary to establish a means of control that will prevent the water table from remaining within about five feet of the surface except for short periods or in the rice areas. This control can be obtained by tubewells with the added advantage of additional irrigation water where they are placed in usable grounwater zones.

3.49 IACA expect the contribution of Persian wheels to dwindle to very small proportions over the next decade and to be replaced and greatly increased by the rapid expansion of tubewell installations under private and public control.

3.50 IACA have given particular attention to the respective rates of private and public tubewell development in the attainment of the above objectives. Although in the long term IACA foresees the need to bring groundwater abstraction under public control in order to integrate it efficiently with the already publicly controlled surface sources, and their whole water demand and distribution program is firmly based on this concept, their approach to planning for the next 10 to 15 years is more flexible and seeks to take best advantage of both public and private activity. By promoting private and public tubewell development in selected parts of the Indus Basin, it should prove possible to accelerate the rate of exploitation of groundwater resources.

3.51 In both cases IACA has assessed the likely rates of development, which are discussed in section C, 3. (d) below. Priorities for public development have been allocated to those areas where economic analyses indicated that a better rate of return and faster growth in production may be achieved by public rather than private wells. IACA's proposed policy would therefore emphasize the early development of usable groundwater zones, by allocating appropriate priorities in the case of public tubewells and by private initiative on the part of farmers who sink their own wells.

3.52 By 1975, according to the IACA program, private and public tubewells would extract some 85 percent of the current usable groundwater recharge. The program for groundwater development put forward by IACA would produce the following quantities of irrigation water over the period under review:

Rate of Groundwater Development
(MAF/Year)

| | 1965 | 1975 | 1985 | 2000 |
|---|---|---|---|---|
| Private Tubewells (in CCA) | 5.3 | 7.0 | 3.5 | -- |
| Public Tubewells | 2.7 | 22.0 | 36.5 | 44.0 |
| Persian Wheels | 1.7 | 1.0 | -- | -- |
| Total in CCA: | 9.7 | 30.0 | 40.0 | 44.0 |
| Private Tubewells Outside CCA | 1.0 | 2.8 | 5.0 | 6.5 |
| TOTAL | 10.7 | 32.8 | 45.0 | 50.5 |

The relationship between groundwater exploitation, total water demand and distribution is discussed more fully in Chapter V.

(b) Water Table Depth and Potential Groundwater Mining

3.53 Control of the water table by public tubewells allows some choice in the level at which the water table should be maintained. The need to maintain the water table sufficiently below the surface to avoid salinity and waterlogging is agreed by all who have examined the problem, but expert opinions have diverged widely on the question of whether fresh groundwater should be continuously pumped to greater depths. IACA points out that the economic cost of mining 1/ is substantially more than that of the immediate pumping involved since allowance must be included for the considerable extra cost of pumping normal recharge from a greater depth in perpetuity. The effective economic cost in terms of power alone to mine an acre foot of water from an acre of the aquifer is calculated at Rs. 37 per acre foot mined compared to Rs. 7.5 per acre foot pumped with groundwater abstractions balanced by recharge at about ten feet. If, however, mining were to form a part of policy for using groundwater resources, allowance would also have to be made for higher capital costs because of the need to penetrate to greater depth. The effective total economic cost of mining to a depth of about 100 feet over a period of 30 years is calculated at Rs. 63 per acre foot mined, compared to a total cost of Rs. 17 per acre foot pumped with groundwater abstractions balanced by recharge at a depth of ten feet. 2/

3.54 The effective cost of mined water is therefore comparatively high and of the same order as surface storage water. However, IACA have stressed that mining cannot be considered in terms of economic costs alone and that there are a number of technical and operational factors which would require detailed analysis before mining could be accepted. The most important of these technical factors is the possible intrusion of saline groundwater, either from adjacent saline groundwater zones down the steep gradient which would have been introduced by mining in the fresh groundwater zones or from the underlying levels of the aquifer. The problem of intrusion from adjacent saline groundwater zones would result in curtailment of the areas of potential mining and most probably in a requirement for deep and expensive saline drainage wells to prevent intrusion. The problem of the increasing salinity of groundwater with depth means that the possibility of mining would have to be rejected throughout almost all the Lower Indus region and probably in parts of the Bari Doab as well as possibly in certain other areas.

3.55 From the operational standpoint, mining would be of value only when it provides water at times of scarcity, e.g. during critical periods

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1/ Continuous overpumping of the groundwater reservoir without replacement is referred to as mining.

2/ See Annex 3.1 for IACA's estimates of the cost of groundwater mining and also Chapter IV for cost of recharge pumping.

of the rabi season and early and late kharif. However, in a number of areas where mining might technically be considered, the pumping of normal recharge would be adequate to meet the requirements for scarce water of the projected cropping intensities. For mining to be valuable in such areas collector and conveyance channels would have to be constructed to transfer the mined water to other areas and this would add extra costs and would require works which would not be feasible within the proposed Action Program. As a possible alternative to surface storage mining is therefore limited primarily by its lack of flexibility in terms of the place at which the mined water could be provided and furthermore by a possible deterioration of water quality. Also, if considered as an alternative to surface storage, allowance would have to be made for the loss of normal recharge attributable to the storage water from losses in the rivers and canals. It is clear that examination of mining on a general basis in the Indus Plains would be misleading. Detailed studies of the characteristics of different areas would have to be undertaken in order to determine the potential for mining.

3.56 Because of these economic, technical and operational considerations, no general case is foreseen at this stage for widespread mining of groundwater, although special cases could arise in particular areas. Rather it is concluded that the main emphasis on groundwater development in the Action Program should be on the installation of sufficient tubewells to enable the annual recharge to be extracted. There are, however, considerable advantages in temporary overpumping in order to meet demand at times of low surface water availability and in anticipation of surface storage projects. Additional pumping would lower the water table which would then be raised again at times of higher than normal surface water availability or with the introduction of new storage water. Deep pumping can also be justified in certain areas such as Upper Rechna Doab where Tipton and Kalmbach Inc. 1/ have shown in the SCARP IV Project Report that a miximum equilibrium depth of 80 feet may ultimately be desirable near the center of the well field. In a similar way, deep pumping to induce additional recharge from the river might be a promising future development in an area such as Panjnad.

3.57 After the water table has reached an equilibrium level, abstractions from the aquifer should be balanced by recharge to the aquifer over a period of years, though not necessarily in any one year. IACA have indicated that a satisfactory average level of the water table would be about ten to 15 feet below ground level, but it should be recognized that such a generalization could not be applied to all project areas. The actual level of the water table would depend on the degree of temporary overpumping required to meet temporary deficiencies in surface water supplies and also on the local topographical and hydrological conditions. The water table would sometimes thus be deeper than the average of ten to 15 feet at times of temporary overpumping and at locations away from the sources of recharge such as rivers and canals.

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1/ Consultants to WAPDA for Regional Planning in the Northern Zone.

(c) Tubewell Planning and Design

3.58 The objectives of public tubewell fields and the policy for their siting in relation to private tubewell areas, as proposed by IACA, calls for certain changes in emphasis in what have hitherto been official lines of action.

3.59 Firstly, the main objective being to supply additional quantities of irrigation water, the previous emphasis on salinity control and reclamation is no longer appropriate. The latter becomes a secondary though not unimportant function of tubewell development. This does not, however, set aside the need to accord certain project priority to areas where waterlogging is now either prevalent or imminent and this is discussed further in section C.5 below.

3.60 Secondly, in order to derive the optimum combined benefits from both the public and private sectors, it will be necessary to depart from the concept of large development entities and adopt a plan that omits areas where private progress is favorable or can be expected to become so, even though this would result in smaller projects and in a more fragmented pattern of public development. It is, however, proposed that public tubewell projects should not be smaller than about 500 wells, unless exceptional circumstances exist, because units of lesser size would lead to constructional and administrative inefficiencies. Public tubewell projects should in general be designed to cover entire areas within which the development characteristics and constraints are as similar as possible and in so doing should embrace either whole canal commands or large parts of canal commands in order to facilitate integration with surface water supplies. The smallest component of a project would be the area served by a distributary canal.

3.61 The first major tubewell field constructed in the Indus Plains, SCARP I, employs steel screens, some of which have within a few years of coming on flow suffered from corrosion leading to a reported reduction of discharge in parts of the project area. This does not detract from the fact that SCARP I successfully fulfills its function in terms of the removal of waterlogging and the provision of the large quantities of groundwater which are abstracted annually. New well fields are now being constructed with fiber glass screens which are resistant to corrosion and there is every reason to believe that such material will give satisfactory service.

3.62 Public tubewells would be operated by electrically powered shaft-driven pumps as in the current SCARPs. The hydrological quality of the aquifer is high throughout most of the Indus Plains and its permeability is such that wells of about 300 to 350 feet in depth will give the favorable yield of between three and five cusecs. The present practice of discharging tubewells into the heads of watercourses or groups of watercourses is endorsed by IACA. In this way, canal enlargement as such would not be required but enlargement of the watercourses would be necessary.

3.63 Whereas the public well fields would completely cover large areas, private tubewells would be installed individually to serve a number of quite small areas. At present, private tubewells vary in quality of construction, in the area served, in capacity, and utilization. The construction in some cases is very crude and unreliable while in others it approaches the level of public tubewells. A typical private tubewell is of about one cusec capacity serving an area of about 100 acres and pumping from about 180 to 200 acre feet of water a year (equal to a rate of utilization of around 27 percent).

(d) Rate of Public Tubewell Development

3.64 The predominant factor in IACA's projected rate of development of groundwater resources over the next 10-15 years is the feasible rate at which tubewells - both public and private - can be installed.

3.65 The principal factors that determine the overall rate at which public tubewell projects can be installed are: Investigations and detailed project preparation; the processes of decision making and administrative procedures including contracting; the drilling and equipping of the wells; and the distribution of electric power. An additional factor which is associated with these technical considerations is the rate at which personnel can be trained in readiness for the staffing of the projects when they come into operation.

3.66 Before the construction of a tubewell project can proceed, the preliminary work necessary would include surveys to provide the latest information on watercourse locations and capacities and the culturable areas commanded and uncommanded, as well as to determine the aquifer conditions and groundwater quality zones where these are not already known. Studies of available soil data and land classification, possibly with supplementary surveys, will also be necessary in addition to seepage tests for the estimation of recharge. The analysis of the operational requirements and the design of the project would follow the receipt of this information, and it would normally take a year or more to carry out this work, depending upon the information already available and the extent and nature of the individual projects. After a detailed project report has been prepared, it would be advisable to allow a further six months for its consideration for financing to be arranged and for a decision to be reached to proceed with the project. The remaining preliminary stages leading to the construction contract could normally be expected to proceed as follows: Finalization of project design and preparation of contract documents - six months; tendering period - three months; and review of tenders and award of contract - three months. The duration of preliminary activities from the commencement of field investigations to the start of project works can, therefore, be expected to be two and a half years or more.

3.67 In the case of projects included in the Action Program (see Chapter IV.B), the phasing of their construction is determined largely by the state of preparation of the field investigations. In some of the project areas concerned, such as Shorkot-Kamalia, and to a lesser extent Rohri North and Panjnad-Abbasia, the investigations are well advanced. In other areas, detailed field investigations have not yet been undertaken and due allowance has been made for the time required. Apart from projects scheduled for early implementation, however, there is no reason why the field surveys could not be carried out in the normal course of events with the technical resources available, and so permit the projects to be designed and the construction contracts to be formulated in accordance with the proposed program.

3.68 For the majority of projects formulated by IACA, covering the construction of 400 to 1,000 tubewells, IACA consider that a sufficient number of drilling rigs would be used so as to complete the drilling of wells in each project area in about three years. Although there would be a practical limit to the rate of well construction on each project, there would be no effective technical constraint on the total number of drilling rigs which could be used simultaneously on all projects under construction so that theoretically the rate of well drilling should not become a limiting factor in the public development of groundwater resources.

3.69 The rate of completion of projects is likely to be limited by the progress attainable on the electrification of tubewells. The Power Consultants 1/ to the Bank Group consider, and past experience supports the view, that a major constraint on installation would be the rate at which the electric distribution system can be expanded. They have estimated that during the Third Plan period 1965-70, electric service could be provided to not more than 8,000 newly installed public wells, and to 12-15,000 public wells in the Fourth Plan period 1970-75 provided that these were concentrated in reasonably large entities of land. Following this advice IACA has adopted tubewell installation rates which are within these rates of electrification. The electrification of wells and the completion of appurtenant works would be expected to follow within a year of drilling the wells. Although this is a longer interval than is desirable from the hydrological or economic standpoints, it is a delay which is likely to be associated with the constraint on tubewell electrification.

3.70 The elimination of the electric distribution constraint by the installation of diesel-engined public tubewells is not considered feasible owing to problems of operation and control and also because of the higher cost of pumping by this means.

3.71 The rate of training and supply of staff for the operation of tubewell projects, particularly with regard to the electrical and mechanical maintenance requirements, and agricultural supporting services, should match the rate of installation of the well fields. The provision of trained staff for tubewell projects will require a considerable increase in the establishment of the responsible departments and in order to derive the benefits that are attributed by IACA to the program, great efforts will have to be made to ensure that the establishments are filled with staff of sound quality and training.

1/ Stone & Webster Overseas Consultants Inc., "A Program for the Development of Power in West Pakistan," May 1966, Volume II, Annexure H.

3.72 The first year of the Third Plan has shown disappointing progress in public tubewell development. Although about 1,000 wells have been drilled no more than about 140 have been electrified and brought into operation in the year 1965-66. Special factors may have influenced progress, but the small number of public wells electrified does emphasize the presence of a serious constraint and defect in planning, and there is a need for a new and more vigorous approach if the levels proposed by IACA are to be achieved. The Bank Group also places considerable emphasis on the problems of project operation to which IACA refer. In the view of the Bank Group, failure to plan and train the required personnel for the efficient operation of the projects could seriously limit progress or drastically reduce the benefits.

(e) Private Tubewells

3.73 The constraints that relate to public tubewell development do not for the most part apply to private development. It escapes some of the political and administrative problems that are associated with public tubewell construction and operation, and the electrification constraint is not as important because it is quite feasible for the farmers to use diesel power.

3.74 The widespread development of private tubewells in West Pakistan is of recent origin and for the most part has taken place over the past seven years. The most spectacular development has been in Bari and Rechna Doabs, the richer farming areas of the Punjab. In its initial stages it has been and continues to be stimulated by the Department of Agriculture and also to some extent by the availability of electricity supplies. It appears, however, that farmers are turning increasingly to diesel-driven wells because of the unreliability of power supplies. The success of these early private tubewells has led to an increasing awareness by farmers of the profitability of exploiting groundwater and, particularly in the past four years, farmers have installed a large number of diesel powered pumps for private tubewells where electricity supplies are either not available or unreliable.

3.75 The main factors which appear to govern the rate of private tubewell installation relate essentially to the farmers' enterprise and financial resources and these, in turn, are related to farm size and to the form of tenure under which the farms are operated. The early initiative for private tubewell development has stemmed primarily from the large farmers and generally from the farmers with more than about 25 acres, a category which covers about 43 percent of the total farm area of West Pakistan. On the other hand, some 48 percent of the farm area is in units of 5-25 acres and nine percent is in units of less than five acres. Thus, although small-scale family farming predominates, almost half the land area is within the farm size category which is demonstrating most readiness to invest in private tubewells. There are, however, other limitations imposed by land ownership. IACA, in its field surveys, found that the principle of forming partnerships between owners and tenants was not well understood, the tenant farmers being unwilling to make improvements such as the installation of tubewells and the planting of trees for fear of losing them to the landlords. Landowners on their side, on whom, in these circumstances, the initiative for tubewell installation must fall, often appear to be disinterested to make the necessary investment. There would thus be a considerable constraint in extending the level of activity shown recently in the owner farmer category into the tenant-operated category. Taking again as a basis farms over 25 acres, about 26 percent of the land is owner-operated and 17 percent tenant-operated. From these statistics and the information gathered by IACA in the field it would be prudent to regard about one quarter of the land area in the usable groundwater zones as potentially best suited for private tubewell activity but at the same time making allowance for restrained extension of such activity into tenant-operated large farms and, by cooperative agreement, into some of the smaller tenant and owner-operated farms.

3.76 Finance does not seem to have been a major constraint in the early development of private tubewells. A feature of the impressive private tubewell development over the last five to six years has been that most farmers have financed their own tubewells either from their own resources or from non-institutional sources of credit and so brought into productive use money which might otherwise have been used in consumption or non-agricultural activities. However, much of the farming in West Pakistan is at subsistence level and it is reasonable to presume that improved credit facilities must be provided if ownership of private tubewells is to spread to the smaller size farms. Considerable success has been achieved in the last two years by the Agricultural Development Bank (ADB) in financing private tubewell development, although loans so far have been mainly to the medium-sized farms of 12-1/2 acres or larger.

3.77 IACA has considered these constraints and has analyzed in detail the reports on private tubewell installations since 1963 when the development of diesel as well as electrically driven tubewells became firmly established. From its analysis IACA has established general trends and has used the trends to estimate the future rates of installation and the numbers of tubewells which are likely to be installed in different areas in the absence of public tubewell projects.

3.78 IACA found that there are great variations in the quality of construction of private tubewells, in the area they serve and in the amount of water they pump. The area served is constrained by the size of farm holding coupled with the readiness or otherwise of the neighbors to buy water and by topographic features such as roads, canals and watercourses. In general, the area served is of the order of 100 acres or less and IACA has taken 100 acres as the average command of a private tubewell at all stages of development. Installation of tubewells beyond the density of 100 acres per tubewell is expected by IACA to be slow and is taken to be insignificant in their projections, though there appear to be indications that the density is likely to increase in the better farming areas with a corresponding decrease of the area served per tubewell. The average capacity of private tubewells was found by IACA in its watercourse studies and farm surveys to be about one cusec and it is considered unlikely that there will be any appreciable change in this average size. The variations in the quantity of water pumped by private tubewells are greater than the variations in capacity. The actual quantity of water pumped depends on many factors including the capacity of wells, the frequency of mechanical breakdowns, size of farm holdings, land tunure problems, disputes over sale of water and fluctuations in canal deliveries as well as the more obvious factor of crop water demands. On average, a private tubewell is operated for about 2,400 hours a year to pump about 180 to 200 acre feet a year, representing a utilization rate of about 27 percent. There is considerable incentive at present for a higher utilization rate as canal deliveries are frequently irregular and many of the tubewells are installed on large farms with a correspondingly high demand for additional water supplies. The fact that average utilization rates are at present rather low indicates that there are constraints on the use of individual tubewells under private enterprise. IACA has therefore assumed that the utilization rate of 200 acre feet a year would not on average be exceeded in future when there would be more reliable canal deliveries and when tubewells would be installed in the smaller farm holdings. The low utilization rates do not provide a true reflection of the utility of private wells for the reason that the owners would limit pumping to times of necessity. The water pumped from private wells would therefore tend to have a greater value per unit consumed than the basic flow delivered through a public system whether the latter be derived from surface or groundwater sources.

3.79 From its study of trends IACA expects private tubewell development to be most rapid in Bari and Rechna Doabs where, as mentioned before, some of the best farming areas are found and where most of the early initiative has been shown. The rate of installation of private tubewells is expected to be slower in the relatively backward areas of the Lower Indus and in Thal Doab and the Indus Right Bank. In all areas, however, the general pattern would be a slow initial development stimulated by the most enterprising farmers and supported by the Department of Agriculture, and then a more rapid development as farmers appreciate the profitability of private tubewells, leading to a declining rate of installation as the constraints of farm size, land tenure and finance become more operative. The rapid stage of development has already been reached in Bari Doab whereas development has only just started in the Lower Indus region.

3.80 IACA's projections for private tubewells in the canal commanded areas, are shown below in the hypothetical case of there being no public tubewell projects other than the completed SCARP I. No projections have been made for the Vale of Peshawar where the aquifer conditions are uncertain and where well drilling may be more difficult.

IACA Projections for Private Tubewells in Operation Without Any Public Tubewell Programs
(thousand wells)

| | Private Tubewells in Operation 1965 | 1970 | 1975 | 1980 | Full Development 1/ |
|---|---|---|---|---|---|
| Canal Commanded Areas: | | | | | |
| Vale of Peshawar | -- | -- | -- | -- | -- |
| Thal Doab and Indus Right Bank | 1.2 | 3.7 | 7.0 | 9.5 | 30 |
| Chaj Doab | 0.8 | 3.0 | 5.3 | 6.8 | 16 |
| Rechna Doab | 9.8 | 16.1 | 20.8 | 22.9 | 31 |
| Bari Doab | 13.0 | 27.0 | 36.0 | 41.0 | 53 |
| Sutlej and Panjnad Left Bank | 1.4 | 4.0 | 6.2 | 7.6 | 18 |
| Lower Indus | 0.7 | 2.2 | 5.1 | 7.7 | 23 |
| Total Canal Commanded Areas | 27.0 | 56.0 | 80.0 | 96.0 | 171 |
| Outside Canal Commands | 5.0 | 9.0 | 14.0 | 20.0 | 25 |
| Total Private Tubewells | 32.0 | 65.0 | 94.0 | 116.0 | 195 |

1/ Full development is taken as full coverage at 100 acres per tubewell and applies at dates which vary but are all after the year 2000.

3.81 It can be seen that development is expected to be very rapid until towards 1975 but that the constraints on development would impose a slower rate of installation thereafter. Even in 1975 less than half of the potential development would have taken place in the canal commands as a whole while in Bari and Rechna Doabs, the most advanced regions, about two-thirds of the potential development would have taken place. These projections emphasize the need to recognize private tubewell development opportunities in the determination of priorities for public groundwater development.

(f) Integrated Public and Private Tubewell Development

3.82 In practice public tubewell projects would continue in parallel with the private development. As public tubewells come into operation in a project area, the installation of private tubewells in the area is expected to reduce to an insignificant level. According to the IACA projections under the proposed expansion of the public program the number of private tubewells in operation in the canal commanded areas would reach a peak by around 1970. Private tubewells would continue to be installed in non-project areas but the total number in operation would decline to insignificance by 1985 when public tubewell coverage of the usable groundwater areas is expected to be complete. Private tubewells would, however, continue to make a valuable contribution to irrigation outside the canal commanded areas and may in many cases continue to be operated in conjunction with public wells.

3.83 The IACA projections are shown below for private tubewells in operation in parallel with the IACA program for public tubewell projects:

IACA Projections for Private Tubewells in Operation with IACA Public Tubewell Program 1/
(thousand wells)

| Region | Private Tubewells in Operation 1965 | 1970 | 1975 | 1980 | 1985 |
|---|---|---|---|---|---|
| Canal Commanded Areas: | | | | | |
| Vale of Peshawar | -- | -- | -- | -- | -- |
| Thal Doab and Indus Right Bank | 1.2 | 2.4 | 2.8 | -- | -- |
| Chaj Doab | 0.8 | -- | -- | -- | -- |
| Rechna Doab | 9.8 | 10.3 | 9.4 | -- | -- |
| Bari Doab | 13.0 | 25.5 | 19.5 | 1.3 | -- |
| Sutlej and Panjnad Left Bank | 1.4 | 2.9 | -- | -- | -- |
| Lower Indus | 0.7 | 2.0 | 2.5 | 1.7 | -- |
| Total Canal Commanded Areas | 27.0 | 43.0 | 34.0 | 3.0 | -- |
| Outside Areas | 5.0 | 9.0 | 14.0 | 20.0 | 25.0 |
| Total Private Tubewells | 32.0 | 52.0 | 48.0 | 23.0 | 25.0 |

1/ Numbers given are IACA original projections, they have been subsequently revised to include more recent counts as well as changes in priorities. See Chapter IV, para 4.67.

3.84 It should be noted that by 1980 public tubewells would have substituted for some 93,000 private wells that would otherwise have been installed and in operation in accordance with the IACA estimates.

3.85 IACA has emphasized that its projections are based on data for only a few years at an early stage of development and that it is therefore difficult to assess the limits of accuracy of the development which has been projected. It should also be noted that IACA's projections of private tubewells in operation are based on a continuation of existing trends without any specific stimulation unless there is a falling off in the rate. However, since the IACA Report was published, valuable information on private tubewell development in Lower Rechna Doab has been produced by Tipton and Kalmbach Inc. for WAPDA in the SCARP V Project Report of August 1966. Tipton and Kalmbach's investigations of private installation in over two million acres in the Lower Rechna Doab provide some confirmation for the IACA figures. The average command of private tubewells is 100 acres and the average delivery from a tubewell is about 200 acre feet a year, both of which figures are the same as used by IACA. However, Tipton and Kalmbach place greater emphasis than IACA on the constraints of farm size, land tenure and finance. They show that the initial rapid installation of private tubewells occurred on the larger farms and that this lead is not automatically being followed on the small farms. The rate of installation of private tubewells has in fact declined sharply since 1963 in this specific area where a high density has been reached and in the view of Tipton and Kalmbach will continue to decline.

3.86 Tipton and Kalmbach are also making detailed studies, as yet unpublished, of private tubewell development in Bari Doab. Figures for private tubewells in over 500 union councils are being collated and analyzed. It would appear that the figures for Bari Doab bear out the general expectations of IACA but that Tipton and Kalmbach find about 2,000 more wells in existence at present 1/ and expect the constraints on further development to be more severe than projected by IACA. In particular, Tipton and Kalmbach find that the commanded areas and the utilization rates of private tubewells decrease as the density of wells increases. They tentatively expect that the average tubewell command in the Bari Doab may reduce to about 60 acres and that on this basis the area commanded would not exceed about 60 percent of the culturable area.

3.87 Under IACA's proposed program for public tubewell projects, the main and crucial influence of private tubewells on agricultural production would be during the next decade. The differences between the IACA and the Tipton and Kalmbach projections for private tubewell development in the northern zone are not great during this period but the IACA projections are slightly higher.

3.88 The Bank Group consider it essential that the IACA projections for private tubewell installation should be achieved and where possible exceeded if there is not to be a serious shortfall in the growth of agricultural production.

3.89 The present policy of the Government of West Pakistan to encourage private tubewell development is strongly endorsed by the Bank Group. The Bank Group recommend that it should be supported through the provision of technical advice on the construction and siting of private wells and through an expansion of the activities of the ADB in providing loans.

3.90 When the IACA program for public tubewells is consolidated with the projections for private tubewell installation the following numbers would be in operation in each of the four reference years:

1/ As shown in para 1.12.

Private and Public Tubewells in Operation According To the IACA Projections

| | 1965 | 1975 | 1985 | 2000 |
|---|---|---|---|---|
| Number of Public Wells: | | | | |
| In Usable g.w. zones | 2,200 | 19,800 | 34,300 | 35,000 |
| In Saline g.w. zones | -- | 200 | 9,800 | 15,000 |
| Number of Private Wells: | | | | |
| Electric Powered | 9,000 | 26,000 | 23,000 | 30,000 |
| Diesel Powered | 23,000 | 26,000 | 2,000 | 3,000 |
| Total Pumping (MAF): | | | | |
| For Irrigation | 11 | 33 | 45 | 50 |
| For Drainage 1/ | -- | 15 | 18 | 27 |

1/ Not strictly pumping: figures given are the re-charge to the saline areas and would include some horizontal drainage effluent.

The figures are based on the assumptions that the private wells would have a capacity of about one cusec as compared with four cusecs for the public wells and the projected annual yields would be about 200 acre feet and 1,000 acre feet a year respectively.

## 3. Canal Enlargement and Remodelling

3.91 The present withdrawal capacity of the canal system is 13.3 MAF/month, which equals or exceeds the combined mean flow of the Indus, Jhelum and Chenab for all except the three summer months of high flow, June, July and August. During these three months the combined mean flows are about 23, 32 and 28 MAF respectively. In addition, in May and again in September there is also a period of about two weeks when the natural flows of the three rivers exceed existing canal capacity. The above comparison of natural flow and canal capacity is not in itself a measure of the scope for canal enlargement. Some of the surplus flow has to be hypothecated for storage in the new reservoirs and there are problems of geographical distribution and considerable variations from the mean conditions. It must also be borne in mind that canal enlargement alone as a means of using surplus river flows would not be very effective in adding to achievable kharif cropping intensities without complementary additional supplies from storage reservoirs and groundwater at the beginning and end of the season since there are few summer crops that can be matured within the short period of high flow. Additional water would be needed for planting and maturing of most crops.

3.92 The potentiality for canal enlargement has been carefully analyzed by IACA and they estimate that the total withdrawal capacity would have to be increased by about 40 percent to some 19 MAF/month in order to achieve the cropping intensities of about 150 percent in perennial areas and 95 percent in those few areas likely to remain non-perennial (or an average of 145 percent for a CCA of 29.5 million acres). Remodelling on this scale coupled with IACA's surface water storage program would, by the year 2000, result in the complete diversion of the mean year river flows into the system. Any water that enters the sea in a year of mean inflow to the Plains would be essentially derived from saline drainage effluent discharged either through the river channels or through the proposed Left Bank Outfall (see Chapter V, Section B and Map 7).

3.93 The need for canal enlargement varies considerably between different areas according to the availability of usable groundwater and the original design of the canals. The need would be greatest in areas where the underlying groundwater is not of a suitable quality to be used for irrigation and the potential demand of the crops must be met from surface supplies alone. Many individual canals in such saline zones would require increases of 100 percent or more in capacity. On the other hand, there are intensive areas where development of fresh groundwater in combination with surface water deliveries in the existing canal system would be adequate for optimum irrigation supplies. Within the development CCA of about 29.5 million acres, IACA estimated that varying degrees of canal enlargement would need to be undertaken over about 16 million acres to permit full agricultural development.

3.94 IACA has considered the possibility of enlarging certain canals beyond the level required to meet the surface water requirements of the optimum cropping intensities in an integrated ground and surface water supply. The purpose would be to maintain sufficient flow in the mid-summer months to obviate groundwater pumping and the resulting recharge during summer would then be sufficient to meet rabi requirements from groundwater pumping alone. This method could only be applied to fresh groundwater areas which are mainly in the Punjab and would therefore necessitate major link canal enlargement. It would also entail some difficult hydraulic problems in operating the enlarged canal system with wide variations in flow and would be a costly and time consuming measure. It might be adopted in the long term but would find no place in the proposed Action Program, which concentrates on the canal enlargement to remove constraints in the mixing and saline groundwater zones. Additional enlargement may at some future date represent an alternative procedure to surface water storage but not before a reasonable degree of regulation has been established on the present variable river flows.

3.95 Enlarging the withdrawal capacity of the canal commands would in many cases require enlargement of the capacity of the link canal system. IACA considers that the existing link canals combined with the links under construction are at present adequate to serve the canal system, but that by about 1980 there would be a need for additional link capacity to transfer water across the Punjab to Bari Doab and the Left Bank of the Sutlej River. It is recommended that the possibility should be investigated of constructing a new link canal with a capacity of about 1-1/2 MAF/month on an alignment across the Punjab running from the tail reach of the Chasma-Jhelum link to cross the Chenab River in the vicinity of Chiniot and then leading ultimately into the Sutlej. Such a project would have two major functions. Firstly, as a link it would supplement the supplies to the east of the Punjab Plains in the same way as the links under construction. Secondly, it would add greatly to the flexibility of the irrigation system by bringing much more land under both Jhelum/Chenab and Indus command instead of under the Jhelum/Chenab command alone.

3.96 IACA has also examined alternative methods of canal enlargement in relation to different canals and they conclude that the simplest and cheapest method for major enlargement would generally be to construct a parallel channel alongside the existing canal. Where the degree of enlargement required is less than about 60 percent, the existing channels could be widened and deepened.

3.97 Costs of enlargement would depend on the increase in capacity required, on the local conditions and in some cases on the complementary enlargement of link canals. It is estimated that within a canal command the investment costs per acre of CCA are likely to vary from about Rs. 100 in areas where enlargement would be slight up to about Rs. 250 in areas where a more considerable degree of enlargement is required. The cost of providing additional link capacity would apply only to canal commands on the tributary rivers and would vary considerably between different areas. As a general average the cost of additional link canal capacity is at least equal to the cost of enlargement within the related canal commands and generally more. Subsequent to the submission of their report, IACA have examined the average cost of canal enlargement, over all parts of the canal network where it is required on the basis of annual incremental water supply. By discounting both costs and incremental discharge at eight percent they have arrived at an average cost of about Rs. 19 per acre foot. After taking into account the limited flexibility in the use of additional water from diversion during high flow months and the consequent need to provide complementary supplies in the early and late kharif period by other means, canal enlargement would appear to be a more expensive form of development than groundwater but cheaper than stored water. This does not, however, imply that there would be a wide choice of mode of development because under IACA's integrated proposals all three modes of development -- surface storage, groundwater, and canal enlargement -- would have converging functions in the program and their phasing would be interrelated in meeting the projected requirements as explained in Chapter V. The cost analysis does, on the other hand, demonstrate the attraction of canal enlargement and the need for a substantial program of enlargement, especially in the decade 1975-85.

3.98 IACA has drawn attention to the need for remodelling and maintenance of the canals to prevent excessive siltation or scouring, when the pattern of surface water distribution is changed. Remodelling and maintenance of this nature is to a large extent a routine matter but would require an increasing rate of expenditure and this has been allowed for in the IACA program.

3.99 In connection with future development of the distribution system, IACA has considered the possibility of lining canals as a means of reducing losses due to seepage and reducing the need for drainage in areas underlain by saline groundwater. It is estimatedthat, discounting the cost of lining at eight percent, the cost of preventing one acre foot of water from being lost from the canal would be about Rs. 110. If allowance is made for the saving in drainage of saline groundwater areas, this cost might be reduced to around Rs. 65 per acre foot. However, drainage to dewater would have to precede lining in areas with a high water table. There are also practical problems in lining that most of the saline groundwater areas, other than southern rice areas, receive perennial canal supplies. Canal deliveries would have to be maintained and so lining in most areas would have to be associated with the construction of new channels. Because of the comparatiively high costs and technical factors involved, IACA has concluded and the Bank Group concurs that canal lining would not at present be generally justifiable except in special isolated circumstances and would not deserve priority in the current program for development and water conservation.

3.100 A further aspect of the present distribution system is the inflexibility in the method of delivering water through the distributary canals. However, IACA considered that a change to a more flexible system of distribution based on individual demands would involve such large-scale problems of construction and administration that it would have to be deferred until after the currently proposed program for development.

3.101 The program for canal enlargement will necessarily be related to the program for groundwater development, sub-surface drainage and surface water storage. In areas where there is a high groundwater table, canal enlargement should be preceded by sub-surface drainage so as to prevent further waterlogging and reduction in crop yields. The higher cropping intensities which would accompany canal enlargement would accentuate any shortages occurring during the periods of sowing and maturing of kharif crops. These shortages would have to be met by releases from surface storage or by additional groundwater pumping. In addition, an increase in the withdrawal capacity of several canals which command land in the Bari Doab and on the Left Bank of the Sutlej River would have to be accompanied by the enlargement of the RQBS 1/ and TSMB 2/ (see Map 7) link canals or by the construction of the new Punjab link canal discussed above. These factors would have to be taken into account in future programming of canal enlargement.

3.102 Although much experience has been gained in the construction of new canals in West Pakistan, enlargement of the capacity of existing canal systems on an extensive scale has not yet been undertaken. The enlargement work envisaged would be much greater in scope than any canal remodelling so

1/ Rasul-Qadirabad-Balloki-Suleimanke.
2/ Trimmu-Sidhnai-Mailsi-Bahawal.

far carried out, including that required under the Indus Basin Project. The planning, survey, design and construction of the work would be of a magnitude and complexity which would require a strong central organization of the Irrigation Department to carry it out. Methods of carrying out the work with the least amount of disruption of canal operation or interference with the distribution of water supplies would need careful study if loss of production is to be minimized.

3.103 IACA estimates that initially, enlargement could be carried out at an average rate of about 150 miles of channel per year, covering one canal sub-division. A total of about one million acres of CCA would then be provided with enlarged channels by 1975, in selected areas which are not subject to the previously mentioned constraints of drainage, storage availability and link capacity. After this, the rate of enlargement should increase rapidly so that a further five million acres of CCA might be served by enlarged channels by 1985 (see Chapter V). The Bank Group urges that steps should be taken at once to prepare plans for the initial works. Bearing in mind that little progress has been made in this direction to date, vigorous action will be required if IACA's projection for 1975 is to be realized.

4. Surface Water Conservation

3.104 Allied to the development of groundwater and the enlargement of canals would be steps to increase the availability of surface water through the medium of surface storage, which would have the prime function of equating seasonal fluctuations of river flows with the seasonal variations in surface water requirements. The present period of water shortage is generally between mid-October and mid-April. With the growth of cropping intensities this period of shortage would gradually expand to include more of October, April and the early part of May. A second function of storage is to provide regulation of flow within the rabi season thus enabling the supplies in conjunction with groundwater to match as closely as possible the rabi pattern of cropwater requirements. This would eliminate the severe monthly shortages which occur under the present system and provide the farmer with a firmer base for his cropping program and reduce the risks of employing higher levels of non-water inputs. Thirdly, the surface reservoirs would in the long term provide a measure of flood control.

3.105 Within the context of its principal function, transferring surplus kharif water to rabi shortages, three stages can be distinguished.

(i) Replacement of the rabi flows of the rivers Ravi and Sutlej, which are allocated to India under the Indus Waters Treaty.

(ii) Increasing the availability of rabi supplies by the storing of the firm kharif surplus, i.e. seasonal regulation.

(iii) In the longer term, utilization of the fuller potentialities of the Indus river by carrying over the larger kharif surpluses to years with lower than average surpluses, i.e., over-year storage.

3.106 The first stage of development should be substantially completed by 1967/68 when Mangla reservoir comes into operation but full replacement of the eastern tributaries would not become effective until the Indus link canals have been completed. In accordance with the IACA program, the second stage of storage development to provide seasonal regulation would need to be implemented during the subsequent thirty years. IACA has not programmed for the long term aspects of the Third stage providing over-year storage.

3.107 For a region that is so dependent on water, the Indus Basin is not well suited geographically for the development of storage reservoirs. The topography of the country does not provide large reservoir sites which would be technically or economically easy to develop. Furthermore, the high silt content of the rivers, particularly of the Indus itself, would result in a fast rate of depletion of storage capacity. The potential reservoirs are discussed in the Bank Group's Report, Volume III, "Program for the Development of Surface Water Storage."

3.108 The cost of stored water in the Indus Basin has been estimated by IACA taking the Bank Group's Dam Site Consultants' 1/ estimates of dam cost and relating these to water yield. Stored water at the dam site would thus cost about Rs. 37 per acre foot. When translated to watercourse head the figure is almost doubled because of distribution losses, thus giving a cost on the land that is about three times the cost of tubewell water, i.e. about Rs. 63 per acre foot. Large reservoirs tend to generate surpluses or make available quantities of water which may temporarily exceed the farmers' ability to use it efficiently in the early years of the reservoir operation. This would increase the effective cost per acre foot used. In the conditions of West Pakistan, however, this disadvantage may be partly overcome by over-pumping from the aquifer during the years prior to the addition of surface storage and subsequently replenishing it in the years immediately after the commissioning of the reservoir, and thus employing the reservoir as a long term regulator.

3.109 Despite the relatively high cost of stored water, surface storage development would need to proceed for the following reasons:

(i) There is a need to regulate the natural river flows in the rabi season; a substantial degree of regulation on the Jhelum River would be provided by Mangla Dam and the principal requirement for the next phase of rabi regulation is on the Indus itself.

(ii) Provision of surface storage has a key role in increasing the rabi irrigation supplies which would enable Pakistan to move towards self-sufficiency in food grains.

(iii) The cost of surface storage, although high, is sufficiently below the benefits obtainable for a storage development to be economically viable.

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1/ Charles T. Main International, Inc., Boston.

[illegible]ically [illegible]able.

(iv) Surface storage is an important part of the development plan for without it there could be little development in the extensive areas underlain by saline groundwater, and development would be curtailed in areas where regulated surface water is required for mixing with groundwater.

(v) Once groundwater development reaches its full potential, extra rabi water would be available only from storage.

(vi) In view of the specific constraints and interdependent nature of all modes of water resource development, it is necessary that each should be advanced in accordance with an integrated time schedule. Surface storage has a key role in the development and is particularly important in view of the existing familiarity with the distribution and use of surface water supplies. By contrast, there is as yet little experience with large-scale public groundwater development, especially in areas with varying groundwater qualities.

3.110 The ultimate storage potentialities of the rivers are best considered in two groups: firstly, storage on the Indus together with its tributaries, the Kabul and Swat, and secondly, storage on the Jhelum jointly with the Chenab.

3.111 The Indus has a large seasonal fluctuation in flow; of the total mean annual discharge of 93 MAF about 72 percent or 67 MAF occurs in the four kharif months June to September. The flow of the Jhelum and Chenab display only slightly less seasonal fluctuation with 31 MAF or 64 percent of the total of 49 MAF occurring in the peak four months, May to August - one month earlier than the Indus. Apart from the slightly earlier flood season, the Jhelum and Chenab rivers differ from the Indus in having slightly greater variation in flows from year to year and also in having lower silt loads.

3.112 The amount of surplus flow available for storage on these rivers depends essentially on the pattern of irrigation demand and this over time depends on trends in cropping intensities and more particularly in the kharif-rabi cropping ratio. When this ratio is high the storable surplus and indeed the need for storage is low. IACA has calculated the storable surplus on the two river systems on the basis of its agricultural projections which leads towards the following average cropping intensity levels and kharif-rabi ratios:

Cropping Intensities and Kharif-Rabi Ratios

| | Average Cropping Intensity | General Kharif-Rabi Ratio |
|---|---|---|
| 1975 | 112% | 1.20 |
| 1985 | 125% | 1.16 |
| 2000 | 145% | 0.94 |

3.113 Under these projected conditions the mean year 1/ storable surplus on the Jhelum after full allowance has been made for maximum use of Chenab water amounts to 11.5 MAF in 1985 and 7.5 MAF in 2000. On the Indus the respective values are 38 MAF and 22 MAF. These figures are derived by subtracting the projected kharif irrigation demands under the IACA projected cropping patterns and intensities from the total river flow during the storage period. The sharp decrease in storable surplus after 1985 reflects the influence of the increase in kharif intensity made possible by IACA's proposed canal enlargement. It also demonstrated the extent to which a high degree of river use can be attained with relatively small storage capacities in the Indus Basin where year-round cropping is practiced and when high kharif-rabi ratios are adopted. For the ultimate stage of development IACA has analyzed how frequently reservoirs of given size might approximately be filled on each river system and the results are given below:

Frequency with which a Reservoir of given Capacity could be filled under Full Development (year 2000) projected by IACA

Jhelum at Mangla

| Storage MAF | Number of Years out of 40 | Storage MAF | Number of Years out of 40 |
|---|---|---|---|
| 2 | 40 | 9 | 9 |
| 3 | 38 | 10 | 6 |
| 4 | 35 | 11 | 5 |
| 5 | 32 | 12 | 3 |
| 6 | 28 | 13 | 2 |
| 7 | 25 | 14 | 1 |
| 8 | 17 | 15 | - |

1/ The mean year storable surplus serves only as a planning base and careful attention must be given to variations from the mean.

Indus at Attock

| Storage MAF | Number of Years out of 40 | Storage MAF | Number of Years out of 40 |
|---|---|---|---|
| 13 | 40 | 22 | 18 |
| 14 | 38 | 23 | 16 |
| 15 | 37 | 24 | 13 |
| 16 | 36 | 25 | 10 |
| 17 | 35 | 26 | 8 |
| 18 | 34 | 27 | 7 |
| 19 | 33 | 28 | 5 |
| 20 | 29 | 29 | 3 |
| 21 | 23 | 30 | 1 |

3.114 These frequency figures for filling the reservoirs taken together with the storable surpluses stated above demonstrate the limited potential for storage development on the Jhelum after completion of the Mangla Dam with its useful initial capacity of 5.2 MAF and at the same time emphasize the scope for storage development on the main Indus.

3.115 Clearly it is not possible to project ultimate storage potentialities and needs with any precision. The latter depend on an array of trends in food and fiber demands, crop yields and intensities and other factors. A general conclusion which may be drawn from the IACA projection is that the second phase of development, or seasonal regulation, may lead to about seven MAF of storage on the Jhelum and 20 MAF on the main Indus. Subject to investigation, the present indication is that the third stage, over-year storage, might extend to nine MAF on the Jhelum and 26 MAF on the Indus. As discussed above, the first major storage reservoir is already under construction at Mangla on the Jhelum River as part of the Indus Basin Project Works.

3.116 The principal benchmark in the IACA program is the projected completion of Tarbela Dam on the Indus River in 1974 with an initial live storage capacity of 8.6 MAF. 1/ The timing of Tarbela Dam was fixed in the IACA terms of reference but the need and the priority for the project as well as its approximate timing have been confirmed by subsequent studies.

3.117 In accordance with the IACA program, the provision of a major storage reservoir at Tarbela in 1974 is adequate to meet the requirement for storage in the system at the time and for some years thereafter. If there were to be other surface storage projects before 1975 they would tend to be in competition with Tarbela within the frame of the IACA program and the economic returns of the projected storage development would consequently be reduced. It has therefore been assumed that storage projects in the next decade would be limited to the already large program of Mangla and Chasma followed by Tarbela.

1/ With a minimum drawdown level of 1,332.

3.118 The future rate of reservoir construction would also be constrained, so far as can be foreseen at present, in that surface storage which is both necessary for development of irrigation and justifiable from an economic standpoint would nonetheless remain an expensive form of development. For agricultural development under West Pakistan conditions it is justified only if efficient and effective use to raise agricultural production can be ensured. On this basis of efficient and effective use, IACA projects that the next requirement for major storage after Tarbela would not occur until after 1980. Bearing in mind that the development of surface water storage involves long term planning and investigations there is a clear need for a vigorous program of investigations. 1/

## 5. Drainage and Flood Control

### (a) Drainage

3.119 There is need for surface and subsurface drainage in many parts of the Indus Plains in order to control respectively the damaging effects of:

(i) The inundation and waterlogging of arable land caused by local storms and occasional river flooding.

(ii) Waterlogging and salinity caused by a rise in the water table.

3.120 The expected increase in cropping intensities and higher yields accentuates the need for both forms of drainage. More intensive irrigated cropping would lead to greater percolation to the water table and the associated reduction in fallow areas would reduce the present opportunities for disposal of rain flood water from the cropped fields. The projected increases in crop yields would enhance the benefits that can be derived from protection against flooding and waterlogging.

3.121 The prevention of damage by storm water, which is particularly severe during the monsoon season, would be effected by a system of surface drainage. In IACA's analysis of the requirement for and capacity of surface drainage in each region, the cost of drainage was compared with the probable crop losses that might otherwise occur. In the northern part of the Punjab drainage systems with capacities varying from one to five cusecs per square mile indicated a favorable cost/benefit relationship. 2/ In the central areas between Multan and Nawabshah, the analysis suggests that there is no justification for surface drainage, but south of this area systems with capacities from one to three cusecs would appear justified (see Map 4).

3.122 The need for water table control by subsurface drainage is demonstrated in IACA's report on drainage and flood control. 2/ The areas in

1/ See Volume III of the Bank Group's Report.
2/ IACA Report, Volume 6, Annexure 8.

which water table control is needed in the Indus Plains are included within the 11 million acres of the canal commanded area in which the groundwater is less than ten feet from the surface. Of this total acreage, about 6.5 million acres are underlain by usable groundwater and the control of the water table can in general be expected to be affected by the various public and private tubewell developments proposed in these areas. The balance of 4.5 million acres, underlain by saline groundwater (more than 3,000 ppm), contains about 1.2 million acres that are expected to be developed for non-perennial rice cultivation for which water table control is not required. It also contains about one million acres which have not been included in the 29.5 million acres scheduled for development under IACA's proposals. Although a water table depth of less than ten feet does not imply an immediate need for drainage, IACA estimates that almost two million acres in the saline groundwater zones of the Indus Plains require special provision for the control of the water table at present or in the near future.

3.123 Subsurface drainage would be carried out by tubewells or tile drains, according to local conditions. As stated above, in the usable groundwater zones the recharge would be recovered by the tubewells sunk primarily for the supply of irrigation water which would at the same time serve to check the rise of the water table. In the saline groundwater zones, however, a separate and specific drainage system would be required and the effluent would have to be disposed of through the river system, into the desert, or into the sea, according to circumstances. In the Punjab Doabs the outfalls can only run into the river channels and to avoid excessive salinization of river water, it would be necessary for saline tubewell effluent to be discharged only during periods of high river flow. In IACA's view this would make the annual cost of tubewell drainage comparable with that of tile drainage. In areas in which it is proposed to provide direct disposal facilities to the sea or to the desert and where the aquifer is suitable for tubewells, tubewell drainage is more economical than tile drainage because large capacity drainage wells could be pumped throughout the year. This applies to the Lower Indus for which area large outfall drains are planned and to the Sutlej Left Bank from which area effluent would be dispersed into the adjacent desert.

(b) Flood Control

3.124 High floods have occurred more frequently in the Indus Plains during the last 25 years than over the previous 65 years of record. In the case of the Ravi River, seven out of the ten highest annual flood peaks observed during more than 90 years of record have actually occurred in this recent peroid. During recent floods considerable damage occurred, estimates of which are summarized below:

Estimated Flood Damage
1948-1962

| | Ravi | | Chenab | | Indus, Sutlej and Jhelum | | Total | |
|---|---|---|---|---|---|---|---|---|
| | 15-year Total | Annual Average | 15-year Total | Annual Average | 15-year Total | Annual Average | 15-year Total | Annual Average |
| | (Rs. mill.) | | | | | | | |
| **Private Property** | | | | | | | | |
| Crops & Produce | 190.0 | 12.7 | 59.6 | 4.0 | 276.8 | 25.1 | 627.2 | 41.8 |
| Housing | 111.0 | 7.3 | 64.9 | 4.3 | 104.8 | 7.0 | 280.7 | 18.6 |
| Cattle | 9.5 | 0.6 | 3.2 | 0.2 | 2.5 | 0.2 | 15.2 | 1.0 |
| Sub-total | 310.5 | 20.6 | 127.7 | 88.5 | 384.1 | 32.3 | 923.1 | 61.4 |
| **Public Installations** | | | | | | | | |
| Irrigation Works | 31.9 | 2.1 | 14.6 | 1.0 | 134.2 | 8.9 | 180.7 | 12.0 |
| Roads & Bridges | 8.5 | 0.6 | 6.8 | 0.5 | 38.7 | 2.5 | 54.0 | 3.6 |
| Railway Facilities | 12.6 | 0.9 | 13.8 | 0.9 | 10.8 | 0.7 | 37.2 | 2.5 |
| Sub-total | 53.0 | 3.6 | 35.2 | 2.4 | 183.7 | 12.1 | 271.9 | 18.1 |
| TOTAL | 363.5 | 24.2 | 162.9 | 10.9 | 467.8 | 44.4 | 1,195.0 | 79.5 |

Source: IACA Report, Volume 6, Annexure 8, page 23.

Although the damage was often caused by breaching of river bunds, the spill from large natural drainage channels and consequent breaching of canals contributed significantly to the inundation and destruction of crops.

3.125 The amount of damage caused by flooding will increase as the state of development rises. Especially in areas scheduled for a high rate of agricultural development, particularly by tubewells, it would become increasingly important to provide reasonable flood protection. This would include measures to prevent increases in deforestation and denudation of the upper catchment areas, which probably contributed to the recent apparent rise in flood frequencies. The West Pakistan Flood Commission has developed preliminary proposals for dealing with the flood problems on the Ravi and

Chenab Rivers. Proposals for the other rivers are still in the course of preparation and not yet available. In general, the measures proposed contain the following items:

Flood Protection Measures

| | | Preliminary Cost Estimates | | |
|---|---|---|---|---|
| | | Ravi | Chenab | Total |
| | | (Rs. mill.) | | |
| (i) | Soil Conservation in Upland Areas | 2.9 | 14.3 mm | 17.2 |
| (ii) | Land and Canal Protection (including 125 miles of new bunds, 280 miles of improvement of existing embankments) | 39.3 | 12.7 | 52.0 |
| (iii) | Drainage Works (including 850 miles of drainage channel remodelling) | 66.7 | 0.2 | 66.9 |
| (iv) | Road and Railway Protection Works | 32.1 | 1.4 | 33.5 |
| (v) | Municipal Protection Works | 1.9 | 5.1 | 7.0 |
| | TOTAL | 142.9 | 33.7 | 176.6 |

In accordance with IACA it would seem reasonable to assume about the same costs for the rivers Sutlej, Jhelum and Indus which would bring total expenditures for flood protection works in the Indus basin to about Rs. 350 million.

3.126 If the proposed works were to be carried out during the next five years, the average annual level of expenditures would be in the neighborhood of Rs. 70 million. Assuming, furthermore, that the average annual damage prevented would equal one-half of that tabulated above, the benefits would, in accordance with IACA, just cover amortization at eight percent interest and maintenance expenditures. It must be borne in mind, however, that flood control works are frequently undertaken for sociological reasons and cannot always be justified on the basis of quantifiable economic benefits alone.

## 6. Interdependence and Integration of Water Development

3.127 In the foregoing section reference has been made to the interrelationship between the three principal water development measures of tubewell installation, reservoir construction and canal enlargement and between further water development and drainage. Each must proceed in its proper sequence. In general, sub-surface drainage should precede the increased flows to the canal that would result from canal enlargement. Canal enlargement would in itself prove effective only over the mid-kharif months and other developments would have to take place at the same time to meet the kharif crop demands in the early and late part of the season. These factors associate canal enlargement not only with drainage but also with surface storage reservoirs and/or tubewell water supplies in usable groundwater zones. In the zones of intermediate groundwater quality where mixing of ground and surface water is necessary, a prerequisite to success is the reliability of surface supply and, although some deficiencies might be accepted initially, the efficient operation of mixing calls for river regulation by surface reservoirs both on the Jhelum and Indus.

3.128 A feature of tubewell development, in addition to its low cost and quick returns, is its flexibility as a means of supplying water in relation to the availability of surface supplies. In the operation of tubewells use could be made of this flexibility by pumping for longer periods than is usual at time of surface water shortage or when the crop water requirements are at a peak. With both private and public tubewells, the pumped water is at present regarded largely as a supplement and not as a substitute for canal supplies. The value of both tubewell and surface water development are enhanced by their joint application to irrigation because incremental surface supplies give rise to greater recharge to the aquifer, thus raising the output of the tubewell fields and at the same time increasing the conveyance efficiency of the surface deliveries.

3.129 Total water supplies under the present system might at certain times be more than adequate in tubewell areas while elsewhere crops are suffering shortages. Achievement of the full benefits of groundwater development would require changes in the present methods of allocating water. One of the most important changes required is that groundwater supplies from public tubewells should be treated jointly with surface water supplies in future allocations.

3.130 There are three main reasons why integration of supplies through appropriate operation of the system is essential to the success of future development. These may be summarized as follows:

(i) Only about half of the CCA proposed for development is underlain by fresh groundwater which can be applied directly to the crops, but surface water supplies could be improved throughout the remainder of the CCA by transfer from fresh groundwater areas. In certain canals, particularly those having relatively large capacities for the areas which they serve, the normal irrigation deliveries at times of high river flow would be sufficient to replenish the aquifer and enable all or most of the demand in the remainder of the year to be met by pumping of fresh groundwater under public tubewell projects. In such cases the rabi surface water supplies could be released and reallocated to other areas. This is referred to by IACA as substitution and further discussed in Capter V.

(ii) A further 15 percent of the CCA is in the mixing zones where groundwater would require dilution by surface water before being applied to crops. Only by carefully operated integrated control of surface and groundwater can a satisfactory quality of irrigation water be maintained.

(iii) Integration of tubewell pumping and surface water deliveries is necessary in order to rationalize the pattern of demand for tubewell pumping power which would represent a substantial part of the total system power and energy demand in West Pakistan.

3.131 On the basis of all considerations discussed in Chapter III, IACA has developed a simulation analysis by which it has tested the relative advantages of various combinations of water development activities. This has enabled IACA to outline a comprehensive water development program which is internally consistent, appears capable of implementation and has been successfully tested for its operational feasibility by a sequential analysis covering the period 1965 to 1985. 1/

3.132 The dominant features of this program is the emphasis on exploitation of fresh groundwater over the first decade (1965 to 1975) supported by surface drainage improvements in the high rainfall areas of the northern zone and some canal enlargement. The operational implications of the withdrawal of the water of the eastern tributaries under the Indus Waters Treaty as well as those of the replacement works scheduled for completion during this decade are fully integrated under this program. At the end of this period (1974/75) main stem storage and regulation (Tarbela) would become available.

3.133 Over the next decade (1975 to 1985) public tubewell fields would be extended into the still undeveloped groundwater areas and increasingly would substitute for private groundwater exploitation. Simultaneously, saline groundwater areas would be provided with both vertical and horizontal drainage facilities. Canal enlargement would become increasingly important expecially in the Lower Indus Region which would also benefit from storage development at Sehwan Manchar and an associated large feeder canal. In the north additional link canal capacity would be provided in conjunction with the canal enlargement towards the end of this period.

3.134 While the broad frame of future integrated water development has thus been determined in full recognition of the numerous interdependencies and operative constraints inherent in a complex system such as the Indus Basin a number of choices remained to be made with regard to the specific allocation of resources especially during the first decade. Since this period is predominantly oriented towards fresh groundwater development the effective choices were largely limited to geographical preferences for public groundwater development.

1/ See Annex 3.2. For further discussion of the long term aspects of system operation see Chapter V.

## D. Selection of Priorities

### 1. Groundwater Development

3.135 The selection of priority areas for groundwater development had as its main objective the allocation of some 13,000 additional public wells for the period up to 1975. The allocation was made in accordance with the production potentialities of the analytical unit areas but within the framework of the various technical factors discussed in the preceding sections of Chapter III. Since no substantial variations in tubewell costs other than those associated with well capacity variations have been observed, the dominating influence in the allocation process was derived from the incremental production attainable with the installation of public wells. This IACA has expressed in terms of "net discounted benefits per four cusec well", installed in a given unit area in 1972 rather than 1977. In other words, priorities reflect the relative merits of early tubewell installation compared with installation at a later date.

3.136 The results of IACA's simplified model analysis are summarized here in terms of relative priorities amongst canal commands and parts of canal commands. 1/ Because the analysis took account of the present status of production and measured priorities in terms of attainable increments, some of the more advanced areas were given a low priority for public projects relative to the alternative private development. While, especially under application of the technical criteria discussed above, there is ample flexibility in the interpretation of these results, a pattern of priorities emerged, giving highest priority to most of the Peshawar Vale areas. Areas for which a similar but slightly lower priority was derived were Rohri North (mixing zone), Thal (fresh groundwater), Lower Chenab (fresh groundwater - perennial zone), and Bahawal below MB Link (fresh groundwater - perennial zone). Next as a general priority group, came the fresh groundwater areas and some mixing areas of the Punjab and Bahawal regions. Groundwater development in the Sind is generally given a low priority, beyond the 1965-75 program, with the exception of Rohri North and Rohri South and Dadu North. 2/ The areas that do not come within the pre-1975 priority ranking are for the most part in zones of intermediate groundwater salinity but some of these areas must for practical reasons be taken in with their contiguous fresh groundwater areas in the same commands. Notable exceptions to this general description of the lower priority group are large fresh groundwater areas in the Bari Doab and fresh groundwater areas in Ghotki. Here it is the projected benefits of private tubewell development that reduces the potential benefits of public development, though in this context some reservations might well be applied to the latter area because of a fast rising water table encountered there.

1/ For further details see IACA Report, Volume 2-A, Annexure 1, Economics, especially Table 2, page 34.
2/ See Annex 3.3.

3.137 In a separate analysis employing linear programming techniques the Bank Group has reviewed the regional allocations of scarce resources derived by IACA. The Bank Group's model, like that developed by IACA, consideres the specific implementation constraints for public groundwater development and canal remodelling. Beyond that, however, it gave explicit recognition to the scarcity of surface water during the rabi period before and after the completion of Tarbela, the scarcity of public development funds, the scarcity of foreign exchange as well as the impact of alternative growth targets for the agricultural sector. Given the difficulty of a judgment about future implementation capacity and resource availabilities, this programming exercise was used to trace the effects of alternative levels of resource availabilities upon size and composition of investment plans. When using the same assumptions about resource availability as were made by IACA, this analysis of the Bank Group confirms to a considerable extent the allocation of scarce resources derived by IACA. 1/ Within the frame of assumptions made especially with regard to private tubewell development and the absorption of additional surface water in specific areas, the analysis showed that if the scale of public tubewell program for the period 1965 to 1975 is reduced from a total of 20,000 tubewells to 17,000 the priority of tubewell projects in Shujabaad, Fordwah Sadiqia, Bahawal, and Rohri South would best be deferred for public groundwater development until after 1975.

3.138 IACA has reviewed the results of its analyses in the light of the quality of information used. On this basis IACA excluded from its development program all Peshawar Vale areas because the data base for groundwater hydrology and geology was insufficient for the purpose. In these areas further investigations would thus be called for to confirm or otherwise the high priority status so far established. In its final analysis IACA has further relied more heavily on its technical criteria where priorities derived in accordance therewith did not coincide with those established on the resource allocation model.

3.139 After exclusion of on-going groundwater development projects from its listing of priority areas IACA has determined 17 areas of sufficiently high priority to be developed through public tubewell installations in the period up to 1975. These are listed below in accordance with their regional distribution:

1/ The Bank Group's linear programming analysis is presented in detail in Part II of the Economic Annex.

Potential Priority Areas for Public Groundwater Development Before 1975

| | | Million Acres C.C.A. |
|---|---|---|
| Rechna Doab: | | |
| Lower Chenab (perennial) | - fresh area | 0.717 |
| Bari Doab: | | |
| Dipalpur above B.S. Link | - total command | 0.372 |
| Ravi-Dipalpur Link Internal | - total command | 0.595 |
| Mailsi below SM Link | - fresh area | 0.393 |
| Sidhnai (non-perennial) | - fresh area | 0.190 |
| Sutlej Left Bank: | | |
| Bahawal above MB Link | - total command | 0.051 |
| Bahawal below MB Link (perennial) | - fresh & mixing area | 0.165 |
| Bahawal below MB Link (non-perennial) | - fresh area | 0.195 |
| Qaim | - total command | 0.042 |
| Fordwah Sadiqia | - fresh & mixing area | 0.360 |
| Panjnad Abbasia | - fresh & mixing area | 0.878 |
| Indus Canals - Punjab: | | |
| D.G. Khan | - fresh area | 0.482 |
| Paharpur | - fresh & mixing area | 0.080 |
| Thal | - fresh & mixing area | 1.360 |
| Indus Canals - Sind: | | |
| Dadu North | - fresh area | 0.082 |
| Rohri North | - fresh & mixing area | 0.598 |
| Rohri South | - fresh & mixing area | 0.528 |

While the above list of priority areas accorded in principle with the general development criteria of IACA it did not yet provide a satisfactory basis for selection of project areas. Further factors had to be taken into account in project area identification and in establishing a timely sequence of development. Amongst these IACA gave special significance to the following:

(i) state of investigations required for project formulation;

(ii) introduction of Tarbela water in 1974/75;

(iii) extent of high water table and/or effective waterlogging;

(iv) estimated annual recharge;

(v) incidence of soil salinity;

(vi) the need to formulate projects on a contiguous area basis;

(vii) existing and projected private tubewell development.

The qualitative recognition of all factors, technical criteria, economic determination of priority areas, elements of project formulation, led IACA to diverge partially from the above list.

3.140 On pragmatic grounds but guided by quantitative analyses IACA has thus concentrated its proposals for new public tubewell projects before 1975 in three major regions of the Indus Basin. 1/ The project areas are identified (see Map 5) and their main groundwater characteristics are given in the following summary table. Aspects pertaining to project formulation and evaluation are discussed in Chapter IV.

1/ With the exception of Haveli (Shorkot-Kamalia).

Priority Project Areas Identified by IACA
for Public Tubewell Development before 1975

| Name of Project Area | Principal Canal Command | (000' acres) | Fresh (%) | Mixing (%) | Saline (%) | Watertable 10' (%) |
|---|---|---|---|---|---|---|
| Rechna Doab: | | | | | | |
| Shorkot Kamalia | Haveli | 294 | 76 | 11 | 13 1/ | 78 |
| Bari Doab: | | | | | | |
| Ravi Syphon Dipalpur Link | " | 595 | 43 | 45 | 12 1/ | 30 |
| Dipalpur Above BS Link | " | 372 | 92 | 8 | - | 55 |
| Dipalpur Below BS Link | " | 611 | 59 | 41 | - | 28 |
| Shujaabad | Sidhnai | 379 | 80 | 20 | - | 74 |
| Sutlej Left Bank: | | | | | | |
| Fordwah Sadiqia | " | 359 | 66 | 34 | - | 56 |
| Bahawal-Qaim | " | 522 | 64 | 36 | - | 7 |
| Panjnad Abbasia | " | 878 | 82 | 18 | - | 83 |
| Lower Indus: | | | | | | |
| Begari Sind | " | 349 | 100 | - | - | 90 |
| Sukkur Right Bank | North West and Dadu North | 273 | 59 | 41 | - | 97 |
| Rohri North | " | 598 | 75 | 25 | - | 40 |
| Rohri South | " | 528 | 76 | 24 | - | 5 |
| TOTAL | | 5,758 | | | | |

1/ CCA stated includes some drainage of saline areas and canal remodelling. The public tubewell developments alone would cover 0.257 M.Ac in Shorkot Kamalia and 0.522 M.Ac in Ravi-Syphon-Dipalpur Link.

## 2. Drainage and Flood Control Priorities

3.141 Drainage requirements resulting from a rising water table in usable groundwater zones are in general met by IACA's priorities for tubewell development. To the extent that tubewells cannot perform the dual function discussed above because of saline groundwater conditions tubewell installation for the purpose of drainage alone has been assigned lower priorities. Horizontal drainage in the form of tile drainage is proposed as pilot schemes in conjunction with the tubewell projects in Shorkot-Kamalia and the Lower Bari Doab command. In order to gain experience with this type of drainage tile drains are also proposed at an early stage in two Ghulam Mohammed Barrage commands, namely K.B. Feeder and Tando Bago. Other vertical and/or horizontal drainage works mainly associated with canal enlargement would in accordance with IACA be carried out generally in conjunction with the increase of canal capacities.

3.142 As discussed above IACA have established a need for surface drainage only in the north of the Punjab and the south of the Sind. Within these zones it did not prove possible to analyze the relative priorities for development and IACA's program for drainage depends therefore largely upon the judgments they have made in the light of their field observations.. Broadly they attach high priority to two major surface drainage schemes one being the GOP Sukh Beas Nallah scheme in the Bari Doab for which they prepared a project report 1/ and the other is LIP's proposed Left Bank Outfall scheme in the Lower Indus region (see Map 7). In addition the IACA program allows for various small drainage undertakings in the Rechna Doab and for on-going works in Ghulam Mohammed command. For the Sukh Beas project IACA propose some modifications to the GOP proposals. A descriptive summary of the main features of the project is given in Chapter IV.

3.143 The Left Bank outfall drain in the Lower Indus Region is described in Chapter V. Although the greater part of the work is programmed for execution in the period 1975-85, the expenditure to be incurred in the Third and Fourth Plan periods is large and in estimated at about Rs. 380 million. IACA endorses this scheme and its timing, although no project report is as yet available. IACA's conclusions on flood control measures have been summarized in Section C.5(b) of this Chapter. Its analysis, albeit based on very limited data, shows that there is not a strong justification for flood protection works. However, flood protection benefits are not always readily quantifiable and to the extent that lives are endangered and the general confidence is undermined such measures should be given proper prominence. For this reason, IACA has allocated some Rs. 74 million for flood protection in the Third Plan period. Once the draft flood control plan for West Pakistan, presently under preparation by the West Pakistan Flood Commission, has been finalized these allocations may need to be revised in accordance with the project content of that plan.

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1/ IACA Comprehensive Report, Volume 12A, Annexure 15B, "Sukh Beas Nallah Drainage Project".

IACA does not foresee a case for large expenditures on flood control over the next decade; however, in its program the need to deal with some of the more urgent measures of flood control and associated drainage works is recognized.

3. Canal Enlargement

3.144 IACA's analysis and allocation of canal enlargement priorities were based on the specific limitation stated in Section C.2 of this chapter that not more than one million acres of the system should be enlarged over the next ten years which, in terms of acres, is much more restrictive than the limitation imposed on public tubewell development (around ten million acres). Beyond 1975, the analyses were based on a further two million acres of enlargement works in the period 1975-79 and three million acres in 1980-85. The balance of the program needed to complete the work on the 16 million acres where limitations of canal capacity apply would be executed between 1985-2000. The allocation of priorities has been further influenced by the assumption that link canal capacities would not be increased before about 1980 and the Sehwan barrage, with its feeder canal to increase deliveries to the Lower Indus Left Bank area, would come into service in 1982.

3.145 IACA's analysis 1/ showed that prima facie there were high returns to be expected from canal enlargement in many parts of the Punjab where the groundwater was either unusable or approached the upper limit of salinity for mixing with surface water. In the Sind, Khairpur West and Khairpur East saline groundwater zones offered the most favorable returns. After taking due account of the limitations stated above, IACA derived the following priorities:

Areas with Priority for Canal Enlargement in Period up to 1975

| Command | M.Ac |
|---|---|
| Ravi-Syphon Dipalpur Link | 0.207 |
| Lower Bari Doab | 0.093 |
| Haveli (perennial) | 0.050 |
| Panjnad Abbasia (perennial) | 0.485 |
| Khairpur West | 0.124 |
| | 0.959 |

As will be seen from Chapter V these areas are slightly modified in the IACA program of works, which includes also Khairpur East, but in principle the priority allocations have been retained in the program for irrigation development. The priorities after 1975 are largely governed by the link canal program which is also treated comprehensively in Chapter V.

1/ IACA Report, Volume 2A, Annexure 1 "Economics".

# IV. PRIORITY DEVELOPMENT PROJECTS

## A. Formulation and Evaluation of Priority Projects

### 1. General Approach

4.01 In the terms of reference, IACA was required to identify projects consistent with sound agricultural development objectives and adaptable to a coordinated program for water and agricultural development in West Pakistan. Projects of high priority were to be studied in sufficient detail to determine the costs and benefits associated with the efficient application and utilization of water. The original expectation was that, excluding on-going projects, this would entail reviewing the priority status and technical aspects of projects already formulated by the Government of West Pakistan and in addition formulating new projects on the basis of regional priorities established by the Study. In the course of the Study it became apparent that - apart from Tarbela and the Sukh Beas Drainage - there were virtually no projects prepared and formulated for which financial commitments had not already been obtained or were being negotiated and which were thus 'on-going' projects and as such outside the purview of IACA. With few exceptions it therefore became necessary (contrary to the original expectation) for IACA not only to identify but also to formulate projects on the basis of the regional priorities established and discussed in Chapter III, D.5.

4.02 With the exception of surface water projects and drainage schemes all water development projects evaluated and introduced in IACA's development program for the period 1965 to 1975 are thus newly formulated projects. In its approach to project formulation IACA has made use of the information made available to it by the Government and its consultants and has supplemented existing studies and investigations by field inspection and detailed studies and investigations of its own. All the projects formulated by IACA have as their central objective the further development of water resources for irrigation and the efficient utilization of existing and enhanced irrigation supplies within the project areas. The review and evaluation of IACA's project proposals by the Bank Group is set out in more detail in Annex 4.1 "Report on Project Content of the Program for Development of Irrigation and Agriculture in West Pakistan", and is summarized below. IACA has not formulated and evaluated any non-water development activities in the form of projects nor has it attempted to establish functional priorities for non-water activities. The following discussion of projects formulated and evaluated by IACA and their integration into an internally consistent development program is therefore limited to the development of water resources and their use for agriculture.

## 2. Surface Water Projects - Tarbela Dam

### (a) Background

4.03 The harnessing of unregulated and wasteful river flows beyond the surface water storage development at Mangla and Chasma is of high priority for the augmentation of rabi supplies throughout the irrigation system. This is particularly the case in areas where either groundwater mixing is required or where the groundwater is not suitable for irrigation. The various alternative possibilities of providing river regulation and storage facilities are discussed in the Bank Group's report on Surface Water Storage. 1/ Here the discussion is limited to the first stage storage development selected and the likely benefits obtainable from this.

4.04 In accordance with the Memorandum of Understanding (dated November 14, 1963) between the President of Pakistan and the President of the World Bank the first part of the Indus Special Study was devoted to the preparation of a report on the "technical feasibility, the construction cost and the economic return of a dam on the Indus at Tarbela". The assessment of the Tarbela project thus had to proceed before a comprehensive appreciation of the needs for further development of the irrigation system as a whole was available. The evaluation of Tarbela in isolation was completed by IACA on November 15, 1964. On the basis of the IACA studies the Bank Group concluded in its "Report on a Dam on the Indus at Tarbela", dated February 15, 1965, that:

(i) the Tarbela project was technically feasible;

(ii) the financial requirements for construction of the project would amount to US$ 900 million, including power installations but before Pakistan duties and taxes;

(iii) the return to the economy from agriculture and power would be about 12 percent.

The Memorandum of Understanding further provided that if the Tarbela project was found justified on the basis of the first phase of the study, funds available in the Indus Fund after appropriate provision for the Indus Basin Works proper would be available for use on Tarbela.

4.05 Consequently the Bank Group in their Guidelines, issued to the consultants on March 26, 1965, stipulated that IACA in its projections for future water development had to assume the completion of the Tarbela Dam by October 1973 or 1974. 2/ Nevertheless, the Bank Group felt obliged

1/ Volume III, Program for Surface Water Storage Development.
2/ Subsequently the target date had to be revised to August 1975 because of further likely delays in the starting date of construction. Partial storage has been assumed for the rabi season 1974/75.

to ascertain in accordance with para 9(e) of the Guidelines that the evaluation of Tarbela project in isolation would also be valid in the context of the comprehensive phase of the Study. In its endeavor to evaluate Tarbela as an integral part of the system development as a whole the Bank received valuable advice from its coordinating consultant, Sir Alexander Gibb and Partners of London, see Annex 4.1. 1/

4.06 The Tarbela project being the first choice for further storage development in the Indus Basin the discussion of surface water projects in the context of "Priority Projects" is limited to this project only. 2/ The indicative sequence of further storage development beyond the ten-year period (1965-75) is discussed in Chapter V below.

(b) Tarbela Dam

4.07 Construction of the Tarbela Dam is the main element of the Action Program for the further development of gravity irrigation. The Tarbela reservoir as proposed would initially contain 11.1 MAF of gross storage with a live storage of 9.3 MAF at a minimum drawdown level of 1,300 feet. For purposes of irrigation planning commensurate with the needs of power development IACA has adopted a drawdown level of 1,332 feet resulting in an initial live storage availability of 8.6 MAF. Because of the high silt content of the Indus water and the associated sediment deposition in the reservoir the live storage would decrease over time. It is estimated that the reservoir would silt up during a period of approximately fifty years after which time the regulating capacity of the reservoir would be about one MAF. Details of the physical works of the dam, the analyses of variations of the drawdown level, and the pattern and rate of sediment deposition are given in the Bank Group's report, Volume III, "Program for Development of Surface Water Storage".

4.08 As stated above, construction of Tarbela Dam was assumed to be completed in time to serve the crops in the rabi season 1974/75. Since it no longer seems feasible to complete construction in time to permit impounding of the full amount of 8.6 MAF by that date IACA has assumed that a limited amount of five MAF - equal to the projected storage requirements of the rabi season 1974/75 - would be impounded during the flood season of 1974. The encountered delay in the start of construction would therefore not affect the irrigation program outlined by IACA. Allowing for sedimentation the storage volume available for irrigation releases at reference years would be as follows:

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1/ Annex 4.1 - the Tarbela Report, Evaluation of the Tarbela Project within the Development Program of the Indus Basin. Sir Alexander Gibb and Partners, London, November 1966.

2/ In this context the raising of Chasma Barrage is considered an ongoing project.

Tarbela Storage Capacity for Irrigation Releases
(MAF)

| On Completion | 1985 | 2000 |
|---|---|---|
| 8.6 | 7.4 | 5.35 |

According to the IACA program impounding to top water level, i.e. 8.6 MAF, would still become possible by the flood season of 1975 with full availability of storage during the release period 1975/76.

4.09 The cost estimates included in the Bank Group's report of February 15, 1965 remain virtually unchanged. Total investment requirements including power facilities, allowance for inflation, and financial contingency are estimated to total about US$ 900 million (Rs. 4,284 million equivalent) with a foreign exchange component of about US$ 559 million. The economic costs proper excluding transfer items and expenditures incurred prior to January 1, 1964 would amount to US$ 625 million (Rs. 2,976 million equivalent), with a foreign exchange component of about US$ 390 million. Details of the cost estimates are given in the Bank Group's report, Volume III, "Program For the Development of Surface Water Storage". Expenditures would extend over a period of about eleven years including pre-contract cost incurred since the beginning of 1965.

(c) Function of Tarbela

4.10 Historically the development of water resources in the basin of the Indus and its tributaries has been concentrated in the eastern part of the Punjab, now partially located in India, because the greater part of the irrigable land lies on the eastern side of the Indus Plains. The future diversion of the flows of the eastern tributaries for Indian use under the terms of the Indus Waters Treaty makes it necessary to transfer substantially larger water resources located in the west for use in the eastern parts of the Pakistan Punjab. This is presently being provided for by the construction of a system of large link canals which will transfer Indus waters from the west to the east nearly as far as Islam Barrage (see Map 6).

4.11 In the absence of storage these diversions will be entirely dependent on the natural flow of the Indus and its tributaries which are largely concentrated in the period from April to October providing mainly water for kharif use. However, even under natural flow conditions there are frequent water shortages for early and late kharif needs. For winter cropping (rabi) the absence of adequate river flows during the period from October to March constitutes a high risk element from which especially the strategically important wheat crop suffers. After Mangla, which will regulate the river flows of the Jhelum, the Tarbela project storing for release about 8.6 MAF on the Indus would thus be the logical continuation of a shift in water development from the smaller eastern tributaries to the major Indus resources in the west. Because of its regulating effect between seasons Tarbela would augment total available irrigation supplies by storing surplus flows of the Indus in the summer for use in the rabi months.

4.12 The functional contribution of the Tarbela project in the future development of irrigation can thus be summarized under these main aspects:

(i) the project is a further step in exploiting the huge water resources in the Indus presently flowing to the sea partially unused;

(ii) the project would provide augmented irrigation supplies and benefit in particular wheat production by increasing the reliability of irrigation supplies for rabi crops as well as the total volume of winter supplies;

(iii) the project would enable an extended utilization of the link canal system by diversion of storage releases through the link canals for use in the central parts of the basin;

(iv) the project would increase the recharge to groundwater and so add to the recoverable recharge in usable groundwater zones.

In quantitative terms the regulating effect of Tarbela would increase the mean flows of the Indus from mid-October to mid-April by about 65 percent. 1/ The immediate utilization of such a large increase during one season may be difficult to achieve by the benefiting farmers but the Bank Group believes that most of the Tarbela storage releases would be rapidly absorbed since the farmers have generally over-extended their cropped acreage relative to existing irrigation supplies in the rabi season.

(d) Interdependence of Tarbela and Water Development Plan

4.13 In formulating its water development plan IACA assumed the availability of Tarbela storage by 1975 as discussed above. The increase of Indus flows during rabi by 65 percent at a pre-determined point in time from a single indivisible source must of necessity carry consequences for associated resource development activities proposed under an integrated program. These consequences relate in particular to the determination of priorities for groundwater development, canal enlargement, and the need for reallocation of surface water supplies. The implications relevant for planning can be summarized as follows:

(i) the need to prevent further deterioration in seriously waterlogged areas requires the provision of sufficient groundwater table control before additional surface water from Tarbela can be admitted. The location and timing of tubewell projects providing such control had thus to be seen in the light of the existence of Tarbela storage by 1975;

1/ Measured at Attock.

(ii) the need for canal enlargement is dependent upon the increase of surface water supplies at critical months during which existing canal delivery capacities would have a restraining effect on further development. Existing capacities are designed largely to meet kharif needs and are in general under-utilized during rabi. However, increased supplies during rabi would also require additional deliveries during the months when kharif and rabi requirements overlap and are likely to exceed delivery capacities. Where this occurs the integration with groundwater development would relieve the constraint by concentrated pumping during overlap months;

(iii) the timing of the development of areas underlain by groundwater which would either require mixing with fresh surface water or would not be usable for irrigation. The further development of these areas would be dependent on the additional availability of surface supplies.

The IACA program for irrigation development (see Chapter V) takes full account of these implications and treats Tarbela as an integral part of a set of mutually dependent water development activities.

4.14 While there is some flexibility with regard to the timing of Tarbela in the context of IACA's development program, any deferment would have the following consequences:

(i) priorities for tubewell development and the feasibility of mining would need to be re-appraised;

(ii) canal enlargement could assume increased importance;

(iii) development of the Lower Indus region would be slowed down since it depends on main-stem storage for additional rabi surface supplies;

(iv) agricultural growth would be adversely affected and importantly the projected production increases in wheat would be jeopardized.

In the absence of an alternative development program without storage equivalent to Tarbela the repercussions of a deferment cannot be quantitatively assessed. 1/ As far as alternative sequences of storage development are

1/ An attempt to quantify the effects of Tarbela deferment has been made in the Bank Group's Methodological Annex Part II, "A Linear Programming Analysis of Irrigation Development Potentialities in the Indus Basin." This confirms that in terms of net present worth at 8% the deferment of Tarbela would be more costly to the economy of West Pakistan than the implementation of the proposed program.

concerned these would largely carry similar implications. In the latter case the problem would be reduced to a comparison of least cost and least risk alternatives which has been set out in Annex 4.1, "Report on the Project Content of the Water Development Program for West Pakistan".

(e) Tarbela Benefits

4.15 In the context of the comprehensive phase of the Indus Special Study it became possible to assess the Tarbela benefits in terms of its contributions within the system as a whole. IACA has assessed the value of stored water from Tarbela in terms of its availability under mean year flow conditions during the so-called scarce period of the rabi season. This period of scarcity 1/ has been defined by IACA as the period during which the water requirements of projected rabi intensities would either exceed the existing diversion capacities or the available unregulated river flows. In general, the scarcity has been determined within existing canal capacities except for the period after 1985 when canal enlargement would be expected to figure more prominently in the development program. Within any storage release season the scarce water period was thus taken to be generally that period of the rabi season during which irrigation demands measured at the rim stations would exceed the river inflow under mean year flow condition.

4.16 The value of scarce rabi water has then been determined by relating total rabi production to total scarce rabi water availability. In accordance with this concept IACA has determined the following values per acre foot of scarce rabi supplies for reference years: 2/

Value per Acre Foot of Scarce Rabi Water
as Estimated by IACA

| | 1975 | 1985 | 2000 |
|---|---|---|---|
| Rs/Acre Foot at Watercourse Heads: | 135 | 150 | 171 |

This does not include benefits resulting from recoverable recharge due to additional surface water deliveries during the rabi season.

4.17 The specific scarcities employed by IACA for the evaluation of Tarbela water would result from increasing rabi intensities supported by additional groundwater pumping at the beginning and at the end of the rabi season. In this way, the pumping pattern assumed by IACA would create an additional water demand for the interim period of the rabi season which would in turn be met by Tarbela releases. The combined beneficial effects of groundwater pumping and storage releases have then been attributed to

1/ 1975: November to March
1985: November to April
2000: October to May

2/ For further details see Annex 4.1, Chapter I, B.

the volume of water available during the period of scarcity. The specific scarcity during the rabi season, as defined by IACA, would be dependent on the associated increased water availability during the early and late rabi. This would generally be provided from groundwater. Because the latter is not included in the scarcity definition, IACA's approach tends to overstate the value of Tarbela water. To reflect the interdependence the value of additional water in the rabi season would need to be adjusted by extending the definition of scarcity to all rabi supplies contributing to rabi intensity growth. Alternatively it could be recognized in terms of the economic costs incurred in providing incremental supplies in early and late rabi (e.g. tubewell pumping).

4.18 IACA's approach also implies that the marginal value of scarce rabi water is equal to its average value. This would assume constant returns to scale at any point in time and also under conditions of surpluses associating with the sudden availability of rather large quantities of water germane to the nature of storage development. This has been partly recognized by IACA in valuing only those quantities of scarce rabi water which are expected to be readily and efficiently absorbed by farmers and by neglecting any excess availabilities.

4.19 IACA's approach was largely necessitated by the absence of an alternative water development program which would minimize the requirement for stored water by a redistribution of the annual groundwater pumping pattern and the possible introduction of groundwater mining. It is further argued by IACA that such a comparison of alternative sequences of water development would have required the determination of priorities under conditions of no stored water availability beyond Mangla and Chasma. This, IACA believes would have led to a different combination of groundwater development priorities than the ones established in conjunction with large-scale main-stem storage development. However, since IACA was required to plan the cohesive irrigation development program on the basis of main-stem storage availability by 1974 as a given item, its evaluation of Tarbela is in full accordance with the terms of reference. On this basis, and allowing for operation and maintenance expenditures as well as adding the net value of recharge from the additional surface water used, IACA has arrived at a return on the investment for Tarbela of 13.3 percent inclusive of power benefits. 1/ The details of the evaluation are set out in Annex 4.1, "Report on the Project Content of the Water Development Program for West Pakistan." 2/

4.20 In testing the results of IACA's evaluation the Bank Group has introduced a number of different assumptions relevant to the reservations expressed above on the IACA methodology. Two separate analyses have been

1/ In its evaluation IACA has used the power benefits as shown in the Bank Group's Tarbela Report of February 15, 1965.

2/ See also Annex 4.1, especially Appendix 1, Sir Alexander Gibb and Partners, "The Tarbela Project", London, November 1966.

carried out of which the first one employs the IACA data but relates total rabi supplies to total rabi production values in the determination of the value of rabi water in the system over time. The second analysis makes use of the average value per acre foot of incremental water in priority project areas as determined in the Bank Group's project reviews. 1/ In this case the total quantity of Tarbela water is assumed to be distributed and used by farmers throughout the system on the basis that in the short-term temporary rises of the water table could be tolerated in the interest of rapid increase in production and that farmers would have sufficient flexibility with regard to cropping intensities to absorb the marginal quantities of Tarbela water which have been given no value under the IACA approach. In the Bank Group's analysis costs incurred for additional recharge pumping have been charged only for the quantity assumed to be recovered for use plus saline recharge pumping but not for drainage pumping in fresh water zones.

4.21 The average values per acre foot of incremental water used in the Bank Group's analysis reflect the effect of additional water on both the kharif and rabi seasons. Tarbela is thus regarded as an additional source of water within a fully integrated water supply schedule supporting the agricultural production process as a whole. This appears justifiable on the basis that the growing degree of integration of groundwater and surface water supplies would make the contributions to production of the various sources of water supply increasingly indistinguishable. It also tends to give a more adequate picture of the nature of the development envisaged by IACA under which tubewell pumping patterns, canal diversions and storage releases would be operationally integrated to serve a specified agricultural production cycle. The evaluation based on project reviews extrapolates the average value of incremental water established in project areas to the total quantities available from Tarbela within as well as outside the project areas.

4.22 For purposes of comparison the results of the IACA evaluation, the two test analyses and the results of the Bank Group's report of February 15, 1965 are set out below:

1/ See Annex 4.1, "Report on the Project Content of the Water Development Program for West Pakistan."

Results of Tarbela Evaluation

| | IACA Evaluation | Modified IACA Evaluation | Bank Group Evaluation I 1/ | Bank Group Evaluation II 2/ | 1965 Bank Group Evaluation |
|---|---|---|---|---|---|
| Net Present Worth of Benefits at 8% (Rs. million) | 3,770 | 3.353 | 1,994 | 2,241 | 3.537 |
| Power Benefits as % of Total | 10% | 10.7% | 18.3% | 27.3% | 18.3% |
| Benefit/Cost Ratio (at 8%) | 1.9 | 1.89 | 1.1 | 1.2 | 1.9 |
| Rate of Return | 13.3% | 12.5% | 8.4% | 9.2% | 13.3% |

1/ Using IACA power benefits.
2/ Using power benefits as assessed in Bank Group's Report, Volume IV.

The power benefits as indicated on page 128, have been included in the evaluation. However, for purposes of the Bank Group's evaluation II, the power benefits assessed on the basis of the comparison of most feasible alternatives in Volume IV have been used. Depending on the variations in the assessment of agricultural and power benefits the latter would vary between ten percent and 27 per cent of total discounted benefits. 1/

4.23 While the above results may be indicative of the range within which the return from Tarbela is likely to fall it is most difficult to establish more than a representative evaluation because of the complex technical interdependencies of the project with other water development activities and the resulting joint cost and benefit occurrences. The efficiency of this project has of necessity to be seen in terms of its functional contribution within an integrated system. The value of surface water storage is enhanced by the presence of large tubewell fields. Simultaneously the provision of main-stem storage greatly improves the value of tubewell development. The development of the two sources of irrigation supplies not only leads to a greater flexibility in the operation of the system but because of incremental groundwater recharge from regulation of surface water flows both tubewell fields and reservoir operate at a greater efficiency.

4.24 The need to develop a balanced supply of irrigation water which reduces the risks involved in the development of groundwater only makes the exploitation of main-stem storage opportunities the most logical next step in surface water development in West Pakistan. The Bank Group is satisfied that the provision of main-stem storage in conjunction with groundwater

1/ Details of the evaluations and assumptions used are given in Annex 4.1: "Report on the Project Content of the Water Development Program for West Pakistan".

development is essential to meet the irrigation requirements projected to prevail in the 1970's. The Bank Group's analyses 1/ show that Tarbela could provide such storage at reasonable cost and would thus make a substantial contribution to the growth of agricultural production as well as towards meeting future power needs. While alternative sequences of storage development appear possible 2/, the Bank Group is similarly satisfied that the Tarbela project would have to be included in any sequence 3/, though possibly at different points in time. Considering the fact that no other storage project of a similar magnitude, which would transfer the irrigation development to the main-stem of the Indus, is advanced enough in preparation and design to effectively compete with Tarbela by 1975, the Bank Group firmly believes that the project should be executed as scheduled.

## 3. Tubewell Projects

### (a) Basic Considerations

4.25 On the basis of criteria discussed in Chapter III, IACA has formulated tubewell projects generally covering from about 300,000 to 800,000 acres and designed to pump on average the mean annual recharge to the aquifer. The additional irrigation supply from groundwater together with existing surface supplies and their anticipated improvements in quantity and seasonal distribution would be generally sufficient to obtain cropping intensities of about 150 percent at full delta irrigation applications in fresh groundwater areas.

4.26 Where, in the interest of formulating projects on a contiguous land base, it became desirable to include mixing zones within the priority project areas, the cropping intensities tend to be influenced by the availability of surface supplies for mixing with groundwater at watercourse heads. Owing to limitations of canal capacities this would result in somewhat lower intensities in mixing zones which in turn, dependent on the extent of the mixing area, would lead to overall lower intensities for the specific projects. However, to the extent that project intensities are always based on full delta applications there would be some opportunities for further increases of intensity, though at some under-watering, subject to the qualifications discussed in Chapter II.

### (b) Projects Formulated

4.27 IACA has formulated 12 public tubewell projects concentrated principally in three regions, the Bari Doab, Sutlej Left Bank and Lower

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1/ See also Bank Group's report, Volume III: "Program for Development of Surface Water Storage" and Volume IV: "Program for the Development of Power".

2/ See Bank Group's report, Volume III, Figures 13 and 14, and also Appendix 1 of Annex 4.1 (Figures 12 through 18).

3/ With the exception of the sequence shown in Figure 14 of Volume III in which the Kalabagh proposal assumes the place of Tarbela.

Indus Region. The total number of tubewells included in these projects would amount to 11,403 of which 4,867 would be of about four cusec capacity and 6,316 of about three cusec capacity. 1/ The projects would cover a total CCA of about 5.8 million acres. All tubewell projects formulated have been reviewed by the Bank Group and the findings are given in Annex 4.1. The following table sets out the salient features of each of the projects:

1/ Variations in capacity result largely from the different pattern of pumping requirements in fresh groundwater and in mixing zones. In mixing zones capacities would vary from two to three cusecs.

## Groundwater Development Projects Identified and Formulated by IACA

| Project | CCA ('000 acres) Fresh-water Zone | CCA ('000 acres) Mixing Zone | CCA ('000 acres) Total | Number of Wells 4 Cusec | Number of Wells 3[1] Cusec | Number of Wells Total | Installed Capacity (cusec) | Depth to Water Table (% of Project Area) Less than 10' (Per Cent) | Depth to Water Table (% of Project Area) More than 10' (Per Cent) | Groundwater Pumped at Full Development (MAF) | Ultimately Attainable Cropping Intensity (Per Cent) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Rechna Doab:** | | | | | | | | | | | |
| Shorkot Kamalia | 222 | 72[2] | 294 | 370 | 56 | 426 | 1,650 | 78 | 22 | 0.61 | 149 |
| **Bari Doab:** | | | | | | | | | | | |
| Dipalpur Above B.S. Link | 344 | 28 | 372 | 580 | 50 | 630 | 2,460 | 55 | 45 | 0.76 | 150 |
| Dipalpur Below B.S. Link | 362 | 249 | 611 | 473 | 377 | 850 | 3,020 | 28 | 72 | 1.01 | 150 |
| Ravi Syphon-Dipalpur | 257 | 338[2] | 595 | 440 | 340 | 780 | 2,600 | 30 | 70 | 0.98 | 150 |
| Shujaabad | 303 | 76 | 379 | 576 | 149 | 725 | 2,730 | 74 | 26 | 0.98 | 149 |
| **Sutlej Left Bank:** | | | | | | | | | | | |
| Fordwah Sadiquia | 237 | 122 | 359 | 495 | 170 | 665 | 2,420 | 56 | 44 | 0.86 | 145 |
| Bahawal Qaim | 335 | 187 | 522 | 618 | 306 | 924 | 3,290 | 7 | 93 | 1.22 | 146 |
| Panjnad Abbasia | 716 | 162 | 878 | 1,315 | 308 | 1,623 | 6,110 | 83 | 17 | 2.37 | 148 |
| **Lower Indus:** | | | | | | | | | | | |
| Rohri North | 451 | 147 | 598 | - | 1,580[3] | 1,580 | 4,210 | 40 | 60 | 1.21 | 145 |
| Rohri South | 400 | 128 | 528 | - | 1,500[3] | 1,500 | 3,730 | 5 | 95 | 1.14 | 130 |
| Begari Sind | 349 | - | 349 | - | 880 | 880 | 2,640 | 90 | 10 | 0.72 | 150 |
| Sukkur Right Bank | 160 | 113 | 273 | - | 820 | 820 | 2,120 | 97 | 3 | 0.72 | 150 |
| **Total:** | 4,136 | 1,622 | 5,758 | 4,867 | 6,536 | 11,403 | 36,980 | 49 | 51 | 12.58 | 150 |

1/ The capacities of wells included under this category would vary from 2 to 3 cusec.
2/ Including some saline areas for which tile drainage proposals have been made by IACA
3/ Including tubewells required on remodelling.

The location of individual tubewell project areas is shown on Map 5.

4.28 Of the total of 5.8 million acres CCA covered by the projects about 4.1 million acres or 71 percent would be in fresh water zones. In about 49 percent of the total area covered groundwater would be pumped initially from a depth of less than ten feet. The total installed capacity would amount to about 37,000 cusecs, designed to extract about 12.6 MAF at full development. The ultimate cropping intensity achievable in the project areas at full delta varies from 145 percent to 150 percent. In general the ultimate intensity level would be achieved within about ten years after initiation of the project and depending on the level of intensity presently prevailing.

(c) Cost Estimates

4.29 IACA's estimates of investment costs are based on recent experience with bids submitted by international contractors plus separate allowances for overheads of the implementing agency. In general, IACA demonstrates an economy of scale with regard to tubewell capacities of about the following order:

IACA Assessment of Capital Costs of Varying Capacity Tubewells 1/

| Capacity | Cost/Tubewell | Cost/Cusec | Cost Index per Cusec |
|---|---|---|---|
| | ------(Rs. '000)----- | | |
| 5 cusec | 103 | 20.6 | 100 |
| 4 cusec | 90 | 22.5 | 109 |
| 3 cusec | 81 | 27.0 | 131 |
| 2 cusec | 72 | 36.0 | 175 |

1/Before customs duties and interest and without power distribution and transmission.

The five cusec well would appear the most economical size. However, the area covered by an individual tubewell (watercourse), the aquifer characteristics, and the pumping requirements under an integrated system of surface and groundwater supplies generally limit the capacity to about four cusecs or less. In the fresh groundwater zones, IACA has based its cost estimates on a four cusec capacity well. Where mixing is required the capacity of an individual tubewell would be generally less than four cusecs and the costs per cusec proportionately higher 1/ The average capital cost per four cusec well, estimated by IACA at Rs. 90,000, would consist of the following:

1/ For details see IACA Comprehensive Report, Volume 5, Annexure 7.

Summary Breakdown of IACA Cost Estimates
per four cusec well

| | Rs. '000 |
| --- | --- |
| Tubewell Construction (excluding power transmission and distribution) | 62 |
| Contingency and Engineering (30%) | 18 |
| Buildings, Maintenance Equipment, Administration and Supervision During Construction | 10 |
| | 90 |

The foreign exchange component of these costs has been estimated by IACA to consist of 62.5 percent of the tubewell construction, 100 percent of plant, machinery and maintenance equipment, and 20 percent of staff housing and buildings, or roughly equivalent to 62 percent of the above shown costs. While no detailed assessment has been made by IACA of duties and taxes since these are liable to vary over time the consultant has generally assumed that these expenditures would amount to about 30 percent of the foreign exchange component. In IACA's assessment total financial requirements per four cusec tubewell before interest during construction would thus amount to about Rs. 102,300.

4.30 In its review of the IACA cost estimates the Bank Group has made some adjustments consisting mainly of the following elements:

(i) an allowance of five percent of direct costs (before contingencies) for project preparation;

(ii) an allowance for improvement of watercourses of Rs. 10/ acre CCA;

(iii) separate allowances for engineering and administration during construction of ten percent of direct costs after duties and taxes;

(iv) contingency allowances of 20 percent of direct costs including duties, taxes, administration and engineering;

(v) a reduction in the duties and taxes from 30 percent of the foreign exchange component to 15 percent;

(vi) a downward adjustment in the unit cost of pumphousing.

Including duties and taxes but before interest during construction the financial requirements per four cusec well in the Bank Group's assessment would thus amount to about Rs. 120,000 or an increase of about 20 percent. 1/

1/ This figure is exclusive of power transmission and distribution. If power is added in to the total the difference between the IACA and the Bank Group estimates is reduced to about 10 percent.

The Bank Group's more liberal allowance for contingencies, supervision and administration during construction, and improvements of internal water distribution facilities are intended to take account of the very preliminary state of project preparation, the increasing burden of supervision and administration of a rapidly expanding groundwater development program, and the need to support farmers in watercourse improvements to ensure immediate and efficient use of the groundwater made available by the projects.

4.31 The cost estimates of individual tubewell projects would vary in accordance with the proportion of lower capacity wells included under the projects as well as with specific requirements of each project area. Following in general the above estimation procedures the financial requirements before interest but including power transmission and distribution for the 12 projects formulated by IACA would compare as follows:

Financial Requirements of the Tubewell Projects Formulated by IACA
(including electrification)

| | IACA Estimate | | Bank Group Estimate | |
|---|---|---|---|---|
| | Foreign Exchange | Total | Foreign Exchange | Total |
| | ------- (Rs. mill) -------- | | | |
| Shorkot-Kamalia | 34.5 | 73.2 | 35.5 | 80.6 |
| Dipalpur Above B.S.Link | 48.5 | 97.2 | 49.9 | 104.4 |
| Dipalpur Below B.S.Link | 64.8 | 129.8 | 65.8 | 140.4 |
| Ravi Syphon-Dipalpur | 67.6 | 135.4 | 75.2 | 189.8 |
| Shujaabad | 55.2 | 110.5 | 55.5 | 117.4 |
| Fordwah Sadiqia | 50.6 | 101.6 | 52.3 | 109.5 |
| Bahawal Qaim | 69.5 | 139.3 | 70.6 | 148.6 |
| Panjnad Abbasia | 123.4 | 247.1 | 124.0 | 261.9 |
| Rohri North | 100.7 | 203.0 | 99.5 | 212.2 |
| Rohri South | 87.7 | 176.9 | 88.3 | 185.4 |
| Begari Sind | 59.5 | 119.8 | 60.1 | 126.0 |
| Sukkur Right Bank | 52.9 | 106.7 | 52.8 | 111.0 |
| TOTAL | 814.9 | 1,640.5 | 829.5 | 1,787.2 |

Details of the cost estimates for individual projects are given in Annex 4.1, "Report on the Project Content of the Water Development Program for West Pakistan".

4.32 Considering the IACA estimates and the Bank Group's revised assessment for the specific projects as the range within which the capital costs of groundwater development in West Pakistan are likely to fall the following general cost criteria can be obtained:

Range of Capital Costs for Public Tubewell Projects 1/

| | |
|---|---|
| Rs. per tubewell on average over all capacities included: | 143,860 - 156,730 |
| Rs. per cusec of installed capacity: | 44,360 - 48,330 |
| Rs. per acre CCA over all areas included: | 285 - 310 |

1/ Total costs including electrification, duties and taxes.

The spread of about 10 percent in addition to the contingency allowances of 20 percent included would appear to provide an adequate safety margin for the high degree of uncertainty necessarily implicit in the tentative formulation of the 12 projects proposed.

(d) Interdependence of Tubewell Projects and Water Development Plan

4.33 As has already been pointed out above under (2) "Surface Water Projects" groundwater and surface water developments are mutually dependent to a considerable extent. With the exception of the Sukkur Right Bank project all tubewell projects would eventually absorb additional surface supplies becoming available after completion of Tarbela. In the early period of operation of the tubewell projects some substitution of existing supplies would be possible because of the need to over-pump the aquifer for purposes of lowering the groundwater table. The generally attainable cropping intensity of 150 percent would thus be supported by incremental supplies from groundwater as well as surface water.

4.34 Neglecting minor variations in timing of tubewell installations likely to occur in the process of program implementation the integrated increases in irrigation supplies as well as possible substitution effects are demonstrated in the following table:

## Integrated Increase in Irrigation Water Availability in Priority Project Areas

| | Groundwater | | | Surface Water | | | Net Increment: Groundwater 1/ | | Net Increment: Surface Water | | Total Net Increase | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Existing 1/ | 1975 | 1985 | Existing | 1975 | 1985 | 1975 | 1985 | 1975 | 1985 | 1975 | 1985 |
| | -------- (MAF) -------- | | | | | | | | | | | |
| Shorkot Kamalia | 0.11 | 0.53 | 0.61 | [illegible] | 0.60 | 0.69 | 0.42 | 0.50 | 0.12 | 0.14 | 0.54 | 0.64 |
| Dipalpur Above B.S. | 0.20 | 0.64 | 0.76 | 0.37 | 0.55 | 0.69 | 0.44 | 0.56 | 0.18 | 0.32 | 0.62 | 0.88 |
| Dipalpur Below B.S. | 0.38 | 0.89 | 1.01 | 0.71 | 1.06 | 1.37 | 0.51 | 0.63 | 0.35 | 0.66 | 0.86 | 1.29 |
| Ravi Syphon-Dipalpur | 0.28 | 0.87 | [illegible] | 0.67 | 0.81 | [illegible] | 0.59 | 0.69 | 0.14 | 0.17 | 0.73 | 0.86 |
| Shujabad | 0.24 | 0.78 | 0.98 | 0.64 | 0.79 | 0.82 | 0.54 | 0.74 | 0.15 | 0.18 | 0.69 | 0.92 |
| Fordwah Sadiquia | 0.10 | 0.61 | 0.86 | 0.49 | 0.45 | 0.69 | 0.51 | 0.76 | (-) 0.04 | 0.20 | 0.49 | 0.96 |
| Pahawal Qaim | 0.17 | 0.90 | 1.22 | 0.91 | 0.82 | 1.13 | 0.73 | 1.05 | (-) 0.09 | 0.22 | 0.64 | 1.27 |
| Panjnad Abbasia | 0.27 | 1.66 | 2.37 | 1.81 | 2.08 | 2.20 | 1.39 | 2.10 | 0.27 | 0.39 | 1.66 | 2.49 |
| Rohri North | 0.02 | 1.07 | 1.21 | 1.45 | 1.27 | 1.71 | 1.05 | 1.19 | (-) 0.18 | 0.26 | 0.87 | 1.45 |
| Rohri South | 0.03 | 0.91 | 1.14 | 1.10 | 0.76 | 1.28 | 0.88 | 1.11 | (-) 0.34 | 0.18 | 0.54 | 1.29 |
| Begari Sind | 0.02 | 0.63 | 0.72 | 0.65 | 0.62 | 0.81 | 0.61 | 0.70 | (-) 0.03 | 0.16 | 0.58 | 0.86 |
| Sukkur Right Bank | 0.01 | 0.64 | 0.72 | 0.94 | 0.50 | 0.60 | 0.63 | 0.71 | (-) 0.44 | (-) 0.34 | 0.19 | 0.37 |
| Total: | 1.83 | 10.13 | 12.58 | 10.22 | 10.31 | 12.76 | 8.30 | 10.74 | 0.09 | 2.54 | 8.41 | 13.28 |

1/ Existing groundwater supplies are provided from private tubewells and Persian wheels. The incremental groundwater supplies shown for 1975 and 1985 would be net of existing private supplies. This would somewhat overstate the contribution of public wells since further private development would be expected until beginning of construction of the public projects. Account has been taken of this in project evaluation.

Of the total net increase in water availability at watercourse heads of 13.3 MAF within the project areas by 1985 surface supplies would contribute about 2.6 MAF or nearly 20 percent. Most of the additional surface supplies would be required during the rabi season which presupposes river regulation by storage. Assuming a loss factor of about 45 percent for distribution between storage sites and watercourses the additional surface supplies required by the priority project areas by 1985 would be about 5.4 MAF at rim stations.

4.35 Considerably less additional surface supplies (about 0.2 MAF at rim stations) would be required by project areas in 1975 partly because of the need for initial over-pumping for the lowering of the groundwater table. As groundwater development would proceed and spread throughout the canal commanded area of the Basin the supply and use of stored water would be increasingly integrated with groundwater supplies providing both for increased flexibility in the irrigation system operation as well as in reliability of supplies during critical periods.

(e) Benefits of Tubewell Projects

4.36 Benefits of tubewell projects have been estimated by IACA on the basis of projections of agricultural growth "with" public tubewell development as compared to projections of growth "without" such development. For the "without" case separate estimates have been made for continuing private groundwater exploitation and the likely growth of agricultural production in the absence of any further water development. Detailed water budgets for the individual project areas have been developed by IACA to determine the likely future irrigation regimen supporting the growth of agiruclt ural production under respective conditions of development. On the basis of these water budgets future cropping patterns and cropping intensities have been projected in accordance with the concepts discussed in Chapter II. By comparing the development of the "with" case against that of the "without" case the benefits of public tubewell investments have been measured in terms of the increment of production obtainable under project conditions. In these calculations allowance has been made for all associated current costs including on-farm expenditures and operation and maintenance costs of the projects proper. IACA, however, did not distinguish between the sources of additional irrigation supplies but attributed the total increment to the project, i.e. the investment in public tubewells.

4.37 In reviewing the benefit evaluation of the individual tubewell projects account has been taken by the Bank Group of the relative contributions to be made by the two principal sources of increased irrigation supplies, namely additional groundwater and additional surface water assumed to be used under the project. In measuring incremental production without further water development after the start of the projects account has also been taken of the displacement of existing and projected private tubewells. Furthermore, wherever deemed technically feasible a check has been made against the alternative of stimulated and accelerated private tubewell development instead of public projects. 1/

4.38 Compared to the IACA evaluations the Bank Group in its project reviews has made some adjustments of which the more important are the following:

(i) allocation of benefits to incremental surface supplies introduced under the project;

(ii) independent projections of yields and incremental production for both the conditions of further groundwater development and no further water development in project areas;

(iii) adjustment of cost estimates (see para 4.30);

(iv) treatment of potential savings to private sector as an addition to benefits rather than a reduction in project costs.

Of these, the allocation of benefits to incremental surface water has quantitatively the biggest impact and should be kept in mind when comparing the results of IACA's and the Bank Group's evaluation results.

4.39 Three criteria have been employed for evaluation purposes:

(i) the internal rate of return;

(ii) benefit/cost ratios at eight percent interest;

(iii) net present worth of incremental production at eight percent interest.

Because of the preliminary nature of the project formulation and in the absence of detailed field appraisals the results obtained should be regarded as indicative of the potential pending the results of detailed studies. The realization of this potential would depend on the adherence to the schedules for construction and an immediate and efficient utilization of the projects as implied in IACA's proposals. The following table summarizes the results of the project evaluations:

1/ The details of the evaluation procedures and the calculations are set out in Annex 4.1, "Report on Project Content of Water Development Program for West Pakistan".

## Summary of Evaluation Results of Groundwater Development Projects 1/

| | Public Development | | | | | | Private Alternative | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Rate of Return | | Benefit Cost Ratio at 8% | | Present Worth of NPV at 8% | | Rate of Return | | Benefit Cost Ratio at 8% | | Present Worth of NPV at 8% | |
| | IACA | Bank Group 2/ | IACA | Bank Group 2/ | IACA 3/ | Bank Group | IACA | Bank Group 4/ | IACA | Bank Group 4/ | IACA | Bank Group |
| | --- (percent) --- | | | | --- (Rs.mill.) --- | | --- (percent) --- | | | | -- (Rs. mill.) -- | |
| Shorkot Kamalia | 50 | 21 (17) | 5.4 | 2.2 (1.6) | 401 | 159 | 35 | 88 | 3.3 | 2.0 | 87 | 95 |
| Dipalpur Above B.S. Link | 50 | 25 (12) | 8.1 | 3.7 (1.3) | 645 | 150 | 42 | 52 | 5.5 | 2.1 | 349 | 150 |
| Dipalpur Below B.S. Link | 47 | 36 (12) | 11.4 | 45.0 5/ (1.3) | 982 | 192 | 44 | 49 | 7.5 | 2.5 | 818 | 192 |
| Ravi Syphon-Dipalpur | 48 | 25 (17) | 4.2 | 1.8 (1.0) | 808 | 301 | 46 | 48 | 5.0 | 2.9 | 352 | 301 |
| Shujaabad | 60 | 31 (19) | 4.1 | 4.0 (1.8) | 593 | 259 | 80 | 74 | 5.4 | 2.4 | 198 | 178 |
| Fordwah Sadiqia | 59 | 30 (24) | 6.9 | 3.6 (2.4) | 681 | 302 | 32 | 84 | 2.7 | 2.3 | 49 | 87 |
| Bahawal Qaim | 33 | 34 (26) | 4.3 | 3.7 (2.5) | 519 | 431 | 65 | 74 | 4.5 | 2.1 | 99 | 117 |
| Panjnad Abbasia | 47 | 22 (19) | 5.1 | 2.4 (1.9) | 1,251 | 596 | 18 | 86 | 1.6 | 2.3 | 115 | 288 |
| Rohri North | 35 | 16 (16) | 3.7 | 1.7 (1.7) | 721 | 329 | 29 | 76 | 3.3 | 2.0 | 90 | 162 |
| Rohri South | 45 | 23 (18) | 4.1 | 2.3 (1.9) | 840 | 342 | n.a. | 45 | 2.5 | 1.7 | 196 | 118 |
| Begari Sind | 33 | 14 (13) | 3.4 | 1.6 (1.4) | 424 | 180 | More than 100 | 21 | 8.2 | 1.3 | 139 | 41 |
| Sukkur Right Bank | 29 | 16 (14) | 3.0 | 1.8 (1.5) | 309 | 178 | More than 100 | 76 | 7.7 | 1.8 | 153 | 52 |

1/ Detailed analyses on which the results shown in this table are based are contained in the individual project reviews given in Chapter II of Annex 4.1.

2/ Including potential private savings; figures in brackets indicate results exclusive of potential private savings.

3/ Before allocation of benefits to incremental surface water supplies.

4/ Based on Bank Group's adjusted rates of installation and utilization (see project reviews in Annex 4.1, "Report on Project Content of Water Development Program for West Pakistan").

5/ Because of the deduction of potential private savings from project costs for the large number of private tubewells assumed to be in existence at the start of the project in this area, the B/C ratio allowing for such savings would appear overstated.

The results shown above should not be taken in isolation as indicative of the relative priorities of the various projects. Technical interdependencies especially with regard to the integrated use of groundwater and surface water supplies as well as the state of project preparation and the need to dovetail the proposed program into that on-going need to be considered in the phasing of the groundwater development program.

4.40 The comparison with the private tubewell alternatives indicates that especially with regard to the proposed projects for the Bari Doab region (Dipalpur Above B.S.Link, Dipalpur Below B.S.Link, Ravi Syphon and Shujaabad) the advantages of public development over continued private development are only marginal on the basis of the net present worth of incremental production. In the interest of maximizing agricultural output in the short term, it would therefore seem advisable to defer these projects in favor of areas where there has been little private tubewell development. IACA concurs in general with this view and have consequently given a lower priority to the Dipalpur Below B.S. project. In addition to a better deployment of scarce public tubewells in conjunction with private groundwater development, this would have the advantage of greater flexibility with regard to the ultimate choice of development in areas with high private tubewell coverage. Partially high water tables in the other project areas of the Bari Doab is an important factor in IACA's decision to recommend early implementation. The Bank Group, in ascribing some drainage effects to private wells would suggest that consideration be given to deferment of all public development in the Bari Doab 1/ into the Fourth Plan period (after 1970) by which time private initiative would have demonstrated more clearly its capacity for dealing with water table control as well as groundwater development.

4.41 On the basis of its reviews the Bank Group concludes that the 12 projects tentatively formulated by IACA are sufficiently justified to merit consideration for execution during the period 1965 to 1975. To the extent that decisions on project preparations have to be made in due course the Bank Group would recommend that priority be given to the projects in the following order: Shorkot-Kamalia, Rohri North, Panjnad Abbasia, and Rohri South. Bahawal Qaim and Fordwah Sadiqia should follow during the first half of the Fourth Plan period. The projects Sukkur Right Bank and Begari Sind would appear to warrant consideration only in the later part of the Fourth Plan period. Decision on the Bari Doab projects should be made in the light of further experience with private development as discussed above. The phasing of the projects within the overall frame of the ongoing and future groundwater development program is discussed below in Chapter IV, Section B.

## 4. Drainage Projects

### (a) General Aspects

4.42 As stated before, drainage requirements resulting from rising water tables are in general met by IACA's priorities for tubewell developments

1/ This does not apply to the Wagah area where public tubewells will need to be constructed in the immediate future to substitute surface water withdrawals under the Indus Treaty.

in fresh water zones and partially also in mixing zones. Tubewell installations for drainage only have been assigned lower priorities (see Chapter III). Horizontal drainage in the form of tile drainage for water table control in saline groundwater zones has been proposed by IACA under the Shorkot-Kamalia tubewell project as a pilot scheme. IACA also draws attention to the possibility of employing this drainage technique in the Ghulam Mohammad Barrage area. According to IACA, other sub-surface drainage works would be carried out generally in conjunction with the enlargement of canal capacities and thus mainly in the period after 1975.

4.43 Requirements for surface run-off drainage and saline effluent disposal have also been studied by IACA. The relative priorities for such works have been discussed above. IACA generally endorses the priority for drainage disposal works in the former Sind as determined by LIP but no project has been formulated or evaluated. With regard to surface run-off drainage, IACA has included in the program 1965 to 1975 the G.O.P. Sukh Beas Nallah Drainage Scheme in the northern and central Bari Doab. This project has been reformulated and evaluated by IACA and the discussion of drainage projects hereunder is thus limited to the Sukh Beas Nallah drainage project. The outfall drains proposed for the Sind by LIP would involve prolonged construction periods. These are further discussed in Chapter V in connection with the long-term aspects of irrigation development.

(b) Description of the Sukh Beas Scheme

4.44 The purpose of this project would be to permit reclamation of waterlogged lands and to prevent further waterlogging caused by surface run-off in the upper and central parts of the Bari Doab. The project would include the canalization of the old bed of the Beas River. The course of the proposed drain runs from Kasur in Lahore District to the Chenab River near Jalalpur Pirwala in Multan District. The catchment area is about 5,180 square miles bordering on the Dipalpur, Pakpattan, and Mailsi canals on the east and the lower Bari Doab main canal on the west. The zone of influence of the proposed drainage scheme is shown on Map 5.

4.45 Three alternative project proposals for the excavation and channelling of the Sukh Beas Nallah over part or the whole of its length have been submitted by the West Pakistan Irrigation Department to the Planning Commission. The design discharges are the same in each alternative and the main variations are in alignment and side slopes. The total length of the old river bed is about 440 miles. Because of realignment it would be possible to reduce the total length of the drain to about 320 miles. In its review of the Irrigation Department's proposal, IACA has made some adjustments of the project principally consisting of additions to Alternative I and including the following elements:

(i) 50 percent increase in capacity in the upper reaches of the drain;

(ii) provision for induced seepage to the groundwater aquifer in the lower reaches of the drain;

(iii) extension and remodelling of branch drains;

(iv) rejection of shallow side slopes as proposed by Irrigation Department in Alternatives II and III to eliminate maintenance.

In IACA's assessment the inclusion of these alterations would improve the efficiency of the drainage project.

4.46 The main features of the alternatives including the IACA adjustments are summarized in the table below:

Main Features of Alternative Sukh Beas Drainage Proposals

| | Alternative I | Alternative II | Alternative III | IACA Alternative |
|---|---|---|---|---|
| Design Discharge Capacity: | | | | |
| at head | 426 cusecs | 462 cusecs | 462 cusecs | 462 cusecs |
| at tail | 2424 cusecs | 2424 cusecs | 2424 cusecs | 2263 cusecs |
| Length of Canalized Alignment | 327 miles | 327 miles | 448 miles | 327 miles |
| | Alignment to be shortened by excavation of by-passes across necks of sharp bends, and with 6-mile outfall reach. | | Original alignment to be adopted and excavated to Lacey section, with 6-mile outfall reach. | As under Alternative I but with extension and remodelling of branch drains. |
| Side Slope | 1:1 | 1:3 | 1:3 | 1:1 |

Fields drains would be expected to be constructed by farmers themselves. Further details of the project are discussed in Annex 4.1, "Report on Project Content of Water Development Program for West Pakistan."

(c) Cost Estimates

4.47 The estimated capital costs for the alternatives proposed by the Irrigation Department range from Rs. 37.2 million for Alternative III to Rs. 64 million for Alternative I. With the adjustments to Alternative I proposed by IACA, total cost estimates would increase to Rs. 142 million including the following principal items:

Summary Cost Estimates

| | Rs. Mill. |
|---|---|
| **Alternative I** | |
| Preliminary Costs and Land Acquisition | 5.5 |
| Structures and Buildings | 11.7 |
| Earthwork | 35.1 |
| Other including Contingencies | 11.6 |
| Subtotal | 63.9 |
| **IACA Additions** | |
| Enlargement of Sukh Beas Nallah | 20.0 |
| Extension and Remodelling of Branch Drains | 58.0 |
| Subtotal | 78.0 |
| **Total IACA Alternative** | 141.9 |

IACA estimates that about eight percent of total capital cost or Rs. 11 million would be required in foreign exchange for earth-moving equipment. Farmers' expenditures for construction of field drains has been assessed at Rs. 13 million in addition to the above cost estimates bringing total project costs to about Rs. 155 million before interest during construction.

4.48 It is proposed that construction should begin without delay and extend over a total period of nine years including completion of field drains. The phasing of expenditures would thus be about as follows:

Expenditure Schedule
(Rs.mill)

| | 1965/ 1966 | 1966/ 1967 | 1967/ 1968 | 1968/ 1969 | 1969/ 1970 | 1970/ 1971 | 1971/ 1972 | 1972/ 1973 | 1973/ 1974 | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| Public Expenditures | 2 | 10 | 20 | 20 | 30 | 30 | 30 | - | - | 142 |
| Farmers' Expenditures | - | - | - | - | - | 2 | 2 | 4 | 5 | 13 |
| TOTAL | 2 | 10 | 20 | 20 | 30 | 32 | 32 | 4 | 5 | 155 |

The public expenditures would be mainly incurred for the Irrigation Department force account since it is proposed that the construction would be carried out departmentally.

(d) Drainage Benefits

4.49 The main benefits from the project would be the reduction in flood damage both for agricultural production as well as structures and buildings. No attempt has been made by IACA to quantify non-agricultural benefits. Agricultural benefits have been calculated by IACA by comparing the flood damage which would be likely to occur with and without the provision of surface run-off drainage. On this basis IACA has established, on the basis of agricultural benefits alone, a rate of return of about 15 percent and a Benefit/Cost ratio of 1.8. The project has been reviewed by the Bank Group in more detail in Annex 4.1, Part III. On the basis of its estimates the Bank Group arrived at a rate of return of 13 percent on the "Enlarged Project".

4.50 Considering the fact that the proposed drainage project would serve an area where existing levels of agricultural production are amongst the highest for West Pakistan the Bank Group is satisfied that this project is of high priority. The drainage project would support active private tubewell development as well as public tubewell projects proposed for the later part of the period 1965 to 1975. To the extent that the reduction in prolonged flooding of large agricultural areas would reduce the recharge to the groundwater aquifer, the project would also contribute to the control of the water table in large parts of the Bari Doab.

B. Sequence and Feasible Rate of Tubewell Installations

1. Public Tubewell Projects

(a) The On-going Public Tubewell Program

4.51 The on-going public groundwater development program consists mainly of five projects including a total of 10,118 tubewells. Of these one project (SCARP I) with 1,980 wells was completed in 1962 and is in operation. In addition, 955 wells of a total of 2,830 have become operational in SCARP II. Thus since initiation of the public groundwater development effort on a large scale in the 1950's and the start of construction in 1959, a total of 2,935 wells 1/ have been completed. The on-going projects (SCARP II, III, IV and Khairpur) are in various stages of construction but a further 7,183 wells remain to be completed. At present financial and contractual arrangements are firm for only about 50 percent of these wells.

4.52 The schedule presently proposed by WAPDA for completion of the on-going program is about as follows:

1/ A more recent official communication shows that in fact only 2,566 are presently operational.

Schedule of Implementation for the
On-going Public Tubewell Projects

| Project | Completed 1959-1966 | 1966/ 1967 | 1967/ 1968 | 1968/ 1969 | 1969/ 1970 | 1970/ 1971 | 1971/ 1972 | Total to be Completed |
|---|---|---|---|---|---|---|---|---|
| | | ----- (number | of wells | completed) ----- | | | | |
| SCARP I | 1,980 | | | | | | | |
| SCARP II | 955 | 420 | 630 | 418 | 307 | 100 | - | 1,875 1/ |
| SCARP III | - | 240 | 570 | 495 | 165 | - | - | 1,470 |
| SCARP IV | - | 110 | 500 | 780 | 790 | 745 | 345 | 3,270 |
| Khairpur | - | 80 | 200 | 288 | - | - | - | 568 |
| TOTAL | 2,935 | 850 | 1,900 | 1,981 | 1,262 | 845 | 345 | 7,183 |

1/ Consideration is given by WAPDA to the deferment of 400-500 of these wells located in saline zones.

This would indicate very ambitious targets for the years 1967/68 and 1968/69. Taking all factors into consideration, including the fact that financial and contractual arrangements are still not completed for 50 percent of the wells included above, the Bank Group doubts whether this schedule can be adhered to.

4.53 IACA, in its report on the regional development of the Rechna Doab 1/ suggests the initial inclusion in the on-going program of only 2,260 wells in SCARP IV 2/ and the deferment of the balance of 1,010 wells until after 1973 because of extensive private development in much of the project area. This would considerably reduce the peak targets shown above. Nevertheless, even with this adjustment, for the remaining 3-1/2 years of the Third Plan period this would still amount to a total of about 5,850 wells or about 1,670 wells per year on average. This target rate compares to an average performance between 1959 and 1966 of about 450 wells per annum completed. As discussed in Chapter III the first year of the Third Plan period (1965/66) has shown disappointing progress. Although about 1,000 public wells have been drilled no more than about 140 wells have been electrified and brought into operation during 1965/66. Even with full recognition of the work in progress the nearly fourfold increase in the anticipated rate of implementation of the on-going program would represent a remarkable step-up in the remainder of the Third Plan period.

4.54 The Bank Group is not aware of action on the scale required to meet the organizational, administrative, and financial requirements necessary to support such a rate of implementation in the immediate future. While technically possible the achievement of these targets for the on-going program during the Third Plan period would call for immediate action and the concentrated efforts of all agencies concerned. In particular, this would

1/ IACA Comprehensive Report, Volume 15, Annexure 15E, page 37.
2/ As of the beginning of 1967, finance had been allocated for only about 880 wells of SCARP IV.

require major procedural improvements, stepped-up financial allocations to the executing agency, removal of the constraints on electrification - especially foresighted and integrated procurement schedules for electrical equipment and supplies - and the urgent establishment of management cadres capable of putting tubewell fields into operation immediately upon completion. The task of developing the organization necessary and the coordination of such actions would take time and in the Bank Group's opinion it remains doubtful whether the on-going program can be completed as scheduled unless it is given exceptional priority and the status of an emergency operation.

4.55 The on-going program would thus leave little room for further expansion in the form of new projects during the Third Plan period. To the extent that the on-going program runs into the Fourth Plan period (1970/71 to 1974/75), beyond the remaining 1,290 wells as scheduled, it would also affect the initiation and phasing of implementation of new projects. 1/ However, the Bank Group believes that towards the end of the Third Plan period a higher rate of implementation approaching a total of about 2,000 wells per annum may become feasible if the actions mentioned above are taken. The projects identified and formulated by IACA would thus be executed mainly in the period between 1969 and the end of the Fourth Plan period. Project preparation activities, however, would have to be stepped-up as well during the remaining part of the Third Plan period.

### (b) The 1965 to 1975 Public Tubewell Program

4.56 As stated above the public groundwater development program proposed by IACA includes a total of 11,403 wells. In view of the recent information received from Pakistan authorities on the status of the on-going program and further considerations of relative priorities, IACA has adjusted the sequence of implementation originally proposed in its report. 2/ The revised schedule would defer initiation of the Rohri North, Ravi Syphon-Dipalpur and Bahawal Qaim projects by one year and that of Dipalpur Below B.S.Link by two years. The Rohri South project would be slightly advanced and the Begari Sind project would not be initiated before 1973/74. IACA's revised schedule also takes account of the implementation of SCARP IV as proposed by WAPDA. Initially, IACA had deferred installation of about 1,000 wells of this project beyond the Action Program.

4.57 The sequence of implementation of the IACA proposed projects integrated with the on-going program as well as the continuation of the groundwater development in the Fifth Plan period are detailed in the attached table. 3/ This schedule shows the number of wells expected to become operational each year. In arriving at this phasing IACA has allowed for a time

1/ A decision to defer wells planned for in saline areas in SCARP II could provide some relief in this respect.
2/ IACA Comprehensive Report, Volume 5, Annexure 7, page 91, Table 8.2.
3/ The ADC Tubewell Drainage Scheme in saline areas of Gaja (62,000 acres), for which no details are available, is not included in this schedule.

lag in electrification of one year after completion of drilling for each group of wells. Also IACA estimates that generally detailed project preparation would take about two years and therefore should start about three years ahead of the date shown in the schedule for completion of the first batch of wells in each project. Further details on timing of project preparation and tubewell installations are given in Annex 4.1, "Report on Project Content of Water Development Program".

4.58 Overall this schedule indicates emphasis on the fresh water areas in the Sutlej Left Bank region and in the Sind as well as on non-perennial areas with water table problems in the Bari Doab and parts of the Lower Rechna Doab. Areas where the rise of water table would not appear to be an immediately serious threat and where at the same time private tubewell development has been in the past and is likely to be in the future sufficiently active have been deferred for public development. This applies to the Bari Doab as well as the Lower Rechna Doab. For the latter area WAPDA has prepared and is proposing implementation of a large public tubewell project (2,300 wells, SCARP V) to start in fiscal year 1967/68. The Bank Group is in agreement with IACA that the bulk of the SCARP V development should be postponed because of the already over-extended scope of the public program and the appreciable existing and growing private groundwater exploitation in the Lower Rechna Doab. Those parts of the area suffering most seriously from waterlogging and salinity have been included under the Shorkot Kamalia project which has been given high priority.

ACTION PROGRAM

FOR

GROUNDWATER DEVELOPMENT 1/

(Number of Wells in Operation)

| Project Area | Total Wells | Remainder 3rd Plan Period 1966/67 | 1967/68 | 1968/69 | 1969/70 | 4th Plan Period 1970/71 | 1971/72 | 1972/73 | 1973/74 | 1974/75 | 5th Plan Period 2/ 1975/76 | 1976/77 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ON-GOING PROGRAM | | | | | | | | | | | | |
| Scarp II | 2,830 | 420 | 590 | 615 | 580 | 305 | | | | | | |
| Scarp III | 1,470 | 270 | 520 | 465 | 215 | | | | | | | |
| Scarp IV | 3,270 | 50 | 370 | 565 | 635 | 600 | 600 | 450 | | | | |
| Khairpur | 568 | 80 | 200 | 288 | | | | | | | | |
| Subtotal On-Going | 8,138 | 820 | 1,680 | 1,933 | 1,430 | 905 | 600 | 450 | | | | |
| IACA REVISED PROGRAM 1965-75 | | | | | | | | | | | | |
| Wagah 3/ | 95 | | | 95 | | | | | | | | |
| Shorkot-Kamalia | 426 | | | 100 | 326 | | | | | | | |
| Rohri North | 1,580 | | | | 140 | 360 | 360 | 360 | 360 | | | |
| Panjnad Abbasia | 1,623 | | | | 183 | 540 | 500 | 400 | | | | |
| Dipalpur above B.S.Link | 630 | | | | | 130 | 360 | 140 | | | | |
| Shujaabad | 725 | | | | | 165 | 360 | 200 | | | | |
| Ravi-Syphon Dipalpur Link | 780 | | | | | | 170 | 360 | 250 | | | |
| Fordwah Sadiqia | 665 | | | | | | | 150 | 360 | 155 | | |
| Rohri South | 1,500 | | | | | | | 230 | 360 | 360 | 360 | 190 |
| Bahawal Qaim | 924 | | | | | | | | 210 | 360 | 354 | |
| Begari Sind | 880 | | | | | | | | 180 | 360 | 340 | |
| Dipalpur below B.S.Link | 850 | | | | | | | | 90 | 360 | 360 | 40 |
| Sukkur Right Bank | 820 | | | | | | | | | 180 | 360 | 280 |
| Subtotal IACA | 11,498 | | | 195 | 649 | 1,195 | 1,750 | 1,840 | 1,810 | 1,775 | 1,774 | 510 |
| TOTAL ACTION PROGRAM | | 820 | 1,680 | 2,128 | 2,079 | 2,100 | 2,350 | 2,290 | 1,810 | 1,775 | 1,774 | 510 |
| NEW PROJECTS INITIATED AT END OF ACTION PROGRAM | | | | | | | | | | | | |
| Lower Rechna Doab | 1,850 | | | | | | | | 180 | 360) | Balance of 3,760 | |
| Lower Bari Doab | 2,630 | | | | | | | | | 180) | to be scheduled. | |
| TOTAL ANNUAL RATE OF COMPLETION | | 820 | 1,680 | 2,128 | 2,079 | 2,100 | 2,350 | 2,290 | 1,990 | 2,315 | | |
| ACCUMULATIVE TOTAL OF WELLS IN OPERATION | | 3,755 4/ | 5,435 | 7,563 | 9,642 | 11,742 | 14,132 | 16,422 | 18,412 | 20,727 | | |

1/ Based on WAPDA Program of November 1966 and IACA Revised Program as discussed in para 4.56.
2/ Indicative of overlap only.
3/ Project not formulated; wells required for replacement of surface water withdrawal under the Indus Treaty.
4/ Including 2,935 wells already completed (SCARP I and parts of SCARP II), more recent communications indicate that the number of wells in operating condition may be less.

4.59 The revised IACA schedule, including the on-going projects, would call for a rate of completion exceeding 2,000 wells per annum by 1968/69 and reaching 2,350 wells per annum in the second year of the Fourth Plan period. An effort of this magnitude would require that the program as a whole be put on a plane of activity entirely different from the present. The process of decision-making within the executing agency as well as the complementary authorities would need to be substantially accelerated. Contracting procedures would have to be simplified and speeded up. Exceptional priority for financial allocation, both local and foreign, would have to be assigned to public tubewell project requirements. In addition and most importantly, immediate steps would have to be taken to train and prepare personnel for the management, operation, and maintenance of the tubewell fields to ensure efficient utilization of the investment.

4.60 The on-going program together with the IACA proposed groundwater development would cover approximately 12 million acres of culturable area by 1975. In other words, intensive agriculture based to a considerable extent on groundwater development would be expected to prevail over an area one-and-a-half times that of Holland. The number of public wells in operation by 1975 would be expected to exceed 20,000. The success of a program of this magnitude will depend to a much larger extent on dedicated local personnel for the operation and maintenance of the well fields and the supporting agricultural services than on the purely technical task of installing wells which has been and can in the future be carried out by foreign contractors. The Bank Group would fail in the discharge of its responsibility if it did not warn against a rate of tubewell installation which would exceed the locally available capacity for management, operation and maintenance, and lead to a situation whereby well fields remain either inefficiently utilized or not properly maintained.

4.61 It is the Bank Group's considered opinion that the proposed public tubewell program is technically feasible and economically justified, but that it would in all probability exceed the local technical and agricultural skills likely to be available. However, the Bank Group is equally impressed with the need for a much greater emphasis on agriculture and fully recognizes the importance of tubewell development in increasing production. It is for these reasons that the Bank Group would suggest the adoption of the IACA schedule as an Action Program for 1965 to 1975, delineating the maximum achievable rate of progress in the field of public groundwater development during this period. At all stages, however, care should be taken that construction of new projects would not be initiated until the completion of on-going projects is ensured. Over-extension in both execution and management could lead to a dispersion of effort which would endanger the success of the program.

## 2. Private Tubewell Development

### (a) Past Performance

4.62 IACA's proposed program for groundwater development places great emphasis on public tubewells. While the performance of the public tubewell program in the past has fallen very far short of expectations despite the high priority it has been accorded, 1/ private tubewell development achieved an impressive rate of progress. As discussed in Chapter I private tubewells added more irrigation supplies during the Second Plan period than the public efforts as a whole. In view of the relative performances in the past, the need to ration the deployment of public resources, the urgency of improving agricultural growth, and the desirability of fostering private initiative amongst farmers, any lack of emphasis on continued private development at least for the time being would appear inconsistent with the needs of the situation.

4.63 Private groundwater exploitation has been in the past mainly concentrated in the better farming areas of the Bari and Rechna Doabs and in the non-commanded and outside areas. The rapidly growing and agressive tubewell industry, which has sprung up in the larger urban centers of the Punjab in response to the growing demand, has given farmers ready access to commercial implementation facilities. Because of the possibility of using diesel motors the electrification constraint heavily frustrating the public efforts did not obviously affect the rate of private tubewell installations. In the past some encouragement for private development has been provided by the Department of Agriculture through grants, technical advice and well drilling, but the bulk of private tubewell development occurred without much public support. The present level of private tubewell development has been achieved substantially without any institutional credit support. Farmers have relied mainly on their own resources and non-institutional credit.

4.64 In quantitative terms some 25,000 private wells must have been sunk during the Second Five-Year Plan period, representing private investments of the order of about Rs. 200 million. As shown in Chapter I tentative estimates indicate that by 1965 there were some 34,000 private wells in operation in the Province with the following regional distribution:

1/ The Master Plan for the control of waterlogging and salinity as well as the Second Five-Year Plan implied a target rate of public tubewell installation of about 2,000 to 2,500 wells per annum.

Regional Distribution of Existing Private Tubewells

(1965)

| Region | Number of Wells | Region | Number of Wells |
|---|---|---|---|
| Peshawar and Swat | n.a. | Thal Doab and Indus Right Bank | 1,200 |
| Chaj Doab | 800 | Sutlej and Panjnad Left Bank | 1,400 |
| Rechna Doab | 9,800 | Lower Indus | 700 |
| Bari Doab | 15,000 1/ | Outside Areas | 5,000 |
| Subtotal | 25,600 | Subtotal | 8,300 |
| | | TOTAL | 33,900 |

1/ This includes the results of a recently completed survey by Tipton and Kalmbach, Inc., which indicates that the number of private tubewells in the Bari Doab actually amounted to 17,117 by 1965, of which about 2,000 are assumed to be in the non-commanded (outside) areas of the doab.

4.65 About 30 percent of the private tubewells were connected to the northern zone electrical grid system. The average capacity of these wells was about 1.2 cusecs. By the end of the fiscal year 1964/65 the rate of construction of private wells was about 6,500 per annum. In accordance with official estimates this rate of installation seems to have been maintained during the fiscal year 1965/66. As pointed out in Chapter I this remarkable achievement of the private sector has contributed significantly to the recent growth in agricultural production. This progress in private tubewell development is the more remarkable in view of the fact that it took place without much public support and encouragement. Given the projected rate of public groundwater development discussed above growth of agricultural production in the Third Plan and also to some extent in the Fourth Plan periods must continue to be heavily dependent on the performance of the private sector in the field of groundwater exploitation.

(b) Prospects for Development During the Period 1965 to 1975

4.66 There are widely divergent views on the role private tubewell development is likely to or should play in the future development of groundwater resources in West Pakistan. The difference of opinion arises mainly from the varying emphasis that is being placed on the various constraints likely to be operative in the future. In Chapter III the constraints governing the rate of private development have already been discussed in the context of future water resource development. IACA's rate of private tubewell development is based on the assumptions that there would be no sustained efforts to stimulate private tubewell installations and that public development, curtailing private growth in some areas, would proceed as originally scheduled by IACA.

4.67 IACA has made projections of future private tubewell installations based on assessments of developments in each of the regions shown in para 4.64 above. In making these projections IACA has taken into account the changing density of private tubewells, the constraints outlined in Chapter III and the effects of public development. IACA has also projected private tubewell installations in each region in the absence of public development. Adjusting the Bari Doab projections to reflect the recent findings of Tipton and Kalmbach, Inc. the projections would compare as follows:

Growth of Private Tubewell Installations Based on IACA Projections

| Region | "With" Public Development | | | | "Without" Public Development | | | |
|---|---|---|---|---|---|---|---|---|
| | 1965 | 1970 | 1975 | 1980 | 1965 | 1970 | 1975 | 1980 |
| | | | ----- ('000 wells) ----- | | | | | |
| Peshawar and Swat | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. |
| Chaj Doab | 0.8 | - | - | - | 0.8 | 3.0 | 5.3 | 6.8 |
| Rechna Doab | 9.8 | 10.3 | 7.6 | - | 9.8 | 16.1 | 20.8 | 22.9 |
| Bari Doab | 15.0 | 29.0 | 24.5 | 1.3 | 15.1 | 29.0 | 38.0 | 43.0 |
| Thal Doab and Indus Right Bank | 1.2 | 2.4 | 2.8 | - | 1.2 | 3.7 | 7.0 | 9.5 |
| Sutlej and Panjnad Left Bank | 1.4 | 2.9 | 1.0 | - | 1.4 | 4.0 | 6.2 | 7.6 |
| Lower Indus | 0.7 | 2.0 | 2.5 | 1.7 | 0.7 | 2.2 | 5.1 | 7.7 |
| Outside Areas | 5.0 | 9.0 | 14.0 | 20.0 | 5.0 | 9.0 | 14.0 | 20.0 |
| TOTAL | 34.0 | 55.5 | 52.5 | 23.0 | 34.0 | 67.0 | 96.5 | 117.5 |
| Rate of Growth | | 10.0% | (-)1.5% | (-)17.0% | | 15.0% | 7.5% | 4% |

The IACA "with" public tubewell projection compares to the Planning Commission's estimate 1/ of an incremental number of private tubewells of 40,000 to be installed during the Third Plan period which would bring the total in operation by 1970 to about 75,000 wells. In the light of past experience and the Planning Commission's estimates, the rate of growth implied in the IACA projections appears modest. However, attention must be drawn to the substitution effects implied in the public tubewell program. As shown in the above comparison the public program would reduce the number of private wells to be installed between 1965 and 1970 from 33,000 to 21,500 and for the decade 1965 to 1975 from 62,500 to 18,500 private wells. In other words, about 70 percent of the projected additional and feasible private well installations - amounting to about 44,000 wells - would not take place because of the competition of the public sector in the development of usable groundwater. This would mean that in monetary terms some Rs. 400 million of private investments would have to be substituted by scarce public funds at initial outlays substantially higher than those required for the installation of private pumping capacity.

1/ Government of Pakistan, The Third Five-Year Plan (1965-1970), May 1965, page 300.

4.68 The rate of growth of private wells in operation implicit in the above projections is less than half the rate experienced during the later part of the Second Five-Year Plan period as shown in Chapter I. In absolute terms the average annual rate of private well installation would drop from about 5,000 wells to slightly more than 4,000 wells per annum. Given proper incentives, institutional credit facilities, and a policy conducive to private development as envisaged in the Third Five-Year Plan 1/ a substantially higher rate of private installations may be achievable. While there may be a gradual slowing down in private tubewell development, and there is some indication that areas where private development has already been most active may be approaching a "saturation point", it is reasonable to expect that further extension can be brought about by public stimulation and encouragement. If over time this latter supposition proves to be correct the proposals to install public tubewell projects in areas with a high density of private wells should be reconsidered. The need for such reconsideration would seem to apply with particular force to areas such as the Lower Rechna Doab and the Bari Doab.

4.69 Recent preliminary estimates indicate that the total number of private wells installed between 1965 and 1966 in the northern zone alone exceeded 8,400 of which about 7,900 were apparently new wells while the remainder were replacements. Nearly 65 percent of the new wells installed are diesel-driven. In view of this most recent performance and assuming active support for private development is forthcoming and any undue competition by public groundwater development is carefully avoided, the Bank Group sees no compelling reason why an average annual rate of installation of about 6,500 private wells, achieved at the end of the Second Plan period, should not be maintained during the Third Plan period. This would bring the number of private wells in operation to 66,500 by 1970.2/ Thereafter, substitution by public wells may become more accentuated. Land tenure conditions may increasingly interfere with efficient utilization of private wells. To the extent that the average command per well tends to decrease proportionately to the increase in well density there seems to be ample room for the projected number of wells especially if the non-commanded outside areas are taken into account. Considering the assumed relative short life of private wells, replacements of existing wells would also become increasingly important.

4.70 However, using the projections of private tubewell growth in conjunction with public development as set forth in 4.67 above, private tubewells and Persian wheels would be expected to provide about 10.0 MAF of irrigation supplies at watercourse head by 1970 within the canal commanded areas and about 1.8 MAF in the outside areas. This would be about one MAF

1/ Government of Pakistan, The Third Five-Year Plan (1965-1970), May 1965, page 300.

2/ Adopting the annual rate of installation achieved at the end of the Second Plan period (6,500 per annum) as compared to the Planning Commission's projection of 40,000 over the five-year period or an annual average of 8,000 wells.

more than the public program could at best contribute in accordance with the revised schedule discussed in para 4.58. Furthermore, this resource development would be brought about without major public investments. The total availability of groundwater supplies as calculated in the Sequential Analysis 1/ would nearly be reached in 1970 as well as 1975, though with decreasing reliance on the private sector.

Estimated Mean Year Groundwater Availability
At Watercourse Heads Within Canal Commanded Areas

| | 1970 (MAF) | 1975 (MAF) |
|---|---|---|
| Historic Groundwater Supplies: | | |
| Private (including Persian wheels) | 7.0 | 7.0 |
| Public | 2.7 | 2.7 |
| Subtotal | 9.7 | 9.7 |
| Development of Groundwater Supplies Above Historic: | | |
| Private (including Persian wheels) | 3.0 | 1.5 |
| Public | 7.5 | 19.3 |
| Subtotal | 10.5 | 20.8 |
| TOTAL | 20.2 | 30.5 |
| Requirement in Sequential Analysis: | 21.7 | 31.0 |

The above quantities represent only those pumped within the canal commanded areas and do not include private tubewell pumping in non-commanded areas. Continued private groundwater development on about the scale presently experienced is therefore not only desirable but imperative in the short run if the essential growth of agricultural production is to be achieved. The Bank Group would strongly suggest that the Pakistan authorities implement policies conducive to rapid private tubewell development as a matter of urgency. The improvement of existing institutional supports, in particular credit facilities, technical advice, and council for cooperative ownership and utilization, should be given high priority. Financial resources required for such support would be small if compared to the savings to the public resources on the scale indicated.

1/ Annex 3.2 - Sequential Analysis of a Program for Irrigation and Power Development in West Pakistan. Sir Alexander Gibb and Partners, London, September 1966, page 23.

4.71 IACA expects both private and public tubewells to make important contributions to agricultural growth in the short run. However, IACA regards the distribution of surface and groundwater under full public control as fundamental to the efficient long-term development of water resources, especially because of the need for integrated use of ground and surface water, particularly in mixing zones, and the requirements for effective water table control. IACA maintains that, from a social point of view, public tubewells would ensure a fairer distribution of water, protect the position of the small farmers, and would likely be the only feasible solution to the latent problems of groundwater rights.

4.72 While the Bank Group appreciates the IACA reasoning for eventual complete public control over all water resources it has some hesitation with regard to the operational practicability, at least for the first five to ten years. The integrated irrigation system is meant to provide a service to the farmers who, through their efficient use of the water supplied, determine the success of the system's operation. Farmers' control over at least part of the groundwater exploitation would tend to make them more independent of the rigidities associated with the installation of public tubewell fields as well as the water distribution, project operation and maintenance under absolute public control over all water resources. Increased flexibility of the operation of public well fields may also be achievable through procedures under which farmers would participate in the operational decision making. However, as demonstrated above, in the short run the role of private groundwater development is indispensable.

4.73 On the basis of its estimates of capital cost and current expenditures for public and private tubewells, IACA concludes that there does not appear to be any significant difference between public and private wells in terms of the costs per unit of water pumped. 1/ The following table summarizes IACA's cost projections for the various modes of groundwater exploitation:

1/ IACA Comprehensive Report, Volume 5, Annexure 7, page 43.

Cost of Groundwater Pumping
as Projected by IACA

| | Public Tubewells Electric 3 cusec | Public Tubewells Electric 4 cusec | Private Tubewells Electric 1 cusec | Private Tubewells Diesel 1 cusec |
|---|---|---|---|---|
| Assumed Lifetime (years) | 20 | 20 | 10 | 10 |
| Capital Cost (Rs. '000) | 81 | 90 | 7 | 9 |
| Annual Costs (Rs/year): | | | | |
| Depreciation & Interest at 8% | 7,290 | 8,100 | 980 | 1,260 |
| O&M including power (fuel) 1/ | 8,650 | 11,630 | 2,300 | 3,560 |
| Total Annual Cost (Rs.): | 15,980 | 19,730 | 3,280 | 4,820 |
| Assumed Annual Pumpage (acre feet) | 875 | 1,170 | 200 | 200 |
| Average Annual Cost per Acre Foot (Rs.): | 18.2 | 16.9 | 16.4 | 24.1 |

In this comparison the capital costs do not include transmission and distribution of electricity since these have been accounted for in the power rate. Private diesel-driven tubewells would appear to be the most expensive form of groundwater exploitation mainly because of the comparatively high costs assumed for diesel fuel. However, diesel operated wells would have the added advantage of being independent of power supplies thus providing an interim solution in areas not yet electrified and also a considerably high degree of reliability in areas where power is available but not always dependable. Farmers are already beginning to recognize this by increasing the proportion of installations of diesel-driven wells.

4.74 The cost differential for public and private electric wells is negligible even though private wells are assumed to have a considerably shorter lifetime as well as a lower rate of utilization. If based on comparable quantities of water pumped, private wells would show a superior cost efficiency. However, because of limited commands and difficulties in water distribution, higher rates of utilization of private wells than those used in the cost comparison may be achieved only in individual cases. Nevertheless, while private wells may be pumped at lower rates than public wells, this would generally reflect a pumping pattern directly related to the farmer's actual water requirements rather than to generalized requirements used to establish pumping patterns for large areas. It would therefore tend to lead to a more efficient use of the groundwater pumped. A further and frequently neglected aspect of private tubewells is the fact that they provide a power plant on the farm which can be and is being used for stationary implements such as threshers, grinders, and fodder choppers.

1/ Based on IACA's assessment of economic power or fuel cost. The fuel cost at a rate of Rs. 1.40 per gallon of diesel fuel appears high. Subsequent studies suggest Rs. 0.91 would be a more accurate figure. Assuming a fuel cost of Rs. 1.0, the average annual cost per acre foot pumped by diesel powered wells would be about Rs. 20.0. It should also be noted that IACA based its assessment of private pumping costs on the use of 16 h.p. engines.

4.75 As far as the cost efficiency of groundwater exploitation by individual wells is concerned, there is little demonstrable difference between public and private wells. It may, however, not be possible to achieve the same degree of uniform coverage of large contiguous areas with private wells as is possible under public development. This could result in less effective water table control as well as an overall lower rate of groundwater abstraction. The Bank Group would therefore as stated in para 4.61 accept the IACA proposals for public development as scheduled for the Action Program as indicative of the maximum and would urge the Pakistan authorities to continuously observe the relative performance of public and private development of groundwater resources. In the interest of rapid development emphasis on public or private groundwater exploitation in usable groundwater zones may be changed from time to time as the relative advantages emerge more clearly.

## 3. Integrated Sequence of Groundwater Exploitation

4.76 The project content of the groundwater development program discussed above emphasizes the accelerated installation of tubewells in areas underlain by usable groundwater. Both public and private development are important to this program with emphasis on the latter in the near future and an increasing shift in emphasis on to public development in the later part of the period under consideration. Tubewell installation for the single purpose of water table control in non-usable groundwater zones has been given low priority and would most likely have to be carried out entirely by public means. The proposed program is thus essentially a dual purpose scheme with the primary function of augmenting existing irrigation supplies.

4.77 While in practice there would be some flexibility in deciding on the timing and sequence of tubewell projects it was necessary for IACA to establish a sequence of groundwater exploitation for programming purposes. To the extent that the target quantities of groundwater availabilities at watercourse head are to be met by the public projects and the private tubewell development contained in the Action Program outlined above, they are compared in the following table:

Groundwater Pumped Under the Action Program

| | 1965/66 | | 1969/70 | | 1974/75 | |
|---|---|---|---|---|---|---|
| | Canal Command-ed Area | Outside Area | Canal Command-ed Area | Outside Area | Canal Command-ed Area | Outside Area |
| No. of Tubewells in Operation: | | | | | | |
| Public | 2,900 | - | 9,600 | - | 20,700 | - |
| Private | 29,000 | 5,000 | 46,500 | 9,000 | 38,500 | 14,000 |
| Estimated Annual Pumpage in MAF: | | | | | | |
| Public | 2.7 | - | 10.2 | - | 21.7 | - |
| Private | 7.0 | 1.0 | 10.0 | 1.8 | 8.5 | 2.8 |
| TOTAL | 9.7 | 1.0 | 20.2 | 1.8 | 30.2 | 2.8 |
| Private as percent of Total: | 72% | 100% | 50% | 100% | 28% | 100% |
| Requirement as calculated in the Sequential Analysis: | 9.6 | - | 21.7 | - | 31.0 | - |

The table is based on the sequences of tubewell installations discussed in para 4.67 above.

4.78 The table clearly demonstrates two elements of great significance for the strategy to be followed during the period 1965 to 1975. Firstly, the Action Program as now proposed would by and large meet the required quantities calculated by IACA throughout this period. Secondly, private groundwater exploitation is definitely dominant throughout the Third Plan Period and continues to make an important contribution up to 1975. To the extent that the public program as proposed represents the maximum number of wells likely to come on flow, while the number of private wells scheduled would represent a decreasing rate of growth of new installations and may well understate the probability, care should be taken not to interfere with private development until or unless the successful implementation of consecutive public well fields appears ensured or desirable.

## C. Financial Implications of the Action Program 1965-1975

### 1. Public Expenditures for Investments

4.79 The public investment requirements of the projects included under the above Action Program are summarized in the attached schedule. Total outlays until completion of the projects including interest during construction would amount to approximately Rs. 8.3 billion. Of this amount Tarbela alone would account for about Rs. 5.8 billion or about 70 percent. The on-going tubewell projects would require Rs. 991 million or roughly 12 percent. The remaining Rs. 1.5 billion or 18 percent of total investment requirements would be for the new tubewell projects and the Sukh Beas scheme to be initiated during the period under consideration. These estimates of financial requirements do not include the investment requirements for transmission and distribution of power to public tubewells.

Public Investment Requirements of the Action Program 1965-1975

| | 3rd Plan Period | | | | | 4th Plan Period | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1965/66 | 1966/67 | 1967/68 | 1968/69 | 1969/70 | 1970/71 | 1971/72 | 1972/73 | 1973/74 | 1974/75 | 1975/76 | TOTAL |
| | | | | | ----------------(Rs. million)---------------- | | | | | | | |
| Tarbela: | | | | | | | | | | | | |
| Investment Requirement 1/ 2/ | 12.9 | 94.2 | 111.4 | 565.5 | 629.7 | 616.9 | 694.0 | 625.5 | 531.2 | 321.3 | 81.4 | 4,284.0 |
| Interest during Construction | 0.4 | 4.4 | 10.2 | 31.4 | 70.1 | 112.9 | 160.1 | 210.5 | 259.0 | 301.0 | 332.8 | 1,492.8 |
| Subtotal | 13.3 | 98.6 | 121.6 | 596.9 | 699.8 | 729.8 | 854.1 | 836.0 | 790.2 | 622.3 | 414.2 | 5,776.8 |
| Sukh Beas: 3/ | | | | | | | | | | | | |
| Investment Requirements | 2.0 | 10.0 | 20.0 | 20.0 | 30.0 | 30.0 | 30.0 | | | | | 142.0 |
| Interest during Construction | 0.1 | 0.4 | 1.7 | 3.3 | 8.4 | 14.7 | 23.2 | | | | | 51.8 |
| Subtotal | 2.1 | 10.4 | 21.7 | 23.3 | 38.4 | 44.7 | 53.2 | | | | | 193.8 |
| Tubewell Projects: 4/ | | | | | | | | | | | | |
| (a) On-going Program: | | | | | | | | | | | | |
| Investment Requirements | 96.5 | 204.4 | 248.7 | 143.0 | 90.5 | 60.0 | 45.0 | | | | | 885.1 |
| Interest during Construction | 11.5 | 24.5 | 29.5 | 17.2 | 10.9 | 7.2 | 5.4 | | | | | 106.2 |
| Subtotal | 108.0 | 228.9 | 275.2 | 160.2 | 101.4 | 67.2 | 50.4 | | | | | 991.3 |
| (b) Action Program: 5/ | | | | | | | | | | | | |
| Investment Requirements | | | 25.4 | 80.6 | 122.1 | 182.7 | 205.4 | 194.5 | 172.9 | 165.2 | 50.8 | 1,199.6 |
| Interest during Construction | | | 1.3 | 4.3 | 10.5 | 17.3 | 22.0 | 20.7 | 21.3 | 20.7 | 15.9 | 134.0 |
| Subtotal | | | 26.7 | 84.9 | 132.6 | 200.0 | 227.4 | 215.2 | 194.2 | 185.9 | 66.7 | 1,333.6 |
| Total Tubewell Projects | 108.0 | 228.9 | 301.9 | 245.1 | 234.0 | 267.2 | 277.8 | 215.2 | 194.2 | 185.9 | 66.7 | 2,324.9 |
| TOTAL: Public Projects | | | | | | | | | | | | |
| INVESTMENT REQUIREMENTS | 111.4 | 308.6 | 402.5 | 809.1 | 872.3 | 889.6 | 974.4 | 820.0 | 704.1 | 486.5 | 132.2 | 6,510.8 |
| INTEREST DURING CONSTRUCTION | 12.0 | 29.3 | 42.7 | 56.2 | 99.9 | 152.1 | 210.7 | 231.2 | 280.3 | 321.7 | 348.7 | 1,784.8 |
| GRAND TOTAL | 123.4 | 337.9 | 445.2 | 865.3 | 972.2 | 1,041.7 | 1,185.1 | 1,051.2 | 984.4 | 808.2 | 480.9 | 8,295.6 |

1/ Based on schedule of economic cost, see Annex 4.1, especially Appendix 1, Sir Alexander Gibb & Partners, The Tarbela Project, London, November 1966.

2/ Compound interest @ 6 percent per annum based on equal monthly disbursements.

3/ As per schedule in para 4.48.

4/ Based on IACA estimates and recent IBRD review of Khairpur estimates; simple interest for two years @ 6 percent per annum.

5/ Based on expenditure schedules of project reviews (Annex 4.1) and phased in accordance with groundwater program as shown in Chapter IV B; exclusive of investment in transmission and distribution.

4.80 The Action Program as scheduled would require total public allocations for investment before interest during construction of Rs. 2.5 billion during the Third Plan period and about Rs. 3.9 billion during the Fourth Plan period. An overrun into the Fifth Plan period involving some Rs. 132 million would occur because of the construction schedules of the various projects. The level of investments would increase from about Rs. 110 million per annum at the start of the period and reach a level of nearly Rs. 900 million at the end of the Third Plan period. During the Fourth Plan period annual investment expenditures would be generally maintained at the same level except for a tailing off in the later years of the Fourth Plan period.

4.81 Compared to the level of public expenditures for water development in West Pakistan during the Second Plan period (Rs. 1.4 billion total) the Action Program represents an increase of nearly 80 percent for the Third Plan period and a two and a half fold increase for the Fourth Plan period. This does not yet, however, take into account the on-going Indus Basin Works, other water and drainage development projects not included in the program, and non-development expenditures. The substantial increase in financial requirements for water development in the Third and in particular the Fourth Plan periods is likely to strain the resources available to the public sector and finance may act increasingly as a constraint on the rate at which public water development might take place.

2. Private Expenditures for Investment

4.82 Private investment in water development during the period of the Action Program would be expected to total about Rs. 760 million. Almost all of this would be for the installation of new and the replacement of existing private tubewells. The table below summarizes the anticipated private investments commensurate with the Action Program and the number of private wells in operation shown in para 4.67:

Preliminary Estimate of Private Investment Requirements of the Action Program 1965-1975 1/

| | Private Tubewells | | Sukh Beas Drainage | |
|---|---|---|---|---|
| | New Installations | Replacements 2/ | Farmer Investments | Total |
| | ----- (Rs. million) ----- | | | |
| 1965/66 | 43.0 | 34.0 | - | 77.0 |
| 1966/67 | 43.0 | 38.3 | - | 81.3 |
| 1967/68 | 43.0 | 42.6 | - | 85.6 |
| 1968/69 | 43.0 | 46.9 | - | 89.9 |
| 1969/70 | 43.0 | 51.2 | - | 94.2 |
| 1970/71 | 11.8 | 52.4 | 2.0 | 66.2 |
| 1971/72 | 11.8 | 52.5 | 2.0 | 66.3 |
| 1972/73 | 11.8 | 52.5 | 4.0 | 68.3 |
| 1973/74 | 11.8 | 52.5 | 5.0 | 69.3 |
| 1974/75 | 11.8 | 52.5 | - | 64.3 |
| TOTAL | 274.0 | 475.4 | 13.0 | 762.4 |

1/ For purposes of estimation equal annual installments during the five year periods have been assumed. Actual installments in any one year could deviate considerably from the above schedule.

2/ Estimated on the basis of replacement of 10 percent of wells in operation at respective years.

As already anticipated in the Third Five-Year Plan the average annual level of expenditures during the Third Plan period represents a substantial increase over private investments in the past. While no information is available on the rate of investments in replacement in the past this will acquire increasing importance as the number of private wells in operation increases. Thus the level of investment in new installations is expected to drop slightly below the level reached in the later part of the Second Plan period while substantial replacements are anticipated. This should not create any great financial problems in view of the high return on private tubewells.

4.83 The Action Program as outlined does not foresee substantial new private groundwater development to occur during the Fourth Plan period except in the outside areas and some new installations in the Indus Right Bank and Lower Indus regions. Replacement investments therefore would account for the bulk of private investment during this period. However, this assumption may need to be revised in the light of the rate of public groundwater development. It may indeed become necessary to stimulate private investment in new tubewells throughout the period of the Action Program should there be need to compensate for shortfalls in the public groundwater program. In any case private investments occurring in any parts of the Province and beyond those presently scheduled should find, where technically and economically justified, ready support in the interest of improving agricultural output beyond that projected.

4.84 Compared to public investments the private investments during the period 1965-75 appear much less accelerated. While this may be an underestimate it should also be recognized that new private investments would be more difficult to bring about. The more prosperous and enlightened part of the farming community most likely has already participated to a considerable extent in private groundwater development. To an increasing degree new investments would thus depend on farmers with less own resources, limited access to non-institutional and a much higher dependence on institutional credit. Considering the important contribution private development is expected to make particularly during the Third Plan period it appears imperative that the supporting facilities, e.g. institutional credit, technical advice and agricultural extension, are readily available to the private entrepreneur. This may require further improvement of existing credit channels and most likely an overall review of existing credit policies. The Bank Group, therefore, would invite the attention of the Pakistan authorities to the need for support of private groundwater development and suggest urgent consideration by the authorities of possible means for such support.

### 3. Total Financial Requirements for the Action Program 1965 to 1975

4.85 Total financial requirements for the Action Program including both public and private investments would amount to about Rs. 7.3 billion before interest during construction and exclusive of electrification. Of this amount Rs. 4.3 billion or 59 percent would be for surface water development and Rs. 2.9 billion equivalent to about 40 percent would be for groundwater development. The remainder of Rs. 155 million represents the investment of the Sukh Beas Drainage Scheme. About 90 percent of the total financial requirements would have to be met from public sources. The table below summarizes the total investment requirements of the Action Program and gives an indicative phasing of expenditures:

Tentative Estimate of Total Public and Private Investment Requirements Before Interest of Action Program 1965-1975

| | Surface Water | Drainage | Groundwater | Total |
|---|---|---|---|---|
| | | ----- (Rs. million) ----- | | |
| 1965/66 | 12.9 | 2.0 | 173.5 | 188.4 |
| 1966/67 | 94.2 | 10.0 | 285.7 | 389.9 |
| 1967/68 | 111.4 | 20.0 | 359.7 | 491.1 |
| 1968/69 | 565.5 | 20.0 | 313.5 | 899.0 |
| 1969/70 | 629.7 | 30.0 | 306.8 | 966.5 |
| 1970/71 | 616.9 | 32.0 | 306.9 | 955.8 |
| 1971/72 | 694.0 | 32.0 | 314.7 | 1,040.7 |
| 1972/73 | 625.5 | 4.0 | 258.8 | 888.3 |
| 1973/74 | 531.2 | 5.0 | 237.2 | 773.4 |
| 1974/75 | 321.3 | -- | 229.8 | 550.8 |
| 1975/76 | 81.4 | -- | 103.3 1/ | 184.7 |
| TOTAL | 4,284.0 | 155.0 | 2,889.6 | 7,328.6 |

1/ Replacements for private wells (Rs. 52.5 million) included.

As indicated in the schedule in para 4.79, interest during construction would amount to an additional Rs. 1.8 billion. The above estimates should be regarded as preliminary and would need verification in the light of results of detailed project preparation. The amounts are, however, indicative of the order of magnitude of finance required should the Action Program be adopted in the form outlined.

4.86 The public project content of the proposed program for the Third Plan period would remain within the total Third Plan allocations. This, however, does not take account of the planned expenditures for investigations, flood regulation, and other expenditures totalling about Rs. 400 million (see Chapter VII). In the private sector, investments would be expected to exceed those provided for in the Third Plan period by about 43 percent mainly resulting from heavy replacement investments as pointed out above. The aggregate financial requirements for the Third and Fourth Plan periods are discussed further in Chapter VII.

# V. PROGRAM FOR IRRIGATION DEVELOPMENT

## A. The Development Proposals

5.01 In accordance with the terms of reference, IACA's work was concentrated on the formulation and evaluation of the projects reviewed in Chapter IV. Longer term planning for the Indus River Basin was limited to the preparation of outline proposals intended as guidance for further development beyond 1975. The Action Program described in Chapter IV relates only to the Government's on-going projects and to those projects formulated by IACA and given priority for execution in the period 1965-1975. In this chapter, IACA's longer term proposals for irrigation development in the Indus Basin are reviewed, and the results of IACA's water allocation, distribution and system operation studies are summarized.

5.02 The immediate objectives of a program for irrigation development in West Pakistan are to supply more water to the farmers and to deliver it to the land in a manner which is timely and suited to the crop calendar. The program would also serve to provide subsurface drainage to waterlogged areas, and to improve surface drainage in those parts of the northern Punjab and southern Sind where crop losses frequently occur from flooding following heavy storms.

5.03 The present demand for water, and the potential increase in future demand, are so large in the Indus Basin that for the period up to 1975 demand would at all times exceed the feasible rate at which new water development works can be implemented. In the light of these considerations IACA has selected a development program for this period that lays heavy emphasis on tubewell development in the usable groundwater areas, and has phased tubewell construction throughout the Indus Plains in accordance with the economic and technical criteria discussed in Chapters III and IV. From the standpoints of the feasibility rate of installation, operational efficiency and cost, all as estimated by IACA, no other mode of water development can compete with tubewells where these can be employed for the exploitation of usable groundwater. In addition to affording flexibility in construction and use, tubewells provide the most rapid and the cheapest means of making additional irrigation water available on the land. Tubewells have the advantage that they deliver water directly to the farm watercourses, and so overcome the constraining effect of the present limitations on canal capacity. They also provide a mode of development in which individual land owners or farmers can participate, and to this extent assist in overcoming the present serious financial and implementation capacity constraints. In the usable groundwater zones tubewells provide irrigation water quickly and cheaply while simultaneously providing water table control. Development based on tubewells in the usable groundwater zones is therefore the most appropriate and the most economical means by which to provide additional water supplies.

5.04 For the decade 1965-75, surface water storage developments are very largely predetermined. The Government program calls for completion of the on-going Mangla project 1/ by 1967, provision of a small element of storage at Chasma Barrage by 1971, and completion of the Tarbela Dam storage scheme by 1975. The only major addition which could be made to this program would be the raising of Mangla, which could be done by about 1971/72, but IACA discounts this proposal on grounds of hydrology and cost.

5.05 As discussed in Chapter III, another method of bringing increased water supplies to farmland is to enlarge the canals, and IACA has included about one million acres of canal enlargement works before 1975. This figure reflects IACA's estimate of the design, administrative and construction resources available to execute such works and the inter-related technical factors, notably, the limitations of link canal capacity to bring the bulk supplies of water to the headworks of the enlarged canals. It also reflects the general shortage of river flow at critical times of the year to fill the enlarged systems, a shortage which will remain until reservoir storage is brought into effect.

5.06 Thus, to summarize the program for the first decade, the Tarbela dam project would be the major new surface storage undertaking after Mangla. In addition to the large amount of effort and finance that must be devoted to the Tarbela dam project, IACA proposes that a tubewell program be undertaken up to the limit of the administrative and financial resources available. IACA also includes a considerable amount of drainage works and a substantial though restricted program of canal enlargement. The effects of all these works on the water supply are discussed further in Section C of this Chapter, and are summarized below:

Watercourse Deliveries in Period 1965/75
Mean Year Inflow
(MAF/Year)

| | 1965 | 1970 | 1975 | Increment 1965/75 |
|---|---|---|---|---|
| Surface Water | 58.0 | 56.0 1/ | 63.0 | 5.0 |
| Public Tubewells | 2.7 | 10.0 | 22.0 | 19.3 |
| Private Tubewells (including Persian wheels) | 7.0 2/ | 10.0 | 8.5 | 1.5 |
| TOTAL | 67.7 | 76.0 | 93.5 | 25.8 |

1/ Estimate as derived from sequential analysis with adjustments for surpluses; the reduction in surface water use results from the pumping pattern adopted in the sequential analysis which allows for over-pumping to lower the water table in certain areas.
2/ Includes 1.7 MAF from Persian wheels; canal commanded areas only.

1/ Low Mangla Dam is designed essentially to replace the withdrawal of waters by India from the eastern rivers under the Indus Water Treaty.

In addition to the totals given in the above table, the amounts pumped by private tubewells expected to be installed in areas outside the canal commands are estimated to increase from about one MAF in 1965 to about 2.8 MAF in 1975 (see Chapter IV).

5.07 Beyond 1975 the planning for irrigation development in the Indus Basin becomes more complex. The various methods of irrigation development -- notably, surface supply, tubewell supply, sub-surface drainage and canal remodelling -- together with agricultural constraints on the intensificiation of farming become more closely inter-related, for reasons that have already been discussed in Chapter III.

5.08 With the introduction of 8.6 MAF of stored water in the Indus at Tarbela there would be a radical change, in terms of both quantity and seasonal pattern of delivery, in the rabi flows available for diversion into the canal system. Water available in the rivers during the period of scarcity, i.e. November to April, would be increased by about 30 percent once the reservoir comes into full operation in rabi 1975/76.1/ The completion of Tarbela would come at the end of the first phase in the comprehensive development of the water resources of the Basin. Its additional water deliveries and flow regulation, superimposed on the large tubewell developments of the period leading up to 1975 and the regulating effects provided by Mangla dam on the Jhelum, would create a situation whereby irrigation supplies could be matched, to a much greater extent, to the water requirements of the crops instead of to the natural flows in the rivers as they are at present. The water supplies in the period following the completion of Tarbela would be generally adequate to meet the assumed needs of the increasing cropped acreage projected by IACA at full delta, including the conversion of areas from non-perennial to full perennial cropping where this has not already been achieved by tubewells alone.

5.09 IACA assumes that the present shortages in water supply and the related practices of underwatering should have been largely overcome by 1975-80. A continued program of tubewells and an increased rate of canal enlargement would have to take place in order for irrigation development to enable further expansion of the cropped acreage.

5.10 The IACA program, for the decade 1975-85 calls for the extension of public tubewell fields over the outstanding usable groundwater area, and the full integration of groundwater and surface water supplies. The improvement in irrigation supplies and the control of the water table in usable groundwater zones would form the background to the canal enlargement program, which would be greatly accelerated at this stage and would take the leading role in further development. IACA allows for complete enlargement of the canal system serving some 16 million acres of canal commanded land by the end of the century, in addition to major works on new, and enlargement of existing, link canals.

1/ As discussed in Chapter IV, 5 MAF of stored water, or less than full capacity, is assumed available in 1974/75.

5.11 The Lower Indus region and the Sutlej and Panjnad Left Bank region would benefit particularly from canal enlargement. Additional diversion would be provided in the Lower Indus Region with the construction of the Sehwan Barrage, which would also include an important storage element (1.8 MAF). This would serve a new feeder canal included in IACA's program for 1982. A start would be made to provide additional link canal capacity in the Punjab so that it could be completed by 1985, by which time this capacity would be essential.

5.12 Associated with canal enlargement would be sub-surface drainage of saline groundwater areas. This must precede the intensification of irrigation in all high water table zones, with the exception of certain rice lands. Construction of other storage reservoirs after Tarbela would take place primarily in the Indus Valley where they would be needed to meet the rising demand for water and to make good the loss of capacity caused by siltation of the earlier reservoirs. 1/

5.13 The program for irrigation development, as foreseen by IACA, would be completed around the year 2000, by which time water supply would be the limiting resource. For this and other reasons a salient feature of the development program is the emphasis on intensification of agriculture within the existing system, rather than expansion of canalization into new areas.

5.14 The program of irrigation development works proposed after 1975 would result in the following growth in water supplies measured at watercourse head:

Mean Year
Watercourse Deliveries in Period 1975-2000
(MAF/Year)

| | 1975 | 1985 | 2000 | Increment 1975/2000 |
|---|---|---|---|---|
| Surface Water | 63 | 77 | 91 | 28 |
| Tubewells | 30 | 40 | 44 | 13 |
| TOTAL | 93 | 117 | 135 | 41 |

5.15 Under the IACA program, public tubewells would virtually supersede private tubewells within the canal commanded areas of the Indus Basin by about 1985. Whilst recognizing the importance and merit of the underlying reasoning, the Bank Group would wish to retain an open mind on the relative contributions

1/ The program for investigations of further storage possibilities is treated in the Bank Group's Report, Volume III, "Program for Development of Surface Water Storage".

the two modes of development are likely to make to groundwater exploitation over the longer term. This difference in viewpoint, though fundamental and of great significance in the long-term, does not have any major impact on the short-term proposals.

5.16 The Bank Group considers, with more emphasis than IACA, that both public and private tubewells should be afforded high priority and support in the early stages of development. Both modes of development should be pursued vigorously, each being employed in a manner designed to yield the maximum combined benefit. The decade 1965-75 demands the fullest possible utilization of both possibilities, and with judicious allocation of spheres of influence they would become strongly complementary rather than competitive, as commonly depicted. While firm judgments made at this time may well be based on sound principles, at best such judgments can only be based on inadequate evidence of the eventual relative advantages of the two possibilities under West Pakistan conditions. For these reasons, the Bank Group would prefer to see judgment on the long-term public/private question made later, in the light of careful analysis of performance after, say, five year's time.

## B. The Development Program

### 1. Period 1965-75

5.17 IACA's comprehensive program is set out in Figure 5.1. Tubewell development and land drainage works have been shown there under the canal commands where they are located. Although project areas have in fact been identified for the early period, as shown in Chapter IV, canal commands only have been used in this outline of the program in order to maintain consistency with the period after 1985, for which years project areas have still to be defined.

5.18 A description has been given in Chapter IV of an Action Program comprising the following surface storage, tubewells and drainage projects:

## Action Program - 1965-75

| Project | Canal Commands or Parts of Commands Served | Construction Period | CCA Served |
|---|---|---|---|
| | | | (mill. acres) |
| **Surface Water Projects** 1/ | | | |
| Tarbela Dam | All commands | 1967/75 | - |
| **On-going Tubewell Projects** | | | |
| Scarp II | Upper Jhelum<br>Lower Jhelum | 1964/71 | 1.6 |
| Scarp III | Muzaffargarh<br>Rangpur | 1965/70 | 0.9 |
| Scarp IV | Marala Ravi Link<br>Upper Chenab<br>Lower Chenab | 1966/73 | 1.7 |
| Khairpur | Khairpur East<br>Khairpur West | 1966/69 | 0.3 |
| Subtotal CCA | | | 4.5 |
| **New Tubewell Projects** | | | |
| Wagah 2/ | Wagah | 1968/69 | 0.05 |
| Shorkot Kamalia | Haveli<br>Lower Chenab | 1968/70 | 0.3 |
| Rohri North | Rohri North | 1969/74 | 0.6 |
| Panjnad Abbasia | Panjnad Abbasia | 1969/73 | 0.9 |
| Dipalpur above BS Link | Dipalpur above BS Link | 1971/72 | 0.4 |
| Shujaabad | Sidhnai, Mailsi below SM Link, Lower Bari Doab | 1970/73 | 0.4 |
| Ravi Syphon-Dipalpur Link | Ravi Syphon Dipalpur Link | 1972/74 | 0.6 |

1/ A small amount of storage (0.5 MAF) would be provided at Chasma Barrage.
2/ Small project designed to replace water withdrawn under Indus Treaty. It was not evaluated.

| Project | Canal Commands or Parts of Commands Served | Construction Period | CCA Served |
|---|---|---|---|
| Bahawal Qaim | Qaim | | |
| | Bahawal | 1973/76 | 0.5 |
| Fordwah Sadiquia | Fordwah and E. Sadiquia | 1973/74 | 0.4 |
| Rohri South | Rohri South | 1972/76 | 0.5 |
| Sukkur Right Bank | North West Dadu | 1974/77 | 0.3 |
| Dipalpur below BS Link | Dipalpur below BS Link | 1974/76 | 0.6 |
| Begari Sind | Begari Sind | 1974/76 | 0.3 |
| Subtotal CCA | | | 5.8 1/ |
| Drainage Projects 2/ | | | |
| Sukh Beas Scheme | Most of Bari Doab Region | 1966/71 | |

1/ Rounded figures, for details see Chapter IV.
2/ See para 5.23 for Lower Indus Left Bank Outfall Project.

5.19 Most of the tubewell projects cover only parts, and often small parts, of the canal commands stated, and hence it will be seen from Figure 5.1 that further tubewell development often occurs in the same commands at later dates. The above list of tubewell projects, together with projects in Figure 5.1 scheduled for commencement near the end of the period 1965-75, would comprise an installation of 17,800 public tubewells in the decade. These wells, together with some 2,900 existing wells would cover eleven million acres (about 60 percent) of the usable groundwater areas of the Plains by 1975. In addition, as estimated in Chapter IV, there would be about 52,500 private tubewells in the Indus Basin by 1975, and the combined pumping of private and public wells would approach the estimated recharge to the aquifer.

5.20 The large Sukh Beas drainage scheme, described in Chapter IV, would have substantially overcome the outstanding surface drainage problems of the important Bari Doab region by the end of the decade.

5.21 Finally, the completion of the Tarbela dam project in 1975 would provide the first step in the control of the Indus River, and would mark the completion of an initial phase in the achievement of an integrated system of ground and surface water delivery throughout the Indus Plains. In addition to the on-going and Action Program projects listed above, IACA has included in the 1965-75 program some GOP projects which have not yet been formulated, but have been tentatively indentified and were not referred to in Chapter IV.

5.22 Drainage works to be started in the period 1965-75, other than the Sukh Beas scheme, would be the Left Bank Outfall, several small drainage schemes in Rechna Doab, and some rice area drainage in Ghulam Mohammed command.

5.23 The Left Bank Outfall is the first stage of the large drainage complex proposed for the Sind by the LIP consultants. It would have the objectives of removing saline sub-soil drainage water to the sea from the greater part of the Indus Left Bank south of Sukkur, and at the same time providing surface drainage in areas south of Nawabshah (see Map 7). It would have an overall length of 257 miles stretching from near Khairpur to the Rann of Kutch, and would provide a maximum discharge of 15,000 cusecs. The cost has been estimated by LIP consultants at Rs. 610 million, exclusive of the branch and lateral drainage system. The massive scale of the works in this project, involving a construction period of some 16 years, necessitates an early start, and IACA has concurred with the LIP consultants' proposals that construction start in 1968. This would mean that a program of studies and site investigations must now be rapidly undertaken. Total expenditures for these works during the Third and Fourth Plan periods have been estimated at Rs. 374 million.

5.24 Some of the more urgent work of canal enlargement in the Basin would be undertaken before 1975 but only in canal commands where it does not involve additional link canal capacity. The program would allow for implementation of the following canal enlargement works, including pilot projects, during the first decade:

Canal Enlargement 1965-1975

| Canal Command | Million Acres | |
|---|---|---|
| Khairpur East | 0.330 | |
| Khairpur West | 0.124 | |
| Panjnad Abbasia | 0.100 | (balance of 0.545 MAc for completion, mainly after 1975) |
| Ravi Syphon Dipalpur Link | 0.330 | |
| Lower Bari Doab | 0.070 | |
| Haveli | 0.060 | |
| TOTAL | 1.014 | |

The areas shown above are mainly in saline groundwater zones, but in some cases, such as Panjnad Abbasia, mixing zones are included.

5.25 The program for canal enlargement is generally based on the priorities set out in Chapter III, Section D.3, except that Khairpur East, an entirely saline groundwater area of 339,000 acres CCA, has been added. This addition follows the LIP consultants' program except that they anticipated that construction work in the southern part of the area would be continuing into the Fifth Plan period. Thus only about 125,000 acres would be completed by 1975, which would reduce the total coverage of canal enlargement completed before 1975 to about 800,000 acres. (The acreages tabulated above are the result of IACA's more specific identification of canal enlargement requirements.) Also, the canal delivery constraint in Ravi-Syphon Dipalpur Link command would probably be relieved by a small degree of underwatering or, alternatively, minor adjustments in the cropping patterns. This would further reduce the need for canal enlargement during the period of the Action Program.

5.26 The small area (70,000 acres) shown for canal enlargement in the Lower Bari Doab is in the head reach of that command where IACA has proposed a pilot tile drainage project. A similar small tile drainage scheme (37,000 acres) has been proposed in the Shorkot Kamalia project area in the southern tip of the Rechna Doab, and is discussed in Chapter IV. Both are saline groundwater areas.

5.27 The more important tile drainage projects proposed are in the Lower Indus Region where they would constitute the commencement of an extensive program to be implemented later, mainly in the Nara command.

Tile Drainage Projects Starting Before 1975

| Command | Area M.Ac. | Construction Period |
|---|---|---|
| Khairpur East | 0.03 | 1971/75 |
| Kalri Baghar (Ochito and pumps) | 0.12 | 1973/78 |
| Tando Bago | 0.09 | 1970/75 |
| Lower Bari Doab | 0.07 | 1969/71 |
| Haveli | 0.04 | 1969/70 |
| TOTAL | 0.35 million acres | |

Horizontal drainage has been introduced in pilot projects in the IACA program in order to gain experience with this drainage method under West Pakistan conditions 1/ as part of an effort to determine the most appropriate method for draining saline areas.

2. Period 1975-2000

(a) Tubewell Installation

5.28 As may be seen from Figure 5.1, the initial emphasis after 1975 would still be on the completion of the public tubewell program in the usable groundwater zones, and where after 1975 the progressive substitution of public for private well development would take place in the IACA program. While this appears logical in the context of IACA's planning approach, the decision for large-scale substitution for private development should be reviewed in each case. By 1980 only a few such areas would remain undeveloped by public wells, notably Upper Swat, part of Pakpattan, and part of Ghotki and Warsak. By 1985 only the Warsak area would remain to be done. As the tubewell program in usable groundwater areas approaches completion, the resources required for such work would be diverted to the drainage of saline groundwater areas to make possible the further intensification of irrigation by canal enlargement. Some of the saline areas with shallow water tables require urgent attention and would be tackled at an early date, notably those in the

1/ For details, see IACA's Comprehensive Report, Volume 6, Annexure 8.

Panjnad Abbasia and Rohri commands. From 1980 onwards there would be a steady program of tubewell installation in saline areas amounting to about 500 units per year. The projected numbers of public tubewells in all groundwater zones would be as follows:

Projected Number of Public Tubewells in Operation

| | 1975 | 1980 | 1985 | 2000 |
|---|---|---|---|---|
| Usable Groundwater Zones | 20,200 | 32,200 | 34,300 | 35,000 |
| Saline Zones | 500 1/ | 4,500 | 9,800 | 15,000 |

1/ IACA estimates raised by 300 wells to account for Government intention to place drainage wells in SCARP II saline area.

5.29 The phasing of tubewell development as proposed by IACA after 1975 can only be taken as a broad indication of priority. Much is based on judgment which must be checked by further investigations and analyses. The main reasons for IACA's proposed sequence of tubewell development in the various regions may be summarized as follows (see Map 6):

(i) Kabul and Swat Rivers. Initial emphasis should be placed on the Lower Swat area, where some areas of shallow groundwater occur, and on the Kabul River command. Later development would extend to the Upper Swat and Warsak's High Level commands where the groundwater potentialities appear less attractive.

(ii) Areas Commanded by the Indus River Alone. The Thal, Paharpur and D.G. Khan tubewell developments have been phased to come into operation by about the end of the Fifth Plan period, consistent with the objective of completing the development of usable groundwater areas by that time. About half the commanded land in each area is underlain by fresh groundwater, and roughly another quarter in each would cover mixing zones of varying quality. The remaining portions of area are underlain by saline groundwater which should not require sub-surface drainage by tubewells until later in the program, as indicated in Figure 5.1.

A saline area of 70,000 acres, mainly in the Muzaffargarh commands of the SCARP III project area, has been scheduled for drainage in 1976. Drainage would be provided for the rest of the saline area in this and the adjacent Rangpur command, after 1985, though it is now understood that WAPDA's consultants propose to include these in the on-going SCARP III program.

(iii) Areas in the Punjab Commanded Jointly by the Indus, Jhelum and Chenab Rivers. The first priority for a major saline groundwater tubewell drainage scheme in the Punjab has been given to the Panjnad Abbasia area, where waterlogging is already a problem with a water table shallower than ten feet in nearly 85 percent of the total CCA of 577,000 acres.

Early priority has also been given to those parts of the Sidhnai canal command usable groundwater area which lie outside the Shujaabad project area. Here the groundwater is generally of good quality, and the area is at present served with perennial supplies of water.

Pakpattan below S.M. link has been given rather low priority in the program for usable groundwater zones, mainly for the reason that a high proportion of the area (70 percent) falls in the mixing zone.

Mailsi below S.M. link is an area for which IACA deferred public development in favor of private development (except for 98,000 acres in the Shujaabad project). It is hydrologically well suited to tubewell development by virtue of being predominantly in a good quality groundwater zone. It is included in the 1975-80 period as part of IACA's program to complete public tubewell installations in all usable groundwater areas. The Bank Group has some reservations about this proposal, and would recommend that it be reviewed in the light of future progress in the private sector.

Saline groundwater drainage has been programmed to follow in the Pakpattan and Mailsi commands, both above and below the S.M. link, in conjunction with canal remodelling, mainly in the period 1985-2000.

(iv) Areas Commanded Jointly by the Indus, Jhelum and Chenab Commands in the Lower Indus. By 1975 the only outstanding tubewell installations of importance in usable groundwater areas in the Lower Indus amount to 360,000 acres in the Ghotki command. Following the LIP proposals, IACA designated this initially as a private development area to be superseded by public tubewells in 1979-85. Since the submission of the LIP and IACA Reports, WAPDA has stated that a more immediate program may have to be undertaken here because of the rapid rise in groundwater that has recently occurred. If the waterlogging hazard cannot be avoided by better control of surface water supplies, and if private tubewell development does not make sufficient progress, the IACA priority for Ghotki may have to be revised.

The main tubewell program in the Lower Indus after 1975 would be in the saline groundwater areas, and the order of priority has been largely that provided by the LIP Report which places initial emphasis on the Rohri and Gaja commands, followed by Eastern Nara. The Rohri and Nara proposals are related to increased surface water supplies that would come from canal enlargement. The first group of Gaja tubewells would be designed to replace the present ADC project wells in this already waterlogged area, and the balance of the saline area would be drained in the early 1980's.

(v) Areas Commanded by the Jhelum River Alone. All usable groundwater areas would be previously developed in this region by the SCARP II project, but there would remain about half a million acres underlain by saline groundwater in the Lower Jhelum command that would call for tubewell drainage before canal enlargement could be effected. IACA has scheduled this work for 1976-83. IACA has suggested in its report that the saline groundwater areas of SCARP II in the Lower Jhelum command should be deferred until after 1975. The Bank Group does not disagree with IACA's suggestion, but has nevertheless retained the GOP schedule for the currently on-going SCARP II program, including the saline groundwater areas.

(vi) Areas Commanded Jointly by the Chenab and Jhelum Rivers. These areas, which stretch across the central parts of the Rechna and Bari doabs, contain some large usable groundwater sites where IACA would defer public tubewell development in favor of private enterprise. This would include the greater part of the area designated for SCARP V, and the extensive perennial areas of the Lower Bari Doab and Pakpattan and Mailsi above S.M. link. But, in accordance with its principle that all groundwater areas should ultimately come under public control, IACA would include the usable groundwater zones of these commands in the public tubewell program as an early priority in the period following completion of the Action Program works described in Chapter IV. The related saline areas have deferred tubewell development, again in conjunction with canal enlargement, and are phased mainly for the period 1985-2000.

(vii) Areas Commanded by the Chenab River Alone. Tubewell installation in these areas would be almost entirely included in the on-going SCARP IV scheme and in the proposed Action Program. Only small saline areas would remain to be drained in the Ravi-Syphon Dipalpur link command in the 1980's.

(b) Canal Enlargement

5.30 The priorities for canal enlargement after 1975 finally adopted by IACA vary considerably from those derived from the eonomic analysis. The enlargement of the canal systems within the commands depends, as stated before, both upon the program adopted for the enlargement of the link canals, which provide for the bulk water transfers to the various barrage headworks, and also upon sub-surface drainage which must be phased to come into effect before more surface water can be introduced in the areas concerned. As may be seen from Figure 5.1 the emphasis on canal enlargement would not begin until around 1980, in anticipation of the increase in link canal capacity as proposed by IACA in the Punjab. This would require the construction of a new canal leading from the Chasma Jhelum link eastwards acress the Punjab and connecting up with the main canals of the Chaj, Rechna and Bari doabs en-route. At about the same time (1982) IACA has scheduled the Sehwan barrage and Sehwan-Rohri feeder for completion. This feeder would be the first stage of the Sehwan-Nara feeder referred to in Figure 5.1.

(i) Kabul and Swat Rivers. IACA has not developed a case for canal enlargement in this area, though some work may be required on a limited scale late in the program. IACA does, however, draw attention to what may prove an exception to their concept that new areas should not be taken into the canal system when they refer to the possible extension of the Upper Swat canal system to incorporate a further 200,000 acres of CCA. 1/

(ii) Areas Commanded by Indus River Alone. The canals in these commands are relatively large, and attainable intensities with the existing design capacities are, in general, little less than the average agricultural maximum set at about 150 percent. There are, however, extensive saline areas in Thal, Paharpur, D.G. Khan and Muzaffargarh (amounting in total to about 600,000 acres), and about the same area of mixing zones in Thal that would call for some degree of canal enlargement late in the program.

(iii) Areas in the Punjab Commanded Jointly by the Indus, Jhelum and Chenab Rivers. Rangpur command, like the Indus commands referred to above, calls for very little canal enlargement. This would mainly be some in a 10,000 acre saline groundwater zone, and IACA would defer such work until late in the program.

The present cropping intensity is high in those parts of the Sidhnai command not included in the Shujaabad project, but there is considerable underwatering. Tubewells alone would provide only a partial solution because of the existing canal capacity constraints. IACA has given this area a high priority for canal enlargement in the period following the Action Program, and that this work could be undertaken together with public tubewell installation in the period 1976-81.

Pakpattan below S.M. link would require extensive remodelling in all groundwater zones, and this has been scheduled after 1985 at the same time as the saline groundwater drainage and when additional link capacity should be available to the Bari Doab.

Mailsi below S.M. link, on the other hand, would require remodelling only in the saline and a small part of the mixing areas. This work would be undertaken at the same time it begins in the adjacent Pakpattan command.

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1/ See IACA Comprehensive Report, Volume 18, Annexure 15H.

High average intensities can be achieved with tubewells and existing canal capacity in Bahawal below M.B. link and this command has been given relatively low priority for canal enlargement.

Panjnad Abbasia would be given the highest priority for the enlargement of a large part of the canal system. Even with tubewells, but without canal enlargement, big areas of mixing zones would be constrained to about 120 percent (full delta) cropping intensity, and the saline zones would be constrained to much lower levels. After the construction of the Chasma-Jhelum and Taunsa-Panjnad links there should be adequate capacity to provide supplies to an enlarged canal system, and thus achieve 150 percent cropping intensity in such areas.

(iv) Areas Commanded Jointly by the Indus, Jhelum and Chenab Commands in the Lower Indus. Canal enlargement would form a very important part of the development program in the Lower Indus.

The program may be divided into three phases:

(a) The early work in Khairpur which could be undertaken without major link canals;

(b) The enlargement of the Rohri and Nara commands as part of the Sehwan-Nara feeder scheme;

(c) The canal enlargement in other commands where the general priority for such work is relatively low, with the exception of Dadu South. There the existing canal capacity restrains intensities to about 90 percent as compared with a potential intensity of 150 percent.

The Khairpur enlargement program has already been discussed in paras 5.24/5.25. It involves a total of about 450,000 acres in the saline zones of the two branches of the command where otherwise the achievable full delta cropping intensities would remain low (about 100 percent).

In the Lower Indus the main canal enlargement program hinges essentially on the Sehwan barrage project. This project would serve two purposes. First, it would act as a diversion dam to command a major feeder canal, which would run eastwards to convey more water into the Rohri and Nara commands. Second, it would provide about 1.8 MAF useful storage capacity. The LIP Report 1/ proposed that the Sehwan barrage and that reach of the link canal serving Rohri South should be completed by 1976, but the additional works required to develop the storage possibilities of the barrage should be deferred until the early 1980's. IACA has concurred with the date for bringing the storage element into service,

1/ Lower Indus Report, Hunting Technical Services Ltd. and Sir M. MacDonald & Partners, 1966.

but considers that the barrage function and the Rohri Link canal should be deferred in order to treat the Sehwan project as a single stage operation, except for the Rohri-Nara link which would follow later. Recent proposals made by WAPDA are similar to those in the LIP Report, except for deferment of an extensive canal enlargement program in the Rohri North and South saline and usable groundwater areas. However, without substantial canal enlargement the benefits of the barrage and feeder would be limited. Under the latest WAPDA proposal the Sehwan project, without canal enlargement, would serve the initial purpose of raising the intensity by 12 percent in the 880,000 acres of saline zone in Rohri South. Under the IACA proposals the intensities would already be raised by 13 percent above present levels by tubewell projects and Tarbela rabi supplies, 1/ and before Sehwan would come into operation.

There would, therefore, be no clear advantage in adopting an earlier planning date for the Sehwan Barrage than that proposed by IACA, unless the canal enlargement of Rohri South and North can be advanced considerably on the date proposed by IACA. IACA has examined this possibility and judged that it is not feasible.

This conclusion does not detract from the importance of investigating the Sehwan project at an early date, because there is a paucity of information for such an important project. It is suggested that a feasibility study, including appropriate investigations and surveys, be carried out and a project report on the whole scheme be prepared during the Third Plan period so that a program for detailed investigations, which would follow in the Fourth Plan period, can be clearly identified. Such an investigation program would be a few years in advance of that proposed in the IACA Report.

Figure 5.1 retains the program shown in the IACA Report, with canal enlargement in the Rohri North, South, and the Nara commands all phased in accordance with the construction program for the Sehwan barrage and the Sehwan-Rohri feeder (scheduled for completion in 1982), and for the Rohri-Nara feeder (scheduled for completion after 1985).

(v) Areas Commanded by Jhelum River Alone. An intensity of 150 percent could be achieved over most of these commands once tubewells have been installed (SCARP II program). There are, however, canal constraints in parts of the mixing, and in the

1/ See IACA's Comprehensive Report, Volume 20.

whole of the saline, areas for which canal enlargement is proposed in the period 1978-85. IACA considers that the canal enlargement in the Lower Jhelum command, which is included in the present SCARP II proposals, could be carried out more efficiently if it were combined with the construction of the proposed new Punjab link canal. This work has therefore been deferred until the Fifth/Sixth Plan periods.

(vi) Areas Commanded Jointly by the Chenab and Jhelum Rivers. In the Lower Chenab command there are large areas of saline and mixing zones, and the attainable intensity (at full delta) would, on average, be limited by canal capacity to about 114 percent. Despite this, IACA believes canal enlargement should only be undertaken following the introduction of the new Punjab link, and have phased this work for the period after 1985.

In the Lower Bari Doab area above S.M. link there are about 200,000 acres of saline and mixing groundwater zones that would require extensive canal remodelling. This has been phased to coincide with the completion of new link canal capacity to the doab in the early 1980's.

The remaining commands in this group are in the Sutlej Valley, and would come later in the canal enlargement program as the new link capacity would be extended to reach them. The Sutlej Valley commands, other than the usable groundwater areas included in the tubewell projects, would remain very constrained by existing canal capacity, but their full development must be deferred until much more water can be transferred from west to east across the Punjab.

(vii) Areas Commanded by the Chenab River Alone. No major canal remodelling, beyond that tentatively scheduled before 1975 in the Ravi Syphon-Dipalpur link command, is proposed for this area because it can reach almost full intensity with public tubewell development and existing canal capacity. Minor exception is the perennial area of the Upper Chenab command, where some remodelling is included late in the program to raise the achievable intensity from about 145 to 150 percent.

(c) Storage Dams and Barrages

5.31 Surface storage reservoirs included in the program in Figure 5.1 are discussed in Volume III of the Bank Group's Report. 1/ In summary they consist of the following works:

1/ "Program for the Development of Surface Water Storage."

| Reservoir | Live Storage Capacity (MAF) | Date of Completion |
|---|---|---|
| Mangla | 5.2 (Replacement works) | 1967 |
| Chasma (Barrage) | 0.27 | 1971 |
| Tarbela | 8.6 | 1975 |
| Sehwan (Barrage) | 1.8 | 1982 |
| Mangla (Raising) | 3.55 | 1986 |
| Chotiari | 0.90 | 1990 |
| Kalabagh | 6.40 | 1992 |

This sequence of storage development would be subject to change, however, depending on the findings of on-going and further investigations.

5.32 No new barrages other than IBP works and Sehwan are included in IACA's program, except that the proposed new Punjab link canal may call for barrage crossings of the Jhelum, Chenab and Ravi Rivers. This again would be subject to the findings of on-going and future investigations.

(d) Drainage Works

5.33 The major surface drainage works have already been referred to, except for the Lower Indus Right Bank Outfall drain. Its location is shown in Map 7. The drain would serve the Gudu and Sukkur Right Bank areas and drain their effluent into the Indus downstream of the proposed Sehwan barrage. It is the main feature of the final stage of the LIP consultants' drainage proposals, and is scheduled by IACA for completion by about 1990.

## C. Water Availability and Use

### 1. Water Requirement and Distribution Analyses

5.34 In order to set the Action Program for the next decade in long term perspective it was necessary to derive an indicative development program for the Basin beyond the period of the Action Program. It was also necessary to analyze the patterns of water use over time relative to potential water availability. Three reference years (1975,1985 and 2000) were used for detailed analysis of their aspects. In addition, each year from 1965 to 1985 was analyzed against historical and synthetic sequences of river inflow. 1/

5.35 These water distribution and use analyses were undertaken in three stages: one for the calculation of water use within the canal commands, a second for the distribution to canal commands from the river rim stations 2/ and reservoir sites for each reference year, and a third 3/ was a sequential

1/ Sequential Analysis of a Program for Irrigation and Power Development in West Pakistan by Sir Alexander Gibb and Partners, September 1966, Annex 3.2.
2/ Point where river enters the Indus Plains.
3/ Computer program developed by WAPDA's consultants, Messrs. Harza International and used by Sir Alexander Gibb and Partners in cooperation with Harza in the Sequential Analysis.

study testing the operational feasibility of the program. Allied to these water distribution studies a number of reservoir operational studies were carried out for Mangla and Tarbela reservoirs to determine their behaviour for both irrigation and power purposes. 1/

5.36 For the purpose of the Water distribution analysis the 42 principal canal commands in the Indus Basin were sub-divided according to the partitioning of commands that arises from IBP works and from proposals made by the LIP consultants in the Lower Indus. Further sub-division was made to account for differences in existing design capacities of canals (discharge factor). These considerations resulted in the adoption of 61 units of analysis. Each unit of analysis was then further sub-divided and treated separately for the four groundwater salinity zones given in Chapter III, e.g. fresh groundwater, two mixing zones of intermediate salinity and a saline (unusable) zone. The analysis for the reference years dealt with three alternative states of water development. For each of these states it gave the water requirements associated with the achievable levels of cropping intensity for each zone in each canal command. The alternative states of water development were:

(i) Either no development of groundwater or partial development by private tubewells. Watercourse deliveries were limited in this case to the capacity of the canal system, to which was added the appropriate quantity of groundwater pumped by private wells, based on the projected growth of private tubewells for the particular command.

(ii) Full development of groundwater by public tubewell projects. In this case an integrated system was assumed whereby withdrawals from the aquifer would be balanced by recharge to it. In the mixing zones groundwater and surface supplies would be used simultaneously in accordance with the stipulated mixing ratios. In the fresh groundwater zones the greater part of the pumping would be in rabi in order to economize in the use of scarce surface water at that time, and to overcome canal delivery constraints during seasonal overlaps.

(iii) Canals enlarged in addition to public tubewells to allow full intensity to be attained, particularly in the saline and mixing zones.

5.37 Estimates were also made for present conditions and during the period prior to 1975, in the canal commands which were included in the sequential study. Transitional states were assessed from present watercourse deliveries, with the associated under-watering and unregulated deliveries, to optimal deliveries. These transitional states were assessed in three ways:

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1/ See also Bank Group's Report, Vol. IV, "A Program for the Development of Power".

(i) In canal commands where public tubewells were to be installed, full delta watercourse requirements were assumed to coincide with the implementation of the project.

(ii) In the commands supplied by the Jhelum and Chenab Rivers, the Mangla reservoir was assumed to be capable of regulating rabi flows. In these areas historic seasonal totals were maintained, but redistributed by months in accordance with the computed requirements.

(iii) In those commands served by the Indus main stem where no public tubewell development was scheduled before 1975, the mean historic monthly deliveries were maintained without regulation.

In conditions (ii) and (iii) an allowance was made for the contribution of private pumping.

5.38 Important factors in the water distribution planning were the assumptions made by IACA with regard to historic flows. These were generally taken as the monthly mean deliveries over the period 1952 to 1963, but in the newer, developing commands (such as Ghotki and Thal) recent deliveries were used. This method of deriving an historic basis tends to be more favorable than actual occurrences of water deliveries because it understates the impact of adverse variations from the mean. IACA's treatment of water distribution in the immediate future should therefore prove to be on the conservative side because the canal command analysis maintains water supply conditions which are everywhere at least as good as the mean for the recent past, and generally better.

5.39 The study of watercourse requirements related water availability and use on the basis of the state of development assumed to prevail in each canal command in the reference years 1975, 1985 and 2000. These states are essentially a reflection of the development program for tubewell installation and canal enlargement as described in the foregoing Section B. Broadly, this meant that by 1975 most commands were taken to be in state (i) and (ii) and very few in (iii). By 1985 few would be left in state (i), and a greater number would have moved to state (iii) as canal enlargement progressed. By 2000 the whole Basin, with very minor exceptions, would have reached states (ii) and (iii), and all constraints on the achievement of the full agriculture intensity would have been removed. For each canal command a number of variables had to be associated with a given state of development, and these included the following:

Cropping pattern;
Crop water requirements per unit area;
Canal capacity;
Canal and other losses;
Recharge to aquifer;
Agricultural limitation to cropping intensity.

The agricultural limitation to cropping intensity relates only to the situation where increased water availability would permit an expansion of cropped acreage, but farmers fail to do so. The constraints on intensities were refined by successive analyses.

5.40 The information provided by the analyses was essentially the following:

(i) Monthly surface water requirements at watercourse head to achieve the cropping intensities set by agricultural constraints or by canal capacity;

(ii) Monthly quantities of groundwater pumped for irrigation or as saline drainage effluent;

(iii) The attainable cropping intensities with full delta water application in each of the groundwater quality zones.

5.41 The information given under (i) above was then aggregated to derive the requirements for stored water and the pattern of its release from the reservoirs. 1/ A summary of the analyses and the results obtained are given in Section C.4 below. A subsequent analysis dealt with the integrated operation of the reservoirs for irrigation and power. 2/

5.42 The sequential study, 3/ which essentially simulated the operation of the entire irrigation system under conditions of the proposed development program, provided a check on the internal consistency of the IACA program and demonstrated that it would operate successfully over a range of river inflows taken over a sequence of years. Some of the principal results of this study are included in the following paragraphs of this section.

2. The Results of the Water Requirement Analyses

5.43 The results of IACA's analyses gave the following growth in watercourse requirements in the Indus Basin:

1/ For details, see IACA's Comprehensive Report, Volume 5, Annexure 7, Chapter 7.
2/ Bank Group's Report, Volume IV, "A Program for the Development of Power".
3/ Annex 3.2.

Projected Watercourse Requirements
in IACA Program
(MAF/year)

| Year | Total Use | Incremental Use | Cumulative Incremental Use |
|---|---|---|---|
| 1965 | 68 | | |
| 1970 1/ | 75 | 7 | 7 |
| 1975 | 94 | 19 | 26 |
| 1985 | 117 | 23 | 49 |
| 2000 | 135 | 18 | 67 |

1/ Figures derived from Sequential Study and related to transitional condition referred to in para 5.37.

5.44 These watercourse requirements would be met by deliveries, based on mean year conditions, from surface and groundwater sources in the following proportions:

Relative Use of Surface and Groundwater
Measured at Watercourse Head

| Reference Year | Surface Water | | Groundwater | | Total |
|---|---|---|---|---|---|
| | MAF | Percentage | MAF | Percentage | MAF |
| 1965 | 58 | 85 | 10 | 15 | 68 |
| 1970 1/ | 56 | 75 | 19 | 25 | 75 |
| 1975 | 63 | 68 | 31 | 32 | 94 |
| 1985 | 77 | 66 | 40 | 34 | 117 |
| 2000 | 91 | 67 | 44 | 33 | 135 |

1/ Estimate as derived from sequential analysis with adjustments for surpluses; the reduction in surface water use results from the pumping pattern adopted in the sequential analysis which allows for over-pumping to lower the water table in certain areas.

The monthly distribution, as well as geographical location of use, has been fully recognized in the above aggregates and is set forth in detail in the Sequential Study (Annex 3.2).

5.45 This tabulation shows that the proportional contribution from groundwater is expected to more than double over the first ten years. Thereafter the ratio of groundwater to total would remain fairly constant, because under balanced recharge pumping the permissible pumping would become directly proportional to the canal supplies. The increment in canal supplies after 1975 and up to full development follows the pattern of demand created by canal enlargement and the provision of additional surface reservoirs.

5.46 The contribution of private tubewells to the total groundwater abstraction is currently about 50 percent. Although the private supplies rise rapidly from five to eight MAF in the decade 1965/75, the relative contribution is projected to fall to about 25 percent of total by 1975 and would continue to fall thereafter as public tubewells replace private installations. The distribution of water use between the main sectors of the Basin for the reference years is given below:

Watercourse Deliveries to Main Sectors of Indus Basin
(MAF/Year)

| Reference Year | Vale of Peshawar | | Punjab | | Sind | | Total (rounded) |
|---|---|---|---|---|---|---|---|
| | MAF | Percent | MAF | Percent | MAF | Percent | MAF |
| 1965 | 1.7 | 2.5 | 40 | 59.5 | 26 | 38.0 | 68 |
| 1975 | 1.9 | 2.0 | 61 | 65.0 | 31 | 33.0 | 94 |
| 1985 | 2.8 | 2.5 | 75 | 64.0 | 39 | 33.5 | 117 |
| 2000 | 2.8 | 2.0 | 85 | 63.0 | 47 | 35.0 | 135 |

5.47 The distribution of the water supplies between these three sectors -- Peshawar, the Punjab, and Sind -- would remain fairly constant over time, with the Punjab areas taking a slightly increasing share in the early period. This initial trend in favor of the Punjab is largely attributable to the more extensive on-going tubewell program in the northern part of the Basin.

5.48 Although the comparison is not fully valid, for reasons of difference in crop water requirements and other factors, these proportional deliveries of water relate to the following development acreages:

Potential Development Acreages (CCA) and Intensities

| | Million Acres | Percent of Total |
|---|---|---|
| Peshawar Vale | 0.8 | 3 |
| Punjab | 19.7 | 67 |
| Sind | 9.0 | 30 |
| TOTAL | 29.5 | 100 |

5.49 A further breakdown of the results of IACA's analyses dealing with the relative requirements for surface and groundwater in the canal commanded regions of the Basin is given below:

Watercourse Deliveries to Canal Commanded Regions of Indus Basin
(MAF/Year)

| Region | 1965 G/W | 1965 S/W | 1975 G/W | 1975 S/W | 1985 G/W | 1985 S/W | 2000 G/W | 2000 S/W |
|---|---|---|---|---|---|---|---|---|
| Vale of Peshawar | - | 1.7 | 0.03 | 1.88 | 1.21 | 1.63 | 1.21 | 1.60 |
| Thal & Indus Right Bank | 0.7 | 5.6 | 3.89 | 5.03 | 6.68 | 6.02 | 7.48 | 7.75 |
| Chaj Doab | 0.6 | 3.2 | 2.92 | 2.80 | 3.61 | 3.74 | 3.69 | 3.91 |
| Rechna Doab | 4.6 | 6.6 | 8.08 | 6.95 | 8.59 | 7.94 | 9.23 | 9.18 |
| Bari Doab | 3.1 | 9.0 | 7.62 | 11.41 | 10.63 | 13.13 | 11.59 | 14.76 |
| Sutlej & Panjnad Left Bank | 0.6 | 6.4 | 3.21 | 7.53 | 4.45 | 9.46 | 4.93 | 12.60 |
| Lower Indus | 0.1 | 25.5 | 3.66 | 27.19 | 5.15 | 34.31 | 5.87 | 40.97 |
| TOTAL | 9.7 | 58.0 | 29.41 | 62.79 | 40.32 | 76.40 | 44.00 | 90.77 |

This table demonstrates the rapid growth in groundwater contributions that would be made by the tubewell program in the Punjab, particularly in the Chaj, Rechna and Bari Doabs. By contrast, the Lower Indus and Vale of Peshawar, with their more limited usable groundwater resources, are likely to remain much more dependent upon surface water supplies.

5.50 The main Punjab doabs of Chaj, Rechna and Bari show relatively small increments in surface water requirements over the 35-year period, whereas other areas show much greater increases. This is due to a number of factors, but in general it may be stated that the largest contribution by groundwater would be made in the Punjab, while surface water storage would contribute to the main Indus commands in the north-central and southern zones of the Plains.

## 3. Surface Water Requirements at Canal Head and Comparison with River Inflow

5.51 When the surface water components of the watercourse deliveries are expressed in terms of canal head deliveries, after due allowance for canal losses, the total quantities for the reference years are:

Projected Canal Head Surface Water Requirements
for Reference Years and Comparison with River Inflow
(MAF/Year)

| | 1975 | 1985 | 2000 | Total Inflow of Indus, Jhelum and Chenab (Mean Year) |
|---|---|---|---|---|
| October | 7.51 | 8.16 | 9.85 | 5.51 |
| November | 3.71 | 4.40 | 5.52 | 3.20 |
| December | 3.50 | 3.90 | 4.57 | 2.81 |
| January | 4.00 | 4.52 | 5.24 | 2.77 |
| February | 5.90 | 6.40 | 7.33 | 3.01 |
| March | 5.58 | 6.09 | 6.91 | 5.07 |
| April | 5.09 | 6.71 | 7.96 | 8.24 |
| May | 7.07 | 8.26 | 10.26 | 14.22 |
| June | 10.45 | 13.25 | 16.42 | 22.73 |
| July | 10.97 | 13.64 | 16.85 | 32.04 |
| August | 11.22 | 14.03 | 17.39 | 28.39 |
| September | 9.92 | 12.06 | 15.25 | 13.19 |
| TOTAL | 84.92 | 101.42 | 123.65 | 141.18 |

5.52 For comparison, the mean combined river inflows available to meet the projected demands are also shown in the above table. The comparison of requirements with demand gives, however, no more than a general impression of the periods when water should be stored and when it should be released from storage. Apart from the complex matter of limitations in regional distribution from the individual river sources and distribution losses in the rivers and link canals, it is also necessary to make allowance for variations from the mean flow conditions and for time lags. In making proposals for the operation of the reservoirs at Mangla and Tarbela (see Chapter V.D), IACA has adopted solutions which offer a compromise between mean river flow conditions and low flow conditions which might occur fairly frequently. In this context it will be seen in Chapter V.D that an operating reserve is left in the Tarbela reservoir at the end of March for release in April and May, which are months when shortages would occur from time to time. As a very general rule, storable surpluses would occur mainly in June to September, in the first twenty years or more of the program and deficiencies against demand would occur from October or November until about April or May, depending on the state of development reached in the program of irrigation projects and on river flow conditions.

## 4. Results of Surface Water Distribution Analyses

5.53 This analysis was a logical continuation of the analysis of water requirements in canal commands described in sub-sections 1. and 2. above, and was devised to provide the following information:

(i) To find the water requirements by months at the rim stations of the rivers and at the reservoirs of Mangla and Tarbela by integrating and transferring the water requirements for the various canals to these points of supply,

(ii) To determine the reservoir storage and operational requirements by comparing the water supply requirements with the patterns of river flow at the rim stations and above the reservoirs, and

(iii) To estimate link canal capacities required to distribute the supplies at the various stages of development given in the program.

5.54 The analysis is complex, as would be expected with such a large irrigation system as that of the Indus Basin, and the following should be regarded as only an outline description. The surface water requirements derived from the canal command analyses, described in the foregoing parts of this section, were accumulated at the barrage pond or headworks from which they would be drawn, either directly by irrigation canals or by the link canals. The water requirements at the headworks were then transferred upstream through the distribution network of link canals and river reaches to the rim stations. Various conditions of river flow were compared with the water requirements at the rim stations and the monthly surpluses or shortages in flow were determined from this comparison. The analyses made allowances for seepage and evaporation losses from the link canals and rivers, though it must be stressed that reliable data on these factors are lacking.

5.55 Allowance was also made for the important gains in the river reaches in the form of regeneration flows from the river banks, where water is stored at periods of high flood. The net river and link canal losses on the system, after allowing for regeneration, are estimated at about 19 MAF per year. Time lags were built into the analysis and these assume considerable importance in such a large system. There would be about two weeks between Tarbela and Ghulam Mohammed barrage depending on river stage.

5.56 The system was divided into the three main irrigation zones shown in Map 6.

(i) Those areas commanded only by the Chenab River.

(ii) Jhelum or Jhelum and Chenab commands.

(iii) Indus, or Indus, Jhelum and Chenab commands.

In addition, separate allowance was made for Kabul river inflow after providing for the Kabul and Swat commands.

5.57 After meeting the requirements in zone (i), any remaining flows are served into zone (ii) by passing them from Marala to Khanki headworks or beyond. The analysis showed that Chenab flows at Marala were adequate to meet the requirements of zone (i). The analysis of zone (ii) determined the minimum requirements at Mangla after allowance for the available Chenab flow. A release pattern was selected for Mangla, and shortages and surpluses were noted. The surpluses were passed to Trimmu for use in zone (iii).

5.58 The distribution analysis showed shortages at Mangla amounting, for example, to 0.29 MAF 1/ for mean river flow and 1.72 MAF for low rabi flow conditions in 1975. The year 1985 showed a slight increase over these figures. However, the analysis did not make allowance for potential over-pumping of public tubewell fields, although by that year under IACA's program extensive tubewell fields would be in operation in the areas served by Mangla. The sequential analysis does take well field capacity fully into account, and demonstrates that in 1975 the shortages should prove to be quite negligible provided that substitution of good quality groundwater for surface water can be made operationally feasible.

5.59 Shortages in the transitional period from 1965 to 1975 would, however, be more important, and for both mean inflow conditions and a historical sequence of actual water years the sequential study shows the following system totals occurring in the rabi months:

System Shortages
(MAF)

| Year | Mean Year | Historical Sequence 1/ |
|---|---|---|
| 1966 | 2.30 | 3.69 |
| 1967 | 1.97 | 4.13 |
| 1968 | 0.08 | 1.12 |
| 1969 | 0.40 | 0.45 |
| 1970 | 0.29 | - |
| 1971 | 0.27 | 0.96 |
| 1972 | 0.62 | 0.58 |
| 1973 | 1.03 | 1.70 |
| 1974 | 1.23 | 2.48 |
| 1975 | 0.04 | 0.48 |
| 1975-1985 | no shortages | shortages less than 0.5 at all times |

1/ Based on the actual water years 1926 to 1945, see Annex 3.2.

5.60 The total shortage under mean flow conditions of 8.2 MAF over the ten year period occurs mainly in two periods -- the first two years, and the

1/ This result is largely attributable to the fixed release pattern as well as the rigid crop calendars used and the shortage may not prove so much in practice.

two years immediately prior to the completion of Tarbela in 1975. The shortages in the first period arise from restrictions of the Ravi and Sutlej flows to allow for the application of the Indus Waters Treaty. Depending on how these waters will actually be withheld, this may prove to be a somewhat conservative estimate.

5.61 The impact of Mangla reservoir in 1968 reduces shortages to a low level, but the demand later rises in anticipation of Tarbela storage. These shortages are equivalent to only about three percent of the deliveries in October-April 1973, rising to 3-1/2 percent for the comparable period in 1974.

5.62 The absence of shortages under mean year conditions in the sequential analysis after 1975 shows that the IACA program would operate satisfactorily. This is because it is designed to meet requirements under conditions lower than the mean river inflow. As shown in Annex 3.2, the historical sequence of river inflow gave, as would be expected, somewhat larger shortages than under mean inflow. Neglecting the first two years, 1966 and 1967, the October to May shortages averaged about 3-1/4 percent in the period 1968-75 with the highest amounting to 6-1/2 percent in 1974.

5.63 In conclusion, the sequential study has shown that the IACA program contains adequate facilities to meet the projected irrigation demands, though there would be some shortages in the early years before that program would come fully into effect. Furthermore, in project areas developed before 1975 the IACA estimates of full delta requirements, used in the analysis, are liberal when compared with those derived by Pakistani experts for the types of crops now grown, and still likely to be grown in large measure, during the transitional period (1965-75) when potential shortages may cause concern.

5.64 The analysis of link canal behavior was not intended to produce figures for actual operation of the links, but rather to show the minimum requirements and thus indicate potential capacity constraints up to 1985. The only significant constraints appear in the links serving the Bari Doab and the Sutlej Valley (RQ and QB, see Map 7) 1/. IACA considers that this constraint could be alleviated by adjustments to the relative use of the public tubewell fields and the surface flows. It is estimated that more serious link capacity constraints would develop by 1985, and hence IACA has proposed a new trans-Punjab link system. This would result because the IACA program defers canal enlargement within the commands until 1975 and later where this would necessitate link canal enlargement.

## 5. Surface Water Storage

### (a) Requirements

5.65 IACA has derived demand estimates for storage by first using the groundwater available from the tubewell fields, then the natural river flows,

1/ Rasul-Qadirabad and Qadirabad-Balloki.

and finally the releases from storage reservoirs. The last item is thus derived as a residual demand, and in consequence is the most sensitive to any changes in the pattern of requirements. Although this approach is not applicable to an operational study, and for this reason was not used in the sequential study, it is appropriate for the main purpose of determining stored water needs. Natural river flow and tubewells provide the cheaper sources of supply, whereas stored water costs about three times as much as groundwater. The IACA approach therefore leads to sparing use of the most expensive source of additional water.

5.66 The total storage demand can be attributed to two main zones of the Basin -- the areas supplied by the Jhelum and Chenab, and the areas supplied from the Indus. Although Mangla reservoir on the Jhelum theoretically commands almost the whole Basin, in practice its use will be reserved primarily for use upstream of the TSMB link (zone (ii), see Map 6 and also Figure 5.3). Prior to 1974 it would also be used between the TSMB link and the Panjnad confluence with the Indus.

5.67 IACA has based its projections for storage on mean river flow conditions on the assumption that variations below the mean would be compensated for adequately by overpumping of public tubewell fields. This concept has been shown to be satisfactory by the results of the sequential study.

5.68 An important consideration in any study of demand for stored water is that the provision of storage generates ints own demand, and the decision on reservoir timing essentially hinges on what points of time one assumes demand would be growing fast enough to justify the construction of a given amount of storage.

5.69 IACA has shown that in the case of Mangla, as would be expected with a reservoir built for replacement of lost river flow, the existing demand approaches its capacity of 5.2 MAF. While IACA employed a then current capacity estimate of 4.5 MAF in its analysis the difference between this and the latest figure of 5.2 MAF is too small to call for a revision of the work. This is especially the case when practical operational problems are taken into account, and also when slightly more than mean year storage requirements are desirable in the early years of the program because few tubewell fields would be installed to provide a buffer against shortages and low flow conditions.

5.70 The Jhelum storage requirements would rise slowly over time to 7.5 MAF at the stage when agricultural development would enable cropping intensities approaching 150 percent, but some of this demand could be transferred to the main Indus if a link system is built across Punjab commanding land above the level of TSMB link. Further storage could be provided on the Jhelum by the raising of Mangla dam. This would theoretically add 3.55 MAF, but by the time this is needed the enlarged reservoir could probably not be filled every year because of the increased demand on the river for kharif crops. IACA has stated that it is not possible at this time to be conclusive on either the eventual need or precise timing of the raising of Mangla, but IACA does not foresee its need until about 1985-2000.

5.71 IACA projects a more clearly defined and rapid growth in demand for stored water on the Indus main stem. This would amount to five MAF in 1975, nine MAF in 1985, and 19 MAF at full development of cropping intensities by the end of the century.

5.72 In order to test the sensitivity of its analysis, IACA calculated the storage requirements on the system under lower than mean flow conditions, but without using the spare tubewell field capacity as was done in the sequential study. When compared with total water use figures given in paras 5.43 and 5.51, the differences are not great:

Storage Requirements at Various Flow Frequencies
(MAF)

| | Mean Year | | 1 year in 2 Flows | | 3 year in 4 Flows | |
|---|---|---|---|---|---|---|
| | 1975 | 1985 | 1975 | 1985 | 1975 | 1985 |
| River Jhelum | 4.3 | 4.5 | 5.4 | 5.6 | 6.0 | 6.0 |
| River Indus | 5.0 | 8.8 | 5.7 | 9.7 | 6.9 | 12.1 |

5.73 The separate discussions of Jhelum and Indus storage should not detract from the possibility of a high degree of interchangeability within the system, which may be further improved as new link canals are developed. This interchangeability is taken into account in the treatment of the Dam Site Program in Volume III of the Bank Group's Report.

## 6. Water Allocations - Present and Future

5.74 The river flows entering the Indus Plains are presently allocated in accordance with procedures based on the unratified Sind-Punjab Draft Agreement of 1945. These procedures take into account the various possible conditions of river flow, and also a time lag of ten days between the Punjab and Sind.

5.75 Various priorities are established under the terms of this draft agreement. For example, the Thal Canal, Sukkur barrage and certain former old inundation systems share first priority on the main Indus, and thus have fairly well sustained deliveries. The new canals at Taunsa, Gudu and Ghulam Mohammed barrages, on the other hand, have low priority and therefore suffer more marked shortages.

5.76 Similarly, the Upper and Lower Jhelum Canals, Upper and Lower Chenab Canals, and Lower Bari Doab Canal have priority in the Punjab. These "five linked canals" supply a large, and predominantly perennial, area amounting to the whole of the CCA in Chaj Doab, most of the CCA in Rechna Doab, and over one quarter of the CCA in Bari Doab. The other canals of the Punjab have varying degrees of lower priority. The least favored area is the Sutlej Valley and the southern-most part of the Punjab.

5.77 The procedures set by the Sind-Punjab Draft Agreement, though influencing the immediate future plans for the Basin, need to be brought up to date in order to take into account the following new factors which were not foreseen in the Draft Agreement:

(i) Public tubewell contributions;

(ii) The IBP works;

(iii) Main river storage in addition to IBP works;

(iv) Changes in designed discharges of canals.

5.78 In the IACA program for irrigation development and water distribution, the present and immediate future importance of the Sind-Punjab Draft Agreement has been carefully taken into account, mainly through the careful regard for historic deliveries described above. Furthermore, the priorities that have been assigned to public tubewell fields would provide valuable buffers against shortages in some of the low priority areas of the Punjab.

## D. System Operation

### 1. Future Water Rights and Allocations

5.79 It has been stated above that the procedures for allocating water, which have in the past proved successful, must be amended to allow for the changing conditions of the future. These changes area already coming about almost immediately with the completion of the IBP works, 1/ and with the bringing on-flow of large numbers of additional public tubewells included in the current Government program.

5.80 An ideal system of water allocation is one based on demands which, for each individual watercourse area, would be varied throughout the season in accordance with the crop water requirements of the farmers. IACA concluded, however, that such a system could not be achieved in the foreseeable future. The principal reason for this conclusion is that the existing canalization system (as described in Chapter III) has been designed for almost constant flow in the distributary canals, the latter having very few control structures. The constructional and hydraulic problems of changing the system into one operating according to demand are too large to contemplate in the face of other needs for irrigation development. It will, therefore, be necessary throughout the foreseeable future to continue procedures based on determining surface water allocation and distribution in advance, though leaving some discretion to officials at appropriate levels to deal with temporary emergencies that inevitably arise from time to time. Such predetermination of allocations should, as hitherto, be based on indents for surface water

1/ For further details see IACA Comprehensive Report, Volume 5, Annexure 7.

that are compiled from estimates of cropped acres, which in turn are dependent on the likely availability of supplies. These estimates are made up by the irrigation officials at the beginning of each season. For example, in the Punjab the extent of the rabi wheat acreage can be forecast with reasonable accuracy by mid-November and approximate estimates can be prepared much earlier.

> "Lack of flexibility in surface water deliveries can be overcome to a large extent in public tubewell fields in fresh groundwater zones (see Section 2 below) by adjustment of pumping periods. This would also apply locally to private tubewell development where individual farmers adjust the amount of pumping to suit crop water requirements as supplements to canal flow."

5.81 An important need at the present time is to form an organization to establish and authorize procedures for changes in the water allocation patterns. This would be required not just for the immediate purposes referred to above, but also to undertake periodic reviews. With the implementation of a development plan, changes in supply and demand conditions will occur continually. Such an organization should not be called upon to undertake the complex matter of distribution analysis, which can only be handled by an experienced and qualified team of irrigation engineers, but it should be responsible for the policies and general principles that must be established with proper authority. These should take into account a range of administrative, legal and sociological factors, in addition to the largely predominant technical considerations. This consideration does not set aside the need for close cooperation at all stages of planning and implementation between the various agencies concerned with project execution, water allocations and distributions, but is intended to bring about major improvements in this respect and, in particular, to bring more agricultural expertise and outlook into water distribution policy.

5.82 IACA has set out 1/ basic criteria which should be taken into account in the preparation of a new system of water allocation and distribution. These are summarized as follows:

(i) Public Tubewell Fields. Allocations to the farmers should be based on total integrated supplies of surface water and groundwater from public tubewell fields. Further reference to this matter is made in Section 2 below.

(ii) Known Obligations. Known obligations must be related to historic deliveries insofar as these meet known and established needs. It would be illogical and generally wasteful of water at this time to treat known obligations either on the basis of theoretical obligations that have never been met, or conversely on the basis of historic deliveries that are surplus to needs. The latter point will call for

1/ IACA's Comprehensive Report, Volume 5, Annexure 7, "Water Supply and Distribution".

careful consideration in the Sutlej Valley where in the past high summer flows have been available which may have been in excess of requirements for short periods of time. Although there is a need to improve water supplies in this area, there is clearly little purpose in doing so other than on a full seasonal basis. The main limitation to kharif cropping is the water supply in the early part of the season, and this governs the level of demand in the mid-kharif period when river flows are high.

(iii) Seasonal Allocations. Storage reservoirs should be used to regulate river flows so that the total water supplies delivered to the fields are related as closely as possible to the estimated water requirements of the crops. With the introduction of stored water "known obligations" should be reconsidered, and where necessary redistributed on a seasonal, instead of the present monthly or ten-day basis, to the advantage of the farmers.

(iv) Filling of Reservoirs. Reservoirs would normally be filled only with water which is surplus to basin requirements, but where conflict in demands may arise in exceptional circumstances it may be appropriate for priority to be given to reservoir filling because of the greater value relating to rabi crops, especially wheat.

(v) Additional Supplies. Areas with present high priorities for canal deliveries (see Chapter V.C) should not necessarily have any special priority for additional supplies that would become available from storage reservoirs and public tubewell fields.

5.83 The application of these five criteria is essential to the successful operation of IACA's development proposals, and indeed to the efficient use of the water resources that are available to agriculture at present, and would become available in the future. The first criterion relates to the integrated operation of the surface and groundwater supplies. The other four are of particular importance to the economical use of stored water, which is not only expensive to provide but will, as development proceeds, remain scarce.

2. Operation of Public Tubewell Areas and Water Allocations to Them

5.84 In order to ensure a satisfactory and economical integration of water supplies, (see Chapter III, Section C), it would become necessary to adopt a more complex system of operation than has hitherto been used. The complexity stems not only from the basic need to proportion groundwater pumping and canal deliveries, but also from lack of homogenity in the canal systems serving the individual project areas. Here it is important to bear in mind that most of the public tubewell fields would not cover discrete canal command units, but only parts of canal commands. Furthermore, there would be a need to vary the surface water deliveries as between fresh groundwater zones, mixing zones and saline zones. The last two zones must receive a priority for surface deliveries in times of shortage, whereas in the fresh groundwater zones temporary surface water deficiencies could be offset by overpumping. Ultimately, a technological advance towards the proper operation of the tubewell project areas would lie in operation of the tubewell fields by centralized remote control, coupled with some degree of remote control of the canal flows, but for the immediate future this would represent too big a step. Individual manual control together with a good system of communications, is the more feasible method for the present. Remote control and other similar advances in operation, including some separation of surface water deliveries to mixing and saline areas, must be gradually developed,.and the appropriate stages for their application should be related closely to the expansion of the tubewell fields and the consequent formation of larger entities for ground and surface water integration.

5.85 The more critical times of the year for system operation would be when tubewells are supplying, a large or exclusive contribution to crop needs in the fresh groundwater zones, and this would normally be in the mid-rabi months. This period would prove the more critical because each tubewell would be designed to serve its own discrete area (normally an area of 200-600 acres served by one watercourse), and if the well goes out of service large, or even complete, deficiencies in supply would occur.

5.86 To minimize operating hazards at this critical time, care must be taken to ensure that well maintenance receives special emphasis in the previous period. This would also leave the operating agency greater staff resources to concentrate on the canal maintenance that must be mainly undertaken in the mid-winter period when flows are lowest. Such carefully programmed maintenance would lead to a more economical employment of maintenance staff, to the extent that staff personnel are interchangeable. The structure of the operating and maintenance staff organization is discussed in IACA's Comprehensive Report. 1/

5.87 In making allocations to canal commands which would contain public tubewell projects, the "known obligations" referred to in para 5.82 (ii) above should be treated on the basis of total water delivered at watercourse heads, regardless of whether it is derived from ground or surface sources. In these terms, future deliveries would greatly exceed "historic" deliveries. In this way some of the "historic" deliveries from surface sources would be replaced by groundwater. This principle forms part of the planning of the on-going project SCARP IV and would, in varying degree, be extended to other projects. There would be need for a transition period from the present level of "historic" surface water deliveries until the time when the principle of water substitution can be implemented, because the farmers need time to gain

1/ IACA's Comprehensive Report, Volume 8, Annexure 11.

confidence in the reliability and quality of the groundwater supplies. For these reasons, the allocations of water to the various canal commands of the Plains where public tubewells are programmed would need to undergo frequent change.

5.88 Indents for surface water supplies should be prepared in greater detail than hitherto, and with careful regard for the rate of growth of cropping intensity. The latter point would call for close collaboration between the irrigation and agricultural officers, especially in regard to the tubewell fields themselves, but also in the associated canal commands.

### 3. Water Allocations to Areas Without Public Tubewell Development

5.89 IACA has not projected any similar adjustment in surface water supplies in areas where private tubewell development would predominate. Allocations to canal head, and through the distribution system, in areas not covered by public tubewells, would have to be maintained at least at established "historic" levels. This is necessary not only to protect the needs of cultivators who have no private tubewell supplies, but also to satisfy cultivators' expectations and rights to the relatively cheap canal water.

5.90 These areas would also gain considerable benefits from the construction of the storage reservoirs at Mangla and Tarbela, and later from other reservoirs. With the advent of regulation by storage dams, the "historic" deliveries should be adjusted to the advantage of the farmer, the past pattern of monthly delivery being amended to suit indents that are better related to the seasonal pattern of crop needs.

5.91 Additional rabi supplies from the storage reservoirs would be allocated in areas where waterlogging from high groundwater is not a current or imminent hazard. The presently adopted priorities as discussed in Section 6 should not necessarily be followed in making such allocations but allocations should be based on continuous review of the relative developments in the system at large.

### 4. Phases of Development and their Influence on Water Distribution

5.92 The first revision of water allocations would be in May 1967 when the Mangla reservoir comes into operation. It is therefore now a matter of some urgency to develop a system of operation and water allocation, and to have it formally approved in time to put into effect in accordance with that schedule. There is a vital need to meet this initial and difficult objective, because otherwise there is a danger of failing to retain in Mangla reservoir (by the end of the 1967 kharif season) the full capacity needed for replacement of the proportion of the Ravi and Sutlej flow that may be diverted for use in India in the following rabi season. It must be recognized that there may be certain difficulties in meeting allocations during the transitional period of time over which the IBP works are brought into operation. However, IACA has demonstrated in its studies, and it has been confirmed in the Sequential

Analysis on the basis of the proposed program and distribution criteria, that the shortages which may occur should not be of serious proportions (see Section V.C). Much depends on the attitude taken towards "known obligations" but if the principles set out by IACA can be adopted - and these are based on historic mean deliveries rather than on theoretical obligations - it should prove possible to maintain previous standards in irrigation supplies, and in some cases to improve them by better regulation within the rabi season.

5.93 By 1970, when the Indus link canals are scheduled to come into operation, the whole of the Sutlej and Ravi flow would be available to India. The link canals would overcome such problems as may have arisen in serving water to Trimmu and Panjnad in the kharif months during the earlier transitional phase. Mangla reservoir should remain hypothecated to its replacement function, and operating instructions for the dam should be established on that basis, but at the same time allowing for improved seasonal regulation.

5.94 Further tubewell fields built in the latter part of the Third Five-Year Plan, including the important SCARP IV project, should be integrated with the water allocation and distribution plan. In accordance with its design, SCARP IV would release most of the present rabi supplies now flowing to the Upper Chenab canal for use elsewhere in the Punjab.

5.95 Little change would be called for on the Indus main stem until 1975, when Tarbela would come into service and public tubewells would begin to make major contributions to water requirements.

5.96 The advent of Tarbela in 1975 would provide a full opportunity to bring about a major and widespread improvement in water distribution and availability. In this sense Tarbela represents a conclusive stage in the large water development program proposed for the first decade. From this point of time onwards it should prove possible to match water allocations fairly closely to anticipated crop needs in most parts of the basin. Certain constraints would still exist, however, notably in canal capacities in the saline and mixing areas. The need for drainage would still inhibit water allocations to some areas, but broadly the patterns of water supply and demand could be closely related, and in many areas the full requirements of the farmers would be met from a combination of surface and groundwater deliveries.

5. Reservoir Operation and Release Patterns

5.97 IACA has also carried out some operational studies on the reservoirs at Mangla and Tarbela in order to determine the expected pattern of water release and the related hydro-electric power output.1/ IACA's studies

1/ See Bank Group's Report, Volume III "Program for the Development of Surface Water Storage" and also Volume IV "Program for the Development of Power".

indicated that, with the level of development expected by 1975, the period when irrigation requirements would exceed river flow would normally extend from October to the end of March. By 1985 this period would include April and the early part of May. In exceptional cases shortfalls of river flow against requirements would occur outside these periods. Special attention was given to the conditions that would obtain in years of low rabi flow, since the pattern of release would be more significant at such times than in years of average or above average flow. During years of low rabi flow deficiencies in surface water deliveries must be spread throughout the rabi season. This is not only to mitigate their effects on the crops, but also in order that they may be made up as far as possible by overpumping in the tubewell fields.

5.98 Although IACA gave priority to irrigation needs in deriving the suggested release patterns, some allowance was made for electrical demands on the hydro-electric installations in the storage dams and the inter-related power demand of groundwater pumping. The public tubewell fields, which would be integrated with the surface supply system, should be operated mainly in rabi from October to March when there is surplus power available, and as little as possible in April and May when hydro power is in short supply. This has the added advantage of permitting reservoir levels to be held slightly higher in the late part of the storage release period.

5.99 Based on these considerations IACA has developed the following release patterns for Mangla and Tarbela:

(i) Mangla Release Pattern. IACA determined the monthly storage release requirements on the Jhelum at Mangla for various conditions of inflow as set out below:

Monthly Storage Requirments on the River Jhelum
(MAF)

| River Flow | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | Apr. | Total |
|---|---|---|---|---|---|---|---|---|
| | | | | 1975 | | | | |
| Mean | 1.30 | .63 | .51 | .48 | 1.23 | .45 | 0 | 4.29 |
| Median | 1.59 | .75 | .64 | .61 | 1.42 | .48 | 0 | 5.39 |
| Low Rabi 1/ | 1.51 | .75 | .63 | .67 | 1.64 | .84 | 0 | 6.05 |
| Critical 1/ | 1.28 | .62 | .63 | .73 | 1.65 | 1.16 | 0 | 6.03 |
| | | | | 1985 | | | | |
| Mean | 1.57 | .67 | .43 | .39 | 1.26 | .19 | 0 | 4.51 |
| Median | 1.86 | .78 | .56 | .52 | 1.45 | .53 | 0 | 5.60 |
| Low Rabi 1/ | 1.77 | .78 | .55 | .59 | 1.67 | .89 | 0 | 6.24 |
| Critical 1/ | 1.54 | .65 | .52 | .64 | 1.66 | 1.19 | .07 | 6.27 |

1/ It should be noted that the critical year 1954/55 was not the worst occurrence on the River Jhelum, and that it was no more than a low rabi year.

The requirements stated in the table represent the requirements of those canal commands, shown in Map 6, which rely on the Jhelum and Chenab for their supplies and cannot be served directly by the Indus link canals.

The patterns of requirements for 1975 and 1985 do not differ very much, and in the case of the Jhelum the extent of the period of storage requirement remains much the same, namely October to March inclusive.

On the basis of these considerations, IACA proposed the following release pattern for Mangla reservoir:

Mangla Release Pattern
(Expressed as a percentage of useful storage)

| Storage Release | | | | | | | Reservoir Filling | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. |
| 23 | 15 | 10 | 10 | 24 | 18 | Nil | 24 | 36 | 31 | 9 | Nil |

(ii) Tarbela Release Pattern. The requirements for storage at Tarbela were calculated by IACA as follows:

Monthly Storage Requirements on River Indus

| | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | Apr. | May | Total |
|---|---|---|---|---|---|---|---|---|---|
| | | | | 1975 | | | | | |
| Mean | 0 | 0 | .79 | 1.77 | 2.21 | .25 | 0 | 0 | 5.02 |
| Median | 0 | .15 | .91 | 1.79 | 2.24 | .65 | | | 5.75 |
| Low Rabi | 0 | .27 | .94 | 1.80 | 2.41 | 1.31 | .17 | | 6.90 |
| Critical | 0 | .53 | 1.35 | 2.02 | 2.70 | 1.58 | 1.54 | 1.30 | 11.01 |
| | | | | 1985 | | | | | |
| Mean | 0 | 1.21 | 1.35 | 2.41 | 2.73 | 1.02 | .12 | | 8.83 |
| Median | 0 | 1.37 | 1.39 | 2.50 | 2.75 | 1.43 | .28 | | 9.70 |
| Low Rabi | 0 | 1.49 | 1.33 | 2.55 | 2.90 | 2.02 | 1.45 | .39 | 12.11 |
| Critical | 0 | 2.05 | 1.61 | 2.84 | 2.29 | 2.29 | 2.80 | 2.96 | 17.91 |

This table demonstrates how the period of requirement tends to extend, both with time and with the occurrence of more critical conditions of inflow. It is on these grounds that IACA proposes to have some 15 percent of the capacity available in Tarbela after the end of March, as already referred to in para 5.52. The release pattern derived by IACA for Tarbela would thus be as follows:

Tarbela Release Pattern
(Expressed as a percentage of useful storage)

| Storage Release | | | | | | | | Reservoir Filling | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. |
| Nil | 8 | 11 | 21 | 26 | 19 | 10 | 5 | 45 | 55 | Nil | Nil |

IACA's studies of reservoir operation were not intended to provide more than a guide for future planning. A detailed set of operating instructions must now be prepared by WAPDA, in conjunction with other Government Departments concerned, as a matter of some urgency, especially for Mangla.

5.100 To test the validity of their water distribution studies, IACA has examined the probable deficiencies that would arise at Mangla and Tarbela under the rather severe conditions of low rabi inflow. The results are given below:

Surface Water Deficiencies at Mangla for Low Rabi Flow 1/ (1975)
(MAF)

| | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. |
|---|---|---|---|---|---|---|
| Irrigation Requirement | 2.83 | 1.24 | 1.05 | 1.13 | 2.19 | 2.01 |
| River Flow | 0.82 | 0.49 | 0.42 | 0.46 | 0.55 | 1.17 |
| Storage Requirement | 1.51 | 0.75 | 0.63 | 0.67 | 1.64 | 0.84 |
| Storage Release 2/ | 1.09 | 0.71 | 0.48 | 0.48 | 1.18 | 0.85 |
| Deficiency | 0.43 | 0.04 | 0.15 | 0.19 | 0.46 | - |
| Deficiency as % of Requirement | 13% | | 15% | | 11% | |

1/ For details on inflow conditions see IACA Report, Volume 5, Table 1.3.
2/ Based on Mangla capacity of 4.75 MAF.

Surface Water Deficiencies at Tarbela for Critical Year 1/ Rabi Flow in 1975
(MAF)

| | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | Apr. | May |
|---|---|---|---|---|---|---|---|---|
| Irrigation Requirment | 1.43 | 1.73 | 2.34 | 2.90 | 3.46 | 2.56 | 2.75 | 4.04 |
| River Flow | 2.19 | 1.20 | 0.99 | 0.88 | 0.77 | 0.98 | 1.21 | 2.74 |
| Storage Requirement | - | 0.53 | 1.35 | 2.02 | 2.69 | 1.58 | 1.54 | 1.30 |
| Storage Release | - | 0.69 | 0.95 | 1.80 | 2.24 | 1.63 | 0.86 | 0.43 |
| Deficiency | - | | 0.40 | 0.22 | 0.46 | 0.05 | 0.68 | 0.87 |
| Deficiency as % of Requirement | Surplus | | | 12% | | 7% | | 23% |

1/ The "critical year" rabi flow has been adopted for this illustration of deficiencies because it contains lower October and May flows than the "Low Rabi Flow." The flows in these months have considerable importance to Tarbela operation. (see IACA Report, Volume 5, Table 1.3).

5.101 Deficiencies have been treated on a two-monthly basis, partly because this would smooth out sharp distortions and partly because, in some months, the water requirements of the crops have been treated to a limited extent on the same basis. The deficiencies are in no case more severe than would be expected. In practice, they would be alleviated by the following factors.

(i) There would be considerable public tubewell development by 1975 and 1985 with capacity to overpump during the mid-rabi and in April and May, when larger deficiencies would occur at Mangla and Tarbela respectively.

(ii) As stated earlier, Mangla's initial live storage capacity should now be taken as 5.2 MAF or 5.06 MAF by 1975, and not the 4.75 MAF upon which the above deficiencies were based.

Further reference to reservoir operation is made in the Bank Group's Report, Volume III, "Program for Development of Surface Water Storage" and Volume IV, "Program for the Development of Power".

6. Detailed Water Distribution Analyses

5.102 As stated in Section C (i) above, the water distribution analyses carried out by the Bank Group's consultants were designed to set the Action Program for the next decade into its longer term perspective, to match the general pattern of water use against availability, and also to check the operation of the IACA plan of development against a possible repetition of historic sequences of river inflows to the Basin. These analyses were not intended to provide detailed estimates for specific water allocation or distribution patterns, but nevertheless they form a useful framework upon which to build up detailed studies of future system operating procedures and rules. The need to proceed with these detailed studies is now extremely urgent. A start has already been made by WAPDA in its approach to the operation of Mangla dam over the immediate future, and the Department of Irrigation and Power had undertaken similar studies. Mangla represents, however, only part of the new operational problem and one for which responsibility is currently assigned to WAPDA. In its broader context the distribution studies must embrace all the new situations set by the introduction of the IBP link canals and their new transfers of water to the eastern Punjab. These and other aspects of the redistribution of surface water, including the implementation of tubewell programs, involve a number of other agencies including the Agricultural Department, ADC and the LWDB. The procedure for bringing together the views and experience of the various agencies and applying them to a study of water distribution is essentially a domestic one that can only be decided by the Government, but the Bank Group attach such importance to this matter that certain suggestions are set out here.

5.103 In Chapter VI Section 3 (a) the Bank Group endorse IACA's proposal that a Provincial Irrigation Authority be formed to make basic policy decisions on barrage allocations, reservoir release patterns, and other major policy issues such as the use of tubewell fields in relation to surface water deliveries. This body would clearly be charged with the responsibility to ensure that all Government agencies concerned with irrigation should co-operate in the framing of new policies and water allocations, but it would not itself be expected to undertake the detailed analyses of water distribution which should remain the task of the irrigation experts. In the normal course of events, all water distribution analysis per se would be undertaken by the Irrigation and Power Department, which in any case is faced with the implementation of the procedures finally adopted. However, in view of the rather special nature and magnitude of the present task, and on account of the particular role played by WAPDA in the IBP works, in the current operation of Mangla and in the public tubewell program, there is a strong case to set up a semi-independent Study Group or Working Party for this purpose, to be staffed by, say, the Irrigation and Power Department, WAPDA, Agricultural Department and Planning and Development Department. The head of such a Study Group, who would need to be a highly qualified irrigation engineer, could be answerable to either the Provincial Irrigation Authority, or better, to some intermediate Advisory Committee drawn from the main Government Departments.

5.104 The Study Group would need to be well staffed with technical officers competent to carry out the detailed calculations and analyses that the situation demands. At the same time this staff would need to be fully conversant with the practical problems of operating the irrigation system. Clearly the largest contribution to such an establishment would come from the Irrigation and Power Department and WAPDA, but at the same time it would be necessary to incorporate one or more agronomists, a crop water expert, and an agro-economist. Legal advice would also be required at this level in order to save time and trouble when, at a later stage, new water allocation policies are offered for approval to the Provincial Irrigation Authority. In order to economize in technical services it would be advisable, with this organization, to attach to the Study Group those consultant services in water distribution that are currently retained by individual Government departments.

5.105 The Study Group should be given a program of work related in particular to the dates when the various IPB works, and the public tubewell fields now under construction come into service. Much time has already been lost, and unless it can be regained over the next few months there is a risk that costly new works would not fulfill efficiently their designated functions.

# VI. AGRICULTURAL INPUTS AND SUPPORTING SERVICES

## A. Farm Inputs

### 1. General Considerations

6.01 Despite continuing efforts to promote better farming practices and the employment of physical inputs such as fertilizer, better seed, and plant protection on a wider scale, the present level of adoption by the vast majority of farmers is still very low. The Bank Group would not only endorse, but would add to the emphasis which IACA has placed on the importance of improving farming standards. In general, IACA advocates the simultaneous development of improved water supplies and improved farming, with the main emphasis on water while other inputs increase to the maximum extent it considers feasible. The Bank Group supports this policy and agrees that, to the extent farm inputs are in short supply, development areas with adequate and assured water supplies should have priority. To a greater extent than IACA, however, the Bank Group considers that there is scope for increased productivity within the prevailing conditions of water supply. The watercourse studies 1/ suggest that unreliability of water supplies, rather than the absolute quantity of water made available, is in many cases the most serious deterrent to greater investment and enterprise by the farmers. This could no doubt be assisted by better operation of the irrigation system, and would improve with the development of private and public tubewells and with the regulation of the river flows provided by the link canals, Mangla reservoir and, in due course, by Tarbela.

6.02 The Bank Group would place at least as much emphasis on the efforts required to bring about better farming as it would on further water development. As a broad generalization, it would appear that IACA may well have over-estimated the implementation capacity for water development, and, by comparison, under-estimated the capacity to stimulate, and the benefits which could accrue from, the use of other inputs. A rapidly expanding use of agricultural inputs would call for organizational and institutional improvement in all sectors -- procurement, distribution, promotion, and technical and financial support. It must, however, be emphasized again that no single input in isolation, be it water, fertilizer, seed or anything else, would succeed or make much of an impact on its own. The proper application of the various inputs in the right combination, at the right time, and in the appropriate manner depends essentially upon the skill and judgment of the farmer. Unless the majority of farmers have the knowledge and the incentive to enable them to apply the opportunities which can be opened up for their particular circumstances, the whole developmental effort could be seriously impaired. This underlines the importance of agricultural education, research and extension in the realization of the potential which undoubtedly exists.

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1/ See Annex 2.1.

6.03 The progress which has been made in some directions is impressive. Probably the best examples are fertilizer usage, development of improved varieties of wheat and rice, and private tubewell installation. The quantities involved, however, are as yet very small in relation to the opportunity and need. The organizational and institutional difficulties of rapid introduction of the whole package of inputs are formidable. This applies to water and fertilizer, but with even greater force to other inputs such as plant protection, improved seed varieties, mechanization, agricultural credit, genetic improvement of the livestock herd, and the general dissemination of information on the adoption of better crop and animal husbandry practices. Nevertheless, West Pakistan's agriculture will become increasingly dependent on the proper use of such inputs.

6.04 The efficient utilization of existing irrigation supplies, as well as those to be developed depends to a very large extent upon the availability and application of non-water inputs in proper combination. In its projections of agricultural growth in West Pakistan, IACA has assumed a continuing increase in the use of such inputs. The growth projections are thus the result of an envisaged program of water development as well as increased provision and use of agricultural inputs. As discussed in Chapter II, the Bank Group believes that great scope exists for a development strategy which gives high priority to, and adequate incentives for, the distribution and use of these inputs. The Bank Group believes that if proper public support is given, some of the IACA projections of input use could be exceeded, and it therefore looks upon these projections as the minimum requirement needed to support the agricultural growth projected by IACA.

6.05 The input requirements, including a somewhat more optimistic assessment of the increased use of fertilizer, are discussed below in more detail. While recognizing the inherent difficulties, the Bank Group is convinced that an agricultural breakthrough can only be achieved if water development is matched with a corresponding increase in the use of other inputs. Further water development alone would only extend and continue the traditional pattern of agriculture. The transformation of agriculture in West Pakistan from a subsistence oriented pattern to a commercially-oriented one will proceed only as fast as the responsible institutions succeed in making farmers aware of the untapped opportunities available to them, and provide the incentives and the means for their exploitation.

## 2. Fertilizer

6.06 Taking into account the projected increase in cropped acres from 41.6 million in 1965 to nearly 60 million acres by the end of the century, IACA has projected fertilizer requirements by regions for the reference years 1975, 1985, and 2000. These estimates are based on both prescribed rate of application for major crops and increasing coverage of the areas assumed to receive fertilizer applications. Annexure 6.1 summarizes the percentage of area covered and the quantities applied per cropped acre. IACA's rates of application have been developed from rates presently recommended by the Department of Agriculture. IACA also took into account the spread of new and improved wheat varieties. It assumed that some 50 percent of the area would be covered by new or improved varieties by 1975, and the whole wheat area by 1985.

6.07 The aggregate fertilizer requirements based on the above outlined assumptions would thus rise from about 90,000 nutrient tons at present to about 320,000 nutrient tons by 1975, and to slightly above 1.8 million nutrient tons by the end of the century. These amounts would represent applications of about nine lbs. per cropped acre in 1965 and 29 lbs. per cropped acre in 1975. The table below sets out IACA's aggregate projections by crops:

IACA Projections of Total Fertilizer Requirements by Crops in West Pakistan (1,000 tons nutrient)

| | 1965 1/ | | 1975 | | 1985 | | 2000 | |
|---|---|---|---|---|---|---|---|---|
| | N | $P_2O_5$ | N | $P_2O_5$ | N | $P_2O_5$ | N | $P_2O_5$ |
| Wheat | 7 | - | 100 | 64 | 248 | 147 | 338 | 211 |
| Cotton | 23 | - | 42 | 14 | 98 | 52 | 196 | 163 |
| Coarse Rice | 9 | - | 10 | - | 24 | 8 | 60 | 42 |
| Fine Rice | - | - | 10 | 4 | 23 | 10 | 45 | 26 |
| Coarse Grains | - | - | 8 | 3 | 35 | 23 | 84 | 50 |
| Fodders | - | - | 15 | 11 | 71 | 54 | 172 | 176 |
| Sugarcane | 49 | - | 22 | 4 | 36 | 12 | 63 | 25 |
| Fruit | 2 | - | 5 | 2 | 15 | 7 | 42 | 17 |
| Other Crops | - | - | 5 | 1 | 23 | 22 | 55 | 62 |
| TOTAL | 90 | - | 217 | 103 | 573 | 335 | 1,055 | 772 |
| Rate of Growth of Fertilizer Use: (% per annum) | 13.5% | | | 11% | | 7.5% | | |

1/ In the absence of any reliable information this is a very rough approximation.

Compared with the experience during the period of the Second Five-Year Plan, the rates of growth of fertilizer use implied in the IACA projections would appear to be rather conservative. As stated in Chapter I, para 1.13, the absorption of fertilizer during the Second Plan period, albeit from a very low base, grew rapidly at an average rate of about 22 percent per annum. Most likely the growth of fertilizer use would have been even higher had not changes in policy, as well as lack of adequate supplies, introduced constraints beyond the control of the farmers.

6.08 Various short-term projections of future fertilizer use in West Pakistan have been made in the past, and these are discussed in greater detail in Annex 6.2. These projections tend to coincide at an offtake figure of about 370,000 nutrient tons by 1969/70, or a rate of growth of fertilizer use well above 30 percent per annum. This would imply a further acceleration over the already impressive experience during the Second Plan period. While the actual performance during the first year of the Third Plan (1965/66) does not show a major increase over 1964/65, the recent steps taken by the Government of West Pakistan would tend to support such an optimistic assessment. For the fiscal year 1966/67 the Planning and Development Department of the Government of West Pakistan hopes to have more than 250,000 nutrient tons (equivalent to about one million tons of nitrogenous fertilizer) available for distribution. An off-take of 80 percent of this amount in 1966/67 would represent a level of absorption of nitrogen approaching that projected by IACA for 1975, and would by far exceed IACA's general expectations.

6.09 The Bank Group is satisfied that scope for the use of such quantities exists. However, the problems of production and procurement, as well as transportation and actual distribution, should not be discounted, nor should the influence of price supports be under-estimated in an environment where the mass of farmers are still preoccupied with subsistence farming. As an upper limit the Bank Group considers that a target of about 350,000 nutrient tons (equivalent to about 1.6 million tons of ammonium sulphate fertilizer) would be feasible for 1969/70. This implies a rate of growth in fertilizer use of around 30 percent per annum, and would be about double the IACA estimate if their implied rate of growth were applied to the existing fertilizer consumption. The coverage and rates of application envisaged by IACA for 1975 are thus expected to prevail by the end of the Third Five-Year Plan period.

6.10 During the period of the Fourth Plan (1970/71 - 1974/75) it may become more difficult to maintain a similar momentum in the absorption of increasing quantities of fertilizer. Assuming that the rate of growth of fertilizer offtake would drop to about 15 percent per annum, the level of consumption would reach about 700,000 nutrient tons by 1975. This would again be double the IACA estimate. While a high degree of uncertainty is necessarily inherent in all these projections, it should be possible for the West Pakistan authorities to reach these targets if appropriate arrangements are made for supplies and distribution. For the reference years thereafter (1985 and 2000) the Bank Group would expect the increasing off-take of fertilizer to slow down considerably and approach the levels estimated by IACA, as shown in para 6.07.

6.11 In summary the Bank Group's more optimistic assessment with regard to the future absorption of fertilizer compares to IACA's as follows:

Range of Fertilizer Off-Take for Reference Years

| | 1964/65 | 1970 | 1975 | 1985 | 2000 |
|---|---|---|---|---|---|
| | (in '000 tons of nutrient) | | | | |
| IACA: | | | | | |
| (a) Nitrogen | 90 | 120 | 217 | 573 | 1,055 |
| (b) Phosphate | - | 55 | 103 | 335 | 772 |
| TOTAL | 90 | 175 1/ | 320 | 908 | 1,827 |
| Rate of Increase (% per annum) | 14% | 13% | 11% | 5% | |
| Bank Group: | | | | | |
| (a) Nitrogen | 90 | 250 | 470 | 620 | 1,100 |
| (b) Phosphate | - | 100 | 230 | 330 | 700 |
| TOTAL | 90 | 350 | 700 | 950 | 1,800 |
| Rate of Increase (% per annum) | 30% | 15% | 5% | 4.5% | |

1/ IACA has made no estimate for 1970; the above figure is based on the implied average annual growth between 1965 and 1975.

In the Bank Group's opinion the above estimates would delineate the range within which future fertilizer off-take is likely to fall. Using the Bank Group's estimate, the quantities of fertilizer (in terms of ammonium sulphate equivalents) would increase from 1.6 million tons in 1970 to 3.3 million tons in 1975.

6.12 The financial outlays implied in these estimates are considerable for the farming community, and for the public sector as well if the rapid growth of off-take would continue to be supported by subsidies, at least through 1975. Assuming that present price levels would not change substantially, and that subsidies would continue at a rate of about 30 percent of the present price to farmers, the annual level of expenditures for fertilizer use as estimated by the Bank Group would be about as follows:

Growth of Private and Public Expenditures for Fertilizers
(at present prices and subsidy rates)

| | Farmer Outlays | Public Subsidies | Total | Growth % p.a. |
|---|---|---|---|---|
| | ----- | (Rs. million) | ----- | |
| 1964/65 | 84 | 36 | 120 | - |
| 1969/70 | 325 | 140 | 465 | 30 |
| 1974/75 | 650 | 280 | 930 | 15 |

The above estimates may be too high since the costs of fertilizer production should be substantially reduced by the introduction of new technology. The expectation is that such reductions would diminish or eliminate the need for Government subsidy, while the price paid by the farmer would remain substantially the same. Also, the above costs and the quantities in the previous table are based on sulphate of ammonia equivalents. To the extent that urea is substituted for these, the physical quantities would be more than halved resulting in reduced transportation and distribution costs. Care should, however, be taken to ensure that the prices to farmers do not rise substantially until such time as the use of fertilizer has become a well established practice.

6.13 The expanding fertilizer use outlined above constitutes a very ambitious program in itself, requiring determined efforts by all concerned. Given proper support, the targets should be achievable. Such a program would warrant the highest priority, since the increased use of fertilizer is likely to be the most important single factor in bringing about rapid agricultural growth in the near future. To the extent that the Bank Group's assessment of future fertilizer use exceeds that of IACA, it obviously carries implications for the projection of future agricultural production. These are dealt with in Chapter VIII below.

3. Seeds and Planting Material

6.14 A further agricultural input of the utmost importance is improved seed material of superior varieties, particularly of wheat, cotton, and rice. Important progress has recently been made in the case of wheat. West Pakistan, in collaboration with Mexican wheat breeding experts supported by the Rockefeller Foundation, has been embarked on an active wheat improvement program since 1959. Several higher yielding varieties have been developed and are in various stages of progress from the research stations to commercial multiplication. Imported Mexican varieties (Penjamo and Lerma Rojo) are already being multiplied, while the locally produced Mexipak varieties have not yet reached the stage of distribution for commercial production.

6.15 The technical yield potential of these newly introduced varieties under Pakistan farming conditions, according to the wheat-breeding experts, is about 45 maunds per acre on average. This compares to an average of about 13 maunds per acre presently being obtained in the better farming areas of West Pakistan. The potential is thus considerable, and its realization will again depend on whether West Pakistan succeeds in implementing an efficient program of multiplication and distribution, providing adequate incentives, and supplying the associated inputs to farmers. The performance during the first year of commercial multiplication (1965/66 rabi season) on an area of about 12,000 acres distributed over the major agricultural regions of West Pakistan was very impressive indeed. 1/ On the basis of harvesting data available for 5,000 acres, average yields ranged from 26 to 34 maunds per acre under actual farming conditions. Maximum yields exceeded 80 maunds per acre, but the level of yields on some of the ADC seed farms did not even approach those presently achieved with indigenous varieties in the better farming areas of West Pakistan.

6.16 The general shortfall of yields, as compared with the technical and biological potential, has been attributed mainly to the following five causes:

(i) Sub-optimum moisture conditions of the seed beds;

(ii) excessive depth of sowing, carried over from practices used with indigenous varieties;

(iii) low seed rates which were only about 60 percent of the recommended seed rates for improved varieties;

(iv) shortage of irrigation water, as well as insufficient number of waterings; and

(v) deficient application of fertilizer.

It is important to recognize that not any one single factor led to the shortfall, but that practically all major elements of efficient cultivation practices were lacking to some extent. The future success of the accelerated wheat improvement program is thus not only dependent on the availability of adequate quantities of improved seeds, but on an overall improvement of crop husbandry practices as well.

6.17 IACA assumes in its projections that the wheat acreage covered with improved varieties would approach 50 percent by 1975, and 100 percent by 1985. 2/ On the basis of the projected acreage under wheat by 1975 (15.2 million acres) and 1985 (15.4 million acres), and the recommended seed rates of about 100 pounds per acre, about 350,000 tons (9.4 million maunds) of improved wheat seed material would be required by 1975, and nearly 700,000 tons (18.8 million maunds) by 1985. Assuming that seed is produced by the best farmers at an average yield of about 30 maunds of seed material per acre (or 1.1 tons per acre), some 320,000 acres would have to be devoted to improved

1/ As reported in "Annual Technical Report, Accelerated Wheat Improvement Program West Pakistan, 1965/66", S.A. Qureshi and Ignacio Narvaez, Agriculture Dept. of West Pakistan, Lahore, August, 1966.

2/ IACA Comprehensive Report, Volume 7, Annexure 9, Agriculture, page 85.

seed production in 1975 and 635,000 acres by 1985, compared to a current acreage of about 12,000 acres under improved wheat varieties. This would mean a 26-fold increase over the next decade, or a rate of growth in acreage devoted to the production of improved seed of nearly 40 percent per annum. In order to provide a base for this off-take, IACA estimates that the present 6,000 acres under Government seed farms should be raised to 25,000 acres for the production of Government-controlled foundation seed.

6.18 While IACA's projections imply an ambitious target with regard to the multiplication, distribution and acceptance of improved wheat varieties, the wheat breeding experts advising the Government of West Pakistan on the accelerated wheat improvement program have predicted an even faster progress. Their estimate is that by the end of the Third Five-Year Plan period (1969-70) about six million acres of irrigated land would be sown with improved wheat seeds. This would require the availability of some 265,000 tons of improved seed material by 1969/70, and implies a target acreage for improved seed production of at least 250,000 acres, or a growth of more than 100 percent per annum over the remainder of the Third Plan period.

6.19 As desirable as the achievement of such ambitious targets undoubtedly would be, they do appear somewhat optimistic. The production, handling and distribution of such quantities of improved wheat seed would require a crash program for improved extension services, commercialization of multiplication and strict quality control over extensive areas, provision of adequate storage facilities to retain high germination rates, and an extensive and efficient distribution network. None of these aspects is well developed at present, nor are there, to the knowledge of the Bank Group, any definite plans for such a comprehensive program. While the IACA estimates regarding the introduction of improved wheat varieties appear to be somewhat conservative in comparison with those of the seed specialists, their achievement would represent a very important advance in the development of West Pakistan's agriculture.

6.20 The widespread use of improved seed material is presently confined to cotton. IACA estimates that about 40 percent of the present cotton acreage is already covered with improved seed material, and that such use would become general practice by 1975. The problem with cotton seed is mainly one of maintaining the purity of seed material of individual varieties. To this end, a Cotton Control Act was passed in 1949 providing for the cultivation of specific staples in specified zones. Although initially limited to the Punjab and Bahawalpur, new legislation is now extending this control to the whole of West Pakistan, while simultaneously providing for stricter supervision of seed extraction and handling at the ginneries. However, a major source of inter-mixture of seeds, and an obstacle to adoption of improved varieties, is the continuing practice of retaining some cotton for hand-spinning on the farms. The poor quality cotton seed derived therefrom is frequently used for planting.

6.21 In IACA's option, the poor seed quality contributes to the low plant population commonly achieved under present farming conditions. IACA found in the watercourse studies 1/ that the most frequent plant population for cotton ranged between 6,500 and 7,000 plants per acre, as compared to a recommended plant population of 16,000 plants per acre. The low plant population is not entirely due to poor quality seed, but also to low seed rates, emergence difficulties and post-emergence mortality. Thus, in conjunction with improving cotton seed quality, IACA proposes increasing seed rates and full plant populations to achieve the yield potential associated with improving levels of all inputs. By applying improved seed rates to the projected cotton acreage, IACA estimates future cotton seed requirements would be about 58,000 tons for 1975 and 95,000 tons for 1985. Seed is severely damaged by pests, and every effort should be made to control these pests and improve seed storage conditions in order to improve seed quality. The Bank Group feels that effective pest control might reduce the seed requirements somewhat below these IACA estimates.

6.22 Important progress has been made with the development of high yielding dwarf varieties of coarse rice at the International Rice Research Institute in the Philippines. These varieties are being tested at Dokri Rice Research Station in West Pakistan with apparently good results. The possibilities of large scale introduction are under consideration by the Agricultural Department, which plans to cover about one million acres with improved varieties by 1970. Assuming seed rates of about 20 pounds per acre, this would require about 90,000 tons of improved seed material, roughly equivalent to IACA's target for 1975. IACA expects improved rice varieties would be in common use by 1985, and require more than twice the above seed production per year.

6.23 There are further opportunities in the increased use of improved plant varieties of maize and sugarcane. In the case of maize, the development of so-called synthetics, as well as hybrids, holds considerable promise for West Pakistan. However, the introduction of hybrids requires considerable organizational and scientific support for maintenance breeding as well as large scale planting in contiguous areas. Furthermore, it appears that the yield potential of good straight maize varieties has not yet been exhausted, and that considerable progress could be made immediately with a proper package of inputs applied to available varieties. The choice of sugarcane setts material needs improvement, as does the planting rate. At present, only about half the recommended number of setts is being planted. Most of these are two node setts, although IACA considers three node setts to be more desirable. However, the actual supply of new sugarcane varieties should not be a major problem, since the propagation is vegetative and there is no danger of varietal deterioration.

6.24 IACA believes an improvement in the general quality of sowing material would, come from broad realization by farmers that improved seed has value to them, and from the development of seed supplying agencies, partly Governmental and partly private, which would supply tested and certified material.

1/ IACA Comprehensive Report, Volume 10, Annexure 14, Watercourse Studies.

6.25 The Bank Group, in agreement with IACA, has no doubt whatever that improved quality seed could and should make an important contribution to the growth of agirucltural production through higher yields. It is of the utmost importance that stimulation and support be given to the present efforts being made to develop varieties which would respond to the use of additional inputs, and to make them available on a commercial scale. In general, the Bank Group would accept IACA's assessment of the probable progress and contribution to production from this source of growth as reasonable for planning purposes, but it retains the hope that IACA's projections may prove to be on the conservative side. Improved seed constitutes an influence which is extremely difficult to measure. It is not a specific term, and it could be quite meaningless to measure progress in terms of the amount of improved seed employed. In the past, many reports suggest that much of what has been called"improved seed" has been little, if any, better than farmers' own stocks. If, however, "improved seed" is interpreted as meaning seed of high genetic quality, produced and distributed under controlled conditions which provide a high degree of assurance that it would be true to type, free from adultrants and of high germination, then Bank Group believes that IACA's estimates -- for example, 50 percent of the wheat area sown with such seed by 1975 and 100 percent by 1985 -- are not unreasonable. The main point is that progress must be measured qualitatively as well as quantitatively, and much depends upon the institutions responsible for production, multiplication and supervision of the distribution of improved seed material. If the authorities are successful in covering the areas estimated by IACA with improved seed of high quality, at appropriate seed rates, this would have an impact all down the line and lead to progressive improvement of the seed used on any areas remaining uncovered. The Bank Group would attach the utmost importance to the development of the necessary institutional arrangements required to secure the widespread use of better seed.

6.26 The following table shows the magnitude of the seed requirement for the present situation, and IACA projections for the future for the three major crops.

Seed Requirements for Major Crops
(Million Maunds)

| | 1965 | 1975 | 1985 | 2000 |
|---|---|---|---|---|
| Wheat | 8.90 | 16.00 | 18.80 | 17.80 |
| Cotton | 0.90 | 1.60 | 2.60 | 4.00 |
| Rice | 0.70 | 0.80 | 0.80 | 0.90 |
| TOTAL | 10.50 | 17.40 | 22.20 | 22.70 |

The Agricultural Department and the ADC are already active in the provision of improved seed. The distribution in 1964/65 for the above three crops was: wheat 0.4 million maunds, cotton 0.3 million maunds and rice 0.7 million maunds. These figures serve to indicate the magnitude of the problem and, with the exception of rice, the large gap between requirements and supply for these crops. In addition, coarse grains and fodder would require large quantities of improved seed. Kharif and rabi fodder together already require about 2.0 million maunds of seed at present, and under the IACA projections would require 6.0 million maunds in the year 2000.

6.27 IACA does not envisage a situation in which all seed would be drawn from either Government or registered private seed farms. They suggest a system of segregated zones in which there is strict Government supervision, and in which all farmers are required to use good quality seed supplies from seed farms or of known origins and standards. The principle is to flood the zone with good quality seed, renewed at regular intervals so that good seed replaces bad. The system would work better with cotton than with other seeds because Government supervision can be easily applied at the ginneries, and it would be possible to prevent ginneries from drawing their seed cotton from areas outside the zone where another variety may be being sown. There are, at present, 5,000 acres on cotton seed farms, and this area is sufficient, even at existing yield levels, to serve a 90,000 acre segregated zone from which seed would be drawn for wider distribution.

6.28 Because wheat seed is freely available from local sources, the process of flooding an area with improved seed would be more difficult. The success would depend heavily on the attractiveness of the Government foundation seed and its controlled multiplication. In the case of the Mexican and Mexican-derived varieties, the superiority of the new seed may help achieve rapid saturation.

## 4. Plant Protection

6.29 The West Pakistan Government has been providing virtually free pest control to farmers through the agricultural extension services. While the provision of free plant protection service as a maximum incentive to establish the practice was a laudable intention, the actual achievements appear to have been very unsatisfactory. It is estimated that, at best about 12 percent of the cropped area received some form of plant protection, 1/ which may or may not have been effective. It is also estimated that about 15 percent of the potential yield of all cultivated crops is lost annualy through pest damage. The personnel carrying out this service are generally poorly trained, treatments are usually neither timely nor of proper dosage, insecticides have not been available in adequate quantities at the critical time, and the selection of areas for treatment often appears to be the result of a particular landowner's influence rather than an objective assessment of the most pressing needs.

1/ Agricultural Department of West Pakistan, "Plant Protection: Recommendation for improving the effectiveness of plant protection research and field applications in West Pakistan". Hendivil, F.P., Lahore, October 1966.

6.30 IACA considers that farmers do not pay much attention to the elimination of weeds which serve as host plants for pests. Destruction of crop residues immediately after harvesting, expecially those of cotton and rice, is not practiced on a wide scale. Also, little attention has been given to the adjustment of planting dates in accordance with pest control needs, and the possibilities of pest and disease control through adequate cultural practices appears to have been largely neglected in the past.

6.31 Chemical pest conrol, though provided free by Government, has suffered from severe defects, including inadequate storage facilities which serves to reduce the specific effective properties of chemicals, inadequate means for transportation and spraying, and indiscriminate use of insecticides which are potentially harmful to the beneficial fauna. It has furthermore diverted a substantial number of potential extension workers from important extension activities to plant protection with inadequate means. 1/

6.32 As farming practice improves and intensifies, plant protection would become increasingly important as a direct contribution to the improvement of yields and an essential ingredient to safeguard all other inputs. There appears to be an increasing awareness among agricultural authorities, technicians, and agriculturists that the provision of plant protection could be more efficiently organized through a transfer of these activities to the private sector. There does not seem to be very good grounds for the occasionally expressed fear that this might result in a decrease of the acreage under effective control. Plant protection as a private service industry would merge the interests of the supplier to render better service with the need of the farmer to get improved protection. While this may initially entail a continuation of some forms of subsidy, it is very likely that increasingly progressive farmers would become willing to acquire plant protection services at reasonable costs.

6.33 Both the ADC and the Department of Agriculture now aim to transfer the responsibility for plant protection to the farmer himself, while making education in pest identification and control an important part of extension. As IACA has pointed out, 1/ there is usually a very short period during which pesticides are effective and the farmer's own interest in them is therefore critical for satisfactory control. With the exception of well-managed estates and fruit gardens, such a conversion from public services to the farmer's own control would be a slow and difficult process. Instruction, timely identification and remedial action, acceptance of the concept of paying for plant protection, and the problem of cost sharing between landlord and tenant are all serious constraints. Nevertheless, continued ineffective plant protection can greatly reduce the projected production from future investment in water development and other agricultural inputs.

1/ IACA Comprehensive Report, Volume 8, Annexure 11, page 46.

6.34 In view of these observations, IACA does not foresee a growth in the use of plant protection similar to the growth in fertilizer use. It is not likely that the plant protection situation would improve much before there has been more general acceptance of the use of fertilizer and better husbandry, and therefore improvement in yields. In projecting the requirements for plant protection inputs, IACA has assumed a relatively small increase over the first decade in the acreage sprayed. Thereafter a more general use of chemical control is anticipated, and the desirable number of applications would be gradually reached. For the determination of the desirable number of applications under West Pakistan conditions, IACA has been guided by the experience of the University of Lyallpur, the Risalewala Research Institute, and by experimental results of private companies. The following table gives IACA's projection of the percentage coverage of crops by pesticides, by reference years, and a rough assessment of the situation presently prevailing:

IACA Projection of Plant Protection Coverage
(Percent)

| | 1965 | 1975 | 1985 | 2000 |
|---|---|---|---|---|
| Rice Nurseries | 20 | 45 | 65 | 90 |
| Fine Rice | 3 | 20 | 40 | 60 |
| Coarse Rice | 3 | 5 | 17.5 | 32.5 |
| Cotton | 5 | 20 | 40 | 60 |
| Sugarcane | 5 | 27.5 | 47.5 | 70 |
| Fruit | 25 | 25 | 45 | 65 |
| Vegetables | 10 | 15 | 35 | 65 |
| Maize | 3 | 7.5 | 27.5 | 60 |
| Kharif fodder | - | 5 | 17.5 | 20 |
| Oilseeds | - | 5 | 20 | 42.5 |
| Wheat | - | - | 10 | 25 |
| Rabi fodder | - | - | - | 20 |
| Gram | - | - | - | 20 |
| Kharif pulses | - | - | 10 | 30 |

6.35 IACA's cost estimates per acre treated are given in the following table:

IACA Cost Estimates of Insecticides Per Acre of Major Crops Treated
(in Rs.)

| Crop | 1975 | 1985 | 2000 |
|---|---|---|---|
| Rice Nurseries | 27.00 (3) | 25.50 (3) | 24.00 (3) |
| Coarse Rice | 18.00 (2) | 17.00 (2) | 24.00 (3) |
| Fine Rice | 18.00 (2) | 25.50 (3) | 24.00 (3) |
| Cotton | 33.80 (3) | 63.80 (6) | 80.00 (8) |
| Wheat | - (-) | 6.80 (1) | 12.00 (2) |
| Maize | 27.00 (2) | 25.50 (2) | 24.00 (2) |
| Oilseeds | 13.50 (2) | 12.80 (2) | 24.00 (2) |
| Pulses | - (-) | 9.30 (1) | 17.60 (2) |
| Sugarcane | 27.00 (2) | 51.00 (4) | 48.00 (4) |
| Fruit | 16.20 (2) | 30.60 (4) | 43.20 (6) |
| Vegetables | 14.40 (2) | 20.40 (3) | 19.20 (3) |
| Tobacco | 9.00 (1) | 17.00 (2) | 24.00 (3) |
| Gram | - (-) | - (-) | 17.60 (2) |
| Kharif Fodder | 13.50 (1) | 25.50 (2) | 24.00 (2) |
| Rabi Fodder | - (-) | - (-) | 24.00 (3) |

Numbers in parentheses refer to the number of applications of pesticides.

Based on the above projections of acreage covered, application per crop, and costs per acre, the aggregate costs of pesticides for reference years have been estimated by IACA to be about Rs. 65 million in 1975, Rs. 206 million in 1985, and Rs. 726 million in 2000. This does not include spraying equipment and labor. It is expected that mechanized spraying would expand *pari passu* with the expansion of mechanization described in the next section. Government help with aircraft for aerial spraying would continue to be necessary in the case of epidemic attack and the Government is already equipped with aircraft for use against locust attack. Depending on the subsidy policy of the Government of West Pakistan, a decreasing proportion of the total costs is likely to come from the public sector. Excluding equipment, the foreign exchange component included in the above cost estimates is assumed to be about 60 percent.

## 5. Mechanization and Agricultural Implements

6.36 Mechanization in West Pakistan covers a broad range of activities -- from Government-operated tractor fleets for the colonization of virgin lands to the development of improved farm implements at the University of Lyallpur. Existing farm implements are adapted to local conditions, and most of them are manufactured from local materials. Improved hand tools and animal-drawn equipment are being popularized through Government subsidies. However, unlike the rapid spread of private tubewells, the improvement in tools and simple equipment appears to be progressing rather slowly.

6.37 The popularity of, and demand for, tractors and tractor-drawn equipment is expanding more rapidly, especially amongst the medium and larger size farms. There are currently about 6,000 tractors working on farms, and mechanized cultivation will become increasingly important and advantageous to farmers in the future. As cropping intensities rise, harvesting and land preparation activities tend to increasingly converge. There is a corresponding reduction in the time available for cultivation and planting, and distinct labor peaks occur at the end or, conversely, the beginning of each crop season. At higher levels of intensity mechanized cultivation is likely to become a prerequisite for dealing with such time schedules and labor peaks, while simultaneously reducing hired labor costs. To the extent that mechanized cultivation would substitute for animal power, it would also set free fodder acreages for production animals or, alternatively, an expansion of cash crops. Mechanized cultivation would also enable better and more timely land preparation, thus providing for better crop performance. Since mechanized cultivation is not generally more expensive than bullock farming, IACA feels that such activity as land preparation, post planting cultivation, harvesting, threshing are likely to mechanized fairly rapidly, though largely limited to the farm size groups exceeding 25 acres per unit.

6.38 However, a rapid increase in mechanization is likely to be restrained by a number of socio-economic factors. The farm size problem and its associated financial implications have already been mentioned above. Land fragmentation and the tenure and share cropping system are likely to be other substantial barriers to rapid mechanization. The small size of individual fields enclosed by irrigation bunds would create physical problems for efficient use of machinery. Furthermore, even on larger farms, the rapid adoption of mechanized farming would depend greatly on the existence of satisfactory service facilities including an adequate supply of spare parts and mechanics. IACA points out that much research is still needed to select the right types of equipment, to adapt the existing equipment, and to develop equipment better suited for the local conditions.

6.39 The importance of mechanization is recognized in the Third Five-Year Plan, which calls for an expansion in the distribution of improved implements at subsidized prices. Additional workshops and repair facilities for the Government-operated tractors are to be established at district levels in order to improve the efficiency of Government-operated machinery. The Plan also anticipates that the total number of tractors would increase, and the requirements of wheel tractors by private individuals would be met increasingly by local manufacturers. 1/

6.40 For projection purposes, IACA has developed a "rate of mechanization" based on a hypothetical percentage of farm area fully mechanized. This would not be the case in practice because mechanization is a progressive process.

1/ The projected assembly plant at Rawalpindi with an annual capacity of 1,500 tractor units is expected to supply a large part of local demand during the Fourth Plan period.

Initially, mechanization would be partial, concentrating on certain specific activities such as cultivation and land preparation. IACA has taken this into account in its approach, and has equated this with full mechanization on a reduced area. The following table shows the coverage and rate of mechanization by farm size groups, as projected by IACA for reference years.

## IACA's Projected Rate of Mechanization

| Farm Size Group | Percent of Total Farm Area In Group | 1975 | | 1985 | | 2000 | |
|---|---|---|---|---|---|---|---|
| | | Percent Mechanization | Percent of Total Farm Area Mechanized | Percent Mechanization | Percent of Total Farm Area Mechanized | Percent Mechanization | Percent of Total Farm Area Mechanized |
| Farms above 25 acres | 40 | 20 | 8 | 50 | 20 | 85 | 34 |
| Farms 5-25 acres | 50 | 4 | 2 | 10 | 5 | 30 | 15 |
| Farms below 5 acres | 10 | - | - | 5 | 0.5 | 10 | 1 |
| TOTAL | 100 | | 10 | | 25 | | 50 |

IACA has identified the components for a complete mechanization unit capable of serving an area of at least 100 cropped acres per annum. Such a mechanization unit would include a wheel tractor with tilling and mowing equipment, seed drill and thresher, and a trailer and miscellaneous equipment. It is estimated that such a unit would cost about Rs. 25,000.

6.41 The area assumed to be mechanized in the above table would imply the use of approximately 33,000, 83,000, and 165,000 mechanization units for the respective reference years. The initial stock of spare parts and its continuous replacement over the life 1/ of the equipment would amount to about 50 percent of the initial capital cost of a mechanization unit. The following table assumes a lifetime of nine years in 1975 and about eight years thereafter, and levels of annual expenditures for mechanization as shown below:

Estimated Expenditures for Mechanization at Reference Years

| | 1975 | 1985 | 2000 |
|---|---|---|---|
| Mechanization Units ('000) | 33 | 83 | 165 |
| Annual Expenditures for Mechanization Units (Rs. mill.) | 90 | 260 | 520 |
| Annual Expenditures for Spares (Rs. mill.) | 40 | 130 | 260 |
| Annual Level of Mechanization Expenditures (Rs. mill.) | 130 | 390 | 780 |

The foreign exchange component of these expenditures is likely to decline as local manufacture provides an increasing portion of the mechanization package. The foreign exchange content by 1975 is estimated at about Rs. 75 million, increasing to about Rs. 200 million by 1985. This assumes that the proportion of locally assembled equipment would be about 40 percent in 1975 and 50 percent by 1985.

6.42 Although the projections of cost are based upon the acceptance of complete mechanization, there is little doubt that for some years to come mechanization is likely to be limited to tractor cultivation. It would seem reasonable to suppose that threshing would soon be recognized as a process which can be power driven, and other operations are likely to follow. However, it is only when such operations as cane crushing and transport are mechanized that the working bullock can be increasingly replaced, thus enabling a larger number of milk and meat producing animals to be maintained on the fodder base.

6.43 The Bank Group, along with the Government and IACA, recognizes the important role that mechanization must play in the progress towards more

1/ IACA estimates that initially the lifetime of a unit may be about nine years (10,000 working hours) but would decrease to about 7-1/2 years by 1985 when cultivation activities become more intensive.

intensive and more highly commercialized agriculture and feels every encouragement should be given in the form of credit, advice on purchasing and suitability for particular conditions and purposes, instruction in operation, ensured supplies of machinery and parts, and adequate service facilities. In view of the preponderance of small farms, careful consideration should be given to the stimulation and support of contract services and cooperative use of machinery, and to the continued improvement of bullock-drawn equipment and hand tools.

6. Improvement of Livestock

6.44 Along with the increase in mechanized farming, IACA envisages a reduction in the proportion of draft animals in the cattle herds -- a decline in numbers accentuated by a progressive increase in the work output of draft animals. The number of working draft animals (expressed in animal units) is expected to decline from 10.4 million in 1965 to 4.2 million in 2000, while the production herd is expected to increase from the current estimate of 9.6 million to 14.5 million by 2000. In view of the substantial contribution from animal husbandry, which IACA projects to increase over time, the rapid build-up of an improved cattle herd assumes special significance.

6.45 The principal change envisaged within the production herds is a change from buffalos to zebu cows as milk producers. This change is likely to be slow in coming about, and the number of buffalo cows is expected to begin to decline only after 1985. At the same time, up-graded zebus would become increasingly important. The buffalo is at present a greatly superior producer of milk, and it is only the anticipated upgrading of the present zebu cows which justifies replacement of the buffalo. To support the anticipated rapid progress in the development of quality stock, it is necessary to use the best bulls available to the fullest extent possible, and the use of carefully selected bulls on the scale required can only be done by an extensive program of artificial insemination. IACA proposes to upgrade the present zebu herds by a massive program of artificial insemination. The technique proposed is the repeated top-crossing of successive generations to selected Sahiwal or Red Sindi sires, leading to the progressive improvement of the national herd.

6.46 There is already a basic artificial insemination organization operating in West Pakistan under the Directorate of Livestock Farms. IACA projects that the number of artificial inseminations would reach five million per year by 2000, and that the organization would be self-financing. In order to sustain the livestock projections made by IACA, it would be imperative to develop the existing organization into a country-wide service. IACA's program and recommendations for artificial insemination are reproduced in the attached Annex 6.3.

6.47 As discussed in Chapter II (para 2.103) the livestock sector is of such importance, and is so little understood, that the Bank Group proposes it be the subject of a special comprehensive study to establish more accurately both its present status and the requirements for its development. This study should include a review of the IACA proposals to replace the Provincial buffalo herd by upgraded Sahiwal and Red Sindii cattle by the extensive use of artificial insemination. The study would seek to establish the practicality, and the genetic and economic desirability of the proposals, bearing in mind the large increases in milk and meat production which would certainly come about from the existing stock when feeding standards are improved and selection is applied under the more intensive systems of husbandry that should evolve. The present system of maintaining two separate classes of stock for the production of milk and working animals may well prove to be wasteful of resources. The study should investigate the effect of applying selection pressure to both buffalo and cattle herds to produce male stock capable of effective draft work from dams whose milk production will be at a sufficiently high level to maintain an economic dairy industry.

## B. Institutions and Organizations

### 1. Introduction

6.48 The development and expansion of the organizational structure to stimulate and serve the rapid growth that is envisaged in the proposed program would be an extremely critical, as well as a very difficult, task. The problem has been studied in depth in recent years by the Food and Agriculture Commission (1959), the Provincial Reorganization Committee (1961), and the White House Panel (1962). In the course of this study, IACA has reviewed the situation in the light of probable future needs and has set out in an annexure to the Comprehensive Report 1/ an analysis of the present situation, together with its views and recommendations.

6.49 This is a subject on which no finality can be reached. The Bank Group does not feel able to do more than draw attention to some of the basic considerations that should be kept in mind, without being very specific as to solutions. One general observation would be that for some time to come any further major changes in the overall pattern of organization should, as far as possible, be avoided. The significant changes that have been made in the recent past, including the setting up of WAPDA, the ADC and the LWDB, require more time to prove their effectiveness. The emphasis should be on adjustment and improving coordination, rather than further radical change. Another would be that, to the extent practicable, the private sector be given maximum opportunity and encouragement to participate. The Bank Group's observations on these and other points relating to the institutional framework are presented in the remaining portions of this chapter.

### 2. Coordination of Planning and Services

6.50 (a) Coordination of Planning: The Bank Group would endorse IACA's view that effective coordination between the bodies responsible for planning (as well as implementation, including construction and operation of projects)

1/ IACA Comprehensive Report, Volume 8, Annexure 11.

is a prime necessity. At the present time, the responsibility appears divided amongst a number of technical agencies and departments. Also, ambiguities of jurisdictional boundaries between agencies occur, and a good deal of planning is done in isolation of the ideas and programs of other departments concerned. In addition to WAPDA and ADC, most of the line departments are concerned with planning, and the Agriculture and Irrigation Departments are particularly affected. All agencies and departments compete for shares in the available Government resources, and all have skills and experience that should make a contribution to planning. IACA reports that there have been occasions when two agencies have been engaged on plans for the same areas. Also, it seems clear that the Agricultural Department has not had much influence on WAPDA and the Irrigation Department project planning for agricultural development. All too frequently there have been open differences of opinion between agencies on matters of responsibility and methods to be employed. The operational responsibilities for the preparation of sector and inter-sectoral plans must be assigned to particular bodies, but this should be done in a manner that ensures constant review and the incorporation of experience and views from all the interested line departments.

6.51 At the Provincial level the logical place for coordination of these issues would appear to be the Planning and Development Department of the Government of West Pakistan, but this Department does not have enough professional staff to enable it to exercise an effective coordinating role. In the opinion of the Bank Group, the situation should be carefully reviewed and arrangements made which would ensure effective coordination and afford full opportunity to the line departments and agencies concerned to make their contribution on a continuous basis.

6.52 (b) Coordination of Services: The services offered by the line departments and agencies are all complementary, each making a contribution to the package required by the farmer. A high degree of coordination is necessary to ensure that the advice and the services provided are in keeping with policy and developmental objectives, and that supplies are available in the right quantities and at the right time. Observations on the individual services essential for the success of the program are made in succeeding sections. The concern here is with the machinery to ensure both inter- and intra-departmental coordination. Important considerations would include the establishment of the principles which govern the definition of jurisdictional boundaries, and continuous review of how policy is implemented in important matters such as procurement, deployment of scarce resources, project construction and operation, and management. Again, the Planning and Development Department would appear to be the logical body to play a key role in bringing about more effective coordination.

## 3. Policy for Water Distribution.

### (a) Province-wide Allocations

6.53 As discussed in Chapter V.D, procedures for allocating water must be amended to allow for the changing conditions of the future. The canal system would be subject to major changes in operation when the alterations brought about by the Indus Treaty go into effect in the near future. The increasing scale of new development projects would further add to the complexity of water and power supply problems. To meet this situation, IACA has recommended the setting up of an Irrigation Authority. This body would make basic policy decisions on barrage allocations, dam release patterns, and tubewell pumping policies with reference to both water and power considerations.

6.54 The Bank Group believes that a Provincial Irrigation Authority is required in order to use the available water resources in the most efficient manner. Its responsibility for Province-wide water allocations, and its determination of overall policy regarding the operation of the system, would place it in an important policy-making position entrusted with decisions affecting the equitable and economical use of all West Pakistan's water resources. It should therefore be constituted at the highest level and equipped to take fully into account the whole range of administrative, legal, sociological and technical considerations to the extent that they effect policy and general principles.

(b) Project Operation and Management

6.55 Closely related to future efforts to develop the water resources of West Pakistan is the question of which institutional mechanisms would assist farmers make the best use of new production opportunities. Earlier comments on institutional support 1/ listed the range of institutions already established to promote agriculture, and cited Government's willingness to introduce administrative innovations where these appeared necessary. In point of fact, there has been considerable experimentation with new administrative units, much of it in response to suggestions of non-Pakistani advisors and observers, but the end results have not always matched expectations. This has been partly due to personnel and administrative problems germane to Pakistan's present stage of development, as well as to the function and role of particular institutions which have been created. Because the organization of public projects for water resource development is critical to the program under review, the Bank Group's observations on this aspect are presented in somewhat greater detail.

6.56 IACA has based its recommendations for project operation and management on certain major assumptions and policy positions. These include:

(i) surface water distribution and public tubewell operation must be under the same organizational control;

(ii) the private sector should rapidly assume responsibility for supply and distribution of inputs such as fertilizers, plant protection, and improved varieties of seed;

(iii) reclamation as such would not be as high a priority objective as in the past; and

1/ See Chapter I.D above.

(iv) while it is important to unify control over sources of irrigation water, there is less need to integrate the supplying of water with agricultural extension activities and provision of material inputs.

6.57 Two organizations currently have responsibility for development activities in project areas in West Pakistan. One of these, the Agricultural Development Corporation (ADC), has jurisdiction over four barrage commands (Thal, Taunsa, Gudu, and Ghulam Mohammed), though not over the barrages themselves. Within the commands, the ADC has responsibility for water supply, for provision of agricultural inputs, and for extension activities related to implementation of project objectives. This semi-autonomous agency thus fulfills all functions normally carried out by regular Departments of Government, and does this in a unified, or integrated, way in the areas under its jurisdiction. Only one of the projects proposed by IACA falls within an area currently under the ADC, and IACA believes it would be logical for the ADC to assume responsibility for this project area. On the other hand, IACA does not favor ADC responsibility for any of the other proposed projects. IACA's proposed projects are smaller than complete canal commands, or cut across the boundaries of canal commands, which places the source of surface water to the project outside of the project area. ADC control over a project (other than the one noted above) would therefore result in a situation where the source of surface water could be separate from the use of all irrigation water, and control would be divided between two different agencies. This would run counter to the most important of IACA's working assumptions.

6.58 The second institution, the Land and Water Development Board (LWDB), is also a semi-autonomous body and was organized specifically to promote development in the SCARP project areas. The Chief Secretary is ex officio Chairman of the LWDB, and the members include Secretaries of all Government Departments concerned with agricultural development. The activities of the LWDB to date have been limited to the SCARP I area, where a Project Director has been placed in overall command of developmental activities. The staff, who are seconded from the regular Departments, carry out extension, reclamation, input supply, and irrigation activities. The number of extension workers per unit of area is somewhat larger than in other parts of the Province, but in other respects the staffing is comparable to that provided elsewhere. The membership of the LWDB was designed to secure inter-departmental coordination at the highest levels, but meetings of the full Board are held only once every two months. The effect of this is to leave much of the coordination task to the Project Director. The LWDB participation in SCARP I has been relatively brief, and the project has run into problems unrelated to its administrative makeup (e.g., faulty screens in at least 100 public wells have required replacement). Nevertheless, IACA has concluded that the LWDB model is not well adapted to the project areas it has proposed.

6.59 Foremost among the reasons for this is IACA's assumption that unified control of surface water and groundwater supplies is essential to the successful operation of the projects. IACA therefore suggests that this responsibility be vested in the Irrigation Department. This Department already operates the canal system, and has acquired staff with experience in matters related to water supply and water use. Control and operation of water supply by a single agency would also be consistent with an overall integration of Basin-wide water supply -- an objective which IACA also considers of vital importance. Responsibility for agricultural extension and research would lie with the Agriculture Department, as it does now in non-project areas. IACA also recommends that provision of fertilizers, improved seeds, and plant protection should become a private sector activity as soon as possible, with the ADC, the Plant Protection Service, and the Cooperatives necessarily continuing their present operations in these respects until the private sector has developed its capacity to meet farmers' needs.

6.60 IACA envisages a continuing role for the LWDB, but in a modified fashion. The new role would be a coordinating one at the former level (Secretaries of Departments), but without the present operational emphasis. Instead, an LWDB representative would be assigned to the project area to facilitate field coordination, working through a new administrative unit which IACA calls the Project Field Force (PFF). This representative would be an appointed chairman, at the level of Deputy Commissioner grade in the Civil Service of Pakistan (CSP), and would be preferably an administrator by training and experience rather than a technical man. The PFF would also include the ranking officers from the line departments in the project area, who would represent their departments, and a representative of the local district administration. The PFF would coordinate the activities of all departments involved in the project area, although the chairman of the PFF would have no direct authority over the officers of the departments. Problems which cannot be resolved through normal departmental channels would be referred to the LWDB for ultimate solution at the higher level. The PFF would also have responsibility for monitoring the performance of the project, and for keeping statistical records for later use in analyzing experience under the project. This summary of the IACA proposal 1/ omits other lesser details, but in essence it would constitute a less integrated approach to project implementation than called for under the present ADC or LWDB arrangements, and would depend on contributions from the line departments much as they are now provided outside the ADC and SCARP I areas.

6.61 The Bank Group has reviewed IACA's proposals and has been guided by two major considerations. The first of these is a belief that it may be desirable at this stage to call a moratorium on further major administrative reorganization related to agriculture and water resource development. Frequent administrative reorganization can become counter-productive. Staff morale is affected, and if reorganization becomes a common solution to operational problems, each change gives reason to expect that further change would follow. Staff loyalty and identification with an organization must reflect this uncertainty in some degree. There is thus merit in giving any new organization time to achieve the level of performance expected of it -- staying with an organizational decision until there is a clear reading on either its viability or its failure as an administrative concept. This may

1/ IACA Report, Volume 8, Annexure 11.

be the state of affairs with respect to the ADC and the LWDB, both of which have been in operation too short a time to provide an adequate test of their ultimate workability.

6.62 The second consideration relates to the need for an integrated project management. The Bank Group feels strongly that in addition to efficient distribution the success of the water resource development program depends on emphasis going equally to efficient water use and to better farming practice and the use of more material inputs. Creating the environment which generates this dual emphasis would be a most demanding task, requiring a high degree of close cooperation and overall direction. Earlier sections of this report have dealt with the superior cumulative effects of proper combinations of water and other inputs, and the need to make the entire package accessible to the farmer. The Bank Group agrees with IACA that it would be desirable to have the private sector assume a growing importance in the supply of agricultural inputs, but until the private system has developed the capacity to ensure timely and adequate supplies in the project areas there would have to be continuing promotion and distribution activity by authorities responsible for maintaining the development pace at projected rates. The Bank Group feels that something along the lines of the ADC and LWDB concept, with a Project Director in full charge of all developmental activities and water supply, would provide this close supervision and integration which development requires, and could be consistent with growing private sector competence in meeting input supply requirements. This should not preclude minor changes designed to improve the efficiency of project direction, e.g., locating the Project Director's headquarters in the project area itself, ensuring continuity by long term appointments to the Director's position, and making adequate budget allowances for planning and monitoring activities.

6.63 The Bank Group's preference for integrated project management, in spite of the difficulties it would entail in relation to divided responsibility for surface and groundwater supplies, requires further qualification. Firstly, the line departments should continue to carry out their increasingly important functions in their respective fields, and care should be taken that the discharge of their responsibilities, especially in the non-project areas, is not impaired by the withdrawal of key staff for project areas. Secondly, the Action Program, including the on-going as well as the IACA projects, would bring more than ten million acres under the direct responsibility of public tubewell project management over the next ten years. While it is of utmost importance for the development period of each individual project that direct and undivided responsibility should rest with the project management, this responsibility should nevertheless be regarded as temporary. Once full development has been achieved, the routine operation of the project facilities should be handed over to a more permanent organization which has full farmer participation. Once the management responsible for the development of the project has withdrawn, the line departments should successively assume their responsibilities within the project areas. Some formal procedures would need to be established to determine when such transitions should take place. Consideration should furthermore be given to the possibility of establishing semi-autonomous forms of management for the permanent operation of the tubewell fields. Such operations would be within the frame of natural resource exploitation policies and under the overall control of the Government, but with adequate representation of the farmers.

6.64 The monitoring function deserves special note because it has not been an integral part of the project operation thus far. The Bank Group's review of the IACA Comprehensive Report has brought home forcefully the fact that planners have been handicapped by a lack of firm benchmark data. Moreover, the process by which farmers incorporate opportunities for change is not well understood, and has not been studied carefully under actual conditions of rapid technological and economic change. The watercourse studies of IACA and LIP are initial efforts in the right direction, but they have been limited in the coverage offered and the time which was devoted to the studies. The Bank Group therefore strongly endorses the IACA suggestion that project management should include provision for continuous monitoring of progress, starting with the construction phase when benchmark data representing pre-project conditions could be gathered. Strong support for this type of study, and its incorporation into the institutional structure of project management, could produce data of immense value and importance to development in other countries as well as in Pakistan.

(c) Operation of the System

6.65 A corollary to the Bank Group's preference for something similar to the LWDB or ADC for project management purposes is that the Bank Group does not see an overriding advantage in placing control of all project water supplies with the Irrigation Department. Granting that this Department does operate the canal system and that it has acquired experienced staff for this purpose, it does not follow that extending its jurisdiction to include project tubewells would bring more efficient water management to project areas. With Province-wide responsibilities and diverse activities (e.g., small dams, canal operation and maintenance, tubewell installation, etc.), it is unlikely that the Department would have the interest or the capacity to focus on project area problems to the required extent. Localized coordination through a body such as the PFF, where no authority rests with the PFF Chairman, may be difficult if major departmental interests are centered on departmental activities in other areas. The Bank Group feels that successful projects would depend on responsible project management, wholly concerned with project problems and responsible to project needs. Within the project area, water supplies would be regulated in accordance with specific development requirements. The Bank Group does not expect that the integration of surface and groundwater supplies would be a technically or administratively difficult problem within proposed project areas, once the Province-wide pattern of surface water distribution had been established.

## 4. Technical Support for Agriculture (Research, Education and Training)

6.66 Technical support for agriculture is essentially the responsibility of the Department of Agriculture. Although some of this support reaches farmers through other institutional arrangements such as the ADC and the LWDB, the personnel involved are mostly drawn from departmental ranks. Efforts to strengthen the Department of Agriculture should therefore have beneficial results outside the Department itself. The discussion under this heading thus focuses largely, though not entirely, on the Department.

6.67 It is a truism that effective institutions require good personnel as a starting base. In this respect the Agriculture Department has operated under serious handicaps. Careers in agriculture have not carried much prestige in the past. Salaries have been low and opportunities for advancement have been limited. Working conditions have been poor -- Field Assistants are expected to cover an area of 15,000 acres and the Agricultural Assistants supervising them are expected to cover 60,000 acres, but inadequate transport facilities are provided to enable them to do this effectively. Trained research personnel frequently find themselves in administrative posts, and this is, in fact, a more effective route for their personal advancement despite the waste of scarce technical training it entails. Field assignments usually require living in areas where housing and school facilities for families are poor, but officers posted to extension services usually receive neither housing nor a housing allowance. The result of factors such as these is that it is extremely hard to attract some of the better students into agricultural careers. For those who are capable, opportunities in other Government services are much more promising in almost all respects. Where the basic raw material is drawn from candidates who may be below standard, training alone can go only so far in producing an improved agricultural service.

### (a) Personnel

6.68 Facilities to prepare personnel for agricultural careers currently include two agricultural colleges and one university, which turn out about 300 graduates annually at the B.Sc. and M.Sc. level. These graduates enter service at the level of Agricultural Assistant. An additional five colleges train Field Assistants, and have a capacity to produce 500 students at this level of training. IACA estimates there should be adequate numbers of degree graduates for Government purposes by 1976 or 1977 at the above rates of availability, but that the facilities, which are being improved with the assistance of IDA credits, could handle more than this number of students. The shortage of Field Assistants is considered more serious, however, and IACA recommends that the number of colleges for Field Assistant training be increased from five to eleven. This would raise the annual turnout of Field Assistants from 500 to 1,100 men. The IACA estimates of manpower requirements for graduates and Field Assistants are shown in the following table. If the additional colleges for Field Assistants come into operation between 1970 and 1975, there should be enough trained personnel to staff the Government's needs by 1980. IACA assumes that any surplus in graduates, relative to Government requirements, would be increasingly absorbed by the private sector as development brings a more commercially-oriented agriculture to West Pakistan.

IACA's Estimates of Manpower Requirements for Agricultural Services

| | Graduates | Field Assistants 1/ |
|---|---|---|
| 1965 | 2,225 2/ | 3,900 |
| 1975 | 3,775 | 6,000 |
| 1985 | 4,800 | 9,300 |
| 2000 | 5,070 | 10,000 |

1/ Extension services only.
2/ Existing.
Source: IACA Comprehensive Report, Volume 8, Annexure 11.

6.69 Although it appears possible to train the number of new personnel required to meet the IACA estimates of manpower needs in future years, the quality of the instruction to be offered is more open to question. The course length has recently been raised from one year to two years for Field Assistants, including six months of field work under supervision. This is a desirable direction in which to move, and there should be continuing efforts to make the training period meaningful in the practical terms required for effective work with farmers. Proposals to increase the number of training facilities for Field Assistants should be studied with some care, however, for the important constraint in this type of expansion would be the quality of the faculty available to teach in the new institutions. Because of the limited attractiveness of agricultural service at present, the Bank Group feels that it may be more strategic in the short run to concentrate on improving the quality of instruction than to become too preoccupied with turning out a given quantity of manpower.

6.70 A quantitative personnel deficiency in the technical support for agriculture is likely to occur in the engineering field. This would be primarily a problem for agencies other than the Department of Agriculture, but it may be mentioned here because finding a solution to it would be of obvious major relevance to future departmental activities. Current estimates are that the new graduates of engineering schools during the Third Plan period would be 3,200 fewer than required for all fields. Even allowing for the release of large numbers of engineers from the Indus Basin Project Works at the end of the Third Plan period, IACA estimates there would be an insufficient number of engineers for planning, construction, operation, and maintenance under programs falling within the jurisdiction of WAPDA and the

Irrigation Department. The Irrigation Department alone would require 430 new graduates by 1970, and 1,000 new graduates by 1975. One way to meet this deficiency temporarily would be to continue the use of foreign consultants in positions of critical scarcity. Greater use could also probably be made of opportunities for on-the-job training to up-grade promising young men who may lack full formal training in engineering. Such men could be used in supervisory positions where technical training is less important than good general experience in construction, operation, or maintenance. Foreign consultants could also be used to give specialized post-graduate training to new engineering graduates. The current difficulties arise because West Pakistan does not have a large pool of trained and experienced manpower to draw upon at a time when developmental activities are expanding very rapidly. In the long run, the supply of fully qualified engineers may become more nearly in balance with future needs as a consequence of the gradual expansion and improvement of educational facilities at all levels, but for immediate needs it appears necessary to supplement with trained manpower resources available from outside Pakistan.

(b) Research

6.71 The Department of Agriculture maintains research activities in three regions of West Pakistan. The need for a strong and well-supported research branch is self-evident in an area like West Pakistan where the technical problems of agriculture are numerous and new knowledge is essential to future development. It seems fair to say, however, that research cannot fulfill its vital role under the conditions which now prevail. Research in the agricultural sciences is beset with the difficulties noted earlier with reference to agricultural service in general. Career opportunities are more limited than in other fields, and while research personnel fare somewhat better than extension personnel in pay and allowances, IACA reports research facilities are neither adequate nor uniform in the different research centers.

6.72 An important objective of research in agriculture is to find solutions to farmers' problems, but the second stage of this is to bring the research findings to the farmers in a form which they can understand and use to advantage. This requires close and continuing cooperation between the research and extension branches of the Agriculture Department. Where there are several agencies concerned with agricultural development, as in West Pakistan, the scope for fruitful cooperation is wider than a single department. Research personnel are not only the source of information about their own research results, but they should be familiar with important research findings in countries abroad as well. Improved coordination should therefore result in increased contacts between research workers and the wide range of people connected with agricultural development. The exchange should be in both directions -- the research branch would learn which problems most urgently need futher investigation, and extension workers and farmers would learn what results have already been obtained by research in Pakistan and elsewhere.

6.73 Much of the research work currently undertaken is apparently of limited immediate practical application, and is sometimes more oriented toward publication in the scientific literature than toward solving day-to-day farm problems. The staffs of the research centers include some experienced and distinguished scientists, but much of the research is actually carried out by young and inexperienced research workers who need supervision to initiate and sustain meaningful experimentation. It is difficult to foresee substantial improvement in the agricultural sector without a dynamic research program to deal with such matters as continuing varietal improvement, more efficient treatment of insect infestation and plant disease, and better understanding of soil, crop, water and fertilizer relationships. Building an efficient and contributing research branch would not be a simple task, and would take more than the addition of a few more staff members or some new equipment. It would require dedicated leadership, generous financial support, patience and understanding of the uncertainties which are a necessary part of research, and the infusion of a spirit of service to the agricultural community. Without these elements, research is likely to remain mechanistic and unimaginative, isolated from its constituency, and therefore largely unproductive. Aside from pointing to the general deficiencies, the Bank Group can only underscore the importance of building a strong research organization in support of West Pakistan's developmental needs, and urge that neither the role nor the requirements of research be underestimated.

(c) Extension Services

6.74 The extension services afford the most direct point of contact between the Department of Agriculture and the farmers, but the available evidence indicates that, with some notable exceptions, this contact is generally of limited effectiveness. The reasons are, again, partly due to the general problems of recruitment, the low status of the extension staff, and the consequent poor morale of workers in the field. Added to these are the extension workers' difficulties in getting around the large areas for which they are responsible, for transport is totally inadequate for their task. Many farmers would apparently welcome new ideas and advice, but seldom have an opportunity of meeting an extension worker. Much time of the extension service is devoted to administrative chores, and to the plant protection activities which, according to IACA, are largely ineffective. The low status of the extension personnel, and the Field Assistants in particular, makes it difficult for them to contact and work with the more influential farmers in a community. With weak research support, and having only a poor base of practical training and experience, the advice which many extension workers are in a position to offer is often of little real value to farmers.

6.75 These are only some of the problems confronting the extension services, but they are intended to be indicative of the present situation. The IACA Comprehensive Report 1/ contains a number of suggestions on how extension activities can be improved, many of them similar to suggestions made

1/ IACA Comprehensive Report, Volume 8, Annexure 11, page 60 ff.

earlier by the Food and Agricultural Commission and other groups who have studied this problem. The Bank Group is not in a position to make specific proposals, but its general concern is evident in what has already been said. The agricultural and water development program being proposed for West Pakistan would require the rapid and widespread adoption of a variety of new agricultural inputs and improved farming practices. Without this, the expected rates of growth cannot be achieved. The primary vehicle for transmitting the new knowledge to farmers would be the extension services, and in their present state they simply would not be adequate for the task. The quantitative and qualitative improvement in the extension services is thus a critical link in the success of the program, and the measures adopted to bring about such improvement cannot be partial or half-hearted.

6.76 One important aspect of extension to which the Bank Group wishes to draw attention is livestock management, because it touches directly on the program. The projections of agricultural production anticipate a very large expansion of the livestock component, and call for standards of animal husbandry far higher than have been generally achieved to date. This aspect of extension work would therefore assume increasing importance. Responsibility for extension activities relating to animal husbandry currently rests with the Directorate of Animal Husbandry within the Department of Agriculture. The functions of this Directorate are mainly limited to the prevention and control of disease, and farmers receive little advice on livestock management and improved feeding practices. IACA has suggested that advisory work on animal husbandry should be an integral part of agricultural extension, and that the Directorate of Animal Husbandry should be concerned solely with veterinary matters as it is, in fact, at the present time. The Bank Group believes this point is well taken because livestock production would have to become increasingly coordinated with overall land use planning by farmers, and the agricultural extension personnel should be prepared to advise farmers on how to adjust to the changing production opportunities opened up by the proposed program. Plans for raising the standards of extension work in the future should therefore include provision for the training of extension officers in livestock management techniques.

(d) Assistance to Private Water Development

6.77 Policy for water distribution in West Pakistan must also take into account the contribution which could be made by the private sector. This activity should be stimulated and assisted by organized institutional support. In particular, technical advice should be readily available to farmers and landowners on procurement and construction matters, types of equipment available, water quality, irrigation requirements, and water management. This advice would have particular reference to small dams, watercourse alignment, and private tubewell installation, and should include assistance in organizing cooperative use of facilities. It may also be necessary to devise some form of licensing for private tubewells. The unexpected pace of private tubewell installation during the Second Plan period has been referred to elsewhere in this Report, and it now appears that the present rate of private development may be faster than public development (although coverage may be less complete and restricted to areas where groundwater conditions are most favorable). 1/ To the extent that private resources can be marshalled for this purpose, this frees Government funds for investment in necessary projects which the private sector is unlikely to finance. It is also evident that the anticipated agricultural development would require continuing substantial private tubewell investments up to 1975, and probably beyond that date, even with the most optimistic assumptions about Government's capacity to complete irrigation improvements.

6.78 IACA agrees that it is desirable to encourage private sector investment in tubewells, even though it believes this investment would be eventually replaced by a system of public wells, and that public investment would generally be more efficient than private. IACA also states that it has allocated its public investment in a manner which would provide scope for private participation. The strategy in this respect is to encourage private investment along with public investment in a manner which maximizes the return to the combined capital invested by both sectors. This implies that public investment would not always be made where the internal rate of return is highest. If private investment would provide essentially the same service, even with some loss in efficiency, there could be a case for encouraging the private initiative. Government funds would then be diverted to other projects where private investment is unlikely to take place. Thus, the issues do not arise at a level of generality which contrasts total public and total private investment as the alternatives. The real questions concern the volume of private investment which should be encouraged, and how the private sector might react to Governmental activities in the field of water development.

6.79 The selection of an area for public development is a strong deterrent to further private investment. If the area selected for public development is one where private investment might take place, but there is long delay between project identification and project completion, there could be a substantial loss of benefit from the private development which might otherwise have been in operation. The Bank Group therefore feels that the public investment program should be drawn up with full realization of the consequences of either attempting more than can be readily achieved, or pre-empting areas which can be developed by the private sector. No one can foresee with certainty the conditions which would attract private investment. The private tubewell installations to date have been heavily concentrated in a few areas of the Punjab, and there may be important social, economic and cultural differences between regions which account for the private sector activity, or lack of it. Nevertheless, the Bank Group wishes to state its view that the initial formulation of groundwater projects should be confined to areas and situations where public investment has a clear advantage over private, and where

1/ IACA cites a "most favorable" forecast that a total of 8,000 public tubewells would be installed between 1965 and 1970 (equivalent to less than 32,000 cusecs capacity), as contrasted with a Planning Commission estimate that 8,000 private tubewells could be installed annually (equivalent to 8,000 cusecs) during the same period, or a total of 40,000 cusecs.

private investment is not likely to be very significant in any event. With this in mind, the Bank Group's review of specific IACA projects has examined the possibility of reducing project size, or deferring public investment in tubewells where there appeared to be reasonable prospects that private investment would be forthcoming in the absence of a public tubewell project. Since these project reviews can be only indicative, the Bank Group has further recommended that when the detailed project feasibility studies are made they should include serious examination of whether, and to what extent, development might take place if all, or part, of the proposed project area were left largely to private initiative. In all circumstances where private development is appropriate, the Bank Group would recommend strong institutional support along the lines indicated in para 6.77 to stimulate and assist progress.

## 5. Supply Services for Agriculture

### (a) General Framework for the Supply of Inputs

6.80 This Report has stressed the importance of providing farmers with material inputs to accompany the application of adequate water supplies following water resource development. The institutional means for this are now essentially Governmental. This has been an obvious response to a situation where historically there has been scarcity of supplies resulting from a shortage of foreign exchange and other procurement difficulties, and the need to guard against abuses in such circumstances. Also, it must be recognized that the pressure for supplies has suddenly emerged in the wake of a vastly increased development program. Whether this reliance on Government for such services should be continued into the future is another question. IACA has suggested that the private sector be encouraged to participate in fertilizer supply, plant protection, and improved seed distribution, and has offered fairly specific observations on how this might be accomplished. 1/ Experience in agriculturally developed countries supports this view, and indicates that conditions can be created in which these functions are efficiently carried out by the private sector. The Bank Group substantially endorses IACA's suggestion and is strongly of the opinion that there would be advantages in having the private sector become an important element in the supply network for inputs.

6.81 Since the Government in Pakistan has taken a pragmatic approach towards private sector participation in general, it appears likely there would be little opposition in principle to a growing dependence on the private sector for agricultural input supplies. The transition from public to private supply would, however, be difficult, and would vary for different services. Increasingly the Government's role would become a supporting one. For some time to come it would have to retain overall responsibility for procurement and for the administration of subsidies, so long as the latter continue. Extension and research would continue to be important Government

1/ IACA Comprehensive Report, Volume 8, Annexure 11.

activities, particularly with regard to varietal improvement, effective control of pests and diseases, improved fertilizer use, proper water application, and the like. It would also be necessary for the Government to maintain an effective supervisory role with respect to the quality of inputs offered to farmers, and the advice on use which private sellers give to farmers. While the transition from public to private supply may be a drawn-out process, the developmental priorities are immediate. The Bank Group takes the view that maximum encouragement and opportunity should be given to private sector participation, but the timely provision of a sufficient quantity and range of inputs, at incentive prices and of assured qualities, is more important at this time than the particular institutional arrangements (public or private) by which this is accomplished. In the interest of assuring that material inputs and additional water would be available in all areas, it is probably realistic to assume that integrated supplies must depend heavily on Government initiative for some time to come.

(b) Fertilizers

6.82 Distribution of chemical fertilizers is an activity which private enterprise could enter most readily. It did so briefly in the past (1964-65), but the Government resumed the distribution function when fertilizer shortages arose in 1965 and private dealers began selling at prices above the fixed Government retail price to farmers. There is also, as discussed in Section A and Annexure 6.2 of this Report, a good prospect that domestic manufacturers of fertilizer would sell directly to farmers through the manufacturers own sales organizations. If the supply position improves to a point where prices can be stabilized at a price level fixed by the Government, the Bank Group anticipates that fertilizers would again be sold through private channels. An important element in the Bank Group's modifications of the IACA proposed agricultural and water development program is the projection of a larger use of fertilizers in the early years. The contribution of this input to agricultural production need not be delayed until the full water development program is completed, and there is therefore an immediate need to take the steps necessary to ensure the widest distribution. The Government would undoubtedly continue to provide some sales outlets through the ADC in the ADC project areas and the cooperatives in other parts of the Province. Overall supply permitting, the addition of private sales outlets to the Government's distribution activities would expand opportunities for farmers to obtain fertilizers, thereby enhancing the probability that the projected rapid rate of growth in fertilizer use would be realized.

(c) Improved Seed

6.83 Private participation in the supply of seed of improved varieties is likely to be slower in developing than fertilizer distribution. Production of foundation stock would remain primarily a Governmental activity under the research branch of the Department of Agriculture and the seed farms of the ADC. Farmers have shown interest in obtaining new varieties, and the improved wheat varieties undergoing testing and multiplication have aroused great expectations. Past experience with the production and distribution of improved seed in West Pakistan, mainly under Government control, has not been very encouraging. While good progress has been made in the introduction and breeding of new and improved varieties, further progress is still heavily dependent upon research which is not yet entirely adequate. Also. it is contrary to experience to expect that, once available, improved varieties would spread from farmer to farmer without an intervening process of planned multiplication and improved organization to control purity. Inter-departmental rivalry has apparently been one factor discouraging the use of improved varieties, but it has also been very hard to establish effective controls against adulteration by growers and distributors. There would be many difficulties to surmount before achieving a smoothly functioning private distribution system. IACA suggests that competition between private seed suppliers and the ADC would introduce a check on adulteration, and would be particularly feasible for crops such as wheat. The Bank Group agrees with this general view, but would point out that the full impact of new and improved varieties cannot be realized until supplies of uniformly high quality are widely available to farmers. Under the circumstances in West Pakistan, this situation is unlikely to occur rapidly or easily through a proliferation of independent suppliers, and it may require a large amount of Government supervision and participation for some time to come.

(d) Farm Machinery

6.84 Although mechanization of agriculture has not progressed very rapidly thus far, it would become increasingly important as more irrigation water becomes available under the proposed program. Private enterprise could play a useful role in distributing and servicing farm equipment, but Government would have to take steps to ensure that dealers are able to stock adequate spare parts and are prepared to offer continuing and dependable servicing facilties. The required degree of mechanization would not occur if the initial experiences were unfavorable because of widespread inadequacy and inconvenience in obtaining necessary repairs. With this qualification, the Bank Group agrees that private initiative should eventually replace Government in this supply activity. The rapid growth of domestic production and servicing facilities for private tubewells encourages the belief that private sector capacity would move into other areas of farm mechanization. Because individual ownership of farm machinery is not feasible at present for the majority of West Pakistan's farmers, the Bank Group feels it may be useful to devote attention to ways in which private contractors can be encouraged to provide machinery services, and make the advantages of mechanization available to a larger number of farmers. Another potentially fruitful approach would be the encouragement of cooperative arrangements for sharing major pieces of equipment. An important function which Government should perform is to carry out an expanded research program to determine which kinds of equipment are most suited to West Pakistan conditions and which are the most economical for the farmers to use. Such information would enable farmers to purchase or rent farm machinery which best fits their particular needs, and could minimize the potential waste of resources which would result from the acquisition of inefficient or unsuitable types of equipment. Research should also be carried on which seeks continuing improvements in bullock-drawn equipment and simple hand tools, since these would be of immediate benefit to the many small scale farms unable to adopt more expensive types of mechanized equipment.

(e) Plant Protection

6.85 IACA and most other observers have agreed that the present arrangements for supplying free plant protection services are quite unsatisfactory. Providing this service imposes a large burden on the extension staff. Their numbers are small and they have limited ability to deal effectively with infestation problems. The result appears to be an absorption of much of the time of the extension personnel without significant benefits to the farmers. These circumstances have led IACA and others to conclude that adequate area coverage can come about only when the major responsibility for applying plant protection materials falls on the farmers themselves, because the departmental manpower resources are much too thin. This would also mean opportunities for private sector participation in the production, demonstration, and distribution of pesticides and the equipment used to apply them. The extension services would still be responsible for instructing farmers in control measures, and in safe methods for handling and storing plant protection materials. This would not be easily done on a large scale, in part because the extension workers themselves would have to become more knowledgeable on the complexities of effective plant protection measures. Still, the general trend toward direct farmer participation seems inevitable if the expected contribution of plant protection activities under the proposed program is to be realized. Placing the financial burden as well as the physical task of application on the farmers may create some problems of acceptance. However, if the prices of the materials are sufficiently low to provide incentives to use them, and the results obtained by farmers are visibly significant, the adoption of plant protection materials should pose no greater difficulties than would be true for the other material inputs. The Bank Group feels that in a uniform ecological environment such as the Indus Plains, it may be possible to efficiently control some pests by rule-of-thumb methods evolved from experimental work designed to measure the effectiveness of different spraying programs. Such easy-to-understand spraying regimes would also possibly increase the rate of acceptance of plant protection methods by farmers where they prove successful. They would certainly ease the work of the extension staff. The Bank Group therefore recommends that research effort be applied to spraying experiments, particularly on cotton. Such research would seek to ascertain the optimum stage of growth for commencement of spraying and spraying intervals, bearing in mind both adequate pest control and economy in the measures used as twin objectives.

## 6. Agricultural Credit

(a) The Credit Need

6.86 At the beginning of 1959 the Government of Pakistan appointed a Credit Enquiry Commission to review the credit situation in Pakistan, and to make recommendations regarding measures to be taken to meet the credit requirements of a growing economy and to improve the channels of credit. The Commission presented its report in 1960 identifying the following main problems:1/

(i) an effective credit system designed for the direct benefit of the primary producers has yet to be developed;

(ii) there is a tendency for credit to gravitate towards the well-to-do elements in the community, and to be virtually denied to people who are most in need of credit;

(iii) the cooperative credit movement has become virtually stagnant at the primary level while the financing agencies above the primary societies have largely directed their fund to non-cooperative purposes.

Though some improvement appears to have taken place, by and large the situation reflected in these conclusions continues to exist.

6.87 Following the Credit Enquiry Commission, the Ministry of Finance established a Credit Advisory Committee, under the auspices of the State Bank of Pakistan, for consultation with, and coordination of, rural credit agencies. 2/ It is expected that the work of this Committee would be continued and enlarged during the Third Plan period. The Government sources through which credit is obtained by farmers are the Agricultural Development Bank and, to a lesser extent, the Cooperative Societies. In special circumstances loans have also been made available by the Revenue Department and the ADC. The small farmer -- notably the sharecropper rather than the owner-farmer -- still relies to a very great extent on private sources for credit, principally, relatives, zamindars, merchants and shopkeepers. Rates of interest on such loans may be several times higher than the five to nine percent per annum paid on loans obtained from official sources. Although an increase in the funds made available to credit organizations by Government is certainly needed, the procedures through which a farmer must go to obtain credit, especially short-term credit, are often both complex and slow. The result is that the farmers continue to be very dependent upon private sources.

6.88 In addition to the credit needs for working capital and for medium and long term investments in agriculture, there is an insistent demand for personal credit to meet social obligations. This latter demand has added substantially to the indebtedness of the farming community, but the institutional credit sources do not generally provide for this. Previous studies indicate that more than 50 percent of the indebtedness of farmers in West Pakistan has resulted from borrowings for family expenditures and social obligations not related to agricultural production. 3/

1/ Credit Enquiry Commission Report, Government of Pakistan, Karachi, 1960, page 18?
2/ The Third Five-Year Plan (1965-70) Government of Pakistan, May 1965, page 439.
3/ Credit Enquired Commission Report, page 12.

6.89 Several factors contribute to the chronic problem of agricultural indebtedness. First, the size of the typical agricultural enterprise is very small, and often the cultivators are not the owners of the land. Secondly, the ordinary farmer has insufficient collateral to satisfy institutional credit requirements. In the absence of adequate warehousing facilities or assurances that the crops would be marketed through the credit agencies, the security of crops remains highly dubious in many cases. Land alienation legislation introduced in conjunction with land reform, and designed to prevent the transfer of agricultural land in foreclosure proceedings may even make it difficult for the smaller owner to borrow from institutional sources because he cannot pledge his land as collateral. Thirdly, many farmers work holdings too small to maintain their families from the produce of the land itself at present yield levels, and they therefore remain in perpetual need of funds while at the same time they do not control dependable means of repayment.

6.90 These three conditions result in the perpetuation of non-institutional sources of credit such as money-lenders, relatives and shopkeepers. In the absence of an institutional credit system satisfying the described credit needs, the non-institutional credit arrangements do fill a vital gap without which the public welfare functions would have to be greatly increased. However, this service is performed in many cases at exorbitant costs to the borrowers either through excessive interest rates, or through manipulation of the prices of goods provided or commodities purchased.

6.91 While the Bank Group is not in a position to suggest any ready solution to the chronic problem of agricultural credit, it should be realized that this problem consists basically of two distinctly different kinds of needs. There is the definite need to provide more funds for productive purposes on both a current and long term basis, and there is the social need to provide transfers of purchasing power to the less advantaged. Since institutional credit is not usually available for the latter case, the borrowers achieve some credit standing with non-institutional lenders by repaying through a process of disinvestment. This adds to the growing rural poverty, which is already rapidly spreading as the high rate of growth of the rural population proceeds apace. This, however, is a problem of the economy at large, and neither the agricultural credit system nor the agricultural sector as such can, or should, be expected to carry such social welfare functions. It must be pointed out, furthermore, that this system has definite adverse side effects for agricultural development inasmuch as it tends to make productive credits from non-institutional sources scarce and expensive, and may thus significantly impair the prospects of the small operators who, at reasonable credit costs, might otherwise be able to participate in the development of the agricultural sector.

6.92 IACA estimates that Government credit sources presently provide only about five to ten percent of the working capital requirements. 1/ The

1/ IACA Comprehensive Report, Volume 1, page 197.

Credit Enquiry Commission estimated that the productive credit requirements, on the basis of the technology prevailing in the late fifties, must have been about Rs. 500 million for short-term seasonal credits only. The Commission also received representation that the credit requirements of the agricultural sector would at minimum be about 25 percent of total output or, on the basis of the value added for 1959/60, about Rs. 2 billion equivalent. This seems somewhat high for being representative of productive credit needs, and a rate of 15 percent of total output, roughly equivalent to 50 percent of the annual on-farm expenditures may be more indicative of the true credit requirements. Even on this base, however, the credit requirements for 1965 and 1975 respectively would be Rs. 1.3 billion and Rs. 2.2 billion. While these figures can only be indicative of general magnitudes, it would be unrealistic to expect that the Government could provide funds sufficient to support institutionalized credit on the scale required. The non-institutional source of credit would thus have to continue to fill a vital gap in supporting agricultural development.

6.93 However, as IACA rightly points out, 1/ insufficient attempts have so far been made to mobilize the rural savings potential. There are indications that substantial transfers from agriculture to urban activities take place annually. Furthermore, the rapid growth of private tubewell installations, with little Government support and little participation by institutional sources of credit, again suggests the availability of remunerative agricultural investments on a substantial scale. The Government should therefore explore the possibilities for mobilizing private savings and channelling them into the institutional credit system including the prospects for establishing depositories and actively campaigning to change the attitude of the rural community towards institutionalized savings.

(b) The Agricultural Credit Institutions

6.94 The participation of the commercial banking system in the field of agricultural credit is largely confined to lending to the large farmers who can offer satisfactory collateral. The bulk of the institutional credit (excluding commercial bank sources) is provided by credit channels of the Government or by agencies receiving direct Government support. The Government's declared policy continues to be that the cooperative system remain the main institutional channel for the provision of short and medium term credit, while the Agricultural Development Bank (ADB) should be primarily concerned with the provision of long term credit. In addition, the Revenue Department under the West Pakistan Agriculturists' Loan Act of 1958 can provide advances (so-called taccavi loans) to farmers in distress resulting from natural calamities, as well as for private water development, preparation of land for irrigation, private drainage, reclamation and flood protection works.

6.95 The cooperative credit movement at the primary level has suffered from relative stagnation in the post-Partition period. This resulted

1/ IACA Comprehensive Report, Volume 1, page 197.

partially from massive withdrawal of members and deposits in the course of Partition, and the exodus of experienced staff from the cooperative societies to other more profitable opportunities. Though the cooperative credit societies shifted in the wake of Partition towards multipurpose activities, the generally poor management of the societies led farmers to increasingly work through private marketing channels where they could procure credit exceeding the low credit limits set for the cooperative system. 1/ While there is some indication that the share capital of cooperative societies in West Pakistan has increased substantially, this apparent improvement must be regarded with caution because a portion of loans is sometimes withheld as share-money when these are granted to new members. Towards the end of the Second Plan period the credit outstanding was reported to be over Rs. 600 million, of which about one-quarter was apparently overdue. 2/ The afore-mentioned Credit Advisory Committee is expected to further advise specifically on the operation and improvement of rural cooperatives, and especially to explore ways and means to implement supervised rural credit in conjunction with coordinated farm commodity storage programs tied to the provision of credit. 3/

6.96 The ADB was established in 1961 by merging the Agricultural Development Finance Corporation and the Agricultural Bank of Pakistan (ABP). The ADB has an authorized capital of Rs. 200 million, of which only Rs. 100 million have been paid up. This limited capital base has forced ADB to operate to a large extent on borrowings 4/ and overdrafts from the State Bank, which together with the large staff requirements for the administration of numerous small loans has depressed the ADB's profitability. Nevertheless, since its establishment the ADB has almost tripled its lending volume in West Pakistan, from Rs. 33 million in 1960 to Rs. 95 million in 1965, while maintaining a rate of recovery of more than 75 percent. 5/ This impressive progress in lending commitments may be difficult to maintain unless new capital resources are made available to the ADB in due course. An increase in the Government's share capital of Rs. 75 million has been provided for in the Third Plan period, but no action has been taken on this so far. Though mainly restricted to medium and long term credit, and oriented towards the creditworthy farmer, the performance so far achieved by th ADB in West Pakistan is indeed encouraging and worthy of continued and increased support.

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1/ The ceilings were raised in 1961 and "service" cooperatives now being organized at Union Council levels can provide credit in kind without specific limits.

2/ Andrus, J.R. and Mohammed A.F., Trade Finance and Development in Pakistan, Stanford University Press, 1966.

3/ The Third Five-Year Plan (1965-70), Government of Pakistan, May 1965, page 440.

4/ Including an IDA Credit of US$ 27 million for mechanization and private tubewell development.

5/ This includes arrears inherited from the predecessor institutions.

6.97 State credits for agriculture (taccavi loans) in West Pakistan are made available at a level of nearly Rs. 15 million per annum, though with apparently rather unsatisfactory rates of recovery. The Credit Enquiry Commission pointed out in its report that there is no recourse but the Revenue Department for the provision of credit to new settlers and in cases of distress. However, there appears to be some overlap in the credit functions of the ADB and the taccavi system in the provision of funds for productive investment requirements. Consequently, the Third Plan stipulates that long term taccavi loans should no longer be provided by the West Pakistan Government except in areas where no other institutional credit services exist, or where the special needs of settlement and land reform programs justify the provision of such loans. The Third Plan recommends further that a revolving fund for taccavi loans should be established on the provincial level which should eventually become self-sustaining given the Plan allocation and the recoveries of outstanding loans. It is appropriately stressed that this would require a clear separation between any welfare functions still included in the taccavi system and the specialized credits for production purposes.

6.98 The summary description of the prevailing agricultural credit situation given above only serves to underline the complexities West Pakistan faces in developing an agricultural credit system which would efficiently support the anticipated transformation of the agricultural sector. In this respect the Bank Group has no ready solution to offer, and can only stress the fact that any growing monetization in the rural areas would require a change in attitude toward credit by the majority of farmers. Only when farmers learn to look upon credit as a form of productive input which needs to be recovered by the lender, and maker the distinction between credit in its productive sense and relief grants, will it become possible to provide a larger volume of institutional credit on a commercial basis. Institutional credit arrangements alone may not provide a solution for agricultural credit problems, but there must be a serious effort to organize an effective rural credit system, as has been begun with the Credit Enquiry Commission. Even partial implementation of the Commission's recommendations requires the development of management expertise, and would therefore take time. To a large extent it would also depend on the increase in savings within the rural economy. In the meantime, the non-institutional sources of credit are likely to remain a most important source of finance to the farmers.

# VII. FINANCIAL REQUIREMENTS OF THE DEVELOPMENT PROGRAM

## A. Water Development Investments

### 1. Public Expenditures

7.01 The original Third Five-Year Plan (1965-70) 1/ included an allocation of public expenditures for water development in West Pakistan of Rs. 2,662 million. This allocation did not allow for the IBP works, nor did it make any provision for the construction of Tarbela. Of the total provision of Rs. 2,662 million, about 52 percent, or Rs. 1,390, was allocated to the development of groundwater through public tubewells. A further 30 percent, or Rs. 793 million, was allocated to the further improvement and extension of surface irrigation, including small schemes outside of the Indus Basin and some multipurpose schemes. The remaining Rs. 479 million, or about 18 percent, were distributed over such items as drainage, flood protection and investigations. This allocation of funds is indicative of the continued emphasis that the Government is prepared to give to the development of groundwater resources.

7.02 The water development program IACA has proposed as a result of its studies and the revised IACA Program (see Chapter IV) could both be contained within the above amounts, but this would require some redistribution of funds within the total allocation (para 7.04). IACA's proposals for the Third Plan period would result in a reduction in the public tubewell allocation of about 23 percent or some Rs. 324 million. The expenditures for surface drainage - mainly a start on the Indus Left Bank Outfall Drain and the Sukh Beas Scheme - would be increased by nearly 87 percent, or about Rs. 168 million. In addition, tile drainage pilot projects would require another Rs. 39 million. However, the total allocations for water development under the IACA proposals - excluding Tarbela - would be Rs. 2,365 million, or Rs. 297 million less (equivalent to 11 percent) than the allocations contained in the original Third Five-Year Plan. This reduction in the allocation for water development is principally a reflection of IACA's assessment of what further physical works could reasonably be completed in the remaining four years. In particular, it results from a deferment of some public tubewell construction until a later period.

7.03 Since the completion of the IACA studies, it has become even more obvious that the on-going public tubewell program is falling behind schedule, and this is reflected in the revised public tubewell implementation program shown

1/ Government of Pakistan Third Five-Year Plan, May, 1965. In December 1966 the Government of Pakistan revised the phasing of plan expenditures and the sectoral allocations. The original plan allocation for water development was reduced by Rs. 482 million or about 18 percent. The most drastic reduction was applied in the drainage reclamation and tubewell portion which takes partly into account the shortfall against physical implementation targets. Government of Pakistan Planning Commission, Revised Phasing, Sectoral Priorities and Allocation of the Third Five-Year Plan, December, 1966.

in Chapter IV. Based on IACA's estimates for on-going tubewell projects, and including the Bank Group's higher contingency allowance for new projects (see Chapter IV), the reduction of the public tubewell allocation contained in the original Third Plan period would be about Rs. 345 million under the revised program. Allowing for the costs of raising Chasma barrage (Rs. 105 million before duties and taxes, the cost of the barrage itself being included in IBP works) the expenditures for surface irrigation would increase to Rs. 705 million, as compared to the Government allocation of Rs. 793 million. Overall, the proposed Action Program set forth in Chapter IV and the on-going Government activities (other than IBP works and the construction of Tarbela) would require total allocations of Rs. 2,441 million during the Third Plan period, as compared to the Rs. 2,662 million allocated in the original Third Plan. This would be equivalent to a reduction of about eight percent in the water development program. As stated in para 7.01, however, the most recent revised allocation under the Third Five-Year Plan calls for a reduction of 18 percent, leaving a total allocation of Rs. 2,180 million for water development activities in the Third Plan period. This would be a shortfall of Rs. 261 million against the requirement of the Action Program.

7.04 The financial requirements for Tarbela (including power facilities) during the Third Plan period have been estimated at about Rs. 1,414 million before duties and taxes and interest during construction. This would raise the total requirements for the Action Program during the Third Plan period to Rs. 3,855 million, or increase the original Government allocation by about 45 percent. A more detailed breakdown is given in Annex 7.1 (page 1) and IACA's investment program for water development is shown in Annex 7.1 (page 2). The required allocations for the Third Plan period are compared below:

Comparison of Public Investment Requirements For Water Development During The Third Plan Period

| | Third Five-Year Plan | IACA Proposal | Revised Program 1/ |
|---|---|---|---|
| | (Rs. mill) | | |
| Public Tubewells | 1,389 | 1,065 2/ | 1,044 2/ |
| Surface Irrigation | 793 | 600 | 705 |
| Surface Drainage | 195 | 363 | 363 |
| Tile Drainage | - | 39 | 39 |
| Flood Protection | 73 | 74 | 74 |
| Investigations | 187 | 199 | 191 |
| Miscellaneous | 25 | 25 | 25 |
| Subtotal | 2,662 | 2,365 | 2,441 |
| Tarbela | 1,414 | 1,414 | 1,414 3/ |
| TOTAL | 4,076 | 3,779 | 3,855 |

1/ The reconciliation of the IACA proposal with the proposed Action Program would consist of: (i) inclusion of raising of Chasma barrage (Rs. 105 million), (ii) reduction of investigations included in tubewell allocation (Rs. 8 million), and (iii) rephasing of tubewell program deferring tubewell investments of about Rs. 21 million. There would thus be a net increase of about Rs. 76 million. For details see Chapters IV and V.
2/ Exclusive of electrical transmission and distribution.
3/ Investment requirements including power facilities as phased in investment schedule of Action Program (Chapter IV, para 4.79).

7.05 No Government estimates for the Fourth Plan water development expenditures were available for incorporation in this report. The IACA proposal would call for total allocations, excluding Tarbela, of about Rs. 2,602 million. This estimate, however, has been revised by the Bank Group in the light of the revised public tubewells program (Chapter IV) and the addition of further flood protection estimates. In addition, as stated in Chapter IV, the Bank Group has raised IACA's cost estimates for public tubewell installation by about 20 percent. The combined effects are compared below against the IACA proposal:

Public Investment Requirements for Water Development in the Fourth Plan Period

| | IACA Proposal | Revised Program |
|---|---|---|
| | ----------(Rs. mill)--------- | |
| Public Tubewells | 1,310 1/ | 1,339 1/ |
| Surface Irrigation | 352 | 352 |
| Surface Drainage | 516 | 516 |
| Tile Drainage | 184 | 184 |
| Flood Protection | - | 75 |
| Investigations | 240 | 240 |
| Miscellaneous | - | 30 |
| Subtotal | 2,602 | 2,736 |
| Tarbela | 2,789 | 2,789 |
| TOTAL | 5,391 | 5,525 |

1/ Exclusive of electrical transmission and distribution.

Five tubewell schemes, included in the Action Program and scheduled to start during the Fourth Plan period, as well as some Tarbela expenditures would continue into the Fifth Plan period (1975-80), and there would therefore be a carry-over commitment of about Rs. 130 million from the Action Program to be met in the first year of the Fifth Plan period.

7.06 Excluding the above Rs. 130 million, the total public financial requirements for the period of the Action Program would thus compare as follows:

Public Financial Requirements for the Period 1965/66 to 1974/75

| | IACA Proposal | | Revised Program | | Variations |
|---|---|---|---|---|---|
| | Rs. mill | % | Rs. mill | % | Rs. mill |
| Public Tubewells | 2,375 | 26 | 2,383 | 26 | (+) 8 |
| Surface Irrigation | 5,155 | 56 | 5,260 | 55 | (+) 105 |
| Surface Drainage | 879 | 10 | 879 | 9 | - |
| Tile Drainage | 223 | 2 | 223 | 2 | - |
| Flood Protection | 74 | 1 | 149 | 2 | (+) 75 |
| Investigations | 439 | 5 | 431 | 5 | (-) 8 |
| Miscellaneous | 25 | - | 55 | 1 | (+) 30 |
| TOTAL | 9,170 | 100 | 9,380 | 100 | (+) 210 |

A detailed breakdown of the above estimates, including the regional distribution of investments, is given in Annex 7.1.

7.07 In the absence of detailed cost estimates for all the works included in the above estimates, and because of increasing import substitution effects (especially in the case of tubewell equipment), only an indicative assessment of the foreign exchange component could be made. Assuming that tubewell projects would require about 40 percent foreign exchange, surface irrigation about 60 percent, and drainage and flood protection works about 15 percent, the foreign exchange requirements for the period 1965/66 to 1974/75 would amount to about Rs. 4,150 million or about US$ 874 million equivalent. To this should be added a sum of about Rs. 200-250 million (US$ 42-53 million equivalent) for investigations. Total foreign exchange requirements would thus be about US$ 927 million equivalent, exclusive of the overrun of the Action Program into the Fifth Plan period of approximately Rs. 75 million or US$ 16 million equivalent.

2. Private Expenditures

7.08 Private investment for water development activities would be concentrated on private tubewells and, to some extent, on farm drainage works associated with the Sukh Beas Scheme. IACA's projections of future private tubewell installations are considerably lower than those made by the Government and provided for in the Third Five-Year Plan. The Bank Group, anticipating some encouragement for private tubewell development in the Third and also the Fourth Plan period, 1/ has taken a somewhat more optimistic view of the rate of growth of future private well installations. However, for the purpose of projecting private investment, the revised IACA estimates set forth in Chapter IV have been used, though with an allowance for some cost increases in private well construction. The higher rate of installation shown in these revised projections takes into account the deferment of some public tubewell projects, especially in the Bari Doab as described in Chapter IV.

7.09 Allowing for investments in well replacement and also including on-farm costs for drainage works to be carried out by farmers in conjunction with the Sukh Beas Scheme, the estimates of private investments compare as follows:

1/ In the Third Five-Year Plan a provision has been made for support of some 15,000 private tubewells by the Department of Agriculture.

Estimated Private Investments in Water Development
During the Third and Fourth Plan Period
(Rs. mill)

| | Government | IACA Proposal | | | Revised Program | | |
|---|---|---|---|---|---|---|---|
| | Third Plan | Third Plan | Fourth Plan | Total | Third Plan | Fourth Plan | Total |
| Private Tubewells | 300 | 352 | 236 | 588 1/ | 428 | 321 | 749 1/ |
| Drainage | - | - | - | - | - | 13 | 13 |
| TOTAL | 300 | 352 | 236 | 588 | 428 | 334 | 762 |

1/ Including replacement investments.

Especially the estimates for the Fourth Plan period should be regarded as tentative and subject to upward revision. Any shortfall in the public tubewell program, or any decision to defer public developments because of active on-going private investments in tubewells or lack of public funds, would tend to raise the estimate for the Fourth Plan period. Furthermore, the rate of private installation in the non-commanded areas, both within and outside the Indus Basin, is largely unpredictable and may be substantially above that projected in Chapter IV.

## B. Agricultural Development Expenditures

### 1. Public Sector Program

7.10 The allocation of public funds for agricultural development in the original Third Five-Year Plan amounted to a total of Rs. 1,999.4 million. An additional provision of Rs. 554.2 million in the Central Government's development allocations for agriculture in West Pakistan increased total allocations to Rs. 2,554 million. 1/ This represented a more than three-fold increase over the Second Five-Year Plan allocation. The aggregate provision did not include allocations for other sectors supporting agriculture, such as industry, transportation, power, and agricultural education. 2/ Most of the allocations for agriculture would be for recurrent expenditures of Government services, and to support measures designed to encourage agricultural development.

7.11 The largest single item in the original allocations was for fertilizer subsidies (Rs. 678 million). The three items of fertilizer subsidy, plant protection provided as a free service to farmers, and seed multiplication and distribution accounted for Rs. 1,026 million, or 40 percent of the total

1/ Government of Pakistan, The Third Five-Year Plan (1965-70), May 1965, page 460.
2/ The original Third Five-Year Plan included an allowance for manpower development in agriculture of Rs. 67.2 million.

allocation, which indicates the emphasis the Government is prepared to place on these three strategical inputs. Another Rs. 500 million, or about 20 percent, was allocated for extension, research, mechanization and soil conservation. The remaining Rs. 746 million covered such activities as animal husbandry and range management, colonization, forestry and fisheries, and such institutional factors as cooperatives and the Agricultural Development Bank (ADB).

7.12 In the course of the recent revision of the phasing, sectoral priorities and allocations of the Third Five-Year Plan 1/, the plan allocations for West Pakistan's Agriculture (before provision from the Central Government 2/) were reduced to Rs. 1,622 million. As discussed in Chapter VI, most of these reductions were applied to expenditures on fertilizer subsidies, plant protection, mechanization and extension services. In the Bank Group's assessment, the fertilizer subsidies have been reduced (in keeping with the lower rate of subsidization) from an original level of Rs. 678 million to Rs. 500 million (see para 7.13). The Government's revised allocation would make available no more than about Rs. 400 million. The Bank Group believes this large a reduction is not in accord with the ambitious offtake targets for fertilizers projected for the remainder of the Third Plan period. Similarly, the Bank Group feels that allocations for the extension services are of sufficiently high priority to be maintained at the original level. The Bank Group has no means to assess the relative merits of the selective cuts made under other headings, but would recommend that any reductions of allocations to agriculture (beyond those prompted by revised phasing) be carefully reconsidered in the light of their impact on the use of non-water inputs, and consequently production.

7.13 As stated in Chapter VI, the Bank Group would attach high priority to the accelerated introduction of non-water inputs, especially fertilizer and seeds, but increasingly also to plant protection and mechanization. On the basis of the most recent experience with fertilizer procurement and distribution, the Bank Group has increased the IACA projections of fertilizer consumption for the Third Plan period (see para 6.11). Assuming a continuing subsidy rate of about 30 percent, and employing the higher offtake projection of the Bank Group, the subsidy requirement would amount to approximately Rs. 500 million. The Bank Group also feels that all costs associated with the provision of plant protection services free of charge to farmers should be regarded as development expenditures, and thus charged in full.

7.14 No Government estimates of public development expenditures for agriculture are available for the Fourth Plan period. IACA has placed a global assessment of requirements at Rs. 3,700 million, including fertilizer subsidies of Rs. 155 million, plant protection costs of Rs. 100 million, and extension and

1/ Government of Pakistan, Planning Commission, Revised Phasing, Sectoral Priorities and Allocations of the Third Five-Year Plan (1965-70), December 1966, especially page 17.

2/ Allocated for use by the Central Government in the field of agriculture were Rs. 372 million for both provinces. No separate allocation of these funds to West Pakistan was available to the Bank Group.

research expenditures of Rs. 260 million.[1] While it may be possible to reduce the rates of subsidization as assumed by IACA, the allocation for these three items would appear to be on the low side. The size of the fertilizer subsidy is again due to a rather low fertilizer offtake projection for the Fourth Plan period, as well as reduction in the subsidy rate.

7.15 While the Bank Group has no basis for making a detailed estimate of public development expenditures for agriculture during the Fourth Plan period, its more optimistic expectations would tend to call for increased allocations for fertilizer subsidies and plant protection. Assuming that a further reduction in the rate of fertilizer subsidization (e.g., from the present 30 percent to about 20 percent) would become feasible as a result of reduced procurement costs, and that there would be no substantial increase in the cost of fertilizers to farmers, the total subsidy requirements for the Fourth Five-Year Plan period would still amount to some Rs. 700 million based on the Bank Group's offtake projections. Although the Bank Group would expect increasing participation by private enterprise in the provision of plant protection services, this would be a slow process and not likely to relieve public sector expenditures to the full extent during the period 1970 to 1975. As stated before, plant protection in West Pakistan is presently very inadequate, even though allocations have been considerably increased. In the future, substantially higher levels of production per unit of land would need to be protected, and IACA has estimated[2] that on-farm expenditures for plant protection in the irrigated area of the Basin would average about Rs. 10 per acre by 1975. This would be roughly equivalent to Rs. 300 million in the year 1975. Assuming a gradual increase in the level of outlays for plant protection from about Rs. 100 million in 1970 to about Rs. 300 million in 1975, total plant protection expenditures for the Fourth Plan period would amount to about Rs. 1.0 billion. Allowing for private participation to the extent of about 50 percent, the required public allocation would still amount to Rs. 500 million, or around Rs. 100 million per annum.

7.16 The Bank Group's tentative estimate of total public development expenditures for agriculture during the Fourth Plan period would thus exceed the IACA estimate by about Rs. 950 million, equivalent to an increase of about 25 percent over the IACA figures. The various estimates of required public sector allocations for the Third and Fourth Plan periods are as follows:

1/ IACA Comprehensive Report, Volume 1, page 161.
2/ See IACA Comprehensive Report, Volume 7, Annexure 9, page 134.

Comparative Estimate of Public Development Expenditures
For the Third and Fourth Plan Periods

| | Government | | IACA Estimate | | Bank Group's Provisional Estimates | |
|---|---|---|---|---|---|---|
| | Third Plan 1/ | | Third Plan | Fourth Plan | Third Plan | Fourth Plan |
| | (Rs. mill) | | | | | |
| Fertilizer Subsidies | 678 | (395) | 340 | 155 | 500 | 700 |
| Plant Protection Subsidies | 300 | (184) | 88 | 100 | 300 | 500 |
| Extension and Research | 182 | ( 49) | 180 | 260 | 180 | 260 |
| Mechanization | 214 | (123) | 214 | ( | 214 | ( |
| Soil Conservation | 105 | ( 95) | 105 | ( | 105 | ( |
| Animal Husbandry | 112 | ( 90) | 112 | (2,835 3/ | 112 | (2,835 3/ |
| Colonization | 117 | ( 94) | 117 | ( | 117 | ( |
| Forestry and Fisheries | 304 | (171) | 304 | ( | 304 | ( |
| Others | 364 | (363) | 364 | ( | 364 | ( |
| Subtotal | 2,376 | | 1,824 | 3,350 | 2,196 | 4,295 |
| Capital Liability 2/ | 178 | ( 58) | 178 | 350 4/ | 178 | 350 4/ |
| TOTAL | 2,554 | | 2,002 | 3,700 | 2,374 | 4,645 |

1/ Revised allocation (see para 7.12) net of those from Central Government shown in brackets.
2/ On Government account: Cooperatives, ADB, and Taccavi Loans, revised figure for cooperatives only.
3/ IACA global estimate, based on original Third Five-Year Plan.
4/ IACA estimate.

For the period of the Action Program (1965/66 to 1974/75), total expected public development expenditures for agriculture would thus range from about Rs. 6.0 billion to Rs. 7.0 billion. This compares to Rs. 9.5 billion for water development alone (see para 7.06).

7.17 The foreign exchange requirements of the above outlined public expenditure program would vary considerably, depending on the degree of local manufacture involved. IACA estimates total foreign exchange requirements of about Rs. 378 million, equivalent to about 20 percent, for the Third Plan period. No estimate is available for the Fourth Plan period. However, foreign exchange requirements for fertilizer and mechanization should not increase substantially because of increasing local production capacity of these items (see Annex 6.1). Chemicals for plant protection would, however, continue to be imported. In the absence of any assessment of foreign exchange requirements for the Fourth Plan period, the Bank Group assumes these expenditures to continue at about the present level of about Rs. 400 million. The foreign exchange requirement for public development expenditures in agriculture under the Action Program would thus be about US$ 164 million equivalent.

2. Private Sector Expenditures

7.18 The Third Five-Year Plan 1/ envisages total private investments in the agricultural sector, net of those for private tubewells, of about Rs. 1.9 billion. This would include such items as private development of lands, private improvements of irrigation facilities other than private tubewells, additions to farm buildings and implements, and increases in the livestock herd. This estimate is, however, a very general figure, based on some rural surveys in 1963/64 to which an average annual increase of about five percent has been added. No attempt has been made to detail the estimate, or to allocate it to specific production activities. It is, however, meant to exclude recurrent production expenditures for such items as fertilizer, seeds, etc.

7.19 While IACA has not been able to substantiate the above estimate, it has retained it in view of the recent rapid growth of private investment in agriculture. IACA further assumed that, along with the increase in public investments, the private sector investments in agriculture would also double in the Fourth Plan period, amounting to about Rs. 3.8 billion for the five-year period. Total private investments in agriculture for the period 1965 to 1975 would thus amount to about Rs. 5.7 billion.

7.20 The above estimates would require average annual levels of private investment of about Rs. 380 million during the Third Plan period, and Rs. 780 million during the Fourth Plan period. Assuming that 90 percent of this investment would occur in the irrigated areas of the Indus Basin, it would represent investments of about Rs. 11 per acre and Rs. 23 per acre respectively. On average, this would be considerably less than ten percent of the gross production value per acre, and would thus appear to be within the realm of possibility. Conceivably, the rate of growth of private investments would be significantly influenced by such factors as rural electrification, the development and availability of improved implements, and credit availability. A wide margin of error would therefore be inherent in the above estimate. In the absence of any better evidence, the Bank Group has adopted the assessment outlined above. This may need to be revised in the light of efforts by the Central Statistical Office to provide firmer estimates of private investment activities in agriculture

7.21 It would be desirable to stimulate the rate of private investment in the interest of local resource mobilization. Important in this respect would be the increased availability of capital goods, which may partially depend upon a more liberal import policy, repair and service facilities, and credit. In the long term it should be possible to achieve a rate of private investment in agriculture of around ten percent of gross value added. For the year 1975 this would be equivalent to approximately Rs. 1.3 billion per annum.

1/ Government of Pakistan, Third Five-Year Plan (1965-70), May 1965, page 103.

### C. Total Financial Requirements

7.22 The estimates of financial requirements for both public and private investments during the decade 1965 to 1975 should be regarded as preliminary, and would need further verification by the findings of more detailed investigation and surveys. The amounts shown below would, however, be indicative of the magnitude of finance required for the implementation of the Action Program together with other on-going activities in the field of agricultural and water development.

**Financial Requirements for the Development of Irrigation and Agriculture During the Third and Fourth Plan Periods**

| | IACA | | | Revised Program | | |
|---|---|---|---|---|---|---|
| | Third Plan | Fourth Plan | Total | Third Plan | Fourth Plan | Total |
| | (Rs. mill) | | | | | |
| **Public Sector:** | | | | | | |
| Water Development | 3,779 | 5,391 | 9,170 | 3,855 | 5,525 | 9,380 |
| Agricultural Development | 2,002 | 3,700 | 5,702 | 2,374 | 4,645 | 7,019 |
| Subtotal | 5,781 | 9,091 | 14,872 | 6,229 | 10,170 | 16,399 |
| **Private Sector:** | | | | | | |
| Water Development | 352 | 236 | 588 | 428 | 321 | 749 |
| Agricultural Development | 1,900 | 3,800 | 5,700 | 1,900 | 3,800 | 5,700 |
| Subtotal | 2,252 | 4,036 | 6,288 | 2,328 | 4,121 | 6,449 |
| **Total:** | | | | | | |
| Water Development | 4,131 | 5,627 | 9,758 | 4,283 | 5,846 | 10,129 |
| Agricultural Development | 3,902 | 7,500 | 11,402 | 4,274 | 8,445 | 12,719 |
| TOTAL | 8,033 | 13,127 | 21,160 | 8,557 | 14,291 | 22,848 |

This table indicates the need to increase the financial allocations for the revised program in the Fourth Plan period by about 67 percent above requirements of Third Plan, but with increasing emphasis on agricultural development expenditures in both the public and the private sectors.

7.23 On the basis of the revised program, total water development investments are expected to increase by about 38 percent, with nearly 95 percent coming from the public sector. Total agricultural development expenditures would increase by about 98 percent, with 55 percent contributed from public sources. Thus, even in the Fourth Plan period, the public sector would still have to provide the financial support for irrigation and agricultural development to an extent of more than 70 percent of the total. Such a distribution of the financial burden of agricultural development would appear necessary where the prevailing rural per capita income is low. It also indicates a lack of incentives for investment in agriculture which is probably compounded by the limited access to institutional credit facilities. No reliable estimates of the savings transfers from the rural to the urban sector are available, but a recent tentative estimate 1/ indicates that such transfers may be as high as Rs. 3.6 billion per annum for both provinces. This would indicate that at least Rs. 1.0 billion per annum would find more attractive uses in West Pakistan either in consumption or non-agricultural investment. To the extent that agriculture is likely to continue to be the main contributor to GNP, it would be highly desirable to redirect this flow of funds and eventually reach a position where the private sector would make a substantially larger contribution to capital formation in agriculture.

7.24 The above outlined physical program for water development leaves little room for accelerated private investments inasmuch as the public projects would have exploited most of the attractive opportunities during the decade 1965 to 1975. Only the further deferment of public tubewell projects could lead to increased direct private investments in this sphere. Such a possibility should be kept in mind if available public financial resources for water development should fall short of requirements during the Third and Fourth Plan periods. While considerable opportunities for private investment in agriculture proper appear to exist, their realization would in turn depend on the relative profitability of such investments. It would therefore be imperative that the Government, through appropriate economic policy, would provide an economic environment within which private savings would find an attractive use in agriculture. Basic to this would be price policies and measures to ensure a fair distribution of income within the sector.

7.25 As pointed out earlier, the estimates of foreign exchange requirements can only be indicative. On the assumptions made in Chapter VII. A and B above, and allowing for IACA's estimate of foreign exchange requirements in the private sector, the total foreign exchange requirements of the revised program would be about as follows:

1/ Griffin, K.B., Financing Development Plans in Pakistan, the Pakistan Development Review, Volume V, No. 4, Karachi, 1965.

Indicative Assessment of Total Foreign Exchange Requirements for Irrigation and Agricultural Development During the Third and Fourth Plan Periods

| | Third Plan Period | Fourth Plan Period | Total |
|---|---|---|---|
| | (Rs. mill) | | |
| **Public Sector:** | | | |
| Water Development | 1,700 | 2,450 | 4,150 |
| Agricultural Development | 380 | 400 | 780 |
| Subtotal | 2,080 | 2,850 | 4,930 |
| **Private Sector:** | | | |
| Water Development | 70 | 50 | 120 |
| Agricultural Development | 270 | 1,000 | 1,270 |
| Subtotal | 340 | 1,050 | 1,390 |
| **Total:** | | | |
| Water Development | 1,770 | 2,500 | 4,270 |
| Agricultural Development | 650 | 1,400 | 2,050 |
| TOTAL | 2,420 | 3,900 | 6,320 |
| US$ million equivalent @ 4.75: | 509 | 821 | 1,330 |

The development program for irrigation and agriculture as outlined in this report would thus require, on average, foreign exchange availability of about US$ 100 million equivalent per annum during the Third Plan period, and about US$ 165 million equivalent per annum during the Fourth Plan period. It should be stressed, however, that this assessment would need to be reviewed from time to time as more detailed information becomes available and as specific decisions on the program content would be taken.

# VIII. COMPARISON OF SUPPLY AND DEMAND

## A. Growth of Production

8.01 Having previously examined the IACA proposals from several points of view, this Chapter deals with the growth of production which would be expected to take place if the recommended programs were carried out as scheduled, and the quantities of non-water inputs were utilized as projected. This means focussing here on the aggregate result to be expected from the contributions of the various proposals embodied in the program. Any projection of this kind is an extremely difficult undertaking, dealing as it does with a rural sector where subsistence farming is still an important element and where the benchmark data are of varying degrees of accuracy. Estimates of future levels of agricultural production are particularly difficult for West Pakistan, with its large territory and its great variation in farm sizes, tenure arrangements, climatic conditions, and degrees of irrigation development. It should therefore be clear that projections with respect to such an area can only be indicative at best, and must necessarily reflect the judgment of those who have prepared them.

8.02 To arrive at estimates of the levels of production at the reference years, IACA has analyzed the prospects in each of the canal commands in considerable detail. Starting from an estimated level of production based on an average of the later years of the Second Plan period (approximately the 1965 level) IACA applied its respective yield projections for each year to the estimated cropped acreage in each canal command. These yield projections, as explained in Chapter II, are based on the assumption of full delta irrigation and the application of other inputs. The levels of input use would increase in accordance with the IACA assumptions described in Chapter VI. In applying these yield projections (incorporating full delta and increasing inputs), IACA has adjusted the resulting production on the basis of its judgment with respect to the constraints likely to be operative at any given time. For areas in the canal commands where under-watering would continue in the early years (until more water would become available under the program), IACA has estimated production by first reducing the actual cropped acreage to the equivalent acreage which could be cropped at full delta. IACA then applied its full delta yields to this reduced acreage to estimate production, and this quantity of production was assumed to have come from the larger actual acreage. The resulting implied yields are thus lower than full delta yields, and the difference reflects IACA's approximation of the effects of under-watering on yields. As explained in Chapter II, to make some allowance for the additional production associated with under-watering, IACA added about ten percent to the production of minor crops. Intensity growth in each canal command was also projected as described in Chapter II. The first increment of additional irrigation water was assumed to fill the gap between the degree of under-watering prevailing and full delta. Further increments of water were assumed to bring about increases in intensity at full delta at rates conditioned by the salinity status, the estimated farming constraints, and the cropping pattern prescribed for the particular agricultural zone. The additional cropped acres resulting from increased intensity were assumed to have a yield growth as set forth in IACA's yield projections, but modified in each canal command by the degree of salinity assumed to prevail at any particular time.

8.03 The result of this detailed compilation by canal commands is a set of estimates for the total acreage cropped and total crop production at the reference years. As shown in the following table, the cropped acreage would rise by 42 percent, from 39.12 million acres in 1965 to 55.61 million acres in 2000. The production of major crops is proportionately greater, however, because yields per acre would also be rising. The significance of these production estimates can best be seen in connection with estimates of demand, and this comparison is further discussed in Part B of this Chapter. IACA's projection of cropping patterns anticipates some shift would take place in the acreage devoted to different crops. For example, fine rice is projected to become relatively more important than coarse rice, and the acreage in Jowar/bajra, gram, and rabi pulses would decline. The acreage in oilseeds would become only slightly larger than in 1965. Wheat acreage would rise at first, but would be declining by 2000. In all these examples, production would rise despite smaller, or nearly constant, acreages. Substantial acreage increases (in addition to the fine rice mentioned above) would come in cotton, fodder, and green manure -- the increase for these three crops alone would be 11.1 million cropped acres. In broad terms the contemplated changes can be summed up as constituting a relative shift from grain production for domestic consumption toward export crops and livestock support.

IACA Projections of Cropped Acreage
and Production in West Pakistan, 1965-2000 1/

| | Cropped Acres | | | | Production | | | |
|---|---|---|---|---|---|---|---|---|
| | 1965 | 1975 | 1985 | 2000 | 1965 | 1975 | 1985 | 2000 |
| | (million acres) | | | | ('000 metric tons) | | | |
| **Kharif:** | | | | | | | | |
| Coarse rice 2/ | 2.84 | 2.74 | 2.17 | 2.47 | 1,381 | 1,651 | 2,422 | 4,141 |
| Fine rice 2/ | 0.68 | 0.89 | 1.08 | 1.29 | 442 | 709 | 1,311 | 2,070 |
| Cotton 3/ | 3.71 | 4.50 | 5.72 | 8.07 | 1,097 | 1,634 | 3,553 | 6,618 |
| Maize | 2.16 | 2.33 | 2.71 | 2.89 | 838 | 1,197 | 2,072 | 3,155 |
| Fodder | 2.93 | 3.77 | 4.46 | 5.56 | 21,880 | 35,194 | 62,356 | 102,175 |
| Pulses | 0.49 | 0.72 | 1.06 | 1.24 | 92 | 171 | 360 | 636 |
| Groundnuts | - | 0.04 | 0.17 | 0.56 | - | 26 | 174 | 706 |
| Others | 0.16 | 0.02 | - | - | 41 | 16 | - | - |
| Tobacco 4/ | 0.03 | 0.03 | 0.03 | 0.04 | 13 | 16 | 26 | 32 |
| Jowar/Bajra | 3.01 | 2.33 | 2.20 | 2.31 | 680 | 672 | 738 | 939 |
| Oilseeds | 0.02 | 0.00 | 0.01 | - | 6 | 1 | 9 | - |
| **Rabi:** | | | | | | | | |
| Wheat | 12.71 | 15.21 | 15.42 | 14.60 | 4,659 | 7,408 | 11,212 | 12.870 |
| Fodder | 3.26 | 3.92 | 4.30 | 4.79 | 47,501 | 67,561 | 100,630 | 136,444 |
| Oilseeds | 1.78 | 1.92 | 1.87 | 1.87 | 360 | 464 | 651 | 869 |
| Gram | 2.93 | 2.92 | 1.94 | 2.89 | 711 | 857 | 1,055 | 1,275 |
| Maize | - | 0.21 | 0.67 | 0.85 | - | 120 | 629 | 1,171 |
| Pulses | 0.73 | 0.62 | 0.59 | 0.61 | 133 | 129 | 141 | 165 |
| Others | 0.06 | 0.01 | - | - | 18 | 9 | - | - |
| Green Manure | - | 0.33 | 1.64 | 2.59 | - | - | - | - |
| **Perennials:** | | | | | | | | |
| Sugarcane 5/ | 1.21 | 1.21 | 1.31 | 1.51 | 1,495 | 1,840 | 3,085 | 4,755 |
| Fruit | 0.30 | 0.41 | 0.69 | 0.92 | 814 | 1,162 | 3,199 | 5,680 |
| Vegetables | 0.11 | 0.22 | 0.42 | 0.55 | 510 | 1,158 | 3,005 | 4,937 |
| Total: | 39.12 | 44.35 | 48.46 | 55.61 | | | | |

1/ For the implied average yields see Chapter II, Figure 2.3
2/ Unhusked rice
3/ Seed cotton
4/ Cured leaf tobacco
5/ Gur

8.04 Comparison of the percentage change in acreage and in physical production of important crops and livestock products is another indicator of the relative emphasis given in the IACA projections to the growth of different kinds of agricultural output. Among crops, cotton is shown as having the largest percentage increase in acreage and production. Wheat, which would have a high growth in acreage in the first decade and a decreasing acreage in the period 1985 to 2000, is projected to have the smallest percentage increase of physical production among the major crops. Its overall rate of growth is, in fact, only slightly greater than the projected rate of population growth. The largest increase of all would come in meat production, which is expected to increase seven-fold by 2000. Supporting this is the growth of fodder acreage and fodder production, which together with increased crop residues and grazing would provide the TDN necessary to maintain the production animals required for this level of meat production. Indices for acreage and production for the major crops and livestock products, based on IACA projections, are shown in the following table, in descending order of production growth.

Change in Acreage and Increase in Physical Production
Over 1965 Production Levels - IACA Projections

| Crops | 1965 | | 1975 | | 1985 | | 2000 | | Annual Growth Rate 1965-2000 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Acreage | Production | Acreage | Production | Acreage | Production | Acreage | Production | Acreage | Production |
| | (percent) | | | | | | | | | |
| Cotton | 100 | 100 | 121 | 149 | 154 | 324 | 217 | 603 | 2.2 | 5.3 |
| Fine Rice | 100 | 100 | 131 | 160 | 159 | 297 | 190 | 468 | 1.8 | 4.5 |
| Fodder (kharif) | 100 | 100 | 129 | 161 | 152 | 285 | 190 | 467 | 1.8 | 4.5 |
| Sugar (gur) | 100 | 100 | 100 | 123 | 108 | 206 | 125 | 318 | 0.6 | 3.4 |
| Coarse Rice | 100 | 100 | 96 | 120 | 76 | 175 | 87 | 300 | (-)0.4 | 3.2 |
| Fodder (rabi) | 100 | 100 | 120 | 142 | 132 | 212 | 147 | 287 | 1.2 | 3.1 |
| Wheat | 100 | 100 | 120 | 159 | 121 | 241 | 115 | 276 | 0.4 | 2.9 |
| **Livestock** | | | | | | | | | | |
| Meat | - | 100 | - | 212 | - | 351 | - | 702 | - | 5.7 |
| Milk | - | 100 | - | 149 | - | 234 | - | 381 | - | 3.9 |

Source: IACA Comprehensive Report, Volume 7.

8.05 Converting these estimates of production into value terms, IACA has projected the GPV from crops and livestock for the period 1965-2000. The prices used were IACA's estimates of 1964/65 "farm-gate" prices, and were kept constant except for rice and meat. 1/ The GPV from livestock has been calculated by assuming certain yields of milk, meat, and animal by-products from production animals. The size of the production herds was placed at levels biologically consistent with estimates of available TDN, which include fodder production, crop residues, and an allowance for grazing. Further, the quantities of TDN consumed per Animal Unit were increased over time because it has been assumed that animal husbandry practice would be gradually improving, and the estimated conversion rates were made increasingly more favorable. The projections of GPV, resulting from IACA's input data described in para 8.02 above, are as follows:

IACA Projections of Agricultural GPV Value

| | 1965 | | 1975 | | 1985 | | 2000 | |
|---|---|---|---|---|---|---|---|---|
| | Rs. bill. | % of Total | Rs. bill. | % of Total | Rs. bill. | % of Total | Rs. bill. | % of Total |
| GPV Crops | 5.38 | 61.8 | 7.59 | 56.8 | 13.44 | 58.1 | 20.57 | 52.7 |
| GPV Livestock | 3.32 | 38.2 | 5.77 | 43.2 | 9.70 | 41.9 | 18.47 | 47.3 |
| Total GPV | 8.70 | 100.0 | 13.36 | 100.0 | 23.14 | 100.0 | 39.04 | 100.0 |

Growth Rate Per Annum
(percent)

| | 1965-1975 | 1975-1985 | 1985-2000 | 1965-2000 |
|---|---|---|---|---|
| GPV Crops | 3.5 | 5.9 | 2.9 | 3.9 |
| GPV Livestock | 5.7 | 5.3 | 4.4 | 5.0 |
| Total GPV | 4.4 | 5.7 | 3.6 | 4.4 |

Source: IACA Comprehensive Report, Volume 1, page 203.

By the year 2000, cotton would make the greatest contribution to GPV of any crop. Wheat, which ranks highest in 1965 in terms of GPV, would drop to second place. It should be noted that IACA expects livestock to make an increasing contribution to total GPV, reaching nearly 50 percent of the total by the end of the projection period.

1/ IACA has assumed decreasing prices for rice because of shifts in consumption patterns, and increasing prices for meat reflecting improvement in quality.

8.06 In order to relate the projected growth of agricultural production to the proposed water development program, the Bank Group requested IACA to divide the aggregated canal command production data into areas affected by different types and phasing of development activities. Some error is inevitably introduced in a re-allocation of production among areas in this manner, but it provides another view of the projected growth pattern. A distinction between four areas of activities was made:

(i) On-going Project areas -- CCA within the Indus Basin where groundwater development projects have received sanction under Government planning procedures and are already scheduled for implementation.

(ii) IACA Project areas -- CCA within the Indus Basin covered by the groundwater projects recommended in the IACA Comprehensive Report.

(iii) Deferred Project areas -- CCA within the Indus Basin not scheduled for public groundwater development projects before 1975, but within which portions would benefit from private tubewell installations.

(iv) Outside areas -- non-commanded areas. This includes non-commanded land outside the Indus Basin, as well as non-commanded land interspersed with the CCA within the canal system. Some portions of this category are scheduled for public development and some would benefit from private tubewell development.

The following table shows the resulting allocation of GPV as projected by IACA:

## IACA Projections of Agricultural GPV, by Development Activities

| | Value (Rs. billion) | | | | Growth Rate per Annum (percent) | | | |
|---|---|---|---|---|---|---|---|---|
| | 1965 | 1975 | 1985 | 2000 | 1965-75 | 1975-85 | 1985-2000 | 1965-2000 |
| On-going Project Areas | 1.17 | 2.10 | 3.65 | 5.31 | 6.0 | 5.7 | 2.5 | 4.5 |
| IACA Project Areas | 1.20 | 2.40 | 4.35 | 6.40 | 7.3 | 6.2 | 2.6 | 4.9 |
| Deferred Project Areas | 4.40 | 6.09 | 10.95 | 20.18 | 3.3 | 6.1 | 4.2 | 4,5 |
| Outside Areas | 1.93 | 2.77 | 4.19 | 7.15 | 3.7 | 4.3 | 3.7 | 3.8 |
| Total West Pakistan | 8.70 | 13.36 | 23.14 | 39.04 | 4.4 | 5.7 | 3.6 | 4.4 |

Source: Prepared by IACA at Bank Group's request.

8.07 The annual rates of growth in cropped acreage and in GPV per cropped acre, inherent in the total GPV projections shown in the preceding table, are as indicated in the following table, again disaggregated into the four areas of activities:

IACA Annual Growth Rates in Cropped Acreage
and GPV per Cropped Acre, 1965-2000
(percent per annum)

| | 1965-1975 | | 1975-1985 | | 1985-2000 | | 1965-2000 | |
|---|---|---|---|---|---|---|---|---|
| | Cropped Acres | GPV/ Acre | Cropped Acres | GPV/ Acre | Cropped Acres | GPV/ Acre | Cropped Acres | GPV/ Acre |
| On-going Project areas | 3.1 | 2.9 | 1.7 | 4.0 | - | 2.5 | 1.4 | 3.0 |
| IACA Project areas | 2.8 | 4.3 | 2.0 | 4.0 | - | 2.6 | 1.4 | 3.5 |
| Deferred Project areas | 0.8 | 2.5 | 1.1 | 4.8 | 1.6 | 2.5 | 1.2 | 3.2 |
| Outside areas | 0.5 | 3.2 | 0.6 | 3.6 | 0.4 | 3.3 | 0.4 | 3.4 |
| Total West Pakistan | 1.3 | 3.1 | 1.2 | 4.5 | 0.8 | 2.7 | 1.1 | 3.3 |

Source: Prepared by IACA at Bank Group's request.

8.08 The figure given in the foregoing tables reflect the concentration of public tubewell projects in the Basin, and the rapid growth in production expected by IACA in the early years (1965-85) after their completion. Opportunities for such rapid growth are assumed to be largely exploited by 1985, and in subsequent years additions to agricultural output would be more difficult to obtain. The Outside areas are projected to have low rates of growth in cropped acreage, but yield growth (as measured by the growth rate in GPV per cropped acre) is expected to be better than in the commanded areas. This is because the starting base is lower for the Outside areas (see Annex 8.2, page 1), and also because the yield-improving benefits from increased use of material inputs and better husbandry practice should become widespread throughout West Pakistan during the period covered by the projections, but it is mainly due to the dominating contribution of livestock production attributed to the Outside areas (see Annex 8.2, page 2).

8.09 The IACA Project areas have higher growth rates than either the On-going Project areas or the Deferred Project areas in these projections. The highest rates occur in the period 1965-75 when the projects are being completed and additional water supplies are assumed to result in increased cropped acreage and increased yields. Because these growth rates are calculated between reference years, they mask IACA's assumption of very rapid and spontaneous yield growth in conjunction with increased water availability. The projected growth of GPV declines only slightly during the next decade, but after 1985 further increases in GPV are expected to come only from increases in yield.

8.10 The two major export crops of cotton and fine rice are projected to have the greatest percentage increase in physical production by the year 2000. IACA has made estimates of foreign exchange earnings from cotton and rice up to 1975, and these assume increases of 43 and 85 percent respectively in the volume of exports. IACA states that the foreign exchange earnings from these crops, plus the earnings from hides, skins, and wool, would be three times greater than the foreign exchange requirements for the IACA development program in the Third Plan period. Agricultural exports would also provide more than the amount of foreign exchange required for the IACA program during the Fourth Plan period (ending in 1974/75), but with a somewhat smaller margin of surplus over these requirements than is the case for the Third Plan period projections. The next table summarizes these projections:

IACA Estimates of Foreign Exchange Earnings

| | 1965 | | 1975 | |
|---|---|---|---|---|
| | Quantity ('000 M. tons) | Value (Rs. million) | Quantity ('000 M. tons) | Value (Rs. million) |
| Fine Rice | 100 | 140 | 185 | 185 |
| Coarse Rice | 40 | | | |
| Cotton (raw equivalent) | 175 | 570 | 250 | 820 |
| Total | | 710 | | 1,005 |

Source: IACA's Comprehensive Report, Volume 1, page 207.

In value terms, export production would thus grow at a rate of about 3.5 percent per annum.

8.11 The Bank Group has made a separate, and much cruder, estimate of future production incorporating some modifications of the IACA assumptions. These modifications result in a higher growth rate in the period 1965-75 and involve points which have been discussed in the previous chapters of this Report. They may be summarized as follows:

(i) An important part of the Bank Group's review of IACA's Report has been a detailed examination of the 12 public tubewell projects which IACA has proposed. In the course of this review, the Bank Group has made changes in the projected rates of growth in yields and cropped acreage, and these changes result in a more balanced growth path during the pre-project and immediate post-project periods. [1] These revised production estimates for reference years for the IACA Project areas have been incorporated in the Bank Group's estimates of total agricultural production.

(ii) Because IACA revised its original estimates of livestock production to account for increased availability of TDN, the Bank Group estimates for the IACA Project areas have been adjusted upward accordingly for the purpose of this analysis. [2] The Bank Group, however, retains reservations about the rapid rate of increase in livestock production projected, particularly in the early periods. For this reason, the Bank Group has recommended that a thorough study be made of the special problems and requirements related to improving livestock production. In the meantime, livestock projections used in this Report should be regarded as containing a wide margin of error.

(iii) The Bank Group has assumed that the growth rates which are expected in the IACA Project areas would be equally feasible to attain in the On-going Project areas. Since the On-going Project areas are at a more advanced stage of planning and implementation, the Bank Group's estimates of expected yields in the IACA Project areas have been applied in the On-going Project areas five years earlier.

(iv) The Bank Group has assumed that the use of fertilizers by farmers in 1970 and 1975 would be about double the amount assumed by IACA, although the two projections become similar from 1985 onwards. The full explanation for this assumption is given in Chapter VI above, but briefly, it rests on the expectation that fertilizer use would increase rapidly between 1965 and 1975 if it is available in adequate quantity.

(v) The Bank Group has used a higher CCA acreage for 1965 than IACA has used for the On-going Project areas (SCARP I to IV plus Khairpur). These estimates, totalling 5.53 million acres CCA, are still less than the 5.67 million acres reported by WAPDA, but larger than the 4.86 million acres used in the IACA projections.

(vi) The Bank Group, reflecting prevailing farming practice, has incorporated a modest extension of cropped acreage at earlier points in time because it assumes a higher cropping intensity at a lower level of water application. This would be under-watering by IACA's full delta standards, but would result in more cropped acres and also in higher production per unit of water, as discussed in Chapter

1/ For details, see Annex Volume 4.1 "Report on the Project Content of the Water Development Program for West Pakistan".

2/ In the project reviews cited above, estimates of livestock production have not been revised upward.

II. The Bank Group has also assumed some relaxation of IACA's rigid cropping calendar in order to facilitate water distribution and enable the achievement of higher cropping intensities.

(vii) The Bank Group has assumed higher rates of yield growth independent of increased water availability because it projects a greater use of material inputs. This assumption has its main impact in the early years, before much of the increased water availability occurs, and in areas not scheduled for water development. The converse is true for the period immediately after additional water becomes available, for the Bank Group then expects a more gradual yield growth than IACA.

(viii) Estimates of private tubewell installation, 1965-75, used by the Bank Group are slightly higher than those used by IACA. The result is a somewhat larger cropped acreage and production, particularly in the Deferred Project areas.

Further details on the modifications adopted by the Bank Group are given in Annex 8.1.

8.12 Including the foregoing changes in assumptions, the Bank Group's estimates of GPV and a comparison with IACA's estimates are given in the following table. These projections represent what the Bank Group believes to be a more likely growth path of agricultural production resulting from the developmental efforts. In supplying an alternative set of production estimates, the Bank Group does not wish to imply that these are necessarily more reliable or accurate than those of IACA. However, they reflect the Bank Group's best judgment on what growth of agricultural production would occur if the developmental efforts postulated in this Report were implemented as scheduled. The Bank Group has projected the GPV per acre cropped as an indicator of general agricultural development, and has not attempted to make revised projections for individual crops.

Comparison of IACA and Bank Group Projections of GPV
(Rs. billion)

| | IACA | | | Bank Group | | |
|---|---|---|---|---|---|---|
| | Crop | Livestock | Total | Crop | Livestock | Total |
| 1965 | 5.38 | 3.32 | 8.70 | 5.37 | 3.33 | 8.70 |
| 1975 | 7.59 | 5.77 | 13.36 | 8.80 | 5.61 | 14.41 |
| 1985 | 13.44 | 9.70 | 23.14 | 14.11 | 9.79 | 23.90 |
| 2000 | 20.57 | 18.47 | 39.04 | 21.40 | 19.37 | 40.77 |

8.13 The above aggregate estimates would be equivalent to the levels of GPV per cropped acre shown in the following table for the different areas of activity. It will be noted that the Deferred Project areas as a whole, including the portions covered by private tubewells, have a higher GPV per cropped acre than the IACA Project Areas in the early periods. This would be consistent with current conditions in West Pakistan, for the Watercourse Studies 1/ report that the average GPV per cropped acre in 1965 was Rs. 409 in private tubewell areas. The figure of Rs. 236 per cropped acre used by the Bank Group therefore seems well within the range for an area which includes the bulk of probable future private tubewell development.

Bank Group Estimates of GPV per Cropped Acre

| | 1965 | 1975 | 1985 | 2000 |
|---|---|---|---|---|
| | (Rs. per cropped acre) | | | |
| On-going Project Areas | 261 | 375 | 551 | 760 |
| IACA Project Areas | 227 | 299 | 469 | 760 |
| Deferred Project Areas | 236 | 330 | 469 | 760 |
| Outside Areas | 156 | 215 | 305 | 494 |

8.14 The full effect of the changes made by the Bank Group may be seen in more detail in the Annex tables 8.2 and 8.3. In brief, the changes have resulted in an overall rate of growth of 5.2 percent in GPV during the period 1965-75, against a rate of 4.4 percent projected by IACA. Although the growth rate for the entire period 1965-2000 is rather similar for both projections, the total GPV is higher under Bank Group assumptions. This is mainly because of the assumed higher growth in the Deferred Project areas. The Bank Group believes that increasing awareness of the availability of fresh groundwater supplies, plus supporting efforts by the Government to stimulate private investment, would carry forward the vigorous private tubewell investment which is already underway. The Bank Group also feels there are short term incentives to farmers to use less water per cropped acre than called for under IACA's full delta level, and that the cropped acreage resulting from both private and public tubewell activity would be higher in the early periods of projection than assumed in the IACA projections. This should not lead to declining yields per acre because complementary efforts to expand the use of other inputs, particularly fertilizers, should be at least sufficient to maintain yield growth at about the present rate. Thus, the Bank Group is somewhat more optimistic than IACA with regard to future private tubewell development, the acreage covered, and the future of fertilizer offtake by farmers in West Pakistan. This would obviously call for the utmost continuing effort on the part of all those concerned with agricultural development in West Pakistan, and would require firm decisions on policy, acquisition of the means to implement policies and continuity in policy execution.

1/ IACA Comprehensive Report, Vol. 10, p. 393.

Provided these efforts are forthcoming, the Bank Group feels its projections are consistent with the response to incentives already shown by West Pakistan farmers, and with the technical agricultural possibilities in West Pakistan. Nevertheless, such growth would require a substantial improvement over the performance of the Second Plan period described in Chapter I. It should also be stressed again that this more optimistic assessment by the Bank Group is mainly the result of the assumption that much higher levels of non-water inputs could, and should, be used in conjunction with the water availabilities projected over time. The Bank Group thus places considerably more reliance than IACA on the response to inputs and the initiative and skills of the farmers -- factors which should operate not only under existing conditions, but with increasing force as more irrigation supplies become available. The attainment of the above growth projections would require, however, that the Government continues to give high priority to agricultural development and supports it by appropriate policies.

8.15 Under the Bank Group's projections, per capita GPV would rise from Rs. 228 in 1965 to Rs. 327 in 1975, and would reach Rs. 698 by the year 2000. This latter figure would be about three times the 1965 level. A comparison between these projections and the IACA projections of per capita GPV is given below:

Comparison of Rural Per Capita GPV Projections

| | 1965 | 1975 | 1985 | 2000 |
|---|---|---|---|---|
| IACA GPV Projection (Rs. billion) | 8.70 | 13.36 | 23.14 | 39.04 |
| Per Capita GPV (Rs.) | 228 | 303 | 459 | 668 |
| Bank Group GPV Projection (Rs. billion) | 8.70 | 14.41 | 23.90 | 40.77 |
| Per Capita GPV (Rs.) | 228 | 327 | 474 | 698 |
| Rural Population (millions) | 38.1 | 44.1 | 50.4 | 58.4 |

It should be noted that the above per capita GPV projections relate to the total rural population, and not only to the portion directly engaged in agriculture. The effect of the Bank Group revisions in the early period, 1965-75, is again visible. The difference between the two per capita projections diminishes by 1985, and by the year 2000 the difference is only slightly greater than it is for 1975. The earlier difference is because the IACA growth rates for 1975-85 reflect the IACA assumption that significantly higher growth rates would not occur in the Deferred Project areas until after 1975.

8.16 Expressed in terms of Gross Value Added (GVA) in the agricultural sector, the GPV projections given in para 8.12 have been translated into the following results. The assumptions and procedures employed by the Bank Group are explained in Annex 8.4.

Comparison of IACA and Bank Group Projections of Gross Value Added by Agricultural Sector, Excluding Forestry and Fishery

| Year | Gross Value Added (Rs. billion) IACA | Gross Value Added (Rs. billion) Bank Group | Period | Annual Average Growth Rate (percent per annum) IACA | Annual Average Growth Rate (percent per annum) Bank Group |
|---|---|---|---|---|---|
| 1965 | 7.90 | 8.46 | 1965-75 | 3.5 | 4.5 |
| 1975 | 11.21 | 13.17 | 1975-85 | 5.4 | 4.9 |
| 1985 | 18.94 | 21.31 | 1985-2000 | 3.4 | 3.5 |
| 2000 | 31.34 | 35.44 | 1965-2000 | 4.0 | 4.2 |

8.17 The general pattern of growth in terms of GVA is similar to that in the GPV comparison. The growth rates implicit in the Bank Group's projections are higher than IACA's in the first decade, 1965-75, and are lower during the second decade, 1975-85. The Bank Group estimates result in higher absolute values of GVA in all reference years for two main reasons:

(i) the basic production estimates are higher because of the assumptions described in para 8.11 above; and

(ii) an upward adjustment in the GVA has been made to correspond with the official prices used in national accounts (which average about five percent higher than IACA's prices), and to make allowance for non-reporting areas in West Pakistan.

8.18 The projections of GVA permit some comparison with official Government figures for 1964/65, and with growth rates based on Government data for the period prior to 1964/65. The following summarize the main points relating to the Bank Group's revision of IACA's projections:

(i) The Bank Group's adjustments of IACA data have resulted in a smoother growth path in GVA over the entire 35-year period 1965-2000. This embodies the firm belief, repeatedly expressed in this Report, that the rate of progress in agricultural development in West Pakistan is not entirely determined by the completion of extensive public irrigation projects, but is rather a function of a judicious combination of additional water supplies and other inputs, together with agricultural policies which provide incentives to use them. Not only does this appear more realistic in the light of general experience, but it accords with the pressures for increased agricultural production likely to be present in Pakistan during the foreseeable future.

(ii) Under its more optimistic assumptions, the Bank Group estimates that growth in GVA between 1965 and 1975 would be 4.5 percent per annum, compared to 3.8 percent for the agricultural sector over the Second Plan period. This would, in fact, be a performance rarely matched by countries at a similar stage of development. Nevertheless, by 1975 per capita GVA for the rural population would still be only about Rs. 300.

(iii) Having noted this, it is also necessary to point out that many agriculturists would benefit substantially. The progressive farmers with medium-scale farms or larger should find their production opportunities greatly enhanced, and would be the leading contributors to West Pakistan's increasing agricultural output. It therefore seems reasonable to expect that the execution of the developmental programs would lead to the emergence of a growing number of progressive farmers producing for the market.

(iv) Farmers with small holdings would be less able to make the investments necessary to take full advantage of the production opportunities afforded by the program. Further, even with larger returns per cropped acre, the small-sized holdings of a large proportion of farmers would continue to limit total net incomes to a relatively low level. The long run solution to this type of rural poverty would appear to lie outside agriculture under West Pakistan conditions. It would require deliberate efforts to create greater opportunity for employment outside agriculture, and to reduce the rates of population increase among rural families. If the landowners and tenants with the smallest holdings are to get only small additions to their holdings, or if land reform measures only perpetuate a pattern of very small holdings through further land distribution to those now without land, the rate at which people would feel it necessary to leave the agricultural sector might be slowed down somewhat. However, it cannot and, in the long run, should not forestall the necessity for a large population movement out of agriculture and into other occupations.

(v) Although the projections show lower rates of growth after 1985, this should not be interpreted as an implication that continuation of high rates of growth is in any sense impossible. It does mean that foreseeable growth after 1985, with techniques and inputs now known, would depend largely on improvements in yields, and these may be increasingly difficult to obtain once the levels projected for 1985 have been reached. On the other hand, this period lies far in the future; much can change during the intervening years and advances in agricultural technology could open vast opportunities for increased production which, at this point in time, are not contemplated.

(vi) For the more immediate future, however, it should be clear that meeting West Pakistan's agricultural requirements from its own soil would be an extremely demanding task. Differences in the rates of growth under various projections, or in the bases on which these projections rest, are of less consequence than the major import of the message which runs strongly throughout this Report. This message is that achieving and maintaining any acceptable rate of growth in agriculture would entail a much more vigorous, sustained, coordinated, and comprehensive effort on the part of all connected with agriculture than has ever been exercised in West Pakistan before. The Bank Group has been impressed with the priority accorded, and the steps being taken by the Pakistani Authorities to support agricultural development. The continuation and strengthening of these policies are of the utmost importance.

## B. The Demand for Agricultural Products and Relationship to Supply

8.19 The proposed program of agricultural and water development has been drawn up with its focus on agricultural production. This choice was deliberate because it was the Bank Group's intention that the program as a whole should be properly related to farming conditions and based on cropping patterns, cropping intensities and yield projections which were agriculturally feasible and compatible with the projections of irrigation water availability. The program has thus been oriented towards providing a technically sound and broadly flexible capability for increasing agricultural production, and was not designed to meet production targets fixed in terms of specific crops or groups of crops. Nevertheless, estimates of future effective demand for agricultural production, including both domestic demand and the demand for Pakistan's exports, were made to provide the base for an external check on the relative consistency and adequacy of the production projections outlined in Part A of this Chapter. A comparison of the somewhat separately devised supply and demand estimates is presented in this part of the Chapter.

Because of a continuing situation of production deficit, demand targets as such were not a major influence in the formulation of the production program. The demand estimates are necessarily very rough approximations of what domestic and foreign purchasers would require in future years.

8.20 The reference points for this comparison of future demand and supply are the estimates of current production, trade, and apparent consumption of agricultural products which IACA has made for West Pakistan. 1/ These magnitudes, designed to give some idea of the "normal" levels for 1964/65, are summarized in the following table:

IACA Estimates of Production, Trade and Apparent Consumption of Agricultural Products in 1964/65 in West Pakistan
('000 metric tons gross weight)

| | Production | Import | Export | Feed | Balance Human Consumption |
|---|---|---|---|---|---|
| Wheat | 4,950 | 1,100 | | | 6,050 |
| Other Grains | 1,425 | | | 535 | 890 |
| Rice (Clean) | 1,250 | | 290 1/ | | 960 |
| Sugarcane | 16,800 | | | 3,360 | 13,440 |
| Gram and Pulses | 995 | | | 150 | 845 |
| Potatoes | 135 | | | | 135 |
| Vegetables | 1,050 | | | | 1,050 |
| Fruit | 750 | | | | 750 |
| Milk | 6,007 | | | | 6,007 |
| Meat (carcass weight) | 395 | | | | 395 |
| Eggs | 14 | | | | 14 |
| Fish | 95 | | | | 95 |
| Oils and Fats | 175 | | | | 175 |
| Cotton (lint equivalent) | 400 | 10 2/ | 185 2/ | | 225 3/ |

1/ Including 150,000 tons inter-Province deliveries.
2/ Including lint equivalent of yarn and textiles.
3/ In contradistinction to other products: for the whole of Pakistan.

Source: IACA Comprehensive Report, Volume 1, page 39.

1/ IACA Comprehensive Report, Volume 2, Annexure 2.

8.21 By converting these estimates to a per capita basis, and deducting losses for seed and waste, IACA has concluded that the current (1964/65) nutritional intake in West Pakistan averages 1,973 calories and 58.7 grams of protein per day. This diet is comparable to the low levels of calorie supply and protein found in Far Eastern countries generally, but seems to contain a relatively high consumption of sugar (as a source of calories) and milk (as a source of protein and fat). Consumption of foodgrains provides about 60 percent of the daily per capita calorie intake. Average per capita fruit and vegetable consumption is very low.

8.22 The determinants used to estimate future demand for agricultural products have been limited to two factors: population growth and per capita Gross Provincial Product, the latter being adjusted for a rising average savings rate. The possible effects on demand due to changing price relationships between the various agricultural products, between agricultural and non-agricultural products, and possible changes in income distribution, have not been taken into account. For the purposes of this analysis, IACA has assumed that the present price relationships would continue essentially unchanged. There is some allowance for increasing urbanization over time, because the demand elasticity coefficients used by IACA have been based on FAO international comparisons which allowed for some "normal" degree of urbanization to accompany economic development. However, expected urbanization rates in West Pakistan were not specifically provided for in the IACA demand coefficients.

8.23 The population estimates used by IACA fall slightly below the "high" population growth projections made by the Planning Commission for 1985, which assume that family planning programs would not begin to bring about significant change in the rate of population increase before 1985. On the other hand, after 1975 the IACA estimates are higher than the Planning Commission's "low" estimates. All three sets of estimates are shown in the following table:

Population Projections for West Pakistan
(in million persons)

| Year | Planning Commission "low" Estimate | IACA 1/ | Planning Commission "high" Estimate |
|---|---|---|---|
| 1965 | 51.2 | 51.2 | 51.2 |
| 1975 | 66.0 | 66.0 | 67.0 |
| 1985 | 84.0 | 87.0 | 88.0 |
| 2000 2/ | 112.0 | 124.0 | 126.0 |

1/ IACA Comprehensive Report Volume 1, page 41.
2/ IACA estimates based on extrapolation of Planning Commission estimates for 1985; See IACA Comprehensive Report, Volume 2-A, Chapter I.

It is evident from the table that the "low" population estimate, which is the one officially adopted by the Planning Commission, would result in more favorable per capita production and consumption projections after 1985 than the IACA estimates. The Bank Group feels, however, that IACA's conservative approach to the population question may be the more realistic. In any event, in projecting the more adverse alternative they tend to draw attention to the consequences of failure to achieve the family planning program objectives implicit in the official Planning Commission estimates.

8.24 In order to indicate a range of possible effective demand, IACA has applied expenditure elasticity coefficients to two different growth paths of per capita Gross Provincial Product. The "high" path for Gross Provincial Product is based on growth rates anticipated in Pakistan's Perspective Plan. The "low" path is derived from the growth in agricultural production as projected by IACA and IACA's assumed growth rates for the remaining sectors of the West Pakistan economy. In this exercise, the proportionate contributions of agriculture and all other sectors are the same as in the Perspective Plan for the period 1965-85, but for years beyond 1985 (which extend past the Perspective Plan) IACA has assumed a declining relative importance for agriculture. 1/ Savings rates in future years were assumed to be the same for both growth paths, so the relationship of per capita Gross Provincial Product to per capita expenditures was also similar in both cases. The use of two such alternative growth path estimates has the advantage of tracing the limits within which effective demand is likely to fall. These two alternative growth rates for Gross Provincial Product are as shown below:

Projected Annual Growth Rates of
Gross Provincial Product in West Pakistan

| Year | Growth Rates "High" (% p.a.) | Growth Rates "Low" (% p.a.) | IACA Agricultural Sector (% p.a.) |
|---|---|---|---|
| 1965-75 | 6.3 | 4.25 | 3.5 |
| 1975-85 | 6.7 | 6.5 | 5.4 |
| 1985-2000 | 7.0 1/ | 5.0 | 3.4 |

1/ Derived by IACA Extrapolation of Perspective Plan growth rates.

Source: IACA Comprehensive Report, Volume 2-B, Annexure 2, page 14.

1/ See IACA Comprehensive Report, Volume 2-B, Annexure 2, page 14.

8.25 The coefficients of demand (expenditure) elasticity used by IACA to project future effective demand are modifications of coefficients of income elasticity estimated for all Pakistan by the FAO. 1/ Demand estimates based on per capita expenditures generally employ higher coefficients than those based on per capita income, but in this case the FAO coefficients pertain both to an earlier time period than the IACA starting year and also to all of Pakistan. They were thus deemed not directly suitable for the purpose at hand. In fact, IACA has used coefficients based on expenditures which are generally lower than FAO's, which are based on income. The IACA coefficients (shown in Annex 8.5) decline markedly over time for cereals, but generally exhibit much less decline for the higher valued items of diet. They also vary with the two Gross Provincial Product growth paths. For given future years, the coefficients tend to be higher for the "low" growth path, and the reverse for the "high" growth path. Annex 8.5 sets out in more detail how IACA's demand elasticity coefficients were derived, and also discusses the effects of changes in those coefficients.

8.26 Estimation of future export demand has been restricted to the two export crops of current importance -- cotton and rice. In the case of cotton, Pakistan's export market prospects have been assessed by reference to the varying future needs for fiber and textiles in developed and developing countries, and the assumption that Pakistan would be able to increase its share in world markets. IACA has used "high" and "low" estimates to mark the range within which export demand might fall, and has projected a minimum cotton export increase of about 80 percent by the year 2000, and an upper limit of about 145 percent. IACA notes that there is possibility that future exports could exceed its "high" estimates. Pakistan's exports of cotton in the early 1950's were larger than present export volumes, and declined because its growing domestic textile manufacturing capacity now consumes an important part of domestic cotton production. Increases in future exports would thus represent a recovery of, and some addition to, Pakistan's previous share in world market sales. The share of the U.S. in world cotton markets could also change. The U.S. presently supplies a large and relatively stable volume of exports, partly due to internal price support and subsidy policies, and exercises a significant influence on world market conditions. If these policies undergo gradual change in a direction which reduces the U.S. supplies available for export, Pakistan and other cotton-producing countries could expect increasing export opportunities in the world markets. Considerations such as these are obviously only speculative, but even if they appear remote from the perspective of the present time, they serve to indicate that the "high" estimates are not necessarily fixed upper limits to future export possibilities. The estimates actually used by IACA were based on assumptions of a growth in demand of one to two percent per year in the major cotton-importing countries, and slightly higher growth rates in the remaining countries. These estimates were further modified to include a 25 percent increase in Pakistan's share in world markets over the next few years, which IBRD commodity specialists agree may be possible to achieve.

1/ Agricultural Commodities Projection for 1970, FAO, 1962.

8.27 IACA estimates that rice exports would increase more slowly than cotton, although predictions for this commodity also pose difficulties because of the many uncertainties which are present. Among the uncertainties would be the future role of Mainland China in world markets and the outcome of efforts by other exporting countries to increase production. Estimates of population growth indicate substantial increase in world food requirements by the latter part of this century, but how much of such requirements would represent effective demand for imported foodstuffs has yet to be assessed.

IACA's Cotton and Rice Export Projections
('000 metric tons)

| | Cotton | | | | Rice 1/ | | | |
|---|---|---|---|---|---|---|---|---|
| Year | "High" 2/ | Index | "Low" 2/ | Index | "High" 3/ | Index | "Low" 3/ | Index |
| 1965 | 175 | 100 | 175 | 100 | 290 | 100 | 290 | 100 |
| 1975 | 285 | 163 | 250 | 143 | 385 | 133 | 335 | 116 |
| 1985 | 360 | 205 | 285 | 163 | 450 | 155 | 370 | 128 |
| 2000 | 430 | 246 | 320 | 183 | 565 | 195 | 405 | 140 |

1/ Includes deliveries to East Pakistan.
2/ In terms of lint cotton equivalent for all cotton exports.
3/ Net exports of clean rice after deduction of allowance for seed and loss.

Source: IACA Comprehensive Report, Volume 2-B, Annexure 2, pp. 20-21.

8.28 When the demand projections based on the "low" growth path for Gross Provincial Product (i.e., the path which incorporates IACA projections of growth in the agricultural sector) are set against IACA's estimates of physical production, the expected increase in production appears adequate to meet demand. The fact that the IACA expenditure elasticity coefficients applied to IACA's projections of per capita Gross Provincial Product provide demand estimates approximating the anticipated total domestic supply of agricultural products does not validate the realism of the coefficients as a basis for prediction, but it does indicate they are compatible with the growth estimates used. It further indicates that the assumption of constant prices does not grossly distort the results. In making these comparisons, IACA has allowed for seed and losses by reducing the physical production assumed available for consumption. The seed and loss allowances used by IACA appear reasonable, but it should be noted that IACA allowances are higher than those used by the Planning Commission. They also appear higher than figures used for other countries. IACA has added allowances for losses at the wholesale and retail levels, whereas the Planning Commission estimates apparently apply only to on-farm losses. The comparison between IACA and Planning Commission allowances is as follows:

Allowance for Seed and Losses, As Percentage of Gross Annual Supply

| Commodity | Planning Commission | IACA 1965 | IACA 1975 | IACA 1985 | IACA 2000 |
|---|---|---|---|---|---|
| Wheat | 8.6 | 12 | 11 | 10 | 9 |
| Rice | 4.5 | 7 | 7 | 7 | 7 |
| Maize | 5.0 | 9 | 9 | 9 | 9 |
| Jowar | 4.5 | 9 | 9 | 9 | 9 |
| Bajra | 3.7 | 9 | 9 | 9 | 9 |
| Barley | 11.3 | 9 | 9 | 9 | 9 |
| Sugar | 10.0 | 16 | 16 | 16 | 16 |
| Gram | 6.7 | 11 | 11 | 10 | 9 |

8.29 Within the total demand and supply projections of IACA there are imbalances for specific commodities. Foodgrains (e.g., wheat and coarse grain), in particular, exhibit a tendency to be in short supply relative to projected demand. The shortage is estimated to be about 11 percent of effective demand in 1975 and 1985, and about 18 percent by the year 2000.

8.30 Surpluses are also forecast, but, with the exception of oilseeds and fodder, these would not occur to an important extent before 1985. Rice projections show eventual surpluses, but a shortage is estimated for 1975 equal to about one-half the current gross tonnage exports of that commodity. By 1985 and 2000 small surpluses are general, and occur for all crops except foodgrains and gram and pulses (the latter in 2000 only). Foodgrain deficits, however, would continue to be substantial. The IACA comparisons of demand and supply, based on the "low" growth path for Gross Provincial Product, are as follows:

IACA Comparison of Agricultural Production with Projected Demand (Low Income Growth Path), 1975, 1985 and 2000

| Product | Demand | Production | Surplus (+) or Shortage (-) | Surplus (+) or Shortage (-) 2/ |
|---|---|---|---|---|
| | ('000 mill. tons) | | | ('000 cropped irrigated acres) |
| **1975** | | | | |
| Wheat | 8,405 | 7,405 | - 1,000 | - 1,430 |
| Coarse grain | 2,145 | 1,990 | - 155 | - 310 |
| Rice | 1,740 | 1,575 | - 165 | - 330 |
| Sugarcane | 18,315 | 18,395 | + 80 | + 5 |
| Gram and Pulses | 1,100 | 1,140 | + 40 | + 130 |
| Vegetables | 1,555 | 1,160 | - 395 | - 65 |
| Fruit | 1,165 | 1,160 | - 5 | - |
| Oilseeds 1/ | 355 | 515 | + 160 | + 530 |
| Cotton (lint) | 615 | 545 | - 70 | - 540 |
| Green Fodder TDN | 10,900 | 12,860 | + 1,960 | + 935 |
| | | | | - 1,075 |
| **1985** | | | | |
| Wheat | 12,460 | 11,210 | - 1,250 | - 1,250 |
| Coarse grain | 4,440 | 3,440 | - 1,000 | - 1,110 |
| Rice | 2,405 | 2,490 | + 85 | + 105 |
| Sugarcane | 28,695 | 30,840 | + 3,145 | + 130 |
| Gram and Pulses | 1,545 | 1,550 | + 5 | + 10 |
| Vegetables | 2,660 | 3,005 | + 345 | + 50 |
| Fruit | 1,945 | 3,200 | + 1,255 | + 270 |
| Oilseeds 1/ | 595 | 905 | + 310 | + 690 |
| Cotton (lint) | 1,000 | 1,185 | + 185 | + 925 |
| Green Fodder TDN | 18,900 | 20,730 | + 2,030 | + 725 |
| | | | | + 545 |
| **2000** | | | | |
| Wheat | 18,010 | 12,935 | - 5,075 | - 4,230 |
| Coarse grain | 5,955 | 5,285 | - 670 | - 480 |
| Rice | 3,320 | 4,140 | + 820 | + 745 |
| Sugarcane | 45,875 | 47,550 | + 1,675 | + 55 |
| Gram and Pulses | 2,590 | 2,075 | - 515 | - 1,290 |
| Vegetables | 4,960 | 4,935 | - 25 | - 5 |
| Fruit | 3,765 | 5,680 | + 1,915 | + 310 |
| Oilseeds 1/ | 1,225 | 1,870 | + 645 | + 1,075 |
| Cotton (lint) | 1,730 | 2,205 | + 475 | + 1,585 |
| Green Fodder TDN | 26,100 | 30,940 | + 4,840 | + 1,385 |
| | | | | - 850 |

1/ Excluding cotton seed, including groundnuts.
2/ At IACA yield projections for selected reference years.
Source: IACA Comprehensive Report, Volume 2-B, Annexure 2, pages 22-23.

8.31 These estimates of the magnitude of surpluses and deficits should be taken as incidental to an approach under which production projections were drawn up with little reference to demand estimates. With such an approach it would be totally unexpected if supply and demand showed a balance for each commodity. The assumption of constant prices, consistent with the focus on the technical aspects of the development proposals, rules out production shifts in response to changing market incentives. In any event, predictions of the direction and size of price changes over a period of 35 years would be no more realistic than the assumption of constant prices for the same period. Prices would, however, presumably change in the face of imbalances such as those projected by IACA, and these changes would bring about increased production of some agricultural products and reduced production of others. Some indication of the potential for flexibility can be inferred from the IACA estimates of surpluses and deficits in production and acreage in different reference years. Assuming that (a) water availability would be identical to IACA projections, and (b) with the exception of rice and perennials, crop water requirements would be essentially similar for all crops grown in the same season, most deficit crops could be substituted for surplus crops within the same season and without adverse effects resulting from differing crop water requirements. Even in the case of rice and perennials, acreage could be shifted from these crops to others under the projected water availability, but the substitution could not be reversed (i.e., from other crops to rice and perennials).

8.32 Using the year 1975 as one example, the IACA Comprehensive Report shows a foodgrain deficit of 1.32 million tons. 1/ At yield levels projected by IACA for 1975, 2.07 million irrigated acres would be required to remove the deficit. At the same time, surplus fodder, oilseeds, and gram and pulses occupy about 1.6 million acres and all are crops which are grown in both seasons. If the acreage planted in these surplus crops were divided about equally between the kharif and rabi seasons, 0.8 million acres would be available for wheat in the rabi season. At the implicit yield rates for 1975, this acreage could produce nearly 0.6 million tons of wheat. On a similar basis the remaining 0.8 million acres in the kharif season could produce 0.4 million tons of coarse grains. The total increase in foodgrains from these acreage substitutions would thus be about one million tons, leaving a more manageable deficit of around 0.3 million tons.

8.33 There would actually be more flexibility than the above implies. Further substitution involving oilseeds, gram and pulses might make up the remaining deficit. The reduction in fodder production would not affect the TDN available to meet livestock requirements because the fodder acreage shifted to foodgrain production would be surplus to estimated livestock needs, as given in the demand projections. In fact, fodder acreage could be reduced below the levels set by the demand projections because the shift to foodgrain production would yield additional crop residues for livestock

1/ The terms "surplus" and "deficit" in the following illustrations refer to the difference between estimated production ("low" growth path) and projected demand.

feeding. Much would depend also on the yield levels reached by 1975. An increase in average wheat yields of one-half maund per acre would increase wheat output by more than 250,000 tons on the projected 1975 acreage under wheat.

8.34 Because the IACA projections for 1985 show an overall surplus of 545,000 irrigated acres, the prospects for shifting crops to meet the foodgrain shortage appear even better than in 1975. Surplus rice, amounting to 85,000 tons, would probably substitute directly for wheat as a foodgrain, reducing the deficit in wheat from 1.25 million tons to 1.17 million tons. The surplus acreage in fodder and oilseeds totals 1.42 million acres. If one-half of this, or 0.7 million acres, were shifted to wheat in the rabi season, it should be possible to increase wheat output by 0.7 million tons at projected 1985 wheat yields. A further shift of the estimated surplus cotton acreage (0.93 million acres) to coarse grains would approximately match the deficit in that category. Similar kinds of substitution in the year 2000 would also result in near balance for all crops.

8.35 The foregoing does not imply that the necessary shifts would come about in precisely this manner, but it does indicate the flexibility within the IACA proposed program. The Bank Group recognizes that the Government seeks to attain self-sufficiency in basic foodstuffs, and has therefore made efforts to clarify the nature of the "deficits" which have been projected. The Bank Group is reasonably certain that adequate flexibility exists in the proposed program to allay fears over major shortfalls in foodgrain production, but would add that Government price and marketing policies would have to be fashioned in ways which encourage the shifts in cropping patterns needed to eliminate surpluses and deficits. Such policies should permit price incentives to play a constructive role in allocating agricultural resources.

8.36 Demand based on the "low" growth path estimates, without reference to the availability of supplies to meet it, would lead to the average per capita daily consumption of calories and protein shown in the following table. Bearing in mind that these are based on "high" population growth estimates, they project some improvement in the average diet. To the extent that population growth after 1975 is less rapid than IACA has projected, this picture would improve correspondingly.

Per Capita Calorie and Protein Intake in West Pakistan
Based on IACA's Demand Projection and Population Estimates

| | 1965 | 1975 | 1985 | 2000 |
|---|---|---|---|---|
| Calories per day | 1,973 | 2,183 | 2,524 | 2,787 |
| Proteins (grams per day) | 58.7 | 64.3 | 74.2 | 83.1 |
| Animal Protein (grams per day) | 15.9 | 18.4 | 23.4 | 29.1 |

8.37 IACA has not examined export possibilities other than cotton and rice, but certain surplus commodities, e.g., fruit and oilseeds, might eventually have export prospects. East Pakistan has been a market for oilseeds in the past. Other export possibilities could arise as new comparative advantages emerge in the course of the proposed agricultural and water development program. Livestock is one such example, where it may become more economical for some farmers to use their lands for the support of livestock rather than for the more traditional crops. Development of an export-oriented livestock component would require major changes in the marketing, grading, and processing arrangements which exist, but there are no fundamental reasons for ruling out potential export of livestock products. The Bank Group has not made a special study of the inherent comparative advantages in the production which has been projected, but wishes to call attention to this further element of flexibility in the program. The desire for self-sufficiency in food is understandable, but this could also be achieved with higher levels of productivity through stimulation of agricultural exports based on West Pakistan's comparative advantages. Even without adding new export commodities, if new export markets could be developed for commodities projected to be in surplus supply in West Pakistan under IACA assumptions, some part of the projected foodgrain deficits could be met by imports. The cropping patterns which IACA has used in its Basin-wide analyses would be more justified if such export possibilities were actually developed.

8.38 Larger deficits arise when demand is based on the "high" income path assumed in the Perspective Plan, and matched against the agricultural production which IACA expects to result from the proposed water and agricultural development program. The IACA Comprehensive Report only summarizes this deficit, and expresses it in terms of shortages of cropped irrigated acreage. The shortage would be 6.1 million acres, equal to 21 percent of the Basin cropped acreage in 1975. This would drop to 2.2 million acres in 1985, but would again rise to 6.6 million acres, equal to 15 percent of the Basin irrigated cropped acreage by 2000. It follows that if IACA's agricultural production projections are the more accurate, there is serious doubt that the Perspective Plan growth targets can be achieved. Put in a slightly different way, if the Perspective Plan overall growth targets are achieved instead, either the IACA water and agricultural development program would not meet West Pakistan's future agricultural requirements, or IACA estimates of production potential are less optimistic than the Perspective Plan.

8.39 The Bank Group projections of production anticipate more cropped acreage in reference years than the IACA projections. The comparison is summarized in the following table:

Estimates of Cropped Acreage

| | 1975 | 1985 (million acres) | 2000 |
|---|---|---|---|
| Bank Group Estimates | 47.84 | 54.30 | 58.68 |
| IACA Estimates | 46.19 | 51.88 | 58.59 |
| Additional Cropped Acreage Under Bank Group Estimates | 1.65 | 2.42 | 0.09 |

8.40 With the demand expected under the "low" growth path assumptions, there is apparently sufficient flexibility within the IACA projections to adjust to shortages which are likely to occur. The effect of the Bank Group's revision is to add still further flexibility under these same demand assumptions because more acreage would be cropped, as shown in the previous table. Including both acreage and yield differentials, the additional flexibility can be more comprehensively illustrated in monetary terms. The monetary value of the total deficit in crops for 1975, the reference point when shortages would be most severe in terms of acreage, would be Rs. 531.7 million. This is derived as illustrated in the following table, which is a summation of IACA estimates of surpluses and deficits in 1975, excluding fodder, valued at IACA prices.

Value of IACA Estimates of Deficit in Crops
1975

| Commodity | Price per M. ton (Rs.) | Surplus (+) or Deficit (-) ('000 M. tons) | Value of Surplus (+) or Deficit (-) (Rs. mill.) |
|---|---|---|---|
| Wheat | 348 | - 1,000 | - 348.0 |
| Coarse grain | 294 | - 155 | - 45.6 |
| Rice | 508 | - 165 | - 83.8 |
| Sugarcane | 49 | + 80 | + 3.9 |
| Grain & pulses | 428 | + 40 | + 17.1 |
| Vegetables | 294 | - 395 | - 116.1 |
| Fruit | 294 | - 5 | - 1.5 |
| Oilseeds | 615 | + 160 | + 98.4 |
| Cotton (lint) | 802 | - 70 | - 56.1 |
| | | | - 531.7 |

As shown in Part A of this Chapter, the Bank Group's estimate of GPV crops in 1975 is Rs. 8.80 million before seed and loss allowances, as compared to IACA's estimate of GPV crops for that year of Rs. 7.59 billion. The difference, or Rs. 1.21 billion, is more than twice the value of the deficit in crops shown above for the "low" growth path. The implication is again that under Bank Group assumptions there would be greater flexibility to adjust to the deficits of the size projected by IACA.

8.41 If the Bank Group's projections were realized however, the GVA in the agricultural sector would be higher than IACA's estimate, and therefore the Gross Provincial Product would be higher than assumed under the "low" growth path. Although the Bank Group has not attempted to estimate a new growth path based on its agricultural sector projections, it clearly would fall somewhere between the "low" and "high" growth paths and thus generate a higher demand than that used in the comparison. It does not reach the growth path of the Perspective Plan, but in 1985, for example, the additional cropped acreage under Bank Group projections is approximately equal to the deficit expected under the "high" growth path demand. The deficit for 1975 is more serious, and a substantial difference remains between the Bank Group's and the "high" growth path estimates of supply and demand. An equally large deficit would arise in 2000 under the "high" growth path, but for reasons explained at the end of Part A of this Chapter the estimates beyond 1985 are extremely speculative at this time.

8.42 In reviewing these various possibilities, the following conclusions seem warranted:

(i) It should be possible to meet deficits in specific crops likely to arise if Provincial economic growth follows the "low" growth path.

(ii) Bank Group projections of GVA in the agricultural sector indicate consistency with a somewhat higher overall Provincial Growth Rate than IACA has assumed, although still lower than the Perspective Plan in 1975. The Bank Group regards its projections as realistic, but requiring the most demanding efforts.

(iii) In the Bank Group's opinion, the agricultural sector may perform somewhat better than anticipated by the IACA projections. However, the Bank Group's estimates would still be sufficiently below the levels of the Perspective' Plan to justify the caveat expressed by IACA -- namely, higher growth rates in the non-agricultural sectors than now assumed in the Perspective Plan could raise the demand for agricultural commodities well beyond domestic supplies, and thus require continuing dependence on imports of basic food items.

(iv) To the extent that the inconsistencies of demand and supply require adjustments in the projected production pattern to meet policy objectives, the Government should give increased attention to the possibility of influencing aggregate, as well as specific, production through price incentives. This would appear to apply with particular force to the price for wheat, which may need to be brought more in line with world market prices (including allowances for real foreign exchange costs) in view of the decreasing dependability of PL 480 supplies.

8.43 The achievement of the rates of growth of agricultural production contained in the Bank Group projections would represent a most commendable performance. Agriculture will continue to be the single most important sector in the West Pakistan economy for the foreseeable future, and the growth of the West Pakistan economy as a whole would therefore depend to a large extent on agriculture's performance. It is thus imperative that the agricultural sector receive the attention and support recommended throughout this Report. Although higher levels of production than projected by the Bank Group may appear technically feasible, it is the Bank Group's opinion that, within the given economic, social, and institutional environment, it would be unrealistic to expect growth of production considerably beyond that projected in this Report.

# CHAPTER IX. SUMMARY AND CONCLUSIONS

## Introduction

9.01 The Province of West Pakistan covers almost 200 million acres, and has a present population of about 54 million people. Within this vast area lie the Indus Plains, where the largest irrigation system in the world commands some 33.5 million acres with water drawn from the Indus River and its major tributaries. The Indus Plains include nearly 70 percent of the cultivated acreage, supply about 80 percent of the foodstuffs produced, and contain a large majority of the population of West Pakistan. The importance of the irrigated Plains is therefore predominant, and for that reason this area has received the primary emphasis throughout Volume II of the Bank Group's Report, which deals with irrigation and agriculture in all of West Pakistan.

9.02 The Bank Group has conducted the Indus Special Study with the aid of five international consulting firms. Three of these formed an association, the Irrigation and Agricultural Consultants Association (IACA), and worked exclusively in the fields of irrigation and agriculture. The other two firms worked on surface water storage and power aspects. At all stages, the Bank Group has maintained close contact with, and has benefitted from the full cooperation of, the Government of West Pakistan, its agencies, and its consultants.

9.03 Throughout the Study and in this Report, the Bank Group has endeavored to maintain a proper balance in emphasis between the agricultural aspects of improvement and development (i.e., better farming, employing more agricultural inputs) and further water development. The Bank Group has therefore stressed the need to apply better farming practices to the existing production potential simultaneously with the projected investment in water resource development which would expand the agricultural base. Inevitably, there tends to be a preoccupation in a Study of this kind with projects and investments, but other important features of development, including such aspects as institutions, organization, and recurrent expenditures, have not been overlooked in the Bank Group's concern that all relevant developmental factors be taken into account.

## Background to Water and Agricultural Development.

9.04 The frame within which this Report rests is the actual performance of West Pakistan's agriculture over the past several years. The gross value added by crops grew at an annual rate of 4.7 percent over the Second Plan period (1960-65), and the growth rate for the agricultural sector as a whole was 3.8 percent per annum. Comparison with prior trends indicates that a different set of forces was at work during this time, bringing sustained increases in the acreage cropped and crop yields. Increased water availability was an important factor in this, with public projects adding about 5.5 million acre feet (MAF) to the existing irrigation supplies. More striking was the unanticipated contribution of about 6.0 MAF from private tubewell installations -- an encouraging development which has continued into the Third Plan period at rates equal to, or higher than, those achieved in the Second Plan period. There was also evidence of increased use of other agricultural inputs, notably fertilizer. The quantities of such inputs used did not reach levels which account for any significant portion of the most recent growth, but the rate of increase in use by farmers is a favorable sign for future agricultural development. The Government has moved in a positive way to provide the institutional arrangements necessary to carry out a full program of agricultural development, and its broad economic policies have, on the whole, tended to encourage agricultural production. The setting is thus one in which there is some evidence of apparent readiness by farmers to adopt the means to advance agricultural development, and intent on the part of the Government to promote development by appropriate policy decisions and an adequate allocation of the available resources.

9.05 There are other favorable factors to take into account. The Indus River and its tributaries offer a supply of surface water for irrigation which is currently greater than can be utilized by the existing system. Of an annual mean discharge of 167 MAF from rivers entering the Indus Plains of Pakistan, about 76 MAF, or nearly half, is unused and discharges into the Arabian Sea. Seepage from these rivers and the canal system over time has created huge underground reservoirs of water, a large proportion of which is sufficiently fresh to use for irrigation. Usable groundwater underlies a gross area of 18.8 million acres, or over half the recorded commanded culturable acreage (CCA) of the Indus Basin. The consultants have estimated that at full development it would be possible to pump 44 MAF per year from usable groundwater sources without exceeding the annual recharge to the aquifer. The soils of the irrigated plains generally provide a satisfactory medium for plant growth, and there is no evidence that soils, as such, impose a serious constraint on future development. Salinity and alkalinity, often associated with waterlogging, pose problems in some areas which must be overcome and carefully guarded against in the future. Climatic variations occur throughout the Province, and these affect the selection of crops which can be grown well. But aside from the scarcity of rainfall -- which forces the dependence on irrigation -- climatic factors do not impose a serious constraint. Finally, a large majority of the farms are below five acres in size, and the average holding in the Province is only 10.1 acres. Sharecropping is widely practiced, with its attendant ills of insecurity of tenure, inadequate investment in production facilities, and limited rewards to the actual cultivators. Nevertheless, there is little to indicate that conservatism and resistance to change would prove to be major obstacles to development, and the productivity of tenant farms appears at least equal to that of the smaller owner-operated farms. The large investment in private tubewells which has already been made is a further sign of initiative at the farm level, albeit largely confined to the owner-operators of the medium and larger scale farm units.

The Key Elements in Program Formulation.

9.06 In assessing the opportunities to stimulate agricultural development in West Pakistan the Bank Group studied data on a wide range of agricultural factors. These included crop yields, cropping patterns, cropping intensities, crop water requirements, the relationship between water and other agricultural inputs, land tenure, project organization and implementation, and the institutional base for agriculture in West Pakistan. It examined specific development projects, and reviewed the available information on water supplies from all sources, the requirements for increasing supplies from any of these sources, and the limitation inherent in a complex system where changes in supplies from one source affect the use which can be made of other sources. The more important findings and conclusions derived from these studies, and used in the formulation of a development program, are summarized here under two broad categories:

(a) Agricultural Factors.

(i) The increased use of agricultural inputs other than water would have a beneficial effect on yields at levels of existing irrigation application. From this, two conclusions can be drawn: programs to stimulate the use of non-water inputs by farmers need not be delayed until the supplies of irrigation water are increased, since such inputs would bring economic benefits under present conditions; until the level of farming practice improves to the point where it matches the level of water availability, farmers are likely to respond to increased irrigation supplies by expanding the acreage cropped at less than full delta water applications, rather than increasing the water applications to full delta on the existing cropped acreage.

(ii) Development of water resources should receive high priority in the short run. This is necessary in order to reduce the uncertainty of water supply which characterizes the present system, and the provision of additional and regular irrigation supplies is a prerequisite to increased cropping intensities and full use of other inputs. Farmers are familiar with irrigation water as an input, and are therefore likely to use additional supplies as soon as they become available. Finally, increased and reliable irrigation supplies should stimulate the use of non-water inputs by farmers because water and other inputs are complementary in their contribution to increased yields. Additional cropped acreage also opens opportunities for increased use of non-water inputs, even under conditions of underwatering as noted in (i) above.

(iii) The Bank Group is in general agreement with the yield levels projected by IACA for the year 2000, which are generally two to four times higher than in 1965. Because of assumptions (i) and (ii) above, however, the Bank Group has smoothed out the growth path for yields. Thus, because it believes that increased use of non-water inputs could be beneficial under present conditions, the Bank Group projects a higher growth in yields during the period 1965-75 (before the water development projects become fully operative) than IACA. At the next stage, 1975-85, the Bank Group projects a growth in yields less than IACA. This is because the Bank Group does not assume that increased supplies of water would be applied immediately to bring applications to the level of full delta, or, to the extent that they are used in this way, that the increase in yields due to increased delta alone would be as rapid as IACA has assumed. For the period 1985-2000, both projections are very similar.

(iv) An overall average cropping intensity of 150 percent should be assumed to be a reasonable indicative target for development in the Indus Basin. Attempts to raise this average level would face difficulties primarily because of the incompatibility of certain crop successions, the expense of reclaiming saline land within the projected CCA, and limitations on farmers' capacity to shift rapidly from one crop to another with the equipment, labor, and animal power at their disposal.

(v) The main deficiencies in the present irrigation system are: water availability in rabi and late and early kharif seasons is unreliable and inadequate to sustain optimum crop production; canal capacities in some areas are inadequate to achieve optimum kharif intensities; distributary and watercourse flows are inflexible; crop growth is affected, directly or indirectly, by lack of subsurface drainage; lack of surface drainage causes crop losses and yield reductions in the upper northern and lower southern regions.

(b) <u>Water Resource Factors</u>.

(i) The mean combined flow of the Indus, Jhelum, and Chenab Rivers, after full implementation of the Indus Water Treaty, has been estimated to be 142 MAF per year. Compared to the present average canal head diversions of 79 MAF per year, this indicates considerable potential for future surface water conservation and use in West Pakistan.

(ii) Fresh groundwater, containing less than 1,000 ppm TDS, 1/ is assumed to lie under 14.2 million acres CCA, and groundwater which requires mixing with fresh surface supplies before being used for irrigation is assumed to be found under an additional 4.6 million acres CCA. The current usable recharge to the aquifer is about 30 MAF per year, but this would increase to 44 MAF in the future as more surface water is absorbed by the canal system.

(iii) Heavy emphasis is placed on tubewell development in usable groundwater areas because the potential increase in demand for water is so large, particularly during the rabi months, that it would exceed the feasible rate of new surface water development works over the next ten years. On the basis of the estimated feasible rates of installation, operational efficiency, and cost, no other mode of water development can compete with tubewells where usable groundwater is available on the land. Tubewells have the advantage of delivering water directly to the farm watercourses, and thus they overcome the constraining effect of the present limitations on canal capacity. They also provide a mode of development in which individual land owners or farmers can participate, and to this extent they assist in overcoming the present serious constraints on finances and implementation capacity. In the usable groundwater zones, they not only provide water quickly and cheaply, but also simultaneously provide water table control. The Bank Group assumes that private tubewell installation would continue during the 1965-75 period, and that a total of 55,500 private tubewells would be in operation by 1970 even if the

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1/ Parts per million of total dissolved solids.

public tubewell program maintains the schedule called for under the Action Program. Under these conditions, this estimate of total private tubewells would drop only slightly to 52,500 by 1975. The Bank Group also believes, however, that the private sector could sustain a higher installation rate than this and would do so if public tubewell projects were not going forward in certain areas of the Basin. If the public program should lag behind the Action Program schedule, the Bank Group anticipates that private installation would be greater -- possibly as many as 66,500 private wells in operation by 1970.

(iv) The Bank Group recommends that surface water storage at Tarbela would be available as scheduled, and would be in operation for the rabi crops of 1974/75. The Bank Group also accepts IACA's finding that canal remodelling during the period covered by the Action Program would be limited to one million acres where it would be designed to remove constraints in the mixing and saline groundwater zones.

(v) Public and private tubewells would provide an important part of the need for subsurface drainage in the process of adding water for irrigation but in saline groundwater zones a separate and specific drainage system would be required. In this latter case, the selection of either drainage tubewells or horizontal drainage would depend on the type of drainage problem existing in different areas.

(vi) Damage from flooding would become increasingly important as the state of agricultural development improves, and this would require some flood protection measures. However, the relative importance of this problem, and the costs required for flood protection, appear quite small in comparison with the Action Program as a whole.

(vii) The findings concerning the quantities of water likely to be available for development lead to the further working conclusion that it would be more efficient and economical to use these foreseeable water supplies to intensify farming and develop new areas within the existing CCA, rather than to extend the canal system into new land. Within this guiding principle, the Bank Group has not regarded the IACA estimate of 29.5 million acres CCA as a fixed limit, since it may prove feasible and advantageous to use available water supplies on parts of the existing CCA not included in this 29.5 million acres marked for intensive development. The Bank Group believes that such decisions should be based on conditions existing at some future time when alternatives may come under consideration, but the acreage limitation must be kept prominently in mind when planning for development.

The Action Program

9.07 The Bank Group's Report presents an Action Program for the period 1965-75 which builds upon these findings and considerations. This Action Program is the first stage in long term planning for water resource and agricultural development consistent with West Pakistan's resource base, and incorporates proposals which are technically and operationally feasible under West Pakistan conditions. Many elements in the program require further detailed engineering study and economic evaluation before final decisions can be taken. Further, relative priorities and the specific inclusion or deferment of projects depend, to some extent, on the future course of events, for it is expected that constant review in the light of changing circumstances would result in modifications of the program as it is now conceived. While the development program as a whole applies to the period up to the year 2000, the Bank Group has been particularly concerned that the Action Program relating to the period 1965-75 be achievable within the constraints likely to be operative, and not be merely an expression of goals which are feasible in a technical sense. The program is not intended as a prediction of what will be, but rather as a projection of what could take place if the development of irrigation and agriculture receives the high priority it deserves, and if the required resources are allocated and efficiently and effectively deployed.

9.08 There is emphasis in the early period of the program on development of tubewell installations to supply irrigation water. This emphasis stems from the availability of large underground supplies of water, the comparative cost advantage, and the fact that future expansion in surface supplies would increase the recharge and therefore the potential withdrawal from the groundwater reservoirs. Clearly, either public or private tubewell would serve to tap these underground sources of irrigation water, but for the long term some form of coordinated control would be required. This is because it would be necessary to integrate control over the groundwater table with the supply of surface water (which comes from sources already under public control), and because private development alone may not provide the coverage which would permit all farmers to benefit from groundwater supplies where these are exploitable. It is therefore desirable that public development continue to the extent public projects can be successfully and efficiently implemented. On the other hand, there are limits to the rate at which public groundwater development can proceed, and the existing willingness to expand private tubewell installations should therefore be utilized to bring development where the incentives are greatest to do so. The Bank Group's approach to groundwater development over the next ten to 15 years is thus a flexible one, seeking to take advantage of both public and private initiative and thereby accelerating the rate of exploitation of groundwater resources.

9.09 There are five main elements of water resource investment in the Action Program -- the on-going public groundwater development, Tarbela Dam, the public tubewell projects formulated by IACA, the Sukh Beas Drainage Scheme, and private tubewell installation. The on-going public groundwater development portion consists of public tubewell development projects which are in some stage of construction or project preparation at the present time. These call for a total of 10,118 public wells in five SCARP (Salinity Control and Reclamation Project) areas, of which some

2,900 have been completed in SCARP I and II since the start of construction in 1959. The West Pakistan Water and Power Development Authority (WAPDA) has scheduled the balance of about 7,200 wells for completion by 1971/72. In addition to these, WAPDA has proposed that it begin implementation of one more area (SCARP V) in 1967/68, which would provide 2,300 public wells in the Lower Rechna Doab.

9.10 The Bank Group believes, on the basis of WAPDA's performance to date, that completion of the on-going projects as scheduled is far from assured. There are certainly pressing needs for improved procedures and increased financial allocations to the executing agency, for removal of constraints on electrification, and for the urgent establishment of management cadres capable of putting tubewell fields into operation immediately upon completion. There would thus be little room for additional new projects for implementation during the Third Plan period. Because of this, the Bank Group feels that a portion of the tubewell development included in the Action Program and scheduled for SCARP IV (amounting to 1,010 wells out of a total of 3,270) should be deferred until after 1973. This is suggested because of the implementation problems just noted, and also because the area of Rechna Doab where SCARP IV is located is currently undergoing extensive development by private tubewells. This private activity alone may be sufficient for development of the area in the early years. The Bank Group further recommends that the SCARP V project, noted above, be deferred on the same grounds, and SCARP V has not been included in the Bank Group's Action Program. Areas within SCARP V where waterlogging and salinity are major problems would be included in a separate project within one of the IACA public tubewell project proposals. Despite the apparent constraints on actual implementation, project preparation for projects to be carried out in the Fourth Plan period should nevertheless be vigorously pursued during the remaining years of the Third Plan period.

9.11 Construction of the Tarbela Dam is the main element of the Action Program for the further development of gravity irrigation. The dam should provide an initial live storage availability of 8.6 MAF at a drawdown level of 1,332 feet, but siltation over a 50-year period would reduce this to about one MAF by the end of that time. Under the present construction schedule, the full 8.6 MAF cannot be impounded by 1974/75, but there should be about five MAF impounded during the flood season of 1974 -- equal to the storage requirements expected during the rabi season 1974/75. In quantitative terms, the regulating effect of Tarbela should increase the rabi flows of the Indus from mid-October to mid-April by about 65 percent. Other contributions of the dam include the fact that it would be a further step in exploiting the huge water resources of the Indus which presently flow to the sea partially unused. It would increase the reliability of irrigation supplies for rabi crops (particularly wheat), would enable an extended utilization of the link canal system by diversion of storage releases through the links for use in the central parts of the Indus Basin, and would increase the recharge to groundwater and thus add to the recoverable recharge in usable groundwater zones.

9.12 On the other hand, the construction of Tarbela Dam generates consequences for other aspects of water resource development which must be taken into account under the other parts of the Action Program. For example, there must be sufficient control of the groundwater table before additional surface water from Tarbela storage can be admitted to seriously waterlogged areas. The location and timing of tubewell projects must therefore be decided in the light of the existence of Tarbela storage by 1975. The need for canal enlargement is related to the increase of surface water supplies at critical months. Although existing capacities are designed largely to meet kharif needs, and are generally under-utilized during rabi, increased surface supplies during rabi would also require additional deliveries during the months when kharif and rabi requirements overlap. In some cases, this condition is likely to exceed the current canal delivery capacities, and would call for some canal remodelling. If, however, surface deliveries are integrated with groundwater development, concentrated pumping during the overlap months could relieve this constraint in the earlier years of increased surface availability. Finally, the timing of groundwater development in areas where mixing with fresh surface water is required would depend on when such fresh surface supplies would be available from Tarbela storage.

9.13 The on-going public groundwater projects and Tarbela Dam are thus the parts of the Action Program already under either preparation or construction. IACA has identified and formulated an additional 12 public tubewell projects for inclusion in the Action Program which would further contribute to the irrigation water supplies, drainage, and groundwater table control. These 12 projects are concentrated principally in the three regions of the Bari Doab, the Sutlej Left Bank, and the Lower Indus. IACA has proposed 11,403 tubewells, of which 4,867 would have a capacity of about four cusecs and 6,536 a capacity of about three cusecs. These would cover about 5.8 million acres CCA, of which 4.1 million acres would be in fresh groundwater zones. With the exception of the Sukkur Right Bank project, all would eventually absorb additional surface supplies after the completion of Tarbela Dam, most of this during the rabi season. The total net increase in irrigation water supplies from groundwater and additional surface water in these 12 projects areas would be 13.28 MAF by 1985. If carried out as scheduled, groundwater development projects under the entire Action Program would add some 18,600 tubewells, providing supplementary irrigation water to approximately 12 million acres of culturable area.

9.14 The Bank Group has determined priorities for the 12 new tubewell projects from the preliminary information available. These priorities were derived initially from an examination of the water requirements associated with attainment of optimum cropping intensities under the agricultural and technical constraints believed to be present. This examination resulted in a set of water budgets, one for each canal command, subsequently aggregated into a comprehensive water budget for the system as a whole. The priorities followed from consideration of the technical feasibilities of providing the water requirements stipulated in the budgets. These priorities were then checked against two economic evaluations -- one a ranking which resulted from consideration of the costs and benefits of different water development activities in analytical units based on groundwater quality zones, and the second a linear programming exercise which employed a more comprehensive model based on whole canal commands. The priorities which emerged under these three different approaches were similar for the most part, and the minor differences between them were resolved largely to accommodate technical problems which were involved.

9.15 The 12 projects seem sufficiently justified to merit consideration for the period up to 1975, but highest priority has been given to eight of the projects. The additional four projects, all in the Bari Doab, have only marginal advantages over the alternative of continued private development of the same areas, and may be deferred in the light of factors discussed below. Detailed descriptions of the proposed projects and their evaluation by the Bank Group are provided in Annexure 4.1 Volume II of the Bank Group's Report. The major characteristics of these project areas are summarized in the next table.

9.16 Although all 12 projects have been included in the Action Program, the Bank Group suggests that public groundwater development efforts should be concentrated first in fresh water areas where thus far there has been little private tubewell development. The latter four projects noted above are situated in the Bari Doab where there has been substantial private development, and the indications are this would probably continue in most parts of these project areas in the absence of public projects. The Bank Group also feels that private wells would provide sufficient drainage effects to enable the introduction of additional surface supplies, and therefore suggests that public development in the Bari Doab be generally deferred until after 1970 except in the Wagah area and possibly parts of the Upper Dipalpur Command. By that time private initiative would have demonstrated its capability more clearly, and it may be determined whether it can provide the necessary groundwater table control. Decisions can be taken at that time whether to initiate detailed project preparation, or to defer such action even further. This would require close monitoring of private development in the Bari Doab.

9.17 A fourth element in the Action Program is IACA's revision of a drainage project originally formulated by the Government of Pakistan and known as the Sukh Beas Nallah Drainage Scheme. As revised, this project would utilize a 327 mile alignment, mainly of the old Beas River bed. The catchment area would be about 3.3 million acres, with a design discharge capacity of 462 cusecs at the head and 2,263 cusecs at the tail. This area borders the Dipalpur, Pakpattan, and Mailsi canals on the east, and Lower Bari Doab main canal on the west, and the project would provide drainage for an area of West Pakistan where existing levels of agricultural production are amongst the highest in the Province. The drainage project would support both private tubewell development and the public tubewell projects proposed for the latter part of the period 1965-75. To the extent that reduction in prolonged flooding of large agricultural areas would reduce the recharge to the groundwater aquifer, the drainage project would also contribute to the control of the water table in large parts of the Bari Doab.

Groundwater Development Projects
Identified and Formulated by IACA

| Project | CCA ('000 acres) | | | Number of Wells | | | Installed Capacity | Depth to Water Table (% of Project Area) | | Groundwater Pumped at Full Development | Ultimately Attainable Cropping Intensity |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh-water Zone | Mixing Zone | Total | 4 Cusec | 3[1] Cusec | Total | (cusec) | Less than 10' | More than 10' | (MAF) | (Per Cent) |
| | | | | | | | | (Per Cent) | | | |
| **Rechna Doab:** | | | | | | | | | | | |
| Shorkot Kamalia | 222 | 72[2] | 294 | 370 | 56 | 426 | 1,650 | 78 | 22 | 0.61 | 149 |
| **Bari Doab:** | | | | | | | | | | | |
| Dipalpur Above B.S. Link | 344 | 28 | 372 | 580 | 50 | 630 | 2,460 | 55 | 45 | 0.76 | 150 |
| Dipalpur Below B.S. Link | 362 | 249 | 611 | 473 | 377 | 850 | 3,020 | 28 | 72 | 1.01 | 150 |
| Ravi Syphon-Dipalpur | 257 | 338[2] | 595 | 440 | 340 | 780 | 2,600 | 30 | 70 | 0.98 | 150 |
| Shujaabad | 303 | 76 | 379 | 576 | 149 | 725 | 2,730 | 74 | 26 | 0.98 | 149 |
| **Sutlej Left Bank:** | | | | | | | | | | | |
| Fordwah Sadiquia | 237 | 122 | 359 | 495 | 170 | 665 | 2,420 | 56 | 44 | 0.86 | 145 |
| Bahawal Qaim | 335 | 187 | 522 | 618 | 306 | 924 | 3,290 | 7 | 93 | 1.22 | 146 |
| Panjnad Abbasia | 716 | 162 | 878 | 1,315 | 308 | 1,623 | 6,110 | 83 | 17 | 2.37 | 148 |
| **Lower Indus:** | | | | | | | | | | | |
| Rohri North | 451 | 147 | 598 | - | 1,580[3] | 1,580 | 4,210 | 40 | 60 | 1.21 | 145 |
| Rohri South | 400 | 128 | 528 | - | 1,500[3] | 1,500 | 3,730 | 5 | 95 | 1.14 | 130 |
| Begari Sind | 349 | - | 349 | - | 880 | 880 | 2,640 | 90 | 10 | 0.72 | 150 |
| Sukkur Right Bank | 160 | 113 | 273 | - | 820 | 820 | 2,120 | 97 | 3 | 0.72 | 150 |
| **Total:** | 4,136 | 1,622 | 5,758 | 4,867 | 6,536 | 11,403 | 36,980 | 49 | 51 | 12.58 | 150 |

1/ The capacities of wells included under this category would vary from 2 to 3 cusec.
2/ Including some saline areas for which tile drainage proposals have been made by IACA
3/ Including tubewells required on remodelling.

9.18 Finally, the Bank Group anticipates continuing private tubewell development throughout the period of the Action Program. This is essential to the growth in agricultural production because the contribution to growth from the public portions of the Action Program (which is considered to be the maximum feasible) would be inadequate for West Pakistan's needs. The Bank Group therefore strongly suggests that Pakistan authorities implement policies conducive to rapid private tubewell development as a matter of urgency.

9.19 Although private diesel-powered wells are the most expensive form of groundwater exploitation for the farmers because of their high fuel costs, they have the advantage of being independent of electric power supplies. This could provide an interim solution in areas not yet electrified, as well aa added reliability in areas where power is available but not always dependable. A comparison of public and private electrified wells indicates negligible cost differences per unit of water pumped on the land. Although private wells may be pumped at lower rates than public wells, this generally reflects a pumping pattern directly related to farmers' actual water requirements, and therefore constitutes a more efficient use of the groundwater pumped. The Bank Group has accepted the IACA proposals for public development as scheduled in the Action Program, but would urge the Government to continuously observe the relative performance of public and private development efforts. The emphasis on public or private groundwater exploitation in usable groundwater zones may be changed from time to time, depending on the availability of public funds and the relative advantages of the two approaches as these emerge more clearly with increased experience.

9.20 The Action Program assumes that a total of at least 52,500 private tubewells would be operating by 1974/75, of which 38,500 wells would be in the canal-commanded area. The contribution to irrigation supplies from these private wells and the public wells included in the Action Program, as well as a comparison with the groundwater quantities utilized in the Sequential Analysis, appears in the next table. This Sequential Analysis involved a 20-year sequence, and was undertaken to demonstrate how the system at large would meet the water requirements of each irrigation unit under the year by year conditions of development. It was thus an attempt to test the operational feasibility of the integrated irrigation system which the program calls for. The following table shows that the Action Program, as now proposed, would essentially meet the irrigation water requirements calculated by IACA in its Sequential Analysis for reference years over this period. The table also illustrates another point of significance for the strategy to be followed during the period 1965-75. This point is that private groundwater exploitation is clearly dominant throughout the Third Plan period, and continues to make an important contribution to irrigation water availability up to 1975. The Bank Group believes that the public tubewell program constitutes a maximum number of wells likely to come on flow. Private installations have been projected at a declining rate of increase, which may understate the potential. It is therefore important that private development be given every encouragement until the successful implementation of consecutive public well fields appears ensured.

Groundwater Pumped Under the Action Program

| | 1965/66 | | 1969/70 | | 1974/75 | |
|---|---|---|---|---|---|---|
| | Canal Command-ed Area | Outside Area | Canal Command-ed Area | Outside Area | Canal Command-ed Area | Outside Area |
| No. of Tubewells in Operation: | | | | | | |
| Public | 2,900 | - | 9,600 | - | 20,700 | - |
| Private | 29,000 | 5,000 | 46,500 | 9,000 | 38,500 | 14,000 |
| Estimated Annual Pumpage in MAF: | | | | | | |
| Public | 2.7 | - | 10.2 | - | 21.7 | - |
| Private | 7.0 | 1.0 | 9.0 | 1.8 | 8.5 | 2.8 |
| TOTAL | 9.7 | 1.0 | 19.2 | 1.8 | 30.2 | 2.8 |
| Private as percent of Total: | 72% | 100% | 47% | 100% | 28% | 100% |
| Groundwater pumped in the Sequential Analysis: | 9.6 | - | 21.7 | - | 31.0 | - |

## CONCLUSIONS

(a) The Bank Group recommends an Action Program for 1965-75 which would be the first stage in long-term planning for water resource and agricultural development.

(b) On-going public tubewell projects in five SCARP areas should be completed as scheduled, with the exception of SCARP V and portions of SCARP IV. Public programs in the latter two areas should be deferred because of the constraints on public sector implementation capacity, and because rapid private development in those project areas appears most likely in the coming decade.

(c) Tarbela Dam should be completed in time for impounding water during the flood season of 1974.

(d) Additional surface storage would generate a need for some canal remodelling to accommodate increased flow during the overlapping of kharif and rabi seasons. However, concentrated pumping from tubewells during the overlap months may relieve this constraint during the early years of increased surface water availability.

(e) The 12 public tubewell projects proposed by IACA appear justified, but the Bank Group feels that four of them located in the Bari Doab could be deferred beyond the Action Program period because they show only slight advantages over the alternative of private development in the same areas.

(f) The Sukh Beas drainage scheme should be implemented during the period of the Action Program, and would serve an area of 3.3 million acres along the old Beas River.

(g) Private groundwater exploitation would be clearly dominant throughout the Third Plan period, and would continue to make an important contribution to irrigation up to 1975. Success of the total program thus depends heavily on a continuing exercise of private initiative in tubewell installation, and this should receive every encouragement so that it can make the full contribution expected from it.

Long Term Development Proposals

9121 As noted earlier, the Action Program for 1965-75 places heavy emphasis on tubewell development of the usable groundwater areas throughout the Indus Plains because tubewells provide the most rapid and cheapest means of making additional irrigation water available on the land, in addition to affording flexibility in construction and use. Surface water storage developments for this period are very largely predetermined by the completion of Mangla Dam in 1967, a small amount of storage at Chasma Barrage scheduled for completion by 1971, and the work on Tarbela Dam. Canal enlargement before 1975 is limited to about one million acres because of resource constraints, limitations in the capacity of link canals to bring bulk supplies of water to the headworks of enlarged canals, and the general shortage of river flow at critical times of the year prior to the time the surface storage facilities are completed.

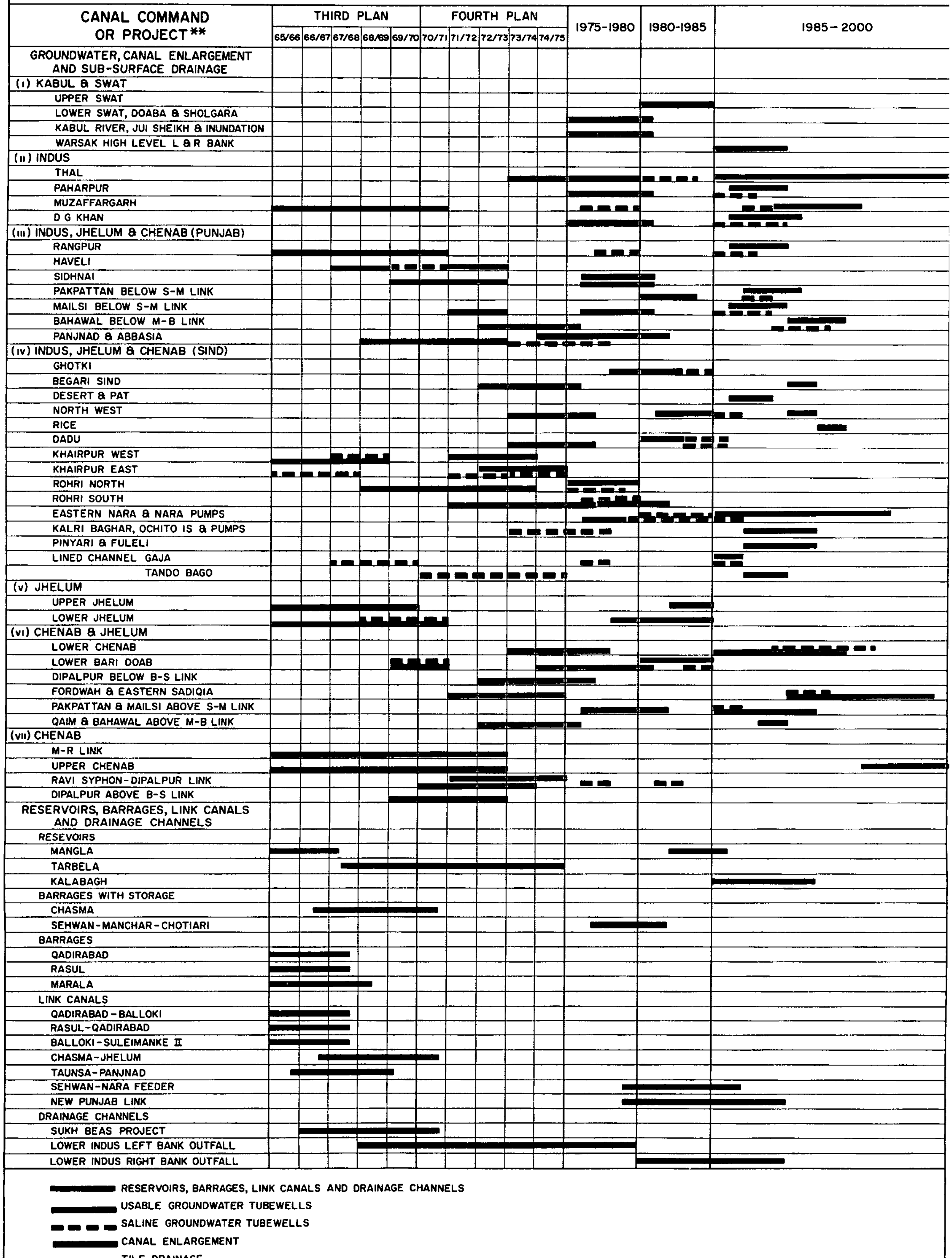
9222 Planning beyond 1975 for irrigation development in the Indus Basin becomes more complex. The various methods of irrigation development -- surface supply, tubewell supply, sub-surface drainage, and canal remodelling -- together with agricultural constraints on the intensification of farming, all become more closely inter-related. The additional water deliveries and flow regulation provided by Tarbela and Mangla, super-imposed on the large tubewell developments expected by 1975, would create a situation where irrigation supplies could be matched to the water requirements of crops instead of, as at present, to the natural flows of the rivers. Thus, after 1975, supplies should be adequate to meet the assumed needs of an increasing cropped acreage at full delta, including the conversion of areas from non-perennial to full perennial cropping where this has not been achieved by tubewells alone. The proposed program, classified by canal commands grouped by river sources, is shown diagrammatically in the following figure. Details are given in Chapter V. During the decade 1975-85 public tubewell fields would be extended over the outstanding usable groundwater area, and full integration of groundwater and surface water supplies would be achieved. The improved irrigation supplies and the control of the water table would enable the canal enlargement program to be greatly accelerated at this stage, and this would take the leading role in further water development. By the end of the century, there should be complete enlargement of the canal system serving some 16 million acres CCA, in addition to major works enlarging existing link canals and providing some new ones.

9.23 Some of the more urgent work of canal enlargement would be undertaken before 1975, but only in canal commands where it does not involve additional link canal capacity. As stated above, this would affect approximately one million acres. The major emphasis on canal enlargement, however, would not come until around 1980. By that time a new canal should connect the Chasma Jhelum link eastward across the Punjab with the main canals of the Chaj, Rechna, and Bari Doabs. At about the same time (1982), the Sehwan Barrage and the Sehwan-Rohri feeder should be completed in the Lower Indus as the first stage of the Sehwan-Nara feeder.

9.24 The extent and nature of the canal remodelling would vary with the different sections of the Indus Basin according to needs and the specific water situation in each. The details are provided in Chapter V of Volume II, but a few general comments may indicate some essentials of the overall program in addition to the background sketched above. Remodelling would take place in the Punjab in those portions where there are extensive saline areas, or where the anticipated tubewell development would not provide enough irrigation water to meet the crop requirements at full delta. Most of this would have to wait until the west-east link across the Punjab was nearing completion. Canal enlargement in the Lower Indus hinges essentially on the Sehwan Barrage project which would act as a diversion dam to command a major feeder canal to the Rohri and Nara commands, and would also provide about 1.8 MAF useful storage capacity. As now proposed, the Sehwan Barrage and Sehwan-Rohri feeder are scheduled for completion in 1982, and the Rohri-Nara feeder is scheduled for completion after 1985.

9.25 The longer term program envisages that public tubewells would virtually supersede private tubewells within the canal commanded areas by about 1985. It should be noted at this point, however, that the Bank Group is less certain about what relative weights should be given to the contributions from public and private tubewells over the longer term. Any firm judgments made at this time may well be based on sound principles, but at best can only rest on inadequate evidence as to what

# REVISED* IACA PROGRAM FOR IRRIGATION DEVELOPMENT




*MINOR REVISIONS MAINLY IN 1965/75 PERIOD - SEE CHAPTER IV **CANAL COMMANDS ARE GROUPED BY RIVER SOURCES

IBRD-3284

the relative advantages would actually be under West Pakistan conditions. For these reasons, the Bank Group would prefer to see such an important judgment made in the light of careful analysis of performance after, say, five years' time.

9.26 As the program now stands, the initial emphasis after 1975 would be on the completion of public tubewell programs in usable groundwater zones, and the progressive substitution of public for private wells. This reflects IACA's belief that public wells are generally more efficient than private wells, and that the complexities of integrating water supplies, water table control, and drainage require public operation of well fields in the long term. The actual phasing of public tubewells after 1975 can be regarded only as a broad indication of priority because much is based on judgment which must be checked by further investigations and analyses. By 1980 only a few areas of usable groundwater would remain undeveloped by public wells, notably Upper Swat, part of Pakpattan and part of Ghotki and Warsak. As this part of the tubewell program nears completion, the resources engaged in such work would be diverted to the drainage of saline groundwater areas to make possible the further intensification of irrigation by canal enlargement. Some of the more urgent saline areas with shallow water tables would be tackled at an early date, particularly those in the Panjnad Abbasia and Rohri commands. From 1980 onwards there would be a steady program of tubewell installation in saline areas amounting to about 500 tubewells per year.

9.27 The largest single drainage work for the long term, the Left Bank Outfall, would actually be started during the period of the Action Program. It is the first stage of a large drainage complex proposed by the Lower Indus Project (LIP) consultants for the Sind, and would have the objectives of removing saline sub-soil drainage water from the greater part of the Indus Left Bank south of Sukkur to the sea and providing surface drainage in areas south of Nawabshah. The drain would have an overall length of 267 miles, stretching from near Khairpur to the Rann of Kutch, and would provide a maximum discharge of 15,000 cusecs. The massive scale of the works in this project requires a construction period of 16 years, and it has therefore been scheduled to begin in 1968. This means that a rapid program of studies and site investigations must be undertaken now. The other major surface drainage work would be the Lower Indus Right Bank Outfall drain. This would serve the Gudu and Sukkur Right Bank areas, and would drain their affluent into the Indus downstream of the proposed Sehwan Barrage. The drain represents the main feature of the final stage of the LIP consultants' drainage proposals, and is scheduled for completion by about 1990.

9.28 In order to determine the Action Program for 1965-75, and to set it in perspective with a longer term indicative development program for the Basin, it was necessary to analyze the patterns of water use over time in relation to the potential availability. Three reference years were used for detailed analysis -- 1975, 1985, and 2000 -- and in addition each year from 1965 to 1985 was analyzed against historical and synthetic sequences of river inflow. The water distribution and use analyses were undertaken in three stages: (a) the calculation of water use within canal commands, (b) routing the demands from canal commands to the river rim stations and reservoir sites for each reference years, and (c) the operation of the reservoirs to correspond with the scheduled supplies from all sources. The sequential analysis, mentioned earlier, was added to test the operational feasibility of the program over its crucial period, 1965-85. In addition, a number of reservoir operational studies were carried out for Mangla and Tarbela reservoirs to determine their behavior for both irrigation and power purposes.

9.29 These water distribution analyses were the means by which various alternatives were tested, and thus found the base for the water development program. They were not intended to provide detailed operational estimates for specific water allocation or distribution patterns, but nevertheless they form a useful framework upon which to build up detailed studies of future system operating procedures and rules. Such distribution studies must embrace all the new situations set up by the introduction of Mangla Dam and the link canals built under the terms of the Indus Basin Treaty, and their new transfers of water to the eastern Punjab. These and other aspects of the redistribution of surface water, including the implementation of tubewell programs, water substitution opportunities, and integration of surface and groundwater supplies, involve a number of agencies. These would include the Agricultural Department, Agricultural Development Corporation (ADC), and the Land and Water Development Board (LWDB) as well as WAPDA and the Irrigation Department. The procedure for bringing together the views and experience of the various agencies and applying them to a study of water distribution is essentially a domestic one that can only be decided by the Government, but the Bank Group attaches great importance to this matter and it has made some suggestions regarding its implementation. The need to proceed with these detailed studies of system operation is now extremely urgent.

## CONCLUSIONS

(a) The long-term program anticipates that irrigation supplies should be adequate after 1975 to meet the needs of increased cropped acreage at full delta, and that full integration of groundwater and surface water supplies would be achieved during the decade 1975-85.

(b) Although some of the more urgent canal remodelling work would start before 1975, the major emphasis would not come until about 1980. This activity is related to the construction of new link and feeder canals, and is phased to enlarge the capacity of existing canals at times when increased surface supplies would be available to them.

(c) The Bank Group anticipates eventual coordinated control of groundwater exploitation, but is reluctant to assign fixed weights to the relative contributions from public and private tubewells over the long term.

Since there are uncertainties over the development pace which public sector tubewell projects can maintain, the Bank Group would prefer to leave decisions on the timing and form of eventual coordinated control until there is a larger body of experience on which to base judgments.

(d) The Left Bank Outfall, possibly the largest single drainage work in the world, should begin in 1968 and continue over a construction period of 16 years. A second major work, the Right Bank Outfall, would constitute the final stage in the drainage program and is scheduled for completion by about 1990.

(e) The Bank Group recommends that detailed studies of the operation of the irrigation system be started as soon as possible, since the efficient operation of the system calls for understanding of the new situations being created by the various elements in the development program.

Program Requirements

9.30 Agricultural Inputs. The program advocates the simultaneous development of improved water supplies and improved farming practices. Improved farming, which includes better farm methods and the use of physical inputs such as fertilizer, better seed, and plant protection, is assumed to come about at rates which are considered feasible in West Pakistan. The Bank Group considers there is greater scope for increased productivity within prevailing conditions of water supply than does IACA. It recognizes the inherent difficulties in achieving an agricultural break-through, but believes this can only be accomplished if water development is matched with a corresponding increase in the use of other inputs. It also believes there is a tendency to overstate the importance of further public water development, and to understate the importance of improved farming employing more and better inputs. Unreliability of water supplies is, in all probability, a greater deterrent to investment and enterprise by farmers than the absolute quantity of water available. The Bank Group would therefore place as much emphasis on efforts required to bring about better operation of the system and better farming as it would on further public water development. It would emphasize that no single input, be it water, fertilizer, seed, or anything else, can have its full impact when used in isolation. The various inputs must be applied in the right balance, at the right time, and in the appropriate manner -- all of which depend on the skill and judgment of the farmers. The need to impart such knowledge to farmers underscores the importance of effective research and extension services. The Bank Group believes that, given proper support, the IACA projections of input use could be exceeded, and therefore looks upon these projections as a minimum requirement needed to support agricultural growth. In its estimates of production, the Bank Group has adopted IACA assumptions on input use, with the notable exception of fertilizer where Bank Group assumptions are markedly more optimistic than those used by IACA.

9.31 The Bank Group considers that an offtake target of about 350,000 nutrient tons, equivalent to about 1.6 million tons of ammonium sulphate, would be feasible by 1969/70, or an increase in fertilizer use of about 30 percent per annum over the Third Plan period. It may become more difficult to maintain a similar rate during the Fourth Plan period, and therefore a 15 percent per annum increase has been projected. The target for 1975 would thus be about 700,000 nutrient tons. Both of these targets are approximately double the IACA estimates of offtake for these years. While a high degree of uncertainty is inherent in all such projections, it should be possible for the West Pakistan authorities to reach these targets provided appropriate arrangements are made for supplies and distribution, and the costs to farmers are kept at acceptable levels. For the years after 1975, the Bank Group would expect the rate of increase in fertilizer use to decline and gradually approach the levels estimated by IACA, i.e., 1.8 million nutrient tons per annum by the year 2000.

9.32 Improved seed material, particularly of superior varieties of wheat, cotton, and rice, constitutes a second important agricultural input. West Pakistan has embarked on an active wheat improvement program, in cooperation with Mexican Wheat breeding experts, and imported Mexican varieties and locally developed Mexipak varieties are currently being multiplied and distributed. The technical yield potential of these varieties appears more than three times greater than the average yields obtained in the better farming areas of West Pakistan. The Bank Group has assumed that about 50 percent of the wheat acreage would be covered with improved varieties by 1975, and 100 percent by 1985. This implies an ambitious target in terms of multiplication, distribution and acceptance of the improved wheat varieties, but wheat breeding experts advising the Government have predicted much faster progress. The Bank Group estimates thus appear somewhat conservative in comparison with those of the seed specialists. While the Bank Group is impressed with the apparent initial successes, it still feels that achievement of its projections would represent a very important advance in the development of West Pakistan's agriculture.

9.33 High yielding dwarf varieties of coarse rice, developed at the International Rice Research Institute in the Philippines, are being tested in West Pakistan with apparently good results. It has been assumed that enough seed would be available for one million acres by 1975, although the Agriculture Department is planning for this much coverage by 1970. The program assumes that improved varieties would be in common use by 1985, and would require more than 180,000 tons of seed annually. Hybrid and synthetic maize varieties also hold much promise for West Pakistan.

9.34 The Bank Group generally accepts, for planning purposes, the above assessment of the probable progress and contribution to production from improved seed material, but it retains the hope that these projections may prove to be on the conservative side. Improved seed represents an influence which is extremely difficult to measure. It is not a specific term, and to measure progress in terms of the amount of improved seed employed could be quite meaningless because much depends upon the complementary improvement of other practices, and on institutions responsible for production, multiplication, and supervision of the distribution of improved seed material.

9.35 Chemical pest control has been provided free to farmers by the Government, but it has suffered from declining importation of pesticides, inadequate storage facilities reducing the specific effective properties of chemicals, and inadequate means for transportation and spraying. It has furthermore diverted a substantial number of potential extension workers from important extension activities in order to provide plant protection service. Nevertheless, plant protection should make a direct contribution to improvement of yields as well as safeguarding the contribution of all other inputs, and this would become increasingly important as farming practice improves and intensifies. This is particularly true for the cotton and rice crops.

9.36 The program does not make allowance for plant protection to develop as rapidly as fertilizers, and regards it as unlikely that protective measures would improve much before the use of fertilizer and better husbandry are more generally applied and yields are improved. Accordingly, a relatively small increase in the acreage sprayed has been projected for the first decade (1965-75), after which more general use of chemical control would occur and the number of applications would gradually reach desirable amounts. Mechanized spraying would increase along with the expansion of farm mechanization, but the Government would have to continue aerial spraying against epidemic attacks such as from locusts. Plant protection is an area where private sector participation could play an increasing role because there would be a merging of the interests of the suppliers and the needs of the farmers for improved protection. This may entail an initial continuance of some form of subsidy, but increasingly the progressive farmers should become willing to acquire effective plant protection services at reasonable costs. The Government should initiate research programs designed to develop simple, practical procedures which can be readily employed by the farmers.

9.37 At higher levels of intensities, mechanized cultivation is likely to become a prerequisite for dealing with tight cropping schedules and peak labor requirements, as well as for reducing hired labor costs. To the extent that mechanized cultivation would substitute for animal power, it would also free fodder acreage which could then be used for an expansion of cash crops. Mechanized cultivation would also enable better and more timely land preparation, and thus contribute to yield performance. Since mechanized cultivation is generally no more expensive than bullock farming, land preparation, post planting cultivation, harvesting, and threshing are likely to be mechanized fairly rapidly, although this would be largely limited to the larger farms. Even here, though, rapid adoption would depend greatly on satisfactory service facilities and an adequate supply of spare parts and mechanics. On the smaller farms, land fragmentation and the share cropping system are likely to be a substantial barrier to rapid mechanization.

9.38 The Bank Group recognizes the important role that mechanization must play in the progress towards more intensive and more highly commercialized agriculture, and feels every encouragement should be given in the form of credit, advice on suitability for particular conditions and purposes, instruction in operation, ensured supplies of machinery and parts, and adequate service facilities. In view of the preponderance of small farms, careful consideration should be given to the stimulation and support of contract mechanization service and cooperative use of farm machinery, and to the continued improvement of bullock-drawn equipment and hand tools.

9.39 IACA has projected a substantial contribution to agricultural production from animal husbandry, and the rapid build-up of an improved cattle herd thus assumes special significance. The principal change in the long term would be from buffalos to zebu cows as milk animals, but the number of buffalo cows is not expected to decline before 1985. To support the anticipated rapid progress thereafter in the development of quality stock, it is necessary to use the best bulls available to the fullest possible extent. IACA had proposed that the upgrading of present zebu herds be done by a massive program of artificial insemination. The technique proposed is the repeated topcrossing of successive generations to selected Sahiwal or Red Sindi sires, leading to the progressive improvement of the national herd. The livestock sector is of such importance to both present and future growth, and is so little understood, that the Bank Group suggests that it should be the subject of a special comprehensive study to establish more accurately the sector's present status, and to provide a detailed basis for deciding the requirements for future development.

## CONCLUSIONS

(a) The Bank Group feels strongly that development requires the simultaneous improvement of farming practices and irrigation supplies. It also believes there has been a tendency to overstate the importance of further water development and understate the importance of improved farming, including the use of more and better inputs.

(b) Bank Group projections of fertilizer use are approximately double those of the consultants for the period up to 1975, reflecting the Bank Group's belief there is much scope for an increased use of agricultural inputs even under prevailing conditions of water supply.

(c) Improved seed material, particularly in wheat, cotton, and rice, constitute a second major agricultural input likely to have significant impact within the next decade. The Bank Group has projected somewhat lower rates of adoption than currently estimated by advisors to the Government, but realization of these more conservative projections would constitute a major advance for West Pakistan. The actual impact of improved seed varieties depends on complementary development in practices and institutions affecting seed distribution and use.

(d) Plant protection is not expected to improve as rapidly as fertilizer use and the introduction of improved seeds. The present program should be thoroughly evaluated, and steps taken to shift the major burden of this service from the extension personnel who now provide it.

(e) Mechanized cultivation should become more prevalent as timely land preparation becomes necessary under conditions of larger and more reliable water supply. Mechanization is more likely to be adopted on the larger farms than on the fragmented smaller farms, but contract service and cooperative use of machinery could help to bring some of the benefits to the smaller farms. Government should also initiate research on improved animal-drawn equipment and hand tools.

(f) The livestock sector is of such importance to agriculture, and yet is so little understood, that the Bank Group suggests that it be the subject of a special comprehensive study to establish the sector's present status more accurately, and to provide a basis for deciding the requirements for future development.

9.40 Institutions and Organizations. The implementation of the development program outlined herein requires an organizational structure capable of stimulating and serving the rapid growth which is envisaged. The development and expansion of such a structure is an extremely critical and difficult task to which the Government should give immediate and careful attention. The Bank Group does feel, however, that for some time to come any further major changes in the pattern of organization should be avoided as far as possible. Emphasis should be on adjustment and improving coordination, rather than further radical change. A second observation is that, to the extent practicable, the private sector should be given maximum opportunity to participate. Aside from these general points, the Bank Group noted a number of areas of special concern:

(a) Because the services offered by line departments are complementary, coordination is required to ensure that the advice and services provided to farmers are in keeping with development objectives, and that supplies are available in the right quantities and at the right time.

(b) There is need for more effective coordination between governmental bodies responsible for planning and implementation of projects in order to avoid duplication of effort, and to afford full opportunity to departments and agencies to make their appropriate contributions to the development effort on a continuous basis. The Planning and Development Department appears to be the logical body to exercise the coordinating function for both planning and service objectives.

(c) A Provincial Irrigation Authority is required to make basic policy decisions on barrage installations, dam release patterns, basin-wide water allocations, seasonal distribution, and tubewell pumping policies with reference to both water and power considerations. It should be constituted at the highest level to take fully into account the range of administrative, legal, sociological, and technical considerations related to water resource policy.

(d) As mentioned before, the Bank Group feels strongly that the success of the water resource development program depends on emphasis going equally to efficient water use and to better farming practices and the use of more material inputs. Creating the environment which generates this dual emphasis would be a most demanding task, and would call for a high degree of close cooperation and overall direction. The Bank Group therefore favors the retention of an integrated project management approach during the development period of projects, despite the difficulties this might entail in relation to divided responsibility for surface and groundwater supplies. In keeping with its belief that further radical reorganization may be counterproductive, the Bank Group feels that there are existing project management institutions, such as the Agricultural Development Corporation and the Land and Water Development Board, which could be strengthened, improved, and initially could serve the institutional needs of project areas. When the major changes associated with the project have been accomplished, the project management would withdraw in favor of a more representative body and the line departments would resume their normal functions in the area. The Bank Group strongly endorses the IACA suggestion that project management should include provision for continuous monitoring of progress in project areas, starting with the construction phase when benchmark data representing pre-project conditions could be gathered. Such monitoring should pay particular attention to the hazards of salinity and alkalinity.

(e) Shortages of engineering personnel, relative to the needs of the water resource development program, are likely to continue for the foreseeable future. Efforts should be made to provide new graduates with further advanced training on-the-job, and to also train promising young men without formal engineering education for appropriate supervisory positions, again while on-the-job. The prospects for training adequate numbers of agricultural personnel for program needs are somewhat better, but the quality of instruction should be improved. As a general rule, the Bank Group feels it may be more strategic in the short run to concentrate on improving the quality of agricultural personnel than to become too preoccupied with a rapid expansion of numbers.

(f) It is difficult to foresee substantial improvement in the agricultural sector without a dynamic research program to deal with such matters as continuing varietal improvement, more efficient treatment of insect infestation and plant disease, and better understanding of soil, crop, water, and fertilizer relationships. Building an efficient and contributing research branch requires dedicated leadership, generous financial support, understanding of the role of research, and the infusion of a spirit of service to the agricultural community. Without these elements, research is likely to remain mechanistic and unimaginative, isolated from its constituency, and therefore largely unproductive.

(g) It seems unlikely that West Pakistan can induce a rapid and widespread adoption of a variety of new agricultural inputs and improved farming practices without an informed and active extension service to conduct the necessary educational programs. The extension services need drastic improvement. Training, noted above, is part of this process, but this branch has suffered from its inability to attract and hold highly qualified personnel. Better career opportunities in agriculture, involving more status, better pay, better working conditions, and improved means for carrying out responsibilities appear to be part of the requirements. Quantitative and qualitative improvement of the extension services is thus a critical link in the success of the program, and the measures adopted to bring about such improvement cannot be partial or half-hearted.

(h) The potential contribution from the private sector should be drawn into participation in agricultural development. Encouragement of private tubewell installation has been discussed in earlier sections, and the dependence of the program on private tubewell water has been noted. With adequate safeguards to ensure high quality performance, the private sector could also participate in the provision of material inputs of various kinds, including fertilizers, farm machinery, improved seeds, and plant protection. Government would continue to assume the major role in research and extension, and would maintain a supervisory role with respect to the quality of inputs offered to farmers and the advice on their use which accompanied sale by private agencies. While the Bank Group thus takes the view that maximum encouragement and opportunity should be given to private sector participation, the timely provision of adequate inputs at incentive prices remains the primary objective at this time.

(i) An effective credit system for the direct benefit of primary producers has yet to be developed. Credit tends to gravitate towards the more well-to-do elements in the community and to be virtually denied to the majority of farmers who operate the smallest-scale farms. The cooperative credit movement has become largely ineffective at the level of the primary society which deals with the farmers. The growing commercialization of agriculture, implicit in the development program, requires better credit facilities and a change in the attitude of farmers towards credit itself. But better institutional credit arrangements alone may not provide a solution to the agricultural credit problem, and Government may have to actively promote a change in farmers' attitudes so that they see a clear distinction between agricultural credit for productive purposes and social credit for relief or domestic needs. The problem has been studied by the Credit Enquiry Commission, but it will take time to implement the recommendations.

## CONCLUSIONS

(a) The Bank Group feels that for some time to come major changes in institutions and patterns of organization should be avoided, and that greater efforts be made to improve the functioning of existing institutions.

(b) There is need for much more effective coordination of planning, operations, and services to agriculture, and the Planning and Development Department appears the logical body to exercise much of this function.

(c) A Provincial Irrigation Authority seems necessary to make basic policy decisions related to the evolving complex system of water supply.

(d) The Bank Group favors a closely integrated project management for public tubewell project areas.

(e) Agricultural development requires effective research and extension services, and this involves both enhancement of career opportunities and better training and equipment for the tasks assigned.

(f) Personnel shortages are likely to be most serious in the engineering field. These can be partially mitigated by expanded on-the-job training and by continued use of outside consultants.

(g) There is scope for much greater participation by the private sector in the supply, distribution, and handling of agricultural inputs, and gradual inclusion of the private sector in these activities should help to accelerate the rate of use by farmers.

(h) Lack of sufficient credit on reasonable terms could act as a curb on agricultural growth, but it would take considerable time to implement the recommendations for change and improvement which have already been advanced by the Credit Enquiry Commission.

9.41 Financial Requirements. Estimates have been made of the financial requirements of the Action Program, for both public and private sector expenditures, over the Third and Fourth Plan periods (1965-75). Excluding Tarbela, the requirements for the Third Plan period appear to fall within the original Plan allocation for the water sector, although some redistribution of the allocation of funds within the sector would be necessary. Similarly, the public sector expenditures on agriculture could be accommodated within the original Third Plan allocation to the agricultural sector. Government estimates of Fourth Plan allocations have not yet been drawn up, and the expenditure estimates used by the Bank Group are extremely tentative because the actual Fourth Plan requirements would depend on progress made during the preceding Plan period. Nevertheless, the orders of magnitude of expenditures, again exclusive of Tarbela, are comparable to the amounts which have been allocated in the Third Plan, and therefore appear to be within reasonable expectations of the resources likely to be available.

9.42 Government allocated Rs. 2,662 million to the water sector for the Third Five-Year Plan (1965-70). 1/ The water resource portion of the Action Program outlined above, not including works associated with the Indus Basin treaty or Tarbela Dam, would cost Rs. 2,441 million. The major redistribution of expenditures called for within the water sector includes a reduction in the on-going public tubewell program relative to the earlier scheduling by WAPDA, and an increase in expenditures for surface drainage. The latter item would reflect a start on construction of the Indus Left Bank Outfall drain, which was not included in Third Plan projections. The Action Program also calls for pilot tile drainage projects, but this is a relatively small addition to the original Third Plan estimates.

9.43 The start of work on Tarbela Dam during the Third Plan period would add Rs. 1,414 million to the water sector total, bringing the full expenditure for the Action Program to Rs. 3,855 million. This is nearly 45 percent larger than the original Third Plan sectoral allocation, and is a reflection of the financial impact of Tarbela -- more than one-third the total cost of the Action Program for the Third Plan period.

9.44 Estimated water sector expenditures for the Fourth Plan period (1970-75), excluding Tarbela, are Rs. 2,736 million. The comparison with the Third Plan costs for the same portion of the water sector shows that expenditures are expected to rise by only three percent. The completion of Tarbela by 1975 would again be the major single item. This has been estimated at Rs. 2,789 million for the Fourth Plan period. Together with the rest of the water sector, total expenditures would thus be Rs. 5,525 million. Of this total, Tarbela alone would cost approximately one-half. Five public tubewell schemes under the Action Program and some Tarbela expenditures would continue into the Fifth Plan period, bringing a commitment of about Rs. 130 million as a carryover from the Action Program period. Third Plan allocations and estimated expenditures for both Plan periods are shown in the next table.

9.45 The foreign exchange component can be estimated in only an indicative way. Tubewells, surface irrigation, drainage and flood protection could involve a foreign exchange cost of about Rs. 4,150 million (equivalent to US$ 874 million) over the period 1965/66 to 1974/75. Investigations could require an additional Rs. 200-250 million (equivalent to US$ 42-53 million) in foreign exchange. Total foreign exchange requirements for the Action Program might thus be about Rs. 4,400 million (equivalent to US$ 927 million), from which would be deducted the foreign exchange component of the overrun of the Action Program into the Fifth Plan period, or about Rs. 75 million.

1/ Government of Pakistan, Third Five-Year Plan, May 1965. A subsequent revision of December 1966 reduced this total to Rs. 2,180 million.

Comparison of Public Investment
Requirements for Water Development

| | Third Plan Period | | Fourth Plan Period | |
|---|---|---|---|---|
| | Plan Allo-cation 1/ | Action Program | Plan Allo-cation | Action Program |
| | (Rs. Million) | | | |
| Public Tubewells | 1,389 | 1,044 | n.a. | 1,339 |
| Surface Irrigation | 793 | 705 | n.a. | 352 |
| Surface Drainage | 195 | 363 | n.a. | 516 |
| Tile Drainage | - | 39 | n.a. | 184 |
| Flood Protection | 73 | 74 | n.a. | 75 |
| Investigations | 187 | 191 | n.a. | 240 |
| Miscellaneous | 25 | 25 | n.a. | 30 |
| Subtotal | 2,662 | 2,441 | | 2,736 |
| Tarbela | 1,414 | 1,414 | n.a. | 2,789 |
| TOTAL | 4,076 | 3,855 | | 5,525 |

1/ May 1965.

9.46 The estimates of private sector investment in water resource development include private tubewells and (in the Fourth Plan period) on-farm costs for drainage carried out by farmers in conjunction with the Sukh Beas drainage scheme. The estimates for private tubewell installation are based on the numbers of wells projected under the Action Program, which takes into account the deferment of some public tubewell projects. It also allows for some increase in the cost of private well construction. Expenditures on private wells have been projected at Rs. 428 million during the Third Plan period and Rs. 334 million in the Fourth Plan period. Expenditures for drainage have been estimated at Rs. 13 million in the Fourth Plan period. These are quite tentative, especially for the Fourth Plan period, because any shortfall in the public tubewell program would tend to raise the private sector estimates. Further, the rate of installation in non-commanded areas is unpredictable, and may well be substantially above the numbers which have been projected.

9.47 Plan allocations to the Agricultural sector in the Third Five-Year Plan place a heavy emphasis on promoting the use of agricultural inputs. About 40 percent of the allocation is for fertilizer subsidies, free plant protection service, and seed multiplication and distribution, of which fertilizer subsidies were the largest single item. An additional

20 percent was allocated for extension, research, mechanization and soil conservation. The balance covered activities such as animal husbandry, range management, colonization, forestry, fisheries, cooperatives, and the Agricultural Development Bank. The total allocation for the Third Plan period was originally Rs. 2,554 million. Third Plan allocations, and estimated expenditures for both Plan periods, are shown in the following table.

Comparison of Public Investment
Requirements for Agricultural Development

| | Third Plan Period | | | Fourth Plan Period | |
|---|---|---|---|---|---|
| | Plan Allo- cation 1/ | | Action Program | Plan Allo- cation | Action Program |
| | (Rs. Million) | | | | |
| Fertilizer Subsidies | 678 | (395) | 500 | n.a. | 700 |
| Plant Protection Subsidies | 300 | (184) | 300 | n.a. | 500 |
| Extension & Research | 182 | ( 49) | 180 | n.a. | 260 |
| Mechanization | 214 | (123) | 214 | n.a. ) | |
| Soil Conservation | 105 | ( 95) | 105 | n.a. ) | |
| Animal Husbandry | 112 | ( 90) | 112 | n.a. ) | 2,835 |
| Colonization | 117 | ( 94) | 117 | n.a. ) | |
| Forestry & Fisheries | 304 | (171) | 304 | n.a. ) | |
| Others | 364 | (363) | 364 | n.a. ) | |
| Subtotal | 2,376 | | 2,196 | | 4,295 |
| Capital Liability 2/ | 178 | ( 58) | 178 | n.a. | 350 |
| TOTAL: | 2,554 | | 2,374 | | 4,645 |

1/ May 1965. Figures in parentheses are from the revision of Dec. 1966, but the revision, as made available, did not provide any provincial breakdown of Central Government allocations. The figures shown in parentheses thus represent the Provincial allocations only.
2/ On Government Account: Cooperatives, ADB, Taccavi Loans.

9.48 The Bank Group has assumed that the rate of subsidy on fertilizer use (approximately 30 percent) would be lower than the rate in effect at the time the Plan was drawn up. For the Fourth Plan period, the Bank Group has raised the allocations for fertilizer subsidies and plant protection in accordance with its expectations relative to increasing use of inputs other than water. There should be increasing participation by the private sector in plant protection activities, but this would be a slow process and not likely to materially relieve the public sector of expenditures on this account during the Fourth Plan period.

9.49 The Bank Group program results in a reduction from the original Third Plan allocation to the agricultural sector of Rs. 2,554 million to Rs. 2,374 million, or about seven percent. Fourth Plan estimates tentatively total Rs. 4,645 million, or about 82 percent more than allocated by Government to the agricultural sector under the Third Plan. Foreign exchange requirements for the Third Plan period have been estimated at Rs. 378 million, or about 20 percent of the total. Despite rising use of inputs, the foreign exchange needs for fertilizer and mechanization should not increase substantially during the Fourth Plan period because there would be increasing local capacity to produce these items. The Bank Group has therefore assumed that foreign exchange requirements would remain at about the present level, or at approximately Rs. 400 million for the Plan period. For the Action Program period as a whole, the foreign exchange costs for agricultural development would be Rs. 778 million, or the equivalent of US$ 163 million.

9.50 The private sector would continue to make investments in land development, improvements of irrigation facilities (other than tubewells), additions to farm buildings and implements, and increases in livestock herds. Recurrent production expenditures, such as for fertilizers, would be excluded from this category. On the basis of the limited information available for such private expenditures, the projections show a total of Rs. 1,900 million during the Third Plan period and Rs. 3,800 million during the Fourth Plan period. The total for the period covered by the Action Program would thus be Rs. 5,700 million. Assuming that 90 percent of such private investment occurs in the irrigated areas of the Indus Basin, this would represent investments of Rs. 11 per acre and Rs. 23 per acre for the two Plan periods respectively. This would be less than ten percent of the gross production value per acre of these lands, and therefore appears to lie within the realm of possibility. It should be emphasized, however, that these are extremely crude estimates of these kinds of private investment.

9.51 The total financial requirements for the Action Program, broken down by categories of water and agriculture, public and private, and the foreign exchange components are shown in the next table. It indicates that expenditures on the whole during the Fourth Plan period would go up by about 68 percent over those during the Third Plan period, and that there would be increasing emphasis on agricultural development expenditures in both public and private sectors. It also indicates that even in the Fourth Plan the public sector would have to provide financial support to the extent of more than 70 percent of the total requirements. While this appears necessary, it also illustrates an anticipated lack of incentives to invest in agriculture which may be compounded by the limited access to institutional credit facilities. Tentative estimates show that at least Rs. 1,000 million may move from the rural to the urban sector each year in West Pakistan, which is a measure of the relative attractiveness of consumption of non-agricultural investment compared to investment in agriculture itself. To the extent that agriculture is likely to continue as the main contributor to GNP for some time, it would be highly desirable to redirect this flow of funds, and eventually reach a position where the private sector

## Financial Requirements for the Action Program
## Irrigation and Agricultural Expenditures 1965-1975

| | Third Plan | | Fourth Plan | | Total | |
|---|---|---|---|---|---|---|
| | Expenditures | Foreign Exchange | Expenditures | Foreign Exchange | Expenditures | Foreign Exchange |
| | - - - - - - - - - - - - - -(Rs. Million) - - - - - - - - - - - - - - | | | | | |
| **Public Sector:** | | | | | | |
| Water Development | 3,855 | 1,700 | 5,525 | 2,450 | 9,380 | 4,150 |
| Agricultural Development | 2,374 | 380 | 4,645 | 400 | 7,019 | 780 |
| Subtotal | 6,229 | 2,080 | 10,170 | 2,850 | 16,399 | 4,930 |
| **Private Sector:** | | | | | | |
| Water Development | 428 | 70 | 321 | 50 | 749 | 120 |
| Agricultural Development | 1,900 | 270 | 3,800 | 1,000 | 5,700 | 1,270 |
| Subtotal | 2,328 | 340 | 4,121 | 1,050 | 6,447 | 1,390 |
| **Total:** | | | | | | |
| Water Development | 4,283 | 1,770 | 5,846 | 2,500 | 10,129 | 4,270 |
| Agricultural Development | 4,274 | 650 | 8,445 | 1,400 | 12,719 | 2,050 |
| TOTAL | 8,557 | 2,420 | 14,291 | 3,900 | 22,848 | 6,320 |
| US$ Equivalent (Mill.) @ Rs. 4.75 = US$ 1.00 | 1,801 | 510 | 3,023 | 824 | 4,825 | 1,334 |

would make a substantially larger contribution to capital formation in agriculture. In this context, private tubewells offer an area of opportunity in which private investment and private initiative should be encouraged to make the maximum contribution.

## CONCLUSIONS

(a) The financial requirements of the Action Program, excluding Tarbela, would appear to fall within the original allocations to the water and agricultural sectors for the Third Plan period. The subsequently revised allocations to the water sector are slightly below Action Program requirements, but revised allocations to the agricultural sector are considerably lower.

(b) The water sector portion of the Action Program, again excluding Tarbela, would require about the same financing in the Fourth Plan as in the Third Plan period. Expenditures in the agricultural sector would rise sharply, however, as a result of the expected increase in the use of agricultural inputs.

(c) The inclusion of Tarbela would increase the required allocation for the water sector by nearly 60 percent during the Third Plan, and would double the allocation for the Fourth Plan period.

(d) Anticipated private investments (other than in tubewells) would be Rs. 11 per acre and Rs. 23 per acre in the Third and Fourth Plan periods respectively. These would be less than ten percent of the gross production value per acre of the irrigated lands, and therefore the investments appear to be within the realm of possibility.

(e) Total expenditures for water and agriculture during the Fourth Plan period should exceed those for the Third Plan by nearly 70 percent, and in the Fourth Plan public sector expenditures would still provide more than 70 percent of total requirements.

(f) The foregoing expectation of continuing reliance on the public sector indicates a need for public policies which increase incentives to invest in agricultural development, and to reverse the apparent net flow of resources from agriculture to other sectors of the economy.

Agricultural Production

9.52 The Bank Group has attempted to estimate the agricultural production likely to result if the Action Program were implemented as scheduled, and if the longer term water resource development program were also carried out. These Bank Group estimates, differing somewhat from the IACA projections of production, reflect the major assumptions outlined under para 9.06 above, and in general anticipate large cropped acreages and greater use of non-water inputs in early years than IACA. This results in higher growth rates in the early years, but a smoother production path over the entire period of 35 years.

9.53 The Bank Group projections envisage a growth in Gross Value Added (GVA) in the agricultural sector of 4.5 percent per annum between 1965 and 1975, and a growth rate of GVA for the entire period, 1965-2000, of 4.2 percent per annum. This compares to a growth rate of 3.8 percent for the Second Plan period. Indices of GVA, total and per capita, are shown in the next figure. The growth rates measured in Gross Production Value (GPV) would be 5.2 percent per annum from 1965-75, and 4.5 percent per annum for the period 1965-2000. The GPV per cropped acre would rise three times or more in most parts of the Indus Basin, and in the canal commanded areas would reach an average of about Rs. 760 per cropped acre by the year 2000. In the early period of development, 1965-75, more than half the assumed increase in production would come from improved yields per acre. The relative importance of yields (compared with expansions in acreage) increases over time, until by 1985 improved yields become virtually the sole means by which further growth in production is achieved.

9.54 While the returns per cropped acre should rise on even the small holdings, the Action Program is not designed to cope with the problems of rural poverty which stem from the existence of numerous farmers with uneconomical small holdings and widespread underemployment. This type of rural poverty requires structural transformation, including the movement of population out of agriculture and into other occupations, as part of the long term solution.

9.55 The Bank Group projections show lower rates of growth after 1985 than before that date because of the declining contribution of acreage expansion, but this is not an implication that it considers a continuation of high rates of growth is impossible. It does mean that foreseeable growth after 1985, with techniques and inputs now known, would depend largely on improvements in yields alone, and these may be increasingly difficult to obtain once the levels projected for 1985 have been reached. On the other hand, advances in agricultural technology during the intervening years could open vast opportunities for increased production which are not now contemplated.

9.56 The Action Program was drawn up primarily on the basis of what is practically achievable and consistent with available resources. Production was projected independently of the assessment of likely future demands. Moreover, while prices of commodities were held constant so that the focus could remain on the technical aspects of development

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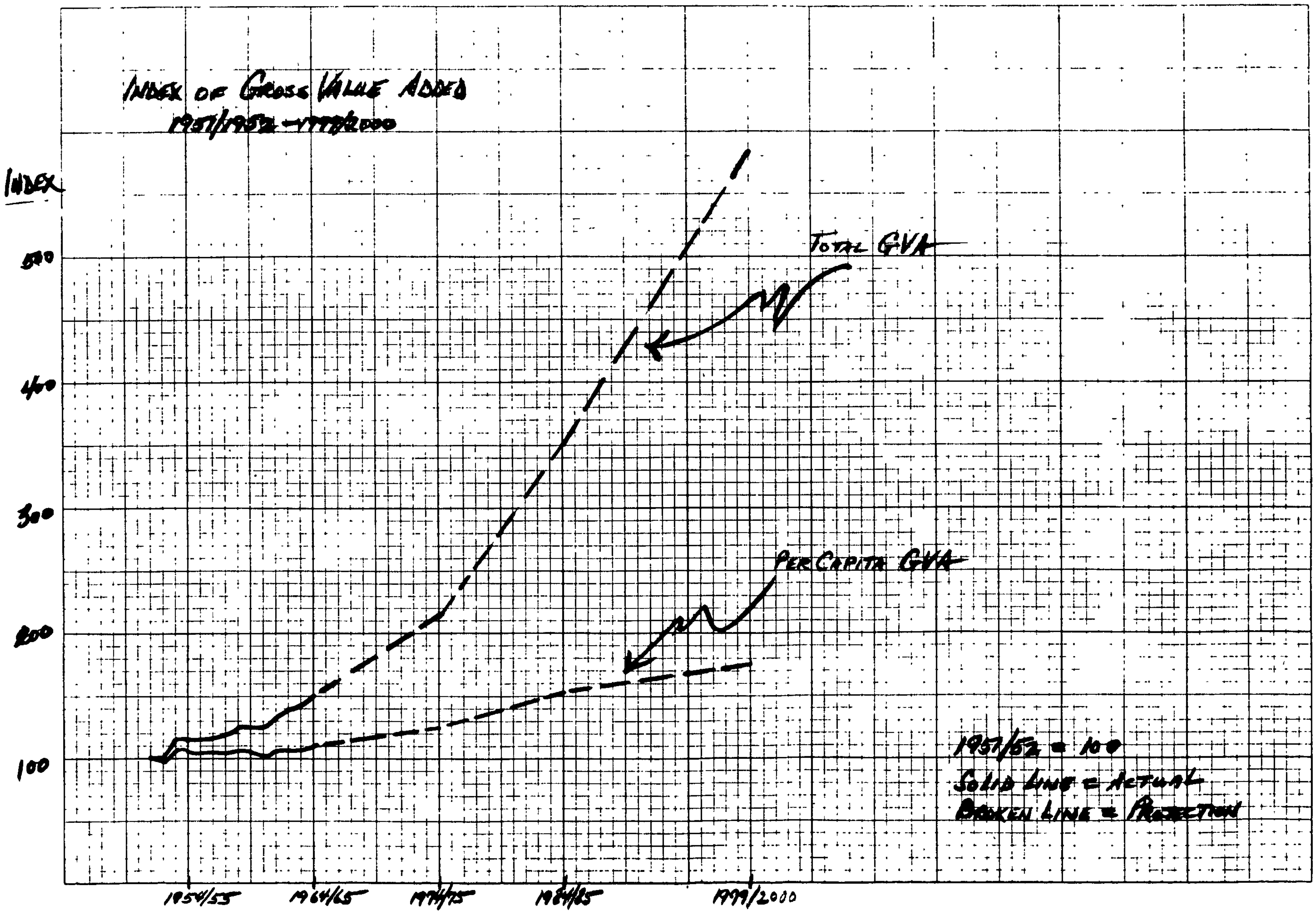


proposals, this also precluded shifts in production in response to changing market incentives. Although this approach to production thus evolved somewhat in isolation from demand considerations, a comparison was made against projections of future demand to determine whether the Program might meet West Pakistan's requirements.

9.57 As would be expected, supply and demand projections did not show a balance for each commodity. Demand was based on the assumed income (expenditure) elasticities for different commodities over time, a "high" population growth rate, and a growth in income (expenditure) consistent with the growth projected for the agricultural sector. While there was a surprising closeness of the projected supply and demand of some commodities, there were also deficits and surpluses in the different reference years.

9.58 The Bank Group concluded that the production and acreage which had been projected offer sufficient flexibility to adjust the surpluses and deficits. This adjustment could come about because acreage in surplus crops can, in many cases, be used for production of deficit crops within the same season and at about the same level of crop water requirements. The Bank Group is confident that adequate flexibility exists in the proposed program to allay fears over major shortfalls in foodgrain production, but would emphasize that Government price and marketing policies would have to be fashioned in ways which encourage the shifts in cropping patterns needed to eliminate surpluses and deficits. Such policies should permit price incentives to play a constructive role in allocating agricultural resources.

9.59 The achievement of the rates of growth of agricultural production contained in the Bank Group projections would represent a most commendable performance, although these rates are short of the targets contained in the Perspective Plan. Agriculture will continue to be the single most important sector in the West Pakistan economy for the foreseeable future, and the growth of the West Pakistan economy as a whole would therefore depend to a large extent on agriculture's performance. It is thus imperative that the agricultural sector receive the attention and support recommended throughout the Report. Although higher levels of production than projected by the Bank Group appear technically feasible, it is the Bank Group's opinion that within the given economic, social, and institutional environment, it would be unrealistic to expect growth of production considerably beyond that projected in the Report.

## CONCLUSIONS

(a) The Bank Group has projected an agricultural sectoral growth rate in Gross Value Added (GVA) of 4.5 percent per annum from 1965 to 1975, and an average 4.2 percent per annum for the period 1965-2000. This compares with a growth rate in GVA of 3.8 percent per annum over the Second Plan period.

(b) The Bank Group has projected a sectoral growth rate in Gross Production Value (GPV) of 5.2 percent per annum from 1965 to 1975, and 4.5 percent per annum for the period 1965-2000. The GPV per acre would increase by three times or more in most parts of the Indus Basin, and in canal commanded areas would reach Rs. 760 per acre by the year 2000.

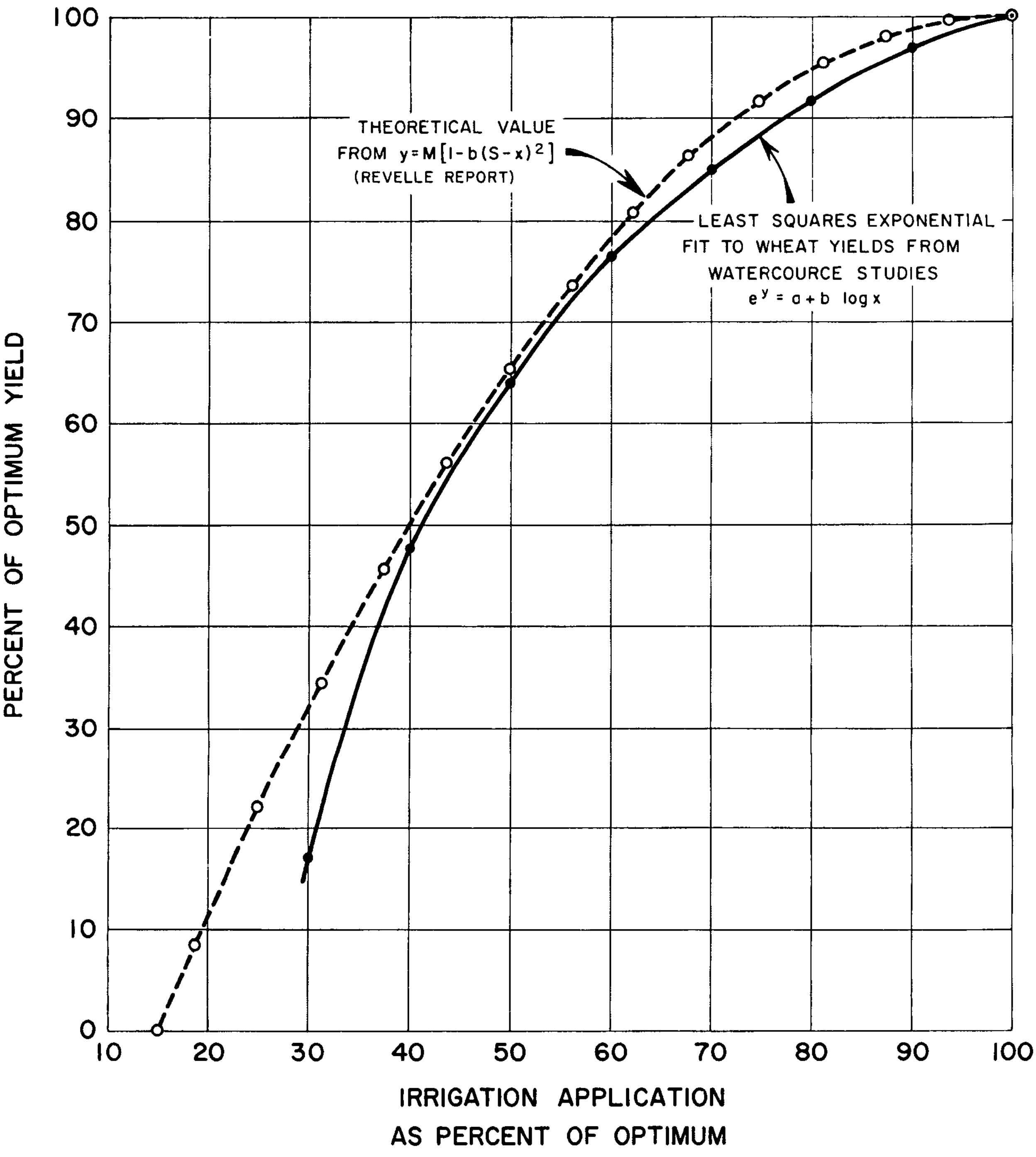
(c) More than half the assumed increase in production would come from improved yields, and improved yields would be virtually the sole means of production increase beyond 1985.

(d) The Action Program is not designed to cope effectively with the problem of rural poverty, which requires a structural transformation in West Pakistan's economy accompanied by a movement of population out of agriculture and into other occupations as part of the long run solution.

(e) Although supply and demand projections did not show balance in the reference years, the Bank Group believes that there is sufficient flexibility in the way the land and water resources can be used to meet future deficits, particularly in foodgrains. Adjusting to meet such possible deficits would require public policies which encourage the required shifts in resource use, including policies which permit price incentives to play a constructive role in allocating agricultural resources.

(f) Higher levels of production than projected by the Bank Group appear technically feasible, but it is the Bank Group's opinion that within the given economic, social, and institutional environment, it would be unrealistic to expect growth of production considerably beyond that projected in the Report.

# RELATIONSHIP BETWEEN YIELD AND IRRIGATION

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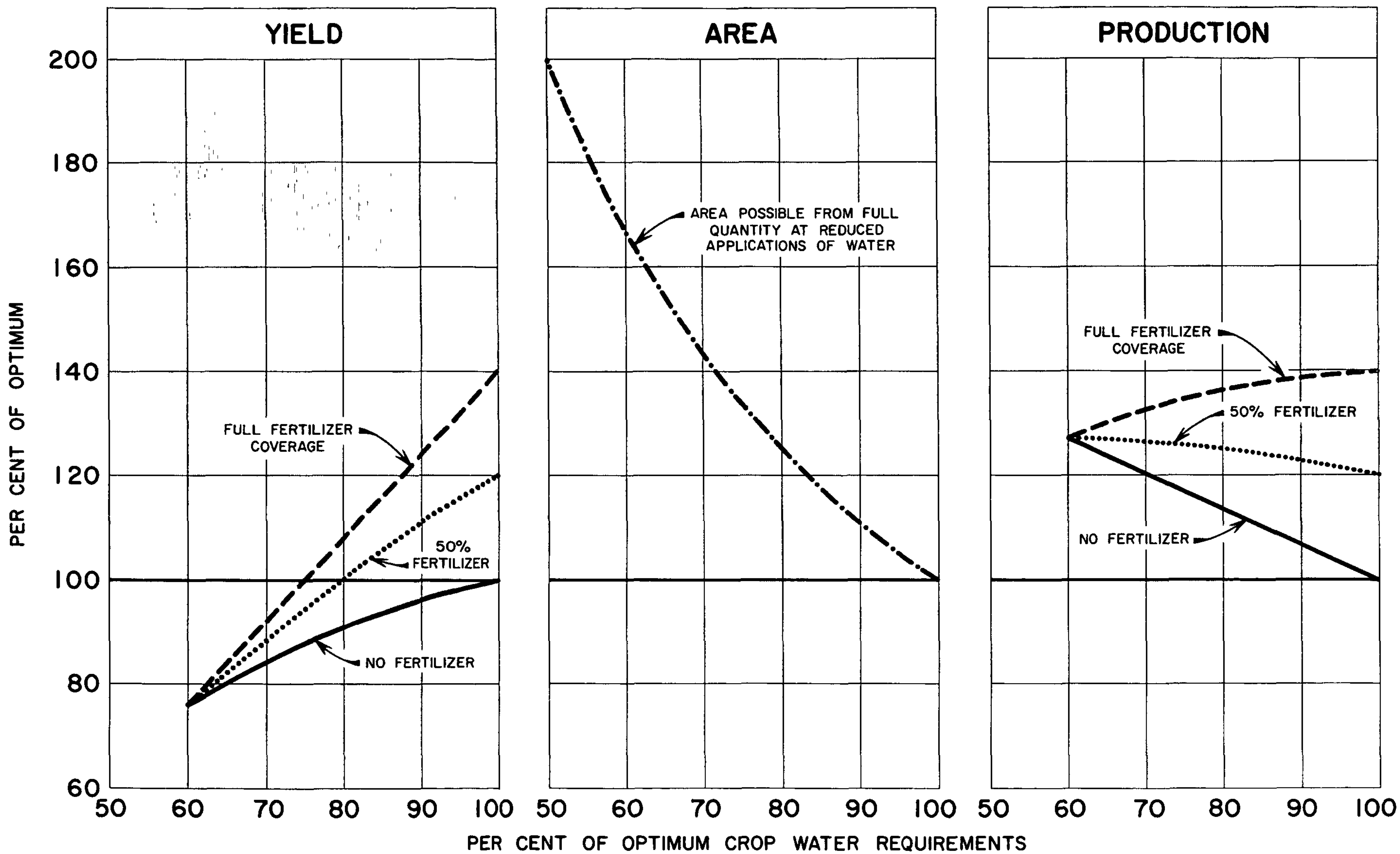
# PRODUCTION FROM A GIVEN QUANTITY OF WATER AT DIFFERENT LEVELS OF APPLICATION WITH AND WITHOUT FERTILIZER

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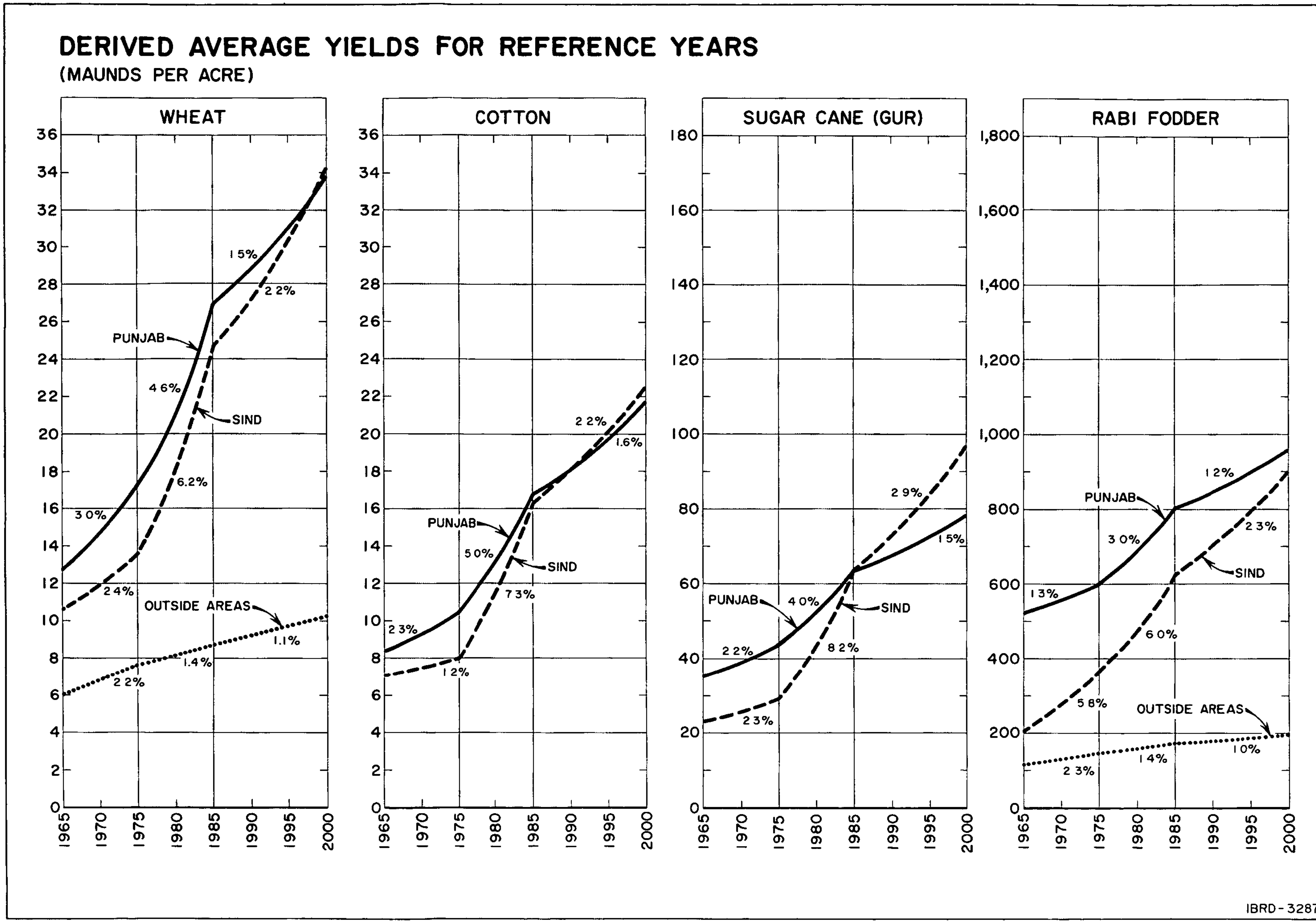
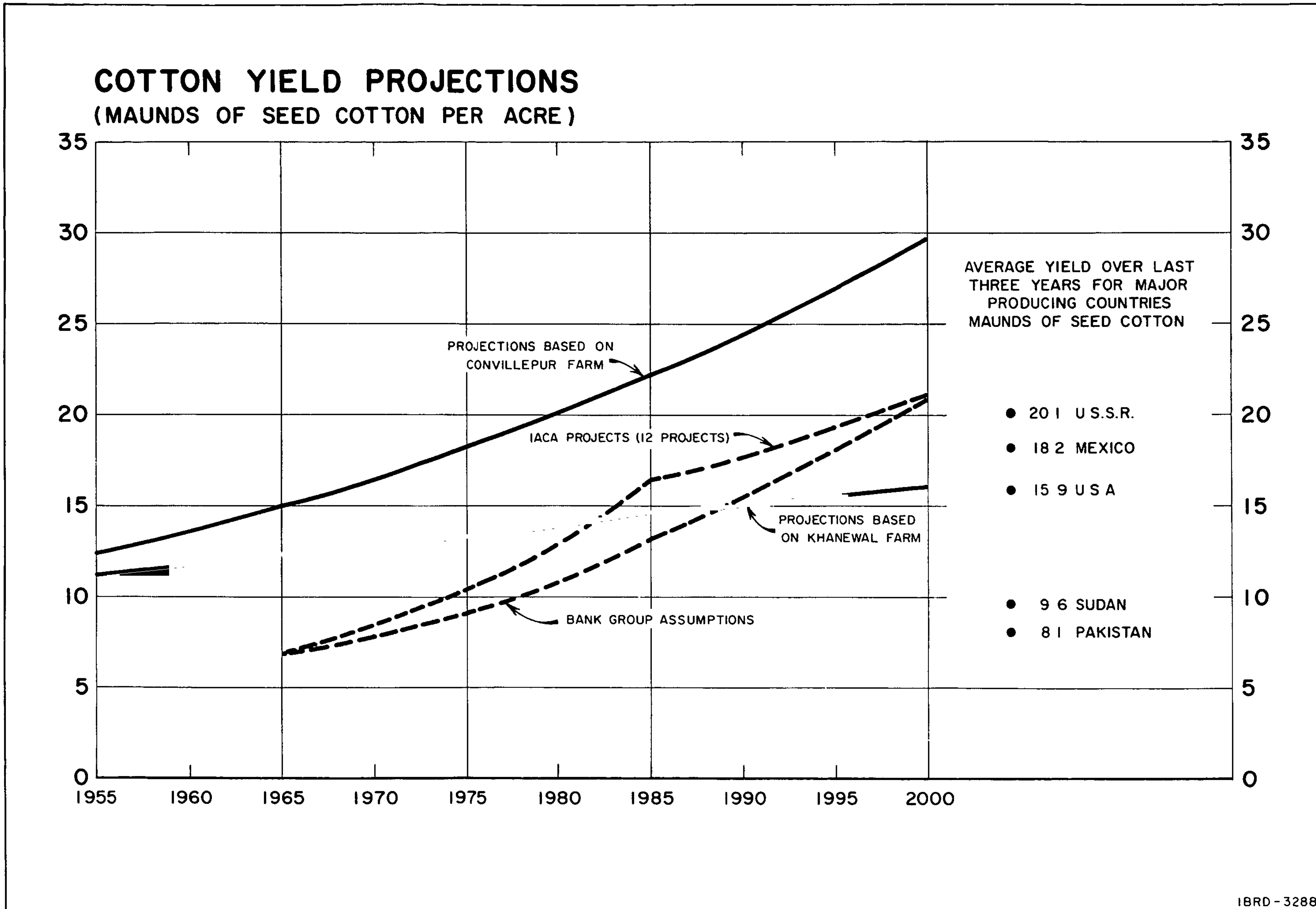
VOLUME II
FIGURE 22



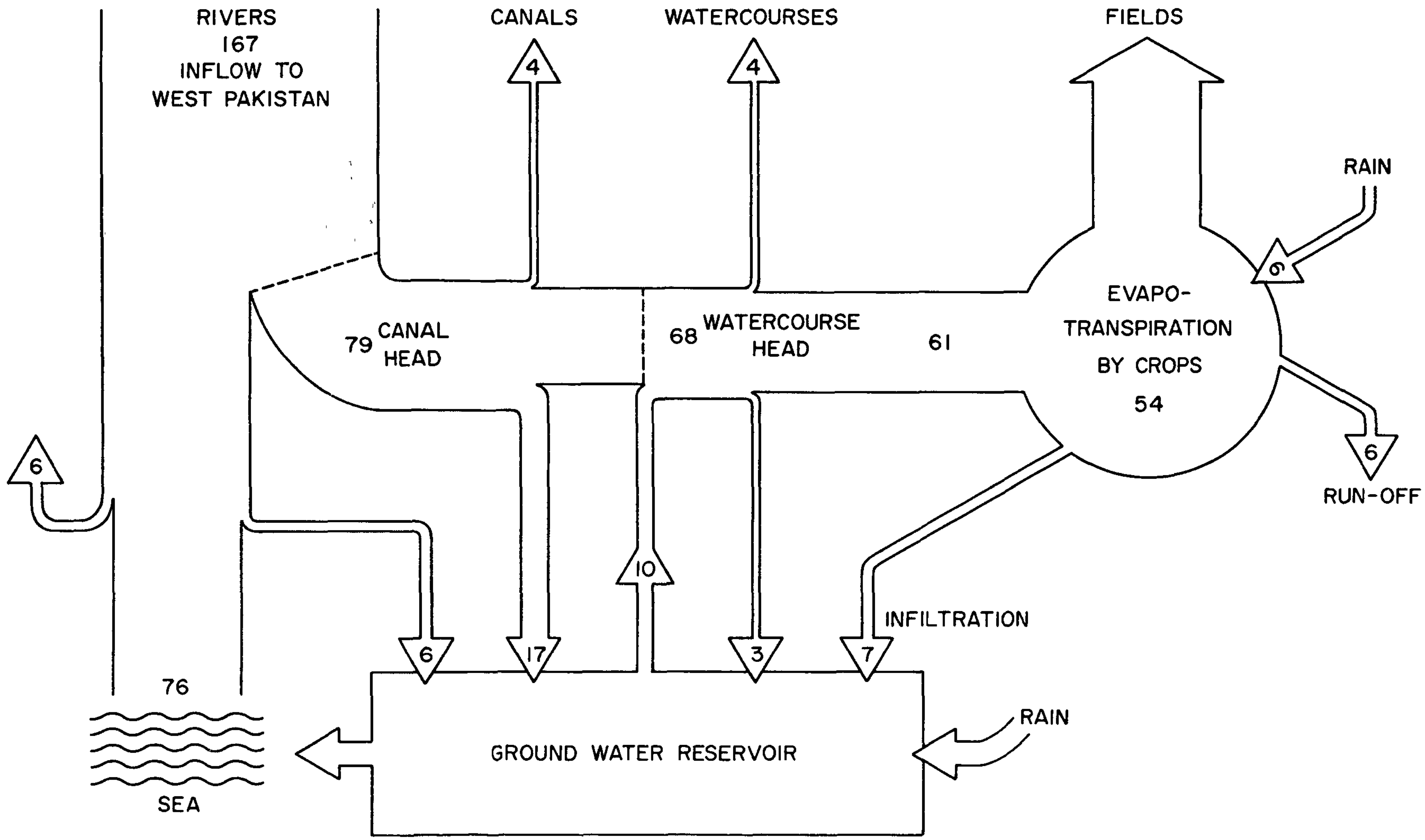

VOLUME II
FIGURE 2.3




VOLUME II
FIGURE 24

# PRESENT WATER BUDGET IN CANAL COMMANDED AREAS

(MILLIONS OF ACRE FEET PER ANNUM)

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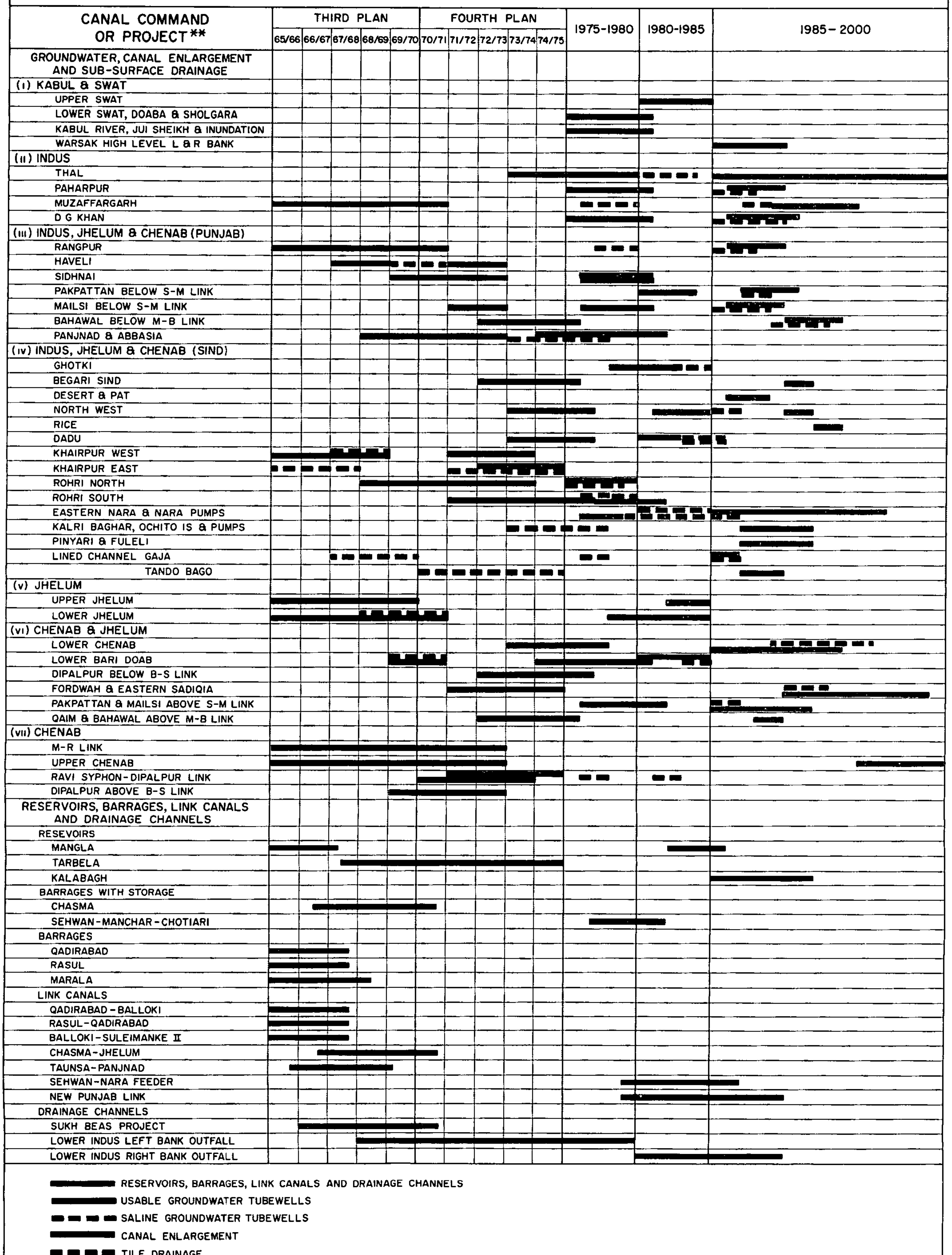
VOLUME II
FIGURE 31

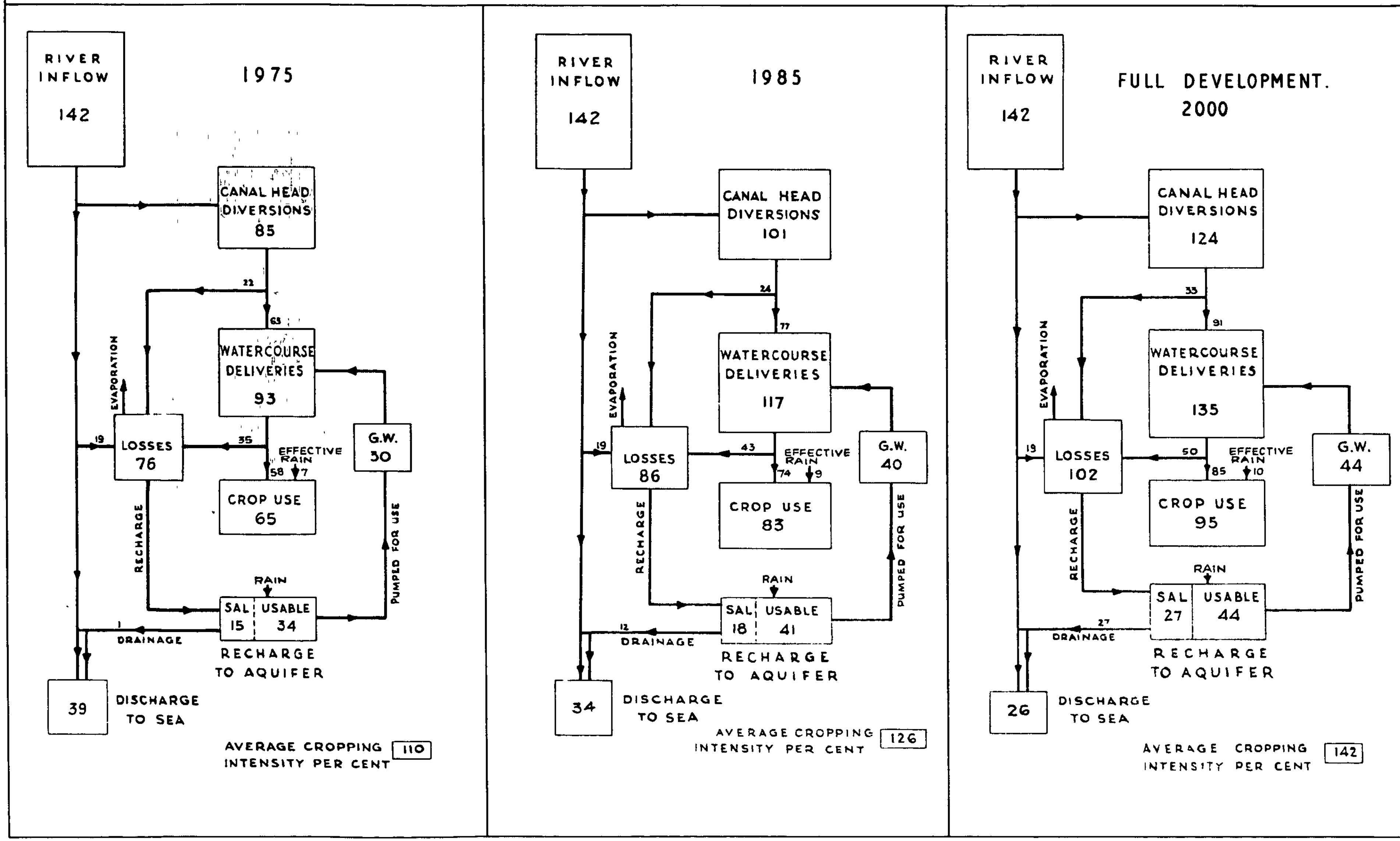
# REVISED* IACA PROGRAM FOR IRRIGATION DEVELOPMENT



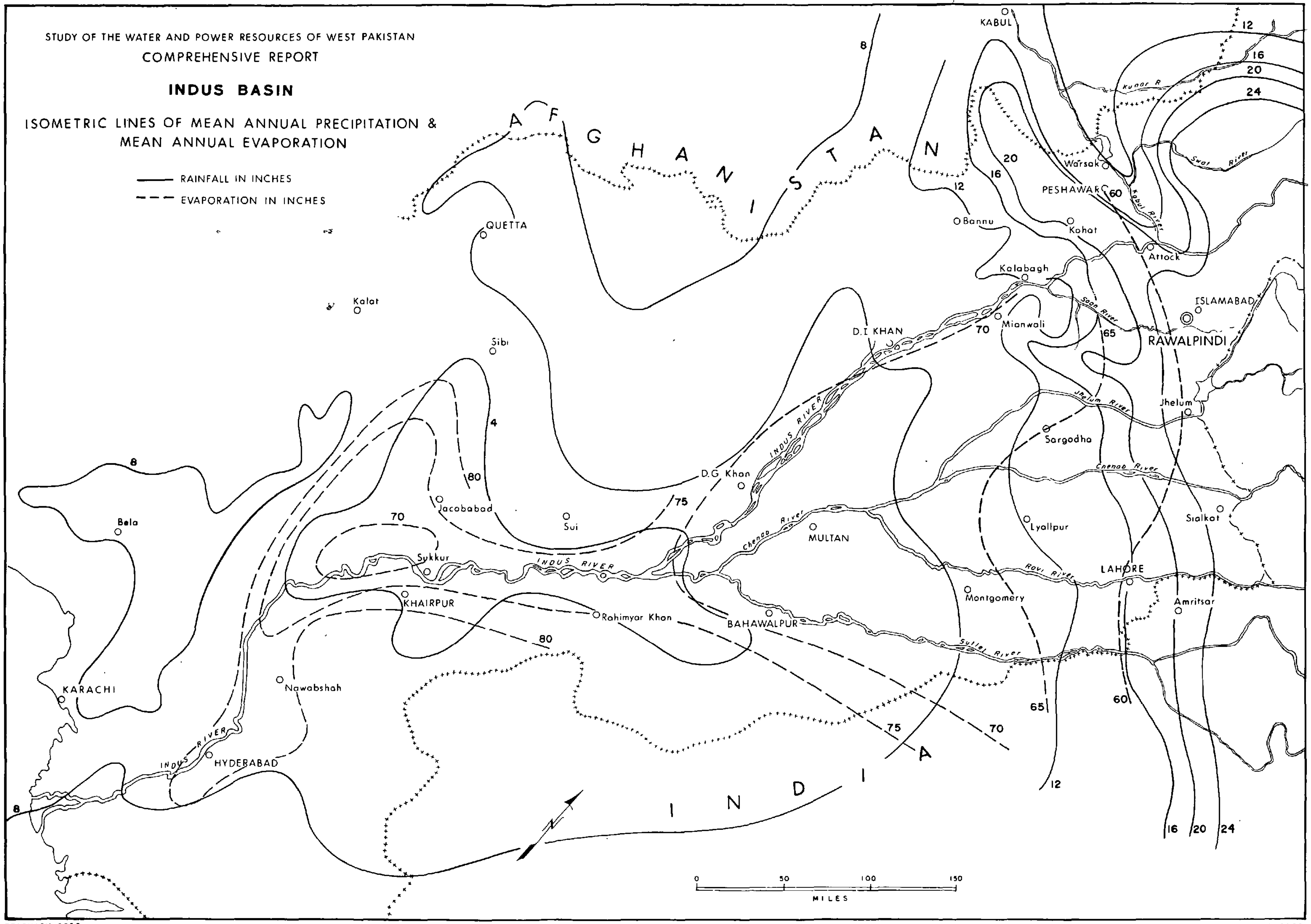

*MINOR REVISIONS MAINLY IN 1965/75 PERIOD - SEE CHAPTER IV **CANAL COMMANDS ARE GROUPED BY RIVER SOURCES

IBRD-3284

# PROJECTED WATER BUDGET IN CANAL COMMANDED AREAS
## MEAN CONDITIONS
(ALL QUANTITIES SHOWN ARE MAF)




VOLUME II
FIGURE 5.2

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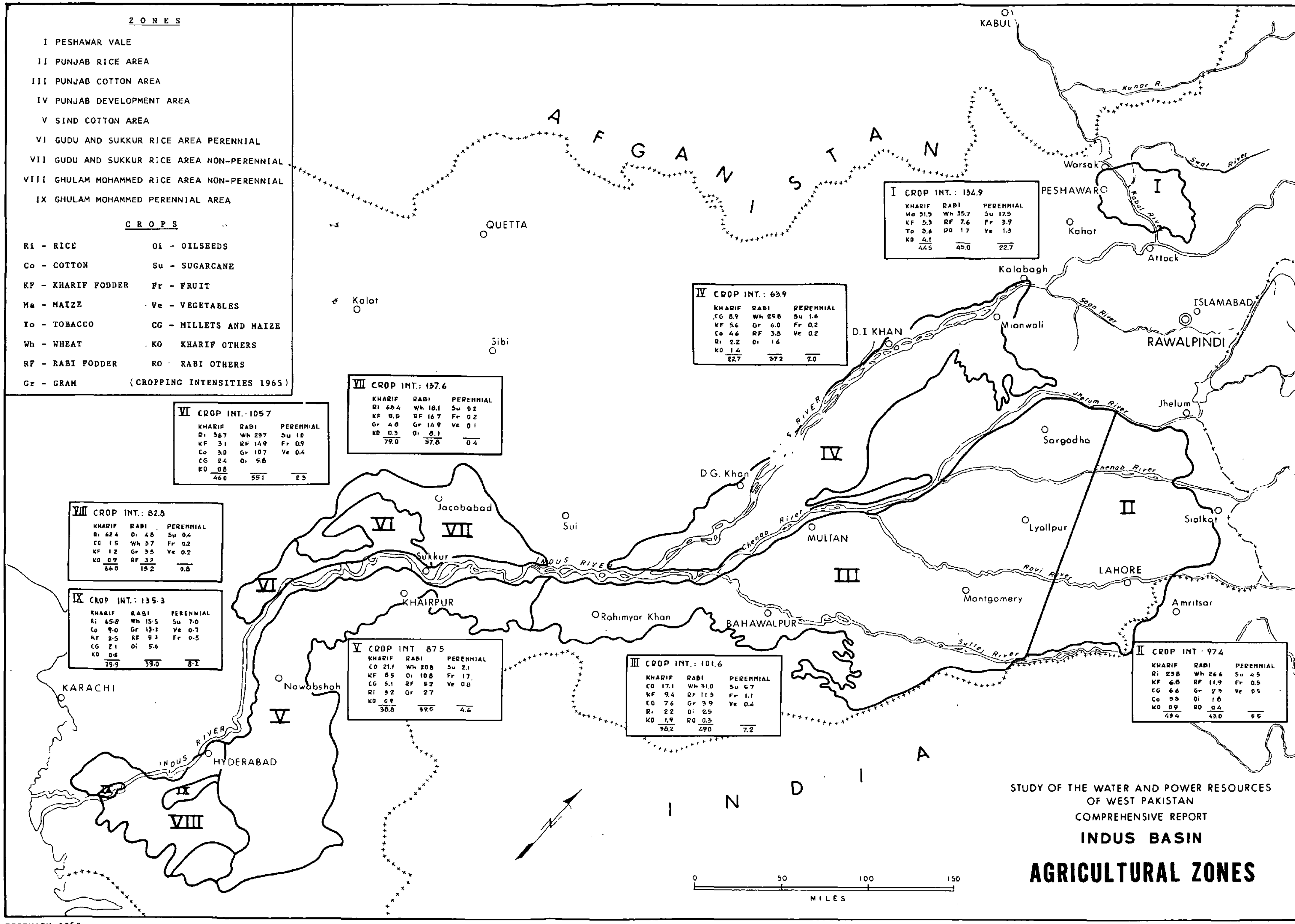
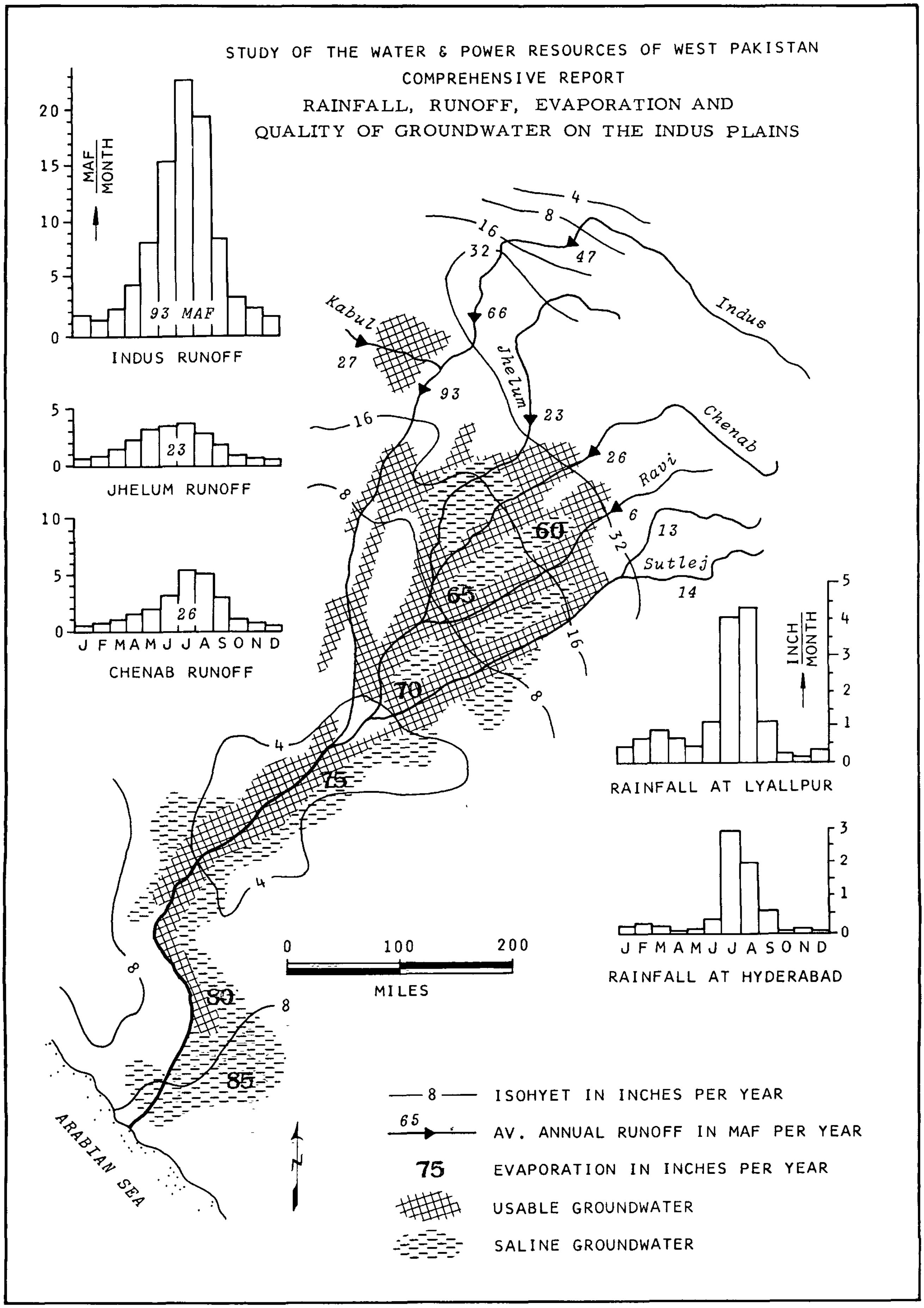
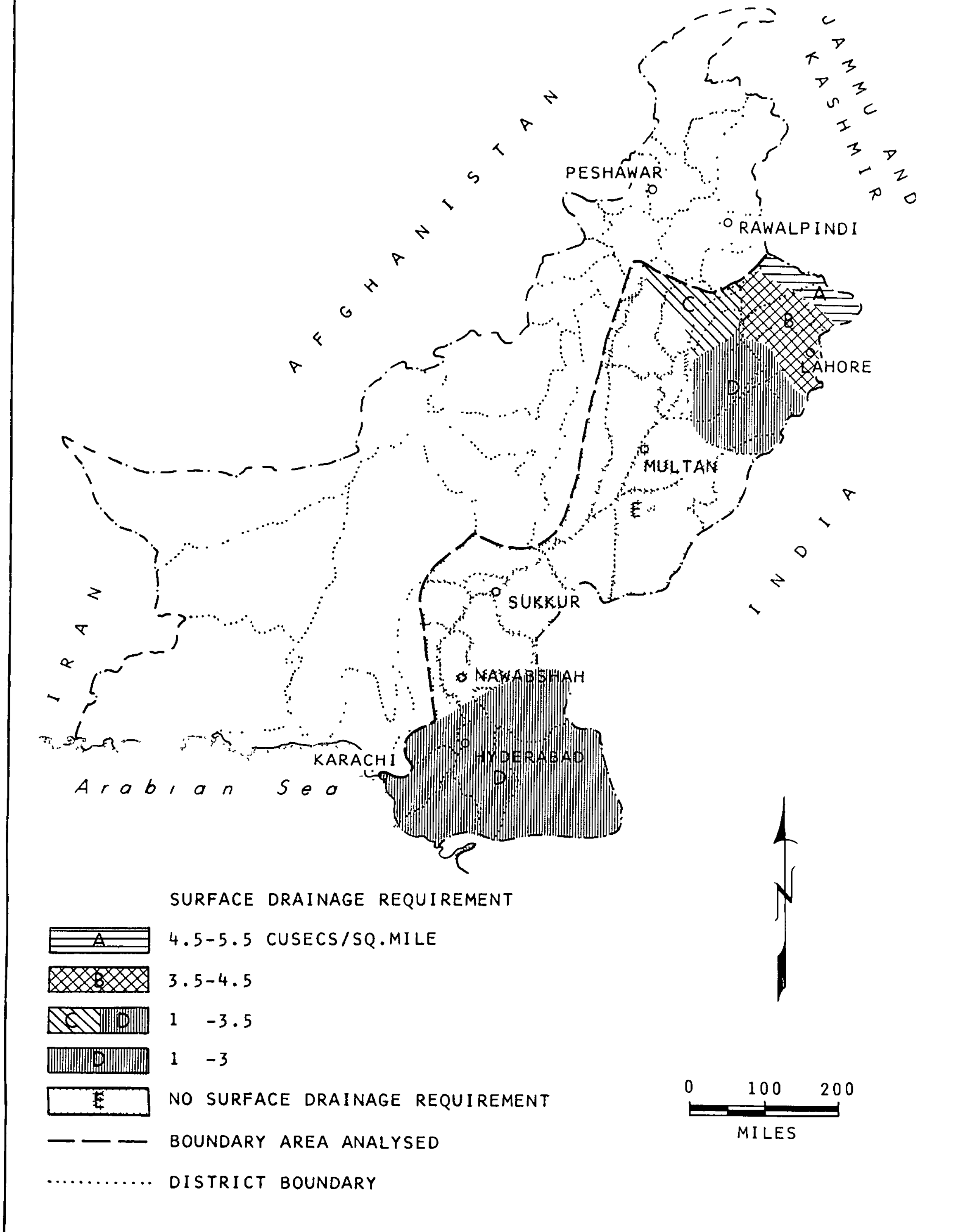

ZONES
I PESHAWAR VALE
II PUNJAB RICE AREA
III PUNJAB COTTON AREA
IV PUNJAB DEVELOPMENT AREA
V SIND COTTON AREA
VI GUDU AND SUKKUR RICE AREA PERENNIAL
VII GUDU AND SUKKUR RICE AREA NON-PERENNIAL
VIII GHULAM MOHAMMED RICE AREA NON-PERENNIAL
IX GHULAM MOHAMMED PERENNIAL AREA
CROPS
Ri - RICE
Co - COTTON
KF - KHARIF FODDER
Ma - MAIZE
To - TOBACCO
Wh - WHEAT
RF - RABI FODDER
Gr - GRAM
Oi - OILSEEDS
Su - SUGARCANE
Fr - FRUIT
Ve - VEGETABLES
CG - MILLETS AND MAIZE
KO KHARIF OTHERS
RO RABI OTHERS
(CROPPING INTENSITIES 1965)
I CROP INT.: 134.9
KHARIF Ma 51.5 KF 5.3 To 3.6 KO 4.1 44.5
RABI Wh 35.7 RF 7.6 RO 1.7 45.0
PERENNIAL Su 17.5 Fr 3.9 Ve 1.3 22.7
II CROP INT · 974
KHARIF Ri 238 KF 6.8 CG 66 Co 53 KO 09 494
RABI Wh 266 RF 11.9 Gr 23 Oi 18 RO 04 43.0
PERENNIAL Su 45 Fr 0.5 Ve 05 65
III CROP INT.: 101.6
KHARIF CO 17.1 KF 9.4 CG 76 Ri 22 KO 1.9 38.2
RABI Wh 31.0 RF 113 Gr 39 Oi 25 RO 0.3 490
PERENNIAL Su 67 Fr 1.1 Ve 0.4 7.2
IV CROP INT.: 63.9
KHARIF CG 8.9 KF 5.6 Co 46 Ri 2.2 KO 14 22.7
RABI Wh 25.8 Gr 6.0 RF 3.8 Oi 16 372
PERENNIAL Su 1.6 Fr 0.2 Ve 0.2 2.0
V CROP INT 875
KHARIF CO 21.1 KF 85 CG 5.1 Ri 32 KO 09 38.8
RABI Wh 208 Oi 108 RF 52 Gr 27 39.5
PERENNIAL Su 2.1 Fr 17 Ve 08 4.6
VI CROP INT. 1057
KHARIF Ri 367 KF 31 Co 3.0 CG 24 KO 08 460
RABI Wh 237 RF 149 Gr 107 Oi 5.8 551
PERENNIAL Su 10 Fr 0.9 Ve 0.4 23
VII CROP INT.: 137.6
KHARIF Ri 684 KF 9.5 Gr 48 KO 0.3 79.0
RABI Wh 18.1 RF 167 Gr 149 Oi 8.1 57.8
PERENNIAL Su 02 Fr 02 Ve 01 04
VIII CROP INT.: 82.8
KHARIF Ri 624 CG 15 KF 12 KO 09 660
RABI Oi 48 Wh 37 Gr 35 RF 32 152
PERENNIAL Su 0.4 Fr 0.2 Ve 0.2 0.8
IX CROP INT.: 135·3
KHARIF Ri 65·8 Co 9·0 KF 2·5 CG 21 KO 0·6 79·9
RABI Wh 15·5 Gr 13·2 RF 93 Oi 5·0 39·0
PERENNIAL Su 7·0 Ve 0·7 Fr 0·5 8·2
AFGANISTAN
INDIA
KABUL
Kunar R.
Swat River
Kabul River
Warsak
PESHAWAR
Kohat
Attock
QUETTA
Kalat
Sibi
Kalabagh
Mianwali
Soan River
ISLAMABAD
RAWALPINDI
D.I KHAN
D.G. Khan
Jhelum
Jhelum River
Chenab River
Sargodha
Sialkot
Lyallpur
MULTAN
LAHORE
Ravi River
Montgomery
Amritsar
Sutlej River
BAHAWALPUR
Rahimyar Khan
Jacobabad
Sui
Sukkur
INDUS RIVER
KHAIRPUR
Nawabshah
KARACHI
HYDERABAD
0 50 100 150
MILES
STUDY OF THE WATER AND POWER RESOURCES
OF WEST PAKISTAN
COMPREHENSIVE REPORT
INDUS BASIN
AGRICULTURAL ZONES

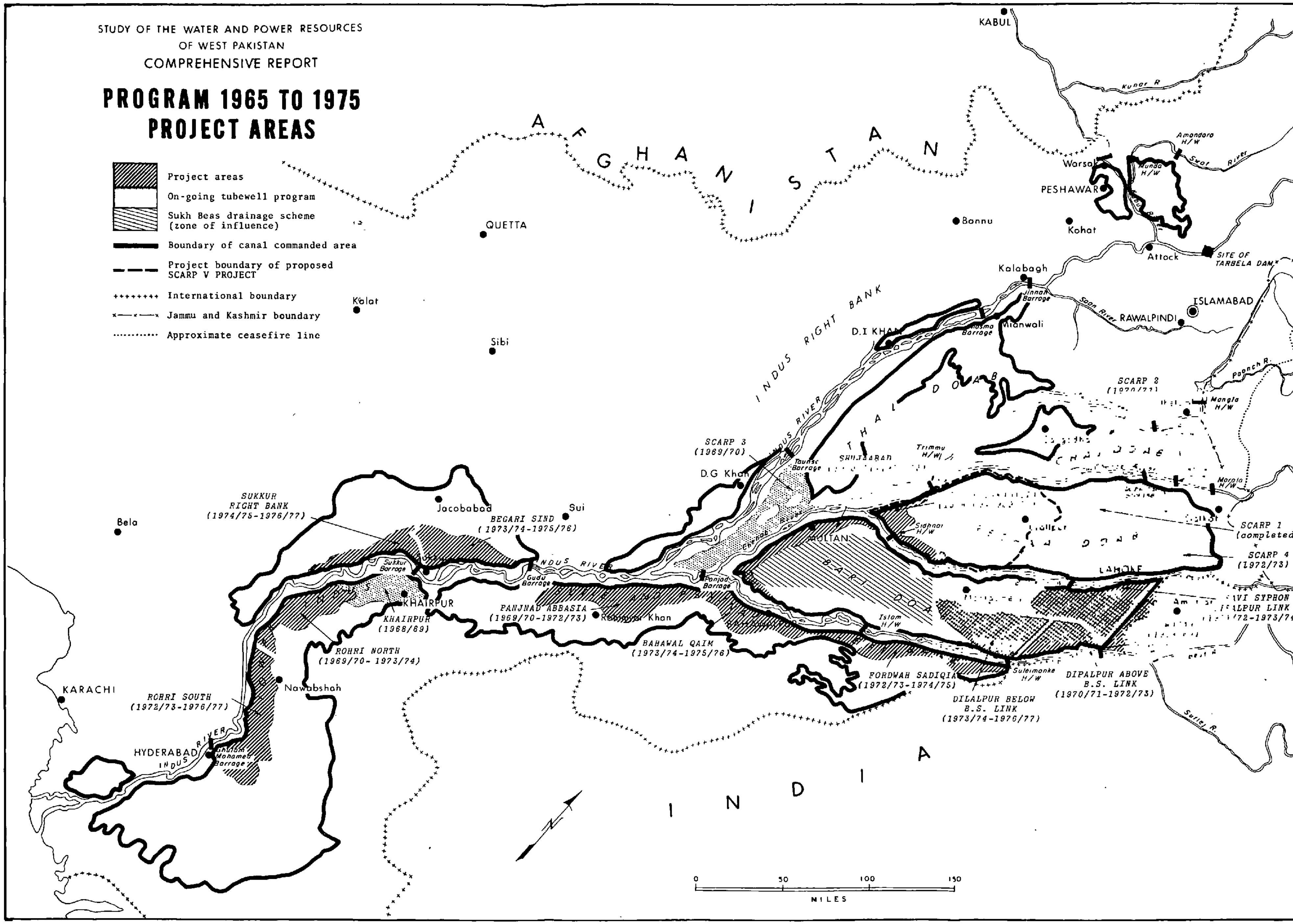


STUDY OF THE WATER & POWER RESOURCES OF WEST PAKISTAN
COMPREHENSIVE REPORT
RAINFALL, RUNOFF, EVAPORATION AND
QUALITY OF GROUNDWATER ON THE INDUS PLAINS
MAF / MONTH
93 MAF
INDUS RUNOFF
23
JHELUM RUNOFF
26
J F M A M J J A S O N D
CHENAB RUNOFF
INCH / MONTH
RAINFALL AT LYALLPUR
J F M A M J J A S O N D
RAINFALL AT HYDERABAD
Kabul
Indus
Jhelum
Chenab
Ravi
Sutlej
ARABIAN SEA
0 100 200
MILES
N
8 ISOHYET IN INCHES PER YEAR
65 AV. ANNUAL RUNOFF IN MAF PER YEAR
75 EVAPORATION IN INCHES PER YEAR
USABLE GROUNDWATER
SALINE GROUNDWATER

STUDY OF THE POWER AND WATER RESOURCES OF WEST PAKISTAN
COMPREHENSIVE REPORT

# SURFACE RUNOFF DISPOSAL REQUIREMENTS BY ZONES



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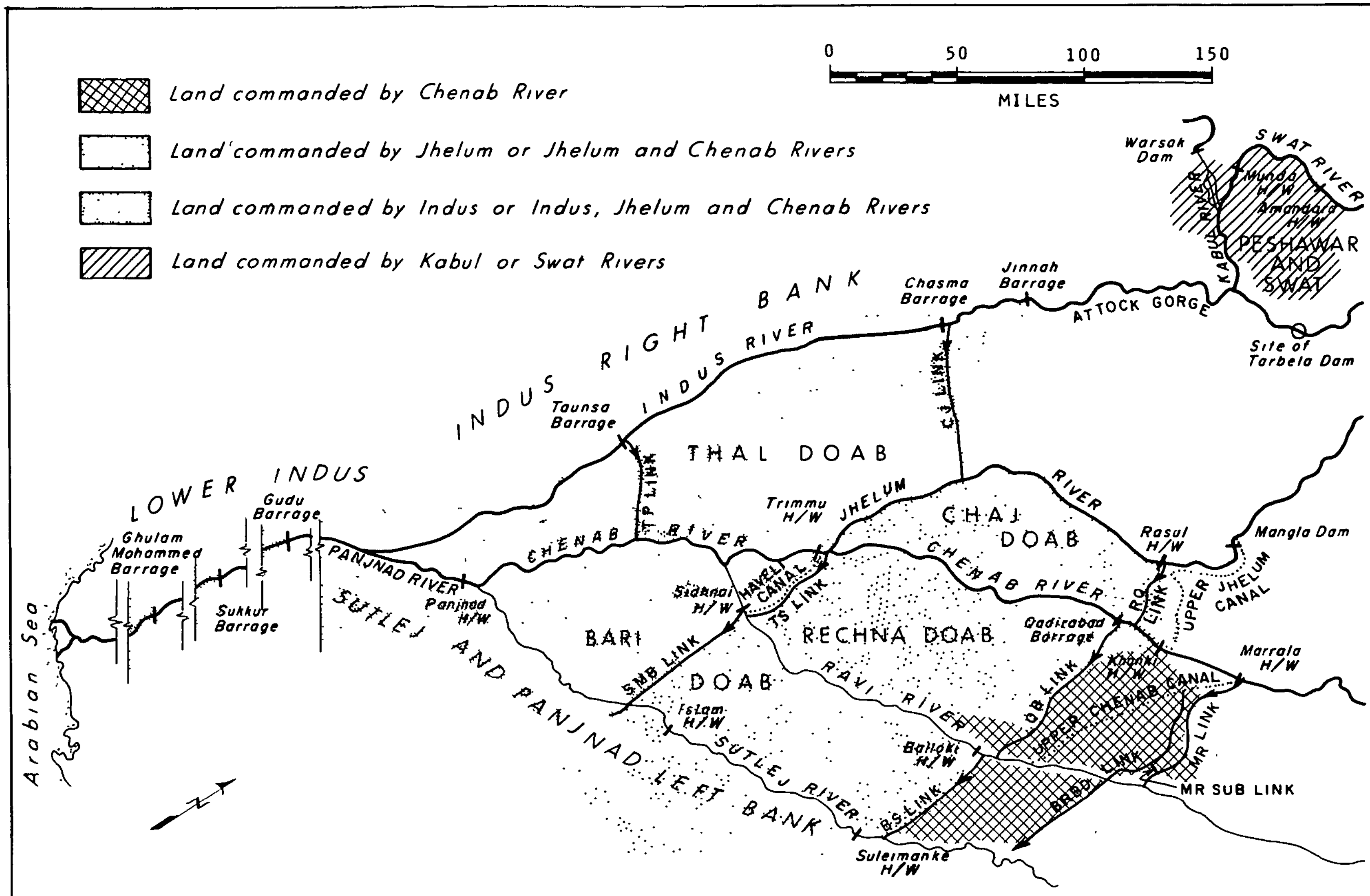


STUDY OF THE WATER AND POWER RESOURCES OF WEST PAKISTAN

COMPREHENSIVE REPORT

## RIVER AND LINK CANAL DISTRIBUTION SYSTEM

*1971 Situation (including I B P Links )*

VOL. II MAP 6

FEBRUARY 1967

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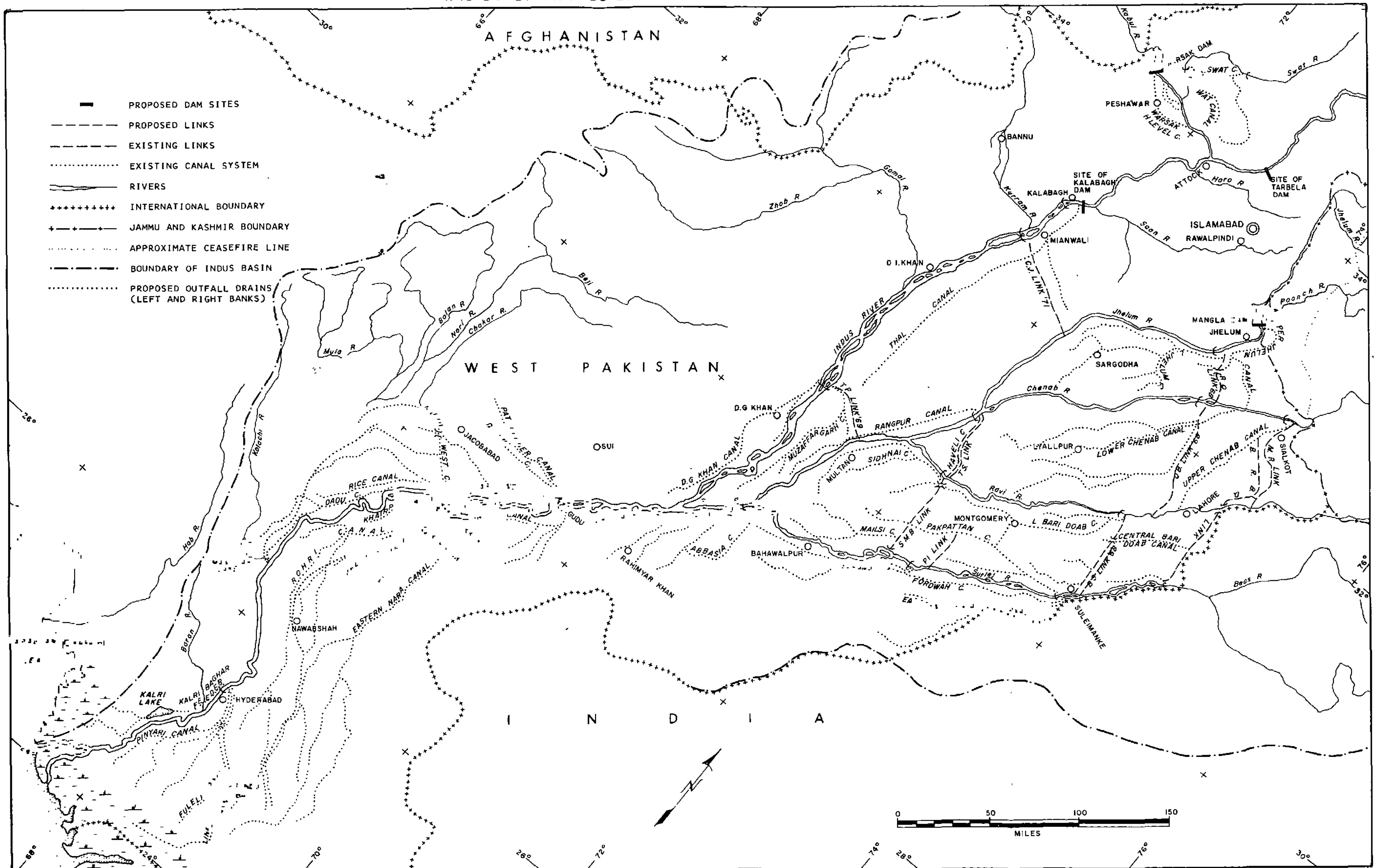
STUDY OF THE WATER AND POWER RESOURCES OF WEST PAKISTAN

COMPREHENSIVE REPORT

# INDUS BASIN - LOCATION OF CANALS AND LINKS

VOL. II MAP 7

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