described for the new areas, and a long-range, persistent, and orderly schedule of accomplishment, area by area, should reduce the 'tremendous' to the 'possible'. Improvement of cultivative practices and efficient drainage appear to be the most significant problems to be tackled. The former may be achieved through the extension of technical services to the cultivator. Efficient drainage should employ all possible means, such as ground-water pumping, construction of surface and sub-surface drains, reduction of the transmission and distribution losses, and improving the flexibility of water deliveries. Losses can be reduced over time by dividing up the system, determining areas of greatest loss, and applying measures to reduce the losses there first.

39. Co-ordinated measures for the recovery and dilution of drainage water, and of pumped ground water and the eventual regulation of the total surface supplies, are necessary for providing an assured water supply for intensive cultivation. Plans should be developed for the effective use of these supplies as they become available.

40. The productivity of the land influences the economic size of the farm unit. Water supply and its efficient use affect the productivity of the land. A rational solution of the problem of the size of tenancy holdings therefore depends, among other things, on improvements in the irrigation system. Hence, the evolution of logical plans and schedules for such improvements is urgent from this point of view also.

41. The reclamation of saline and waterlogged lands must be given an important place in the development of land and water resources. The present rate of deterioration of the soil demands that the problem of salt infestation and high water table should receive more attention than in the past. Millions of acres of land need reclamation. The resources of the country are, however, limited and demand the most careful use. At the same time, land cannot be allowed to remain unattended for too long because of the danger that its eventual reclamation would become uneconomical. Reclamation techniques should, therefore, be evolved for all categories of land. The priority of the areas to be reclaimed should be so fixed as to achieve the maximum efficiency. The reclamation measures, to be effective and permanent, should include (*a*) the provision of supplies for leaching out the accumulated salts, (*b*) adequate supplies to meet the consumptive use requirements, (*c*) additional water to maintain a continuous downward movement of salts, (*d*) suitable cropping patterns, and, above all, (*e*) adequate drainage. Neither the resources of the Government nor the collective resources of the cultivators are, by themselves, adequate to accomplish an effective reclamation programme. But the combined resources of both may accomplish the purpose. The Government may construct, operate, and maintain improvements to the water supply, distribution and drainage systems, which are beyond the collective or individual capacities of the cultivators. The Government may also extend technical services and long term credit to the cultivators, for performing their part of the work. Cultivators should adopt efficient practices, and construct, operate, and maintain such works as they can, collectively or as individuals.

42. Whenever more or better water supplies are introduced into an area, new possibilities for settlement are created, and should be exploited as soon as possible both to raise agricultural production, and to find work for the large numbers of unemployed and under-employed people now on the land. The quality of the land, the water supply, the cropping patterns adopted, the economic size of farms, and the location, size and the nature of the proposed villages and community facilities all affect the location and design of canals and distributaries. The plans for colonisation and community development, on the one hand and those for the completion of structural works, on the other, must as far as possible, be synchronised.

43. Vast areas still remain to be colonised on the lands served by such completed projects as the Sukkur, the Jinnah and Ghulam Mohammad and their canal systems ; the Taunsa and Gudu barrages, and the Ganges-Kobadak project, will provide extensive opportunities for settlement and improvements in existing conditions. Plans for colonisation and improvements should be accelerated in order to reduce delays in the preparation of plans for the construction of the new or remodelled canal systems, so that, as soon as water becomes available at the barrages or the pumping plants, it should be put to immediate productive use. This is particularly true

because schemes of this type lock up very large resources during the long time it takes to complete construction. The same principle applies to the smaller schemes. Reclaimed lands also require similar treatment. The resources available for investment are so limited, and accelerated economic development is so essential that the lag between the investments and the final returns must be reduced to the absolute minimum.

Research

44. Effective organisation of research, in the field of water and power resources development, is essential to provide a sound base for policy, to ensure the application of the best practices in development, and to promote the most efficient use of the developed resources. The country possesses a number of institutes and laboratories, where research is being conducted on various aspects of water resource development and use. There are, for example, the Irrigation Research Institute, the laboratories of the Directorate of Land Reclamation and of the Building and Roads Branch at Lahore, the Hydraulic Research Laboratory at Dacca, and laboratories attached to agricultural colleges. Investigations under field conditions are being carried out at a number of experimental agricultural and reclamation farms. Unfortunately, no research is being done at the engineering colleges and universities, and there is a lack of positive co-ordination between the research activities at the different centres.

45. Although these isolated research activities have been in progress for a long time, future developments should be accelerated by directing the investigations towards specific goals, by co-ordinating the work of the many agencies that now exist, and by balancing the theoretical with the practical approach. As a preliminary, a critical and constructive appraisal should be made of the kind and quality of work being done by the various agencies with a view to determining the best means by which they could integrate their activities to serve the future requirements of research. It is essential that regional research laboratories are established throughout the country but, in order to eliminate unnecessary duplication and avoid waste, the facilities for specialised equipment and national leadership in each field should be sited where the local conditions are most favourable for such research.

46. All research should maintain a close relation with the practical problems of water resource development and use. This can be ensured through co-operation between the executive departments and the research institutes. Although the departments must continue research in specialised fields within their specific responsibilities, it is desirable that, in order to get the utmost benefit out of research institutes, they should be located at the universities, to the advantage of both. The university would gain by affording opportunities to post-graduate students and research staff to work in the laboratories of the research institute, and the staff of the latter would gain by contact with the wider research work under way in the general atmosphere of the university. Universities and colleges should also be equipped and organised to undertake general research on their own account, as well as on specific practical problems remitted to them.

47. Some of the important fields of study, in which research is urgently needed, are indicated in the following list :

(1) *Agriculture*

(*a*) Further investigation of optimum water requirements of crops, as a function of soil type and fertility, climate, growth density, and methods of irrigation and cultivation.

(*b*) Evolution of crops with a short growing season, which could be matured on flood supply.

(*c*) Tolerance of crops to salinity and/or water-logging, and development of strains resistant to excessive moisture and salts.

(*d*) Safe limits of salts in saline water, and the conditions under which saline water may be used.

(2) *Hydraulic*

(*a*) Efficient means of reducing losses in transport of water.

(*b*) Variation of evapo-transpiration losses in space and time.

(*c*) Mechanics of gains and losses in stream flow.

(*d*) The effect of floods on regeneration.

(*e*) Qualitative and quantitative distribution of silt loads in rivers and canals, and their variation in space and time.

(3) *Subterranean supplies and drainage*

(*a*) Effects of river and canal supplies on the quality and quantity of ground water.

(*b*) Determination of the optimum depth and spacing of drains in different soil and sub-soil types.

(4) *Electrical*

(*a*) Determination of system stability, power losses, etc., on network analysers, for the existing and proposed high voltage grids, in order to secure the conditions of optimum efficiency.

(*b*) Study of the practicability and economics of using poles of materials other than steel, like concrete, and indigenous wood, for power transmission lines.

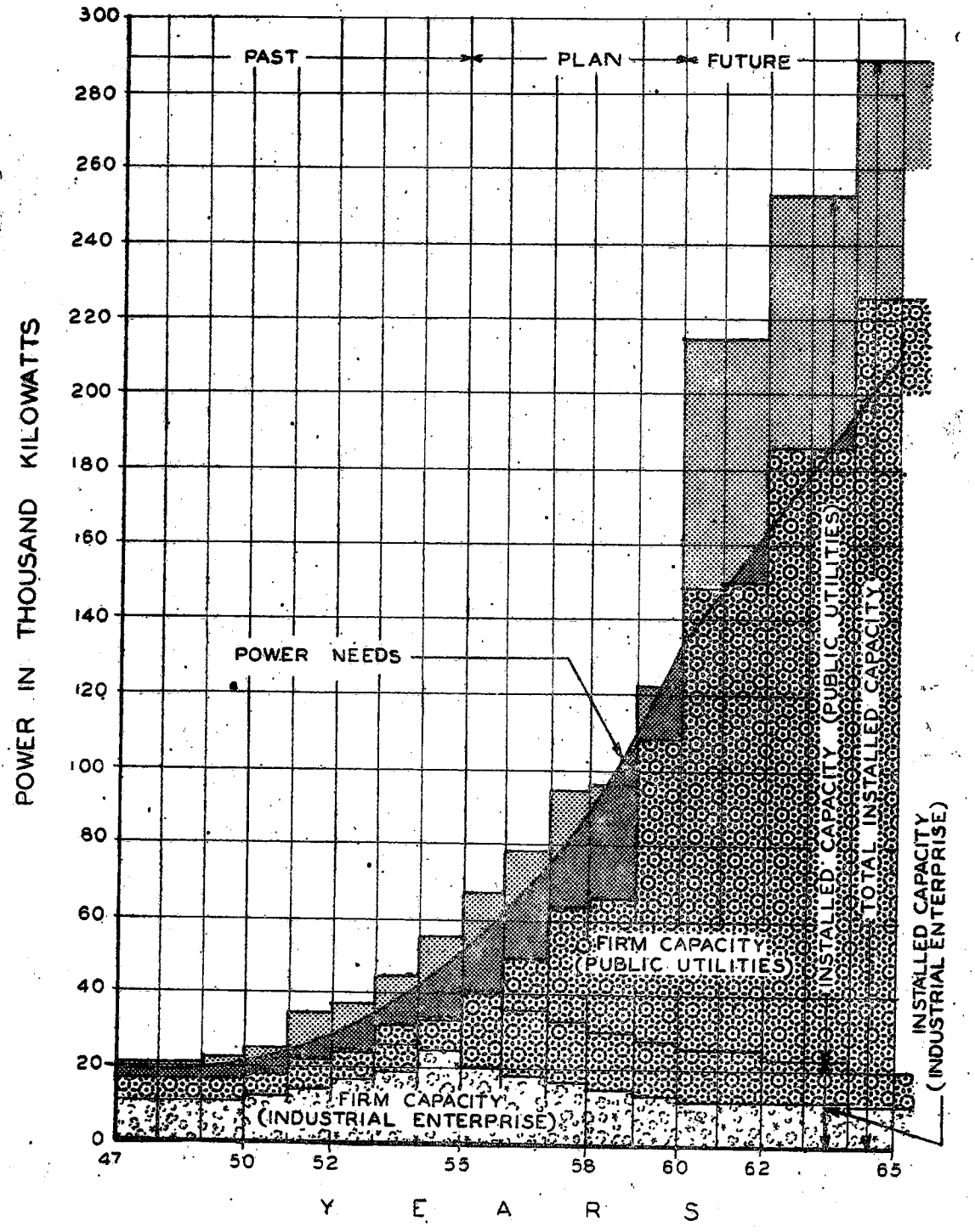
(*c*) Investigations for harnessing the power potential of wind velocities, solar and atomic energy etc., not only for the generation of electricity but also for other useful purposes.

48. Great difficulties have been experienced in securing the services of capable men for research posts, and unless attractive terms are offered, it will be impossible to recruit men of high calibre. Their salaries and status should compare favourably with those of officers of the administrative departments, and they should be given liberal opportunities to visit foreign institutes to acquaint themselves with the latest techniques, to exchange experience, and to establish personal contacts with workers in their particular fields.

49. The main responsibility in each Wing for all these tasks would lie primarily with the water and power development agencies proposed in para. 24 above, and with the Ministries of Natural Resources suggested in the Chapter on Public Administration.

THE HUMID REGION-EAST PAKISTAN

POWER DEVELOPMENT



Chapter 19

REGIONAL WATER AND POWER DEVELOPMENT PROGRAMMES

INTRODUCTORY

1. As indicated in Chapter 17, the country can be divided into three very different hydrological regions for purposes of water and power development. In this chapter we consider the development plans for each of these regions separately.

HUMID REIGON

General description

2. Most of East Pakistan is a remarkably flat alluvial plain, built by the delta-forming activity of the principal rivers, the Ganges, the Brahmaputra and the Meghna. Some older alluvial soils consisting of red clay are found in patches in the districts of Dacca, Dinajpur, Rajshahi, Mymensingh and Tippera. The average slope varies from 1·5 ft. per mile in the north to roughly 3″ per mile in the south. The entire province is laced with a dense network of water-courses. Where the lands are mostly flat and low, the enormous discharges, brought down by the rivers in the monsoons, cause regular floods.

3. Annual floods of varying intensities are a normal feature of about one-third of the cultivated area of the Province. This flooding helps to maintain the fertility of the land but sometimes, as happened in 1954 and again in 1955, assumes very destructive proportions.

4. The climate is tropical, with high temperatures and humidity. There are two seasons, the dry winter season from November to April, and the summer monsoon season from May to October. More than 98 per cent of the cultivated lands are dependent on the rainfall. Although the average yearly rainfall is about 76 inches, it is not evenly distributed, the highest being 226 inches at Lallakhal in the Sylhet district and the lowest 53 at Lajitpur in Rajshahi. Most of the rain (65 inches on the average) falls within a period of 4 to 5 months during the monsoon. The rest of the year is more or less dry.

Natural Resources

5. The principal rivers in the region are perennial, though their discharges are low in winter. They are (*a*) the Ganges series including tributaries and spill channels, (*b*) the Brahmaputra series including the Teesta, and (*c*) the Meghna. The Ganges, traversing a length of 1,540 miles, and draining an average annual rainfall of 42 inches over a catchment area of 350,000 square miles, with a recorded maximum flood discharge of 2 million cusecs (at Sara), is mainly responsible for the building, raising and fertilizing of the delta. The Brahmaputra traverses a length of 1,800 miles, drains an average annual rainfall of 85 inches over a catchment area of 361,000 square miles, and had a recorded maximum flood discharge in 1955 of 1.8 million cusecs (at Gauhati). Though the Meghna does not drain such extensive tracts, its catchment comprises the Cherapunji and other extremely wet areas with some of the highest rainfall records in the world ; it has an estimated maximum flood discharge of about 15 to 20 per cent of that of the Ganges. The total annual volume of water in the rivers flowing into East Pakistan is estimated at 925 million acre-feet, of which, at present, practically nothing is utilised for irrigation, except by the natural process of overflowing the banks during the monsoons, and for a negligible amount of controlled flood irrigation. Table 1 gives the proposed utilisation of water in the Plan ;

TABLE 1

Proposed utilisation of principal rivers in the Humid Region

River system	Estimated average annual flow in million acre-ft.	Proposed Schemes	Proposed utilisation in million acre-ft.
1. Ganges	350	Ganges-Kobadak, Ganges flushing and Tangon irrigation projects.	17
2. Brahmaputra	500	Teesta barrage	5
3. Meghna	50	...	...
4. Karnafuli	16	Karnafuli Project	10

6. The whole of East Pakistan is covered by maps of general-purpose topographical survey. Excepting for the delta proper in the south, the major part of the Province is connected with contour survey bench marks. Some specific-purpose surveys have also been carried out in connection with the major projects, and others are under way. Soil survey is in its infancy, and has been completed only in one of the seventeen districts. There are some hydro-meteorological stations, but not adequately equipped.

Needs

7. The culturable area of the region is about 26·4 million acres, of which only 20 million acres is sown in an average year, most of it being single-cropped ; extensive areas of standing crops are seriously damaged when there are unusual floods. Increased production can be attained by

(*a*) Reducing flood damage to standing and stored crops to the practical minimum ;
(*b*) Maintaining and extending the area of cropped lands ;
(*c*) Increasing crop yields ; and
(*d*) Double and even triple cropping.

8. When account is taken of prospective increase in productivity per acre through improved farming more fertilisers, and better seeds and live stock, there would be need to bring the equivalent of some 1·5 million acres under cultivation, merely to maintain existing living standards for the population of 1960.

9. The ultimate increase in the sown area is limited by the water supply available during the dry winter season. Its maximum availability in winter, for agricultural purposes, has been estimated roughly to be of the order of 50 million acre-feet, which, if properly utilised, would be able to irrigate about 13 million acres. Given adequate supplies of water, it should be possible to sow 25 million acres in the monsoons and 80 per cent of this, or 20 million, in the winter. Although ample supplies would be available for the purpose in the monsoons, the requirement of water in the winter would be of the order of 75 million acre-feet, for which it would be obligatory to conserve some of the flood flows in large storage reservoirs. Although favourable locations for construction of reservoirs exist in the hill tracts, the opportunities for developing appreciable storage in East Pakistan are very limited. The extent of ground-water supplies has not yet been precisely determined. Such supplies as have been developed are used primarily to serve domestic purposes which require good quality rather than large quantities of water. The sub-soils of East Pakistan are of such a nature that water yields from wells are low, but they are generally less contaminated than surface supplies. The yields being low, costs of development are high compared with those of surface supplies, and in general the use of ground water will be confined to domestic and commercial requirements. However, there may be a possibility of ground water development for irrigation purposes in northern districts of the province such as Rangpur, Dinajpur and Rajshahi.

10. Before 1947, what is now East Pakistan was the hinterland for the port of Calcutta, and the chief source of raw materials (mainly jute) for its industries and for export. With the attainment of independence and the expansion of industry it became necessary to develop the baling of jute, and the manufacture of jute products, cotton textiles and paper. In the field of agriculture, there are vast tracts of land in the districts of Kushtia, Jessore and Khulna which require lift irrigation during dry season. We estimate that as a result of the industrial and agricultural development programme included in the Plan, the aggregate power requirements of the whole region, which was divided into a number of distinct power zones for determining those requirements, will increase from 50,000 kw in 1955 to about 135,000 kw in 1960.

Long-range development

11. Historical evidence indicates that a system of water control and use was evolved in the Gangetic Delta, some 3,000 years ago. It consisted of broad shallow canals which carried the crest waters of the river floods, rich in fine silt, to the lands. They were so spaced that water could be distributed with reasonable facility to the rice fields, by means of cuts in the banks called *kunwas*, which were closed when the flood season had passed. During the monsoons, much of the land was covered with water. To avoid inundation, villages were located on the higher ground, generally made higher by earth obtained from the excavation of tanks, which had the double advantage of retaining the monsoon water for use during the dry season. These tanks are dotted by the

thousands all over the country. The lands were bunded to control the amount and time of inundation, and, in the tidal areas, to prevent the inon of salt sea as water.

12. The system of water control and use was managed and maintained by the *zamindars*, and the tenants, on a more or less forced co-operative basis, known as *pulbandi*. The long-drawn campaign of the Mahrattas and the Afghans, marking the decline of the Moghul Empire, brought about disorganisation and negligence in the proper maintenance of the system. None-the-less, *pulbandi* persisted up to the time of independence although in a less positive and effective manner. As a result of the partition of Bengal, a large number of *zamindars* migrated to India, and some measure of reform in land tenure was initiated, but no effective substitute for the *zamindari* system has, so far, emerged, in the form of local leadership, and Government have had to assume the responsibility for such limited maintenance as is possible in the circumstances.

13. The present schemes for flood regulation, drainage, flushing, and over-flow irrigation are outgrowths of the traditional indigenous system, and are more localised in nature, designed to solve immediate and particular local problems. Instances of such developments, as have been carried out from time to time, are the Gumti Embankment in Tippera district, the Ganges flood flushing sluices and embankment at Rajshahi, those along the Lower Kumar river in the Madaripur Bil Route, and artificial channels such as the Halifak cut and the Gaznavi cut. These developments are primarily for the purpose of flushing and improving the channels of the deteriorated rivers.

14. Many flood regulation and drainage projects, most of which are relatively small schemes, were initiated after independence. These schemes are designed primarily to accelerate the drainage of low lying areas, in order to permit the cultivation of the lands affected, and, at the same time, to provide for the navigation of country boats, as well as to improve fishing facilities. These schemes may be considered as a programme of deferred maintenance of river channels and restoration of past developments.

15. Waterways were developed to connect the port of Calcutta with the trade centres of Bengal and the neighbouring provinces of Bihar and Assam, and water routes for inland shipping through the Sundarbans appear to have been in existence as early as 1770. Some canals, with tidal locks, were built early in the 19th century, and the route was gradually improved by the construction of a new canal in 1859, and locks in 1895 and 1910. To shorten the distance between Calcutta and the main Ganges channels, the Madaripur Bil Route was opened early in the century. This is a short cut, about 20 miles in length, through a series of bils, connecting the Madhumati river with the Ganges through the Kumar and the Areal Khan rivers. The route practically monopolised river traffic between Calcutta and Upper Assam, in the early days, before the approach channels to the Ganges started deteriorating.

16. At present, there are about 2,700 miles of navigable channels, open during the monsoons, and about 1,800 miles open during the dry seasons. About 43 per cent of the total mileage can be used by small coastal vessels, barges and large river steamers, the rest being suitable only for medium-sized river steamers, launches and country boats. The channels were kept in good operating condition before the last war, during which they failed to receive adequate maintenance, resulting in progressive deterioration. Positive measures are being planned now to rectify this neglect.

17. Soon after the World War II, serious consideration was given to the development of long-range and comprehensive plans, in order to take full advantage of the beneficial effects of the river flows, and to reduce the destructive effects of floods to a practical minimum. Some investigations and surveys were initiated in north and central Bengal. The 1947 partition of Bengal disrupted this programme, as the areas concerned were located on both sides of the new border. However, the comprehensive approach to water resource development has taken root in East Pakistan, and multi-purpose projects such as Karnafuli and Ganges Kobadak now under implementation are examples in point. This programme has been sponsored on the understanding that developments in the tributary basins of these rivers lying beyond the boundaries of Pakistan will not interfere in their feasibility in any manner.

18. The Karnafuli project proposes to develop one of the very few water storage sites in East Pakistan. It is designed to produce 160,000 kw of hydro-electric power, improve navigation, and to reduce the destructive effects of the frequent floods, from which the Chittagong region has suffered in the past. A part of the power produced is planned to be used for pumping water from rivers for irrigation. The cost of schemes for such development is not included in the Karnafuli Project.

19. The Ganges-Kobadak Scheme proposes to pump the silt-laden waters of the Ganges into canals for irrigating lands which can be double and triple cropped. The deteriorated Kobadak river will be improved as a trunk drain, to be fed by a system of drainage channels, interlacing the irrigated area, thereby controlling the amount and the time of water remaining on the lands, and reducing somewhat the effects of destructive floods. The plans also include methods to resist the invasion of the land by the saline waters of the tides. The canal banks have been designed to accommodate local surface transport and the main canals and drains to provide for limited water transport. The entire Ganges-Kobadak Development will serve about 2 million acres of land on completion.

20. Before independence, most of the industries were concentrated on the banks of the Hooghly river near Calcutta, with hardly any industrial development in the rest of the Province. There were about fifteen small thermal electric power stations, privately owned and operated, which catered mostly for domestic loads, local small industries providing their own generating plant. The total installed capacity was about 22,000 kw in 1947, and acute shortage of power was felt immediately on the partition. Schemes were, therefore, undertaken for the installation of additional thermal plants in the industrial centres of Narayanganj, Chittagong and Khulna and for the acquisition and improvement, by the Government, of the existing and largely depreciated plants at other places. The total installed capacity rose to 67,000 kw in 1955, of which 39,000 kw is estimated to be dependable capacity, available at all times.

21. Of the total land area of 34·9 million acres in East Pakistan, about 22 million, or 63 per cent, is cultivated. No detailed investigations of the extent to which this area could be increased through proper drainage have been made, but, on the evidence available, it may be said that an area of the order of 4 million acres is capable of reclamation over a long period of time through drainage. If that objective could be attained, the cultivated area would be increased to 74 per cent of the total area. The greatest possibility of development, however, exists in improving the agricultural practices, and in double and triple cropping of the presently cultivated area. Extensive and intensive studies must be made before the extent to which flood damage to crops and other valuable property can be reduced.

22. Comprehensive investigations of the land and water resources of the region are needed to determine the practical potential, and to draw up tentative plans and schedule for attaining full feasible development, and the maximum practical reduction of flood damage. Any comprehensive plan must take into account the following possibilities:

(*a*) Beneficial use of the water supplies to increase production;
(*b*) Anticipation and routing of flood flows through existing channels, which should be improved in a manner consistent with the natural regiment of the rivers, in order to reduce the destructive effects of floods;
(*c*) Devices to protect or re-locate valuable property threatened by floods;
(*d*) Improvement of conditions for water and land transport;
(*e*) Surface and ground water supply for domestic and municipal use; and
(*f*) Reduction of the incidence of water borne diseases.

23. The deltaic rivers of East Pakistan form a single river system. Improvements on one river have their effects, beneficial or destructive, on the others. A small local drainage project, for instance, may improve crop production on the lands drained, but destroy crops in an adjacent area in which the drained water may accumulate. All effects of proposed improvements must be taken into full account, by testing the consequences of any development on the river system as a whole.

24. Such comprehensive investigations will require the collection and analysis of vast quantities of basic data, from areas lying outside the boundaries of East Pakistan as well as from within. These data are essential to the preparation of sound plans of water regulation and development. They will also serve the more immediate purpose of issuing flood warnings well in advance of high flows, thus allowing more time for the evacuation of threatened areas and the mobilisation of relief forces.

25. The extension of the general principles of the Ganges-Kobadak project to other areas, susceptible of such treatment, in an orderly and persistent manner, holds promise of comprehensive and conservative exploitation and control of the available water resources. Pending such an expansion, which is necessarily time-consuming, the programme of reclamation, through accelerating land drainage at the end of the monsoons, must be continued, after taking into account possible adverse effects on other areas, at a rate at least to maintain the present acreage of the cultivated area, and to arrest further deterioration. Such drainage would prove to be most effective and of a permanent character, if local leadership could be generated, so that the construction of the drains, and, what is more important, their proper maintenance, could be accomplished through the co-operative effort of those directly benefited by them.

26. The first phase (now under execution) of the first unit of the Ganges-Kobadak project can serve effectively as a pilot plant, to test the practicability of the plans evolved, and to determine the methods by which the general principles, on which they are based, can be applied on a practical scale to future developments. In addition to such practical application, it will also be necessary to engage in more academic research on the natural processes of delta formation and the problems which may be encountered in adjusting the plans of development to be consistent with those processes.

27. The sharp rate of increase in power loads, that has emerged since independence, may level off to some extent, when the arrears of demand have been met. However, it may reasonably be expected that the ready availability of power, particularly if the tariffs are fixed on a rational basis, will increase the power demand for industrial, commercial, domestic and agricultural purposes. Pumping water from low river flows, for irrigation during the dry season, as well as for drainage during and after the wet season, may form a significant component of the future power load. Completion of thermal plants now being planned or constructed, will serve the immediate load, and the Karnafuli hydro-installation should take care of increases in load growth upto 1965.

28. Until recently indigenous power resources of the region appeared very limited. Usable quantities of fuel in the form of oil, gas, and coal had not been found. Some consideration had been given to the use of timber from the Sundarbans as firewood to avoid the necessity for the import of fuels. However, other possible uses of the timber and the cost of extraction and transportation do not appear to justify its use. Hydro-electric potential in East Pakistan other than the Karnafuli development, to the extent they are known, are not attractive.

29. Recent discoveries of natural gas near Sylhet, if in adequate quantity and of optimum quality, could considerably improve the electric power prospects in the area which can be served. Transmission lines proposed or constructed, east of the Jamuna-Padma rivers can be extended to serve power loads as they develop. Plants designed to use imported oil or coal can be converted to the use of indigenous natural gas at reasonable cost. A feasible crossing of the Jamuna-Padma River by transmission lines or gas line will depend upon a spectacular load growth to the west of the river which does not appear in prospect in the reasonable future.

30. Any truly comprehensive plan for the development of the Ganges and the Brahmaputra river basins will tend to reduce destructive flood peaks, and to increase the low river flows. Such adjustments would improve the opportunities for development of the water resources of the region, and reduce the harmful consequences of the frequent floods. The Government should welcome any opportunity to participate in the international development of such plans, and any organisation created to undertake comprehensive investigations should be equipped to perform the staff work essential for such participation.

Development since Independence

31. Developments undertaken since independence comprise (*a*) multi-purpose, (b) flood regulation and drainage, and (*c*) power projects. No multi-purpose project was started before 1952. The first power project was initiated in 1950. Flood regulation and drainage projects are types of development which have been undertaken traditionally in East Pakistan, and a number of them were initiated immediately after independence. A list of all developments undertaken since independence is given in table No. 2.

TABLE 2

Water and power resources development since independence, 1947-55

The Humid Region

Name of scheme	Total estimated cost	Estimated expenditure up to March 1955	Started in	Status	Results achieved by March 1955			Power
					Area irrigated	Area reclaimed	Area drained	
	(Million rupees)				(Thousand acres)			(kw)
I. MULTI-PURPOSE DEVELOPMENT:								
Karnafuli	250.0	33.4	1952	In progress	...	...	...	...
Teesta Barrage ...	115.7	0.1	1953	Do.	...	...	...	...
Ganges Kobadak	233.0	4.1	1953	Do.	...	...	...	...
Total ...	598.7	37.6	...	...	...	...	...	...
II. IRRIGATION:								
Small schemes	0.6	0.2	1953	In progress	...	...	...	...
III. FLOOD REGULATION & DRAINAGE:								
Dredgers	17.9	14.7	1953	Completed	...	...	...	...
Small schemes	23.3	17.3	1947	In progress	...	...	423	...
Total ...	41.2	32.0	...	...	...	...	423	...
IV. POWER:								
Siddirganj thermal	39.5	7.1	1951	In progress	...	...	...	5,100
Chittagong thermal	7.7	2.9	1953	Do.	...	...	...	3,000
Goalpara diesel	7.8	2.3	1953	Do.	...	...	...	...
Chittagong distribution ...	2.0	0.2	1954	Do.	...	...	...	...
Diesel pool	1.6	1.5	1951	Completed	...	...	...	3,000
High Voltage distribution ...	12.9	1.3	1951	In progress	...	...	...	...
4 Small power supply undertakings	1.9	0.3	1950	Do.	...	...	...	751
Total ...	73.4	15.6	...	...	...	...	...	11,851
Grand Total ...	713.3	85.2	...	...	...	...	423	11,851

32. The estimated cost of developments under way by March 1955 totalled 509 million rupees, of which 85 million rupees (17 per cent) was the estimated expenditure by that date. They are designed to provide 243,000 kw of installed power capacity, and irrigation facilities to 2,732,000 acres, and to bring under cultivation an additional 1,120,000 acres of land, which was unproductive due to poor drainage conditions. By March 1955, about 12,000 kw of thermal power capacity had been installed and 423,000 acres of newly drained land brought under beneficial production.

33. The disparity between cost and accomplishment lies largely in the field of multi-purpose development which accounts for nearly 84 per cent of the total estimated costs. In this type of development, large investments have to be made, and considerable time consumed in construction, before tangible results can accrue. These results, when they materialize, are of a higher order of magnitude and of a more permanent nature than quicker returns. Similar lag between costs and accomplishments also exist, but to a much lesser extent, in the other types of development.

34. The multi-purpose projects undertaken were the Karnafuli and the first phase of the first unit of the Ganges-Kobadak. The first project was delayed by changes in plans and changes in decisions. The total estimated cost of the two projects is about 278 million rupees, of which about 38 million rupees were the estimated expenditure by March 1955. Accomplishments in terms of kilowatts installed or acres irrigated will be registered after the substantial completion of construction, some time in the later years of the Plan period.

35. In addition to the measured accomplishments, the multi-purpose developments will create other values difficult to measure quantitatively. The Karnafuli, in addition to producing hydro-electric power, will provide means of reducing damages of frequent floods, and of regulating the flows of the Karnafuli river, thus improving navigational facilities from the bay of Bengal to the port of Chittagong and higher up the river. It will, in addition, provide easy access by boats in the large reservoir behind the dam, for developing the forest resources of the Chittagong hill tracts. It will also provide power for pumping water to irrigate lands during the dry season, and to drain water-logged areas during and immediately after the wet season. This will, however, require further investment in pumps and civil works, which should be planned well in advance of the availability of power. The values enumerated will not accrue till after the main Karnafuli project has been completed. The Teesta and the Ganges-Kobadak will, in addition to irrigating large areas of land, provide means of improving both land and water transport. Both will provide positive drainage as an incident to irrigation.

36. Flood regulation and drainage projects consist of a large number of relatively small schemes for the purpose of opening up congested water channels to facilitate drainage of lands, thereby providing a means of increasing agricultural production. In a number of cases, the improved channels will provide a means of water transport for country boats and improved fishing facilities. Control gates in protective embankments will provide a means of limited flood irrigation of the drained lands to the extent water is available in the river during periods of low rainfall. Because of the silting proclivities of deltaic rivers, such improvements will be subject to relatively high maintenance costs and periodic reconstruction. These developments may, therefore, be considered as a programme for the maintenance of river channels. Three of these projects are large, costing over 1 million rupees each. The cost of the remaining 143 averages about Rs. 1,40,000 each. Since dredgers are used for this programme, their cost (about 18 million rupees) is included as a separate item under this head. Of the total estimated cost of about 38 million rupees, about 32 million rupees (80 per cent) had been spent by March, 1955.

37. The power projects, consisting of thermal installations, were planned, to the extent practicable, for future inclusion into inter-connected and integrated power grids. The programme consists of installations of thermal generating capacity, construction of distribution systems, and the acquisition and improvement of existing depreciated systems. The total estimated cost of these projects is about 73 million rupees of which about 16 million rupees were the estimated expenditure by March 1955. Considerable delays were experienced in deliveries, installation of equipment and construction of civil works. Out of a total of 82,500 kw of thermal capacity planned, only 11,851 kw (14 per cent) were installed by March, 1955.

Programme in the Plan period

38. The water and power programme for the Plan period includes the completion or continuation of such water and power resources development schemes as were under way at the beginning of the Plan period, as well as a number of new schemes, which have been added to meet the production goals envisaged. Their total estimated cost is 122,1 million rupees, of which 76 million rupees were the estimated expenditure up to March, 1955. The outlay proposed on specific schemes for the Plan period is 928 million rupees, or 75 per cent of the total, leaving 217 million rupees to be spent after 1960 to complete the projects in hand. The figures are given in Table 3. Annual figures in the table are based upon detailed discussions, scheme by scheme, with Provincial Governments and Central Ministries held in the latter part of 1956. These figures vary somewhat from those used, in Chapter 2, which are based on 1957-58 budgets of Central and Provincial Governments as published in the spring of 1957. The reserve allocation for East Pakistan in the water and power sector has not been scheduled by years in absence of specific schemes.

TABLE 3

Estimated expenditure on water and power resources development, 1955—60

The Humid Region

(Million rupees)

Name of scheme	Total cost	Actual expenditure upto March 1955	Expenditure estimate for						Balance to complete	Remarks
			1955-56	1956-57	1957-58	1958-59	1959-60	1955-60		
1	2	3	4	5	6	7	8	9	10	11
I. GENERAL INVESTIGATION :										
Comprehensive investigations	22·4	2·4	0·8	0·2	5·0	7·0	7·0	20·0	...	
Investigation of comprehensive drainage scheme, Noakhali district.	0·2	...	...	...	0·1	0·1	...	0·2	...	
Sub-Total ...	22·6	2·4	0·8	0·2	5·1	7·1	7·0	20·2	...	
II. MULTIPURPOSE DEVELOPMENT :										
Karnafuli project	250·0	33·4	15·7	30·0	50·0	70·0	50·9	216·6	...	
Ganges-Kobadak project ...	233·0	4·1	4·5	14·0	20·0	24·0	23·0	85·5	143·4	
Teesta project	115·7	0·1	0·1	2·1	10·0	15·0	22·8	50·0	65·6	
Development of hydraulic research laboratory.	2·1	...	0·1	0·5	0·8	0·7	...	2·1	...	
Sub-Total	600·8	37·6	20·4	46.6	80·8	109·7	96·7	354·2	209·0	
III. IRRIGATION										
Tangon irrigation scheme ...	25·1	...	...	...	5·0	10·0	8·5	23·5	1·6	
Small schemes	4·7	0·2	0·1	1·0	1·0	1·4	1·0	4·5	...	
Provision of 30 pumping sets	0·3	...	...	0·1	0·2	...	...	0·3	...	
Experimental Tubewells ...	4·0	...	...	0·1	0·9	1·5	1·5	4·0	...	
1000 Pumping sets	5·7	...	...	1·0	3·7	0·5	0·5	5·7	...	
Sub-Total ...	39·8	0·2	0·1	2·2	10·8	13·4	11·5	38·0	1·6	
IV. FLOOD REGULATION & DRAINAGE :										
Comprehensive drainage scheme for Faridpur.	43·5	...	...	1·0	7·0	14·4	14·4	36·8	6·7	
Reclamation of low land between Dacca-Narainganj Road & Rly. Line.	18·9	...	...	...	2·0	8·0	8·9	18·9	...	
Purchase of Dredgers ...	17·9	14·7	0·1	1·1	2·0	...	...	3·2	...	
Comprehensive drainage scheme for prevention of flood in Feni Sub-Division.	4·1	...	...	0·5	1·0	1·6	1·0	4·1	...	
Reclamation of Areal beel ...	3·0	...	...	0·1	0·9	1·0	1·0	3·0	...	
Small drainage schemes ...	42·4	6·4	1·8	6·0	10·0	9·0	9·2	36·0	...	
Sub-Total	129·8	21·1	1·9	8·7	22·9	34·0	34·5	102·0	6·7	

TABLE 3—*contd.*

1	2	3	4	5	6	7	8	9	10	11
V. POWER :										
Siddirganj thermal power project.	39·5	7·1	2·2	7·5	9·9	5.0	7·8	32·4	...	
Chittagong thermal power project.	7.7	2·9	0·8	1·4	0·8	1·8	...	4·8	...	
Goalpara diesel power project	7·8	2·3	0·6	2·4	1·3	1·2	...	5·5	...	
Goalpara steam power project	14·0	...	...	1·5	12·5	...	...	14·0	...	
Chittagong electric supply expansion and improvement of L.T. distribution.	2·0	0·2	0·1	1·0	0·6	0·1	...	1·8	...	
Pool of small power plants with total capacity of 1,500 kw.	4·0	...	...	...	1·0	2·0	1·0	4·0	...	
Dacca-Chittagong interconnection.	18·1	...	...	1·0	3·8	1·6	11·7	18·1	....	
High voltage distribution and sub-station.	12·9	1·3	0·2	1·6	3·9	3·0	2·9	11·6	...	
Hardinge Bridge-Goalpara interconnection.	12·2	...	...	0·4	10·6	1·2	...	12·2	...	
Transmission lines (Comilla-Chandpur and Kaliganj-Narsingdi).	5·5	...	...	...	1·8	2·3	1·4	5·5	...	
Small power supply acquisitions	2·2	0·1	0·1	1·0	0·9	0·1	...	2·1	...	
Small power supply undertakings	1·9	0·3	0·1	0·4	1·0	0·1	...	1·6	...	
Sub-total ...	127·8	14·2	4·1	18·2	48·1	18·4	24·8	113·6	...	
Grand Total (scheduled)	920·8	75·5	27·3	75·9	167·7	182·6	174·5	628·0	217·3	
Reserve ...	300·0	...	...	...	...	...	...	300·0	...	
Grand Total	1220·8	...	...	...	...	...	...	928·0	...	

39. The specific schemes included in the Plan are designed ultimately to provide :

(*a*) Irrigation facilities to 5,716,000 acres of cultivated land, for double cropping or increasing production of single crops ;

(*b*) Drainage and flood regulation to 2,476,000 acres, which, at present, are unproductive due to drainage congestion or exposure to floods ;

(*c*) Installation of 250,000 kw of power generating and transmitting facilities ;

(*d*) Protection of 2·2 million acres from the saline waters of the tides ; and

(*e*) Considerable improvement in local transport facilities, both by land and water.

The prospective results by the end of Plan period are :

(*a*) 300,000 acres of land are expected to make productive use of irrigation facilities,

(*b*) 1,619,000 acres are estimated to be brought under production through accelerated drainage or flood protection, and

(*c*) 169,000 kw of generating capacity to be installed with the necessary transmission facilities.

The balance of the designed accomplishments will accrue after the Plan period. The ratios of expected results during the Plan period to the ultimate objectives are (*a*) 5·5 per cent (*b*) 67 per cent and (*c*) 65 per cent respectively. The greatest disparity between the ratios of expected results (5·5 per cent) and of expenditure (68 per cent) during the Plan period lies in the field of irrigation. This is due to the size and the complexity of

the large schemes—the Ganges-Kobadak and the Teesta barrage—in which the benefit will start accruing only towards the end of the comparatively long development periods. The figures relating to expected results in the Plan period are given in table 4.

TABLE 4

Expected results from water and power resources development by March, 1960

The Humid Region

Name of scheme	Period of execution		Expected results during the Plan Period				
			Area irrigated				
	Commencement	Completion	New	Old	Area reclaimed	Area drained	Power
1	2	3	4	5	6	7	8
			(Thousand acres)				(kw)
I. GENERAL INVESTIGATION							
Comprehensive investigations	...	...	...	...	...	...	...
Investigation of comprehensive drainage scheme, Noakhali district ...	...	...	...	...	...	...	...
II. MULTIPURPOSE DEVELOPMENT							
Karnafuli project	1952	1960	...	...	...	...	80,000
Ganges-Kobadak project ...	1953	In progress.	...	...	...	...	10,000
Teesta project	1953	Do.	...	...	...	...	...
Development of Hydraulic Research Laboratory ...	1955	1959	...	...	...	...	...
Total ...	...	...	...	...	...	...	90,000
III. IRRIGATION							
Tangon irrigation scheme ...	1957	In progress.	...	...	...	...	...
Small schemes	1954	1960	15	35	...	...	...
Provision of 30 pumping sets	1955	1958	10	15	...	...	...
50 Experimental Tubewells ...	1956	1960	5	10	...	...	...
1000 Pumping sets	1956	1960	70	140	...	...	...
Total ...	...	...	100	200	...	...	...
IV. FLOOD REGULATION & DRAINAGE							
Comprehensive drainage scheme for Faridpur ...	1956	In progress.	...	...	...	390	...
Reclamation of low land between Dacca-Narainganj Road and Rly. Line ...	1957	Do.	...	...	...	...	...
Purchase of dredgers ...	1953	1956	...	...	...	...	...
Comprehensive drainage scheme for prevention of flood in Feni Sub-Division	1956	1960	...	...	...	22	...
Reclamation of Areal beel in Distt. Dacca	1956	1959	...	...	...	58	...
Small drainage schemes ...	1947	1960	...	...	...	1,149	...
Total ...	...	...	...	...	...	1,619	...

TABLE 4—*contd.*

1	2	3	4	5	6	7	8
V. PGWER							
Siddirganj thermal power project	1951	1960	...	...	...	...	42,900
Chittagong thermal power project	1953	1958	...	...	...	...	7,000
Goalpara diesel power project	1953	1957	...	...	...	...	10,000
Goalpara steam power project	1956	1959	...	...	...	...	16,000
Chittagong Electric Supply expansion and improvement of L. T. distribution ...	1954	1959	...	...	...	...	...
Pool of small power plant with total capacity of 1,500 kw	1957	1960	...	...	...	...	1,500
Dacca-Chittagong interconnection	1955	1960	...	...	...	...	...
High voltage distribution and sub-station	1951	1960	...	...	...	...	...
Hardinge Bridge-Goalpara interconnection	1957	1959	...	...	...	...	...
Transmission lines (Comilla-Chandpur and Kaligunj-Narsingdi)	1957	1960	...	...	...	...	...
Small power supply acquisitions	1955	1959	...	...	...	...	654
Small power supply undertakings	1950	1959	...	...	...	...	777
Total ...	...	...	...	...	...	...	79,471
Grand Total ...	...	...	100	200	...	1,619	169,471

40. For the optimum development of the water and power resources of the region, it is essential that a long-range comprehensive and co-ordinated development plan should be prepared and executed. In order not to lose sight of this objective, and, in fact, to give it the importance it deserves in the economy of the country, a separate classification head, " General Investigation ", has been introduced into the programme, and an amount of 20·0 million rupees provided, for developing an organisation to undertake the necessary investigations, and to prepare the comprehensive plan envisaged, so that all future programmes fit into it in their proper places and at their proper times. The function of the organisation would have to be a continuing one, involving expenses, also of a continuing nature, after the Plan period.

41. Under ' Multi-purpose development ', the Karnafuli, the Teesta barrage and the first phase of the first unit of the Ganges-Kobadak schemes were already under way at the start of the Plan period. The second phase of the first unit, and the second unit, of the Ganges-Kobadak scheme are proposed to be started in the later part of the Plan period. The second unit is designed ultimately to provide irrigation facilities to 2 million acres of land, and protect 2·2 million acres from the invasion of sea water, by means of a system of tidal embankments. In addition, the whole scheme will provide a means of improving both land-borne and water-borne local transport.

42. Of the estimated total cost of 601 million rupees under this head, 354 million rupees or 59 per cent is proposed for expenditure during the Plan period. A sum of 209 million rupees, or 34 per cent will be required to complete the developments after the Plan period. It is expected that the projects will provide 90,000 kw of power capacity, by the end of the Plan period.

43. Two of the small schemes mentioned under ' Irrigation ' have already been started, and were expect ted to be completed in the first year of the Plan period. The Tangon scheme is scheduled to start in the third year. It will provide irrigation facilities to the high and dry lands, about 307,000 acres in area, in the north-western part of the Province, by means of a series of diversion barrages across the Karotoya and Tangon rivers. Practically the whole of the estimated cost of 40 million rupees under this head is scheduled for expenditure during the Plan period, providing irrigation facilities to about 300,000 acres in 1960.

Tube well and lift irrigation schemes will be a new venture in East Pakistan. A provision of Rs. 10 million has been made in the Plan to cover cost of a pilot tube well scheme and for pumping surface water. The utilization of ground water supplies in northern districts of Rangpur, Dinajpur and Rajshahi and pumping surface water during period of low flow, if successful, will ensure irrigation of crops at critical times of the year.

44. Under the head " Flood Regulation and Drainage ", all the large schemes proposed are new developments. The only exception is a provision for the final payment on account of the purchase of dredgers, which will be made in the first three years. The comprehensive drainage scheme aims at improving the sanitary conditions and the agricultural production of deteriorated, water-logged, and swampy areas of the Faridpur district, which have been deprived of the natural delta-building functions of the Ganges river. An area of about 890,000 acres will be benefited by the completion of the scheme. The channels improved will constitute 34 per cent of the total length of the natural rivers and khals in the commanded area. These benefits will, however, accrue after the Plan period.

45. Of the small schemes, 63 (costing 16 million rupees) are already under way, and 139 (costing 27 million rupees) are proposed to be started soon. Their average cost is of the order of Rs. 2,00,000 and all of them are likely to be completed during the Plan period. The total estimated cost of the Flood Regulation and Drainage schemes is 130 million rupees of which about 102 million rupees, or 78 per cent, is scheduled for expenditure during the Plan period. It is expected that about 1·6 million acres will be brought under production during the Plan period.

46. Controlled diversion of peak flows through improved channels of dead and dying rivers, and other protective devices, may be required to prevent loss of life, and to reduce damage to property from recurring major floods in East Pakistan. Investigations are now in progress to plan methods and works for reducing flood hazards ; measures found feasible as part of a unified development programme for water resources could be undertaken during the Plan period in addition to those already included in the Plan by using the reserves provided for such extra schemes.

47. All but five of the schemes included under the head ' Power ' were under way before March, 1955, and all are likely to be completed by the end of the Plan period. Of the total estimated cost of 128 million rupees, about 114 million rupees, or 89 per cent, is scheduled for expenditure during the Plan period. About 79,000 kw of generating capacity (additional to 90,000 kw in multi-purpose schemes) will have been installed during the Plan period, and a corresponding network of transmission and distribution lines and other facilities provided for the disposal of this as well as of the energy made available by multi-purpose development. The present generation of 0·8 unit *per capita* will rise to 8 units by 1960.

48. The expected results during the Plan period consist of irrigation facilities to 300,000 acres of already cultivated land, to permit double or triple cropping, and to 1,619,000 acres of land, drained to permit effective cultivation. This may be taken as very roughly equivalent to bringing something over 1·9 million acres of land into cultivation. It is barely enough to maintain existing living standards for the greater population of 1960. To increase standards would require a larger programme than the available technical resources would permit

In the field of power, a generating capacity of 169,000 kw will have been installed, for which adequate transmission and distribution facilities will also have been provided. This will give a firm dependable capacity of 140,000 kw against an estimated need of 135,000 kw in 1960. The apparent excess of capacity over estimated requirements will be quickly overtaken by the growth of demand after 1960.

49. The programme for the Humid Region is very ambitious. The proposed outlay for the year 1959-60 is expected to be over six times the expenditure in 1959-60, excluding the reserve, and about fourteen times if we take the reserve into account. Only effective and immediate organisation of work on various schemes can implement this ambitious schedule.

THE INDUS BASIN

General description

50. The Indus system of rivers comprises the main Indus and its major tributaries, the Kabul and the Kurram on the right bank, and the Jhelum, the Chenab, the Ravi, the Beas and the Sutlej on the left. The first two join the main Indus soon after it debouches from the mountains, and the others lower down in the plains. All rise in the Himalayas or its western extensions, and are snow-fed. The whole of the Beas and the head reaches of the Ravi and the Sutlej are in India, while those of the Chenab and the Jhelum lie mostly in the Kashmir State. The entire basin covers an area of about 348,000 square miles, of which 204,000 lie in Pakistan. In addition there are about 29,000 square miles which lie outside the Indus basin but are dependent on the Indus river system for their water supply. The plains of the basin consist of alluvial deposits, thousands of feet thick being mostly silt and sand of low permeability and some clay, with no known gravel layers of any considerable extent. The precipitation in the head-reaches of most of the streams is in the form of snow. Lower down, the rainfall averages from 30 to 40 inches along the sub-montane tract to less than 5 inches in the west. The plains may therefore be classified as semi-arid to arid. Almost all of the basin in Pakistan receives less than 15 inches of rainfall, 60 per cent less than 10 inches and 16 per cent less than 5 inches. The rainfall is not distributed evenly throughout the year, but is concentrated in the monsoons (June to September). Local rainfall shows great variation from year to year in respect of quantity, incidence and duration. The maximum deviation that may be expected from the annual mean in any one year is comparatively large.

Natural resources

51. The gross area of the Indus Basin in Pakistan is 131 million acres, of which 75 million are culturable but the net area sown to crops is only 27·5 million, of which 90 per cent produces one crop per annum. The net area irrigated in an average year is 21 million acres, which represents 28 per cent of the culturable and 76 per cent of the cropped area.

52. Except for the irrigated lands, which are relatively free from erosion, the whole region suffers from wind or water erosion in varying degrees. In the former Punjab alone, there are 1·6 million acres that are severely eroded, and 2·8 million acres which have suffered from the invasion of shifting sands. There are over 6 million acres, which are infested with excessive salts or suffer from high alkalinity.

53. The rivers of the Basin are subject to extreme variations of flow, the summer maximum discharge being about 100 times the winter minimum. The run-off is characterised by the absence of any pronounced duration of mean flow, but shows a marked periodicity. There is generally a period of low water flow from the middle of September to the middle of March, mainly derived by seepage from the stored up ground-water. The main rise usually begins by the middle of March, with the melting of the Himalayan snows, reaching a maximum during July or August, as the result of the monsoon rainfall and falling off in September. This does not fit in very well with the agricultural calendar. The dry season discharge in the main river channels it too low, and supplies during the *rabi* and the critical periods of the *kharif* are always short. On the other hand, for 2 to 2½ months, the rivers carry large surpluses over and above the agricultural requirements of the crop areas that can be supported in periods of low flow, and considerable quantities escape from the land without being put to beneficial use.

54. The utilisation of river flow is further complicated by the fact that the fluctuations in the stream flow of all rivers in the region more or less follow the same hydrographic pattern. Whenever the main Indus, the Jhelum and the Chenab are in deficient supply, the Ravi, the Beas and the Sutlej are also correspondingly short. Hence both the shortages and the floods are accentuated. The natural surface waters are of excellent quality, and the quantity of silt carried is very large. Unfortunately, no systematic records of their silt content are available. Based on a 25-year record (1921-22 to 1945-46), the total annual inflow, measured at the six rim stations on the Indus and its tributaries, averaged 168 million acre-feet, varying widely from year to year, the annual maximum being 189 and the minimum 139. The daily discharge variations are very much greater.

55. Not enough is known about the ground -water resources to give a quantitative idea of their potentialities or limitations for development. The formations range widely in permeability even within short distances.

56. Complete general-purpose topographical maps do not exist for the upper hilly reaches of the river catchments. Those that are available lack important details, such as contours and precise levels. Nor has the geology of the area been studied in any detail. The available meteorological or hydrological data are inadequate and no records exist to show the relation between the rainfall and the run-off. No snow surveys have been carried out, and the contribution of the snow to the surface run-off is not known. In the plains, on theot her hand, general-purpose topographical maps are available for the whole of the area which is irrigated , or in which irrigation projects are under construction. Fairly complete meteorological records exist at a number of stations but it is necessary to establish more stations for purposes of comprehensive development. A complete network of gauge and discharge observation sites exists on the main Indus and the tributaries. Adequate information is, however, not available on the variation of evapo-transpiration in space and time, nor does any adequate quantitative analysis of silt loads and their origin exist. Ground-water levels have been observed for a long time past, twice annually, and systematic records of these are available for the former Punjab and the Sukkur barrage area.

57. Various settlement reports and district gazetteers classify areas and soils by visual surface tests. Local surveys were carried out for assessing the capabilities of particular areas to justify certain irrigation projects. Special purpose soil surveys have been conducted in the former Punjab and the Sukkur barrage area for studying the extent of deterioration due to salts, but no scientific and comprehensive soil survey have yet been carried out. Recently, detailed soil surveys have been conducted in connection with some of the reclamation projects. A reconnaissance soil survey for a part of the area has just been completed from the aerial photographs prepared under the Colombo Plan.

Needs

58. Taking account of prospective increases in productivity per acre, we consider that an additional 2·5 to 3 million acres would be needed, merely to maintain existing standards of food and clothing for the increased population of the region by 1960. There is sufficient irrigable land, under the command of the existing canals and those under construction, to provide this extra acreage. Water requirements vary with individual crops, but, assuming water diversion, amounting to an average depth of 3 feet per acre per crop, the additional requirement of water for irrigating the new lands, or double cropping the lands now producing one crop per year, would be 7·5 to 9 million acre-feet.

59. Salinity and the rising water table have already affected over 6 million acres of land, to which over 50,000 acres are being added annually. The proper treatment of the area requires effective drainage, additional supplies for leaching down the accumulated salts, reduction in the present water duty, intensified agriculture and a suitable cropping pattern. Reclamation of the deteriorated lands, on a scientific basis, would thus have to wait for the completion of the Mangla storage dam and the installation of tube-wells. However, for the present, it is essential at least to offset the progressive deterioration by reclaming 50,000 acres every year. Assuming (a) the period of reclamation of any piece of lands as three years, (b) a water diversion allowance of one cusec per 45 acres of the area to be reclaimed, and (c) a field efficiency of 80 per cent, about 1·3 million acre-feet

per year would represent the present requirements for reclamation in addition to the normal irrigation supplies. This process must be continued to maintain the *status quo* till additional supplies become available for reclamation of the 6 million acres of land affected.

60. The region is highly deficient in forests which are unable to meet even a fraction of the minimum requirements for firewood and timber for internal consumption. In economic competition, however, with food for regulated water supplies, forests would naturally rate low.

61. Water requirements for domestic, commercial and industrial use have a relationship to population, and the intensification of commerce and industry. In this country, it may be assumed that such requirements would be of the order of about 0.2 million acre-feet per million of the population, in the early years of the Plan, period, but are bound to increase with the progress of time. Such additional requirements may be estimated at about 0·5 million acre-feet by 1960. Hydro-electric power stations do not consume water, and are so planned that they do not interfere with supplies for other purposes. Thermal plants require water for cooling, but return most of it to the river. The water requirements for thermal plants may be considered to have been included in the estimate of water requirements for domestic, commercial, and industrial use. The combined water requirements for purposes of navigation and control of sea water intrusion have been estimated at 17·2 million acre-feet, below the Ghulam Mohammad barrage at Kotri.

62. Depletions of the 'historical' supplies in the three eastern tributaries, which rise in India, may create water demands of a very high magnitude and variety, which it is not possible to specify in this chapter, as it is the subject of joint study by Pakistani and Indian engineers and representatives of the World Bank.

63. The minimum additional annual water requirement by 1960 (exclusive of navigation and salinity control, and of what may be necessary for the replacement of supplies now received from the three eastern-most tributaries) may be estimated as between 9·3 and 10·8 million acre-feet.

64. Before 1947, the potential demand for electrical energy in the area as a whole was not readily apparent, except for domestic and commercial purposes in the larger municipalities, where public companies or corporations were licensed to generate and supply electricity. To serve the requirements of most of the industries which had been established, generating capacities were installed as a part of the individual industrial plant. Immediately on the attainment of independence, there was a spurt of industrial and other activity, resulting in larger and larger demands for power for all purposes. Recognition of the necessity for reclamation of deteriorated lands, and urgent needs for additional water supplies, led to plans for the exploitation of ground-water resources through the installation of electrically-driven pumps for tube-wells. In 1950 a team of consulting engineers carried out a load survey on behalf of the Government and estimated the power requirements of the Indus basin to be 157,000 kw in 1954 rising to 367,000 kw in 1964. In 1952, the Central Engineering Authority reviewed these forecasts in the light of the accelerated pace of over-all development, especially the more rapid extension of industry and ground-water pumping. The Authority's estimated requirement was 218,000 kw in 1954 rising up-to 417,000 kw in 1964—nearly doubling in the decade. Because of the changed pattern of actual and planned industrial and agricultural development since the completion of the previous estimates, the Government arranged in 1954 for a new assessment of the power requirements of West Pakistan. Because of delays in planned installations, these new estimates showed a rise from 127,000 kw in 1954 to 422,000 kw in 1964.

65. All these estimates needed to be revised to ake account of the inscreased demands for power from the developments now proposed in the Plan; more spindles and looms in the textile industry, the completion of cement plants, new fertiliser factories, metallurgical installations, and sugar mills, and the installation of tubewells for irrigation and reclamation, as well as consequent increases in the domestic and commercial and industrial loads. Our studies based on a sub-division of the whole region into distinct power zones have indicated that total power requirements may rise from about 220,000 kw in 1955 to 495,000 kw by 1960.

Long-range development

66. The most spectacular development in the control and utilisation of water resources in this country has taken place in the area drained by the Indus and its tributaries. An ingenious, intricate and semi-automatic system of water control has been evolved over a long period of recorded and unrecorded history. It has its genesis in the intensive cultivation of land supplied with water by the annual floods. This so-called *sailaba* irrigation still continues to be practised on a substantial scale.

67. The next step was the construction of inundation canals, which drew water during the summer, when the rivers rose above the levels of their inlets, and irrigated lands which otherwise would not have received water by natural flooding. Like *sailaba* inundation canals cannot exploit the minimum river flows.

68. Canals, both perennial and non-perennial, which came next on the scene, are supplied by weirs across the rivers, built at strategic points, to capture the minimum flows, the former all the year round, the latter only during the summer, when the rivers carry higher discharges. A large number of the old inundation canal systems, which naturally suffered from fluctuating river levels, were converted to perennial or non-perennial canal receiving controlled supplies. The first to be installed was at Madhopur on the Ravi, in 1859, to feed the Upper Bari Doab canal. There is no evidence that a plan of the existing intricate system was conceived at the time. Presumably the first and some of the subsequent irrigation works on the eastern tributaries were inspired by economic and political pressures for increasing agricultural production. In spite of the lack of a comprehensive plan, the installations developed into a closely knit and integrated system of works. Those on the eastern tributaries of the Indus now command about 19·5 million acres of culturable land in this country.

69. The ambitious barrage systems on the main stem of the Indus, which came late in the day, were inspired by (a) the fear that extensive development on the eastern tributaries would reduce flows in the main river, below its confluence with them, to a degree which would render the old inundation canals inoperative, and (b) the necessity to increase agricultural production in order to colonise new lands to feed a rapidly expanding population. The first was the major inspiration of the Sukkur, the Ghulam Mohammad and the Gudu barrage systems, and the second of the Jinnah barrage at Kalabagh. These systems, designed to exploit the minimum flow of the Indus, constitute great engineering feats, which rival the intricate systems built on the eastern tributaries. Of the 17·7 million acres commanded by them, about 7 million had not been irrigated previously.

70. The major western tributaries of the Indus are the Kabul and the Kurrum. The developments, existing or under way, on these rivers are :

(*a*) The Kabul river canals ;
(*b*) The Upper and the Lower Swat canals ;
(*c*) The Bannu civil canals ;
(*d*) The Warsak reservior and canals ; and
(*e*) The Kurrum Garhi development.

These are designed to command a total of 783,000 acres of culturable land.

71. The entire system of works, existing and under way, will ultimately command about 38 million acres of culturable land in the whole country. Its primary function is to supply water for irrigation, as and when it becomes available in the rivers. Any function it may or can serve in regulating the river supplies, for purposes other than irrigation, is minor and incidental. In fact, there is an almost complete lack of information necessary to serve other purposes, with the exception of hydro-generation, such as flood control, navigation, reduction of stream pollution and the improvement of fisheries.

72. At the time of independence, the total power installations of this region, owned by public utility agencies, had a capacity of 68,000 kw of which thermal generation accounted for 57,000 kw. By March 1955, the installed hydro-capacity had arisen to about 63,000 kw and thermal capacity to 98,000 kw, a total of 161,000 kw. The percentage of hydro-generation total capacity had thus risen from 15 per cent. in 1947 to 40 per cent. in 1955. Most of the installations have gradually been inter-connected by transmission systems in the north.

The discovery and development of the Sui Gas field in Baluchistan holds promise of partially supplying the increased requirements of thermal generation, and reducing the demand for imported fuels.

73. There is a wide range between the maximum and minimum discharges of the Indus Basin River System, which raises difficult problems in the regulation of stream flows. For instance, the Indus river has a peak discharge of over 900,000 cusecs (at Kalabagh), while its minimum discharge is of the order of 17,000 cusecs. Some measure of protection from damage by moderate floods is provided by a system of dikes as a means of river control. The main Indus is embanked almost continuously from below Kashmore to near Nawabshah, covering a length of about 240 miles. The left bank is further diked almost down to the sea. There have, however, been a number of damaging floods in quick succession since independence. Apparently these floods have been increasing in intensity and frequency in recent years. The increases may be caused by the recurrence of a long-term meteorological cycle. Progressive denudation in the hilly catchments may have aggravated these conditions, but it cannot be said to what degree. This was intensified during the last war, when forest areas were stripped of trees for the procurement of timber, and is still continuing because of the increasing pressure on the land and need for local fuel, thus accentuating the natural process of soil erosion both in the hills and along the river banks. Apparently the silt charges of the rivers have also increased, to what extent has not yet been determined. However, the beds of the rivers are rising, so that, in some places, they are now flowing on ridges higher than the adjoining lands, and so causing more flood damage. The evil is further accentuated by such artificial barriers as the canal head works, railway embankments and road bridges, all of which have been found to offer inadequate waterway to the floods. They naturally cause serious flooding upstream, and result in the intensification of the onrush downstream, in the event of any of them collapsing. The Punjab Flood Commission of 1951 thoroughly investigated the causes of the 1950 floods, which were at the time considered to be of an unprecedented magnitude, and came to the conclusion that no really effective measures could be taken to control floods in the Jhelum, Chenab and Ravi rivers, except by constructing flood detention reservoirs in their hilly catchments. The floods of 1955 proved to be even worse than those of 1950, causing much greater damage.

74. Natural drainage is not well defined in the area commanded by the canal system. The deficiency is due to the general topography and the relative low rates of precipitation, with the result that nature was not compelled to carve out a drainage system to dispose of excessive quantities of water, which did not exist before the advent of the intricate canal system. The introduction, later on, of large volumes of water for irrigation rendered the natural system of drainage completely inadequate to accommodate the excess water and induce free return flows to the streams. On the other hand, the natural drainage system has not been supplemented by artificial drains, except in a very minor degree. The necessity of lifting drainage water by pumping involves serious technical problems and high costs. Hence excess water has been trapped in the lands, inducing high ground water table.

75. The lack of effective drainage has led to the twin evils of (a) water-logging and (b) an increasing and destructive concentration of salts in the root zones of the plants growing in the soils. The high degree of river water control, attained at considerable cost, is thus seriously impaired. These conditions reduce returns on capital investment made in the system, and the productive capacity of the lands is greatly impaired. They further create social and economic problems, because the cultivators who developed the lands have either to move to new locations, or be satisfied with a sharp reduction in their crop production.

76. Attempts are being made to reclaim water-logged and saline lands by tube-well pumping, in order to draw down the water table, and use the pumped water for reclamation and improvement of irrigation. Such installations are concentrated in selected areas, where the results of properly integrated measures could be observed carefully and appraised in rational manner. Greater dependence is, however, placed on tube-well pumping than on a balanced plan of action. The high cost and restricted supply of electric energy for running the pumps have also complicated the experiment.

77. The average crop yields per acre in the area served by the Indus and its tributaries are about 30 to 40 per cent of those attained in other similar areas in Japan and Egypt. Yields depend on good management of the

and, and of the water on the farm. Good management requires, among other things, adequate water supplies at critical times of crop growth. The average depth of water used for irrigation in the Indus basin is about 2 feet for a single crop only, whereas, for intensive diversified cropping and optimum crop production, about 6 to 7 feet is necessary. The low efficiency is also due to the non-coincidence in time of water supply and demand. The present canal system, as it exists, is incapable of regulating the seasonal and annual fluctuations in the river flow. Efficiencies in providing for optimum utilisation of controlled water supplies, for purposes other than agriculture, are also quite low. We have made no attempt to appraise these efficiencies in quantitative terms. Some of these potential uses, such as power, have been recognised ; others have not, because of the pressure of urgent need for service to the main purpose of irrigation.

78. Efficiencies in the maintenance of control of the water supplies may be considered by appraising the water lost in the system from the point of diversion to the point of delivery on the lands. The necessary data for such appraisal are not available. Even supposing such efficiencies are not below efficiencies in other parts of the world, water losses are much more significant in the Indus region, because, owing to the lack of adequate drainage, they cause serious damage. When water is so desperately short in supply in relation to present and potential requirements, and where it is the key to, and the measure of, successful economic development, the practical control of the water potential must be positively established, diligently watched and efficiently maintained.

79. Although good quality lands abound in the region, water supply, however substantial in quantity, is the limiting factor in land development. An estimate of the ultimate water requirement for agricultural use alone, based on the total availability of culturable lands, ranged as high as 460 million acre-feet per annum, which is far in excess of the gross annual supplies of the Indus river system. Effective control in time and quantity, efficient use, and diligent conservation of whatever supply is available are therefore of prime importance to the nation.

80. With the completion of the barrages on the Indus river system, now under construction, its dependable surface flows will be diverted on to the lands to the maximum possible extent. Great progress has been made, in the recent past, in the utilisation of its supplies, by converting the inundation into weir-controlled canals, and so ensuring better supply for long periods. When the existing projects, and those under construction, have fully been developed, the limit of the area that can be brought under cultivation through such irrigation works, will have been reached. There will remain, however, the constant danger of scarcity of water at critical reriods, and the future development of reclamation and irrigation on a large scale will depend on the storage of high river flows during the monsoons, which now run to waste in the sea. Any appraisal of the quantity of waste water, which could thus be salvaged, would remain purely speculative, until comprehensive field investigations and hydrological studies have produced dependable estimates.

81. There are limitations, however, to the possibilities of storage. The complete regulation of the mean annual flow of the Indus river system will require more than one hundred million acre-feet of reservoir capacity whereas the presently known reservoir sites offer capacities of about 25 million. The topographical and geological characteristics of the sites limit the height to which dams can be built. A further limit to the useful capacity, of reservoirs is imposed by the high silt-content of the river flows. Moreover, the construction of large storage reservoirs would involve, of necessity, high initial outlay of capital, compared with the existing works, such as the barrages, for deflecting flow supplies. It has been estimated that about 40 million acre-feet, over and above the existing uses, could be harnessed for useful purposes in the Indus basin, but it cannot be said with certainty what portion of it would be available to Pakistan, as the whole matter is the subject of a joint study by Pakistani and Indian engineers and representatives of the World Bank.

82. After these storage reservoirs have been built, only a limited volume of flood waters will flow down to the sea. The variation from year to year would, however, be very great. Its utilisation, at least in part, for beneficial purposes, should be the objective of a well-considered plan of future water resource development. We recommend that the feasibility of the conservation of such supplies, as are likely to go to waste otherwise, should be examined carefully. The artificial recharge of the ground water reservoir, and the creation of storage basins in desert areas, offer possibilities of their utilisation.

Small projects, for utilising the waters of numerous intermittent hilly streams, offer good possibilities and should not be neglected in favour of the more spectacular larger schemes. Such small projects should be developed. Several of such schemes have recently been projected.

83. Flood control measures, in the past, have been confined to embankments and temporary expedients which have proved to be of little avail. Embankments, to be effective, must be backed by reservoir control. The possibility of utilising reservoirs, for effective flood control, would, however, require enormous storage capacities for which the known reservoir sites are inadequate, although they would undoubtedly exercise a moderating influence. Reservoirs will also have to be supplemented by large-scale conservation measures in the head-waters. Watershed management through afforestation, improved agricultural practices, and a rigid application of forest policy, should be regarded as an integral part of a comprehensive flood-control plan. These will need to be supplemented by numerous smaller projects in the lower reaches of Indus and its tributaries. In undertaking any developments in the flood plains, due precaution should be taken against the possibility of accentuating flood levels. The immediate remedy lies in carrying out moderate channel improvements, and river training works, in the gradual removal of constrictions in the streams, and in providing suitable openings in embankments. Such measures can at best reduce the extent of the damage which now occurs. It can further be reduced if timely flood warnings are broadcast. A flood forecasting and warning system must, therefore, be perfected in the immediate future.

84. The effective utilisation of ground-water supplies presents a much more complex problem than that of surface supplies. Their successful development involves determining their precise extent and quality, their availability at different places, and the relation between rate at which water supplies are depleted and the rate at which they are restored. The greatest limitation will probably be found to be in the quality of ground water, and the question of mixing it with canal water supplies before use will need to be investigated. The ruling electrical tariffs are unduly high, and the raising of ground water for purposes of irrigation cannot be justified on the prevailing crop prices. For any large scale and economical development of ground-water resources, therefore, the problem of obtaining an abundant supply of cheap energy will have to be tackled.

85. The amount of additional water that could feasibly be developed in the Indus Basin for use in this country cannot be forecast with any degree of precision. Whatever these additional supplies may prove to be, we are faced with the problem, of their optimum utilisation. The choice lies between the extension of irrigation to arid lands, and the intensification of production on lands commanded by the existing irrigation system. The final decision would probably be somewhere between these two extremes. Economic and social considerations point towards the latter alternative, but the pros and cons will have to be examined very carefully in the light of conditions that prevail in the different parts of the region. Agronomic and engineering studies are another pre-requisite for determining the most economic use of meagre water resources. The maximum production with varying water requirements and their proper rotation. The value of crop production could be increased substantially if water in sufficient quantity and at the proper time were made available.

86. More important than the complete exploitation of the water resources of the basin is their efficient use. At present, only about 50 per cent of the water diverted at the canal headworks reaches the field, the rest being lost in evaporation and percolation. One of the major problems to be solved by the irrigation engineer is how to reduce these losses to the bare minimum, to enable intensification of agriculture on presently irrigated lands, or expansion of cultivation in those commanded but not irrigated by the existing canals. For this, it is necessary to devise a systematic programme, consistent with economy, to improve those sections of the irrigation channels, in which the losses are the highest. In addition, it is necessary to obviate losses beyond the canal outlet. In the past, irrigation management has not received the consideration it deserves. An extensive study of the various methods of irrigation must be made, and means devised, to reduce the water losses to a minimum during the application of water to the fields.

87. The best possibilities for low-cost hydro-electric development are necessarily to be found in the upper reaches of the Indus and its northern tributaries, where power heads are high, quantities of water adequate, and opportunities for water regulation and storage ample. Their magnitude may run into several million kilowatts of installed capacity. Any system of reservoirs found feasible should be planned to serve all useful purposes. The eventual availability of natural gas, along a pipe line from Sui to Lahore, for service to thermal electric plants, would supplement and complement the hydro-electric potential. The value of an integrated energy production and transmission system would be greater than the sum of the values of production from separate sources.

88. To sum up, any long-range programme for developing the water-resource potential of the region should take into account the following factors in the order listed :

(*a*) Effective maintenance and enhancement of the values of existing development, through the reclamation of deteriorated lands and adjustments in the existing system of works ;

(*b*) Orderly, efficient, and persistent completion of water and power development works under way ;

(*c*) Increase, in quantity and value, of productivity of lands now irrigated, through intensive use of land and water supplies ;

(*d*) Improvement of control of developed water supply, and exploitation of the remaining water resource potential through planning, constructing and operating an integrated system of storage reservoirs in the upper reaches of the Indus and its northern tributaries, for service to all useful purposes each in the order of established priority ;

(*e*) Extension of water service to unirrigated but productive lands under command of the existing control system, to the extent that supplies can be made available in excess of requirements for intensive production of the irrigated lands ; and

(*f*) Extension of the control system to command additional lands of a highly productive character, if and when controlled water supplies are made available beyond the requirements for intensive production on lands commanded by the existing control system.

Development since Independence

89. The developments undertaken in the Indus basin since independence comprise :

(*a*) Multi-purpose projects ;

(*b*) The inter-linking of the Chenab, the Ravi and the Sutlej rivers to increase the flexibility of the irrigation system and the supplies available for the Sutlej Valley Canals ;

(*c*) Projects to arrest the progressive deterioration of soils due to salinity and the rising water table ;

(*d*) Schemes for the regulation of supplies to the inundation canals for the protection of existing irrigation ;

(*e*) Extension of irrigation to new areas ; and

(*f*) The generation, transmission and distribution of electrical energy.

90. The estimated cost of the projects completed and in progress at the end of March 1955, totalled 2,294 million rupees of which 900 million rupees was the estimated expenditure by that date. These projects were designed variously to (*a*) supply weir-controlled water for the irrigation of about 7·5 million acres, (*b*) reclaim an area of about 220,000 acres, and (*c*) provide 348,000 kw of electrical energy. By March 1955, about 770,000 acres of land had been brought under irrigation, 185,000 acres reclaimed, and 83,000 kw of generating capacity installed, representing respectively about 10 per cent. 84 per cent. and 24 per cent of the ultimate targets. The figures are given in Table 5.

TABLE 5

Water and power resources development, 1947—55

Indus Basin

Name of Scheme	Total estimated cost	Estimated expenditure upto March, 1955	Started in	Status	Results achieved by March, 1955			Power
					Area irrigated	Area reclaimed	Area drained	
1	2	3	4	5	6	7	8	9
	(Million rupees)				(Thousand acres)			(kw)
I. MULTIPURPOSE PROJECTS :								
Warsak scheme	267·0	31·0	1949	In progress	...	...	...	...
Kurram Garhi scheme	43·4	18·3	1950	Do.	...	...	...	...
Total ...	310·4	49·3	...	...	...	...	...	...
II. IRRIGATION :								
Gudu barrage project ...	304·4	11·0	1953	In progress	...	...	...	...
Ghulam Mohammad barrage ...	350·2	135·6	1947	Do.	...	...	...	...
Thal irrigation	154·5	145·9	1939	Do.	410	...	...	...
Taunsa barrage project ...	209·6	38·1	1953	Do.	...	...	...	...
Marala-Ravi link	95·2	49·0	1953	Do.	...	...	...	...
Bambanwala link	102·8	75·6	1948	Do.	...	...	...	...
Balloki-Sulemanki link	78·5	64·8	1951	Do.	...	...	...	...
Rasul tubewells	44·0	34·4	1944	Do.	...	...	...	...
Abbasia canal	38·3	3·6	1946	Do.	73	...	...	...
General reclamation	10·6	10·6	...	Completed	...	175	...	...
Misc. irrigation schemes ...	71·4	56·6	1951	In progress	153	10	...	...
Minor irrigation schemes ...	8·7	3·0	...	...	134	...	...	...
Total ...	1468·2	627·2	...	...	770	185	...	...
III. POWER :								
Karachi Electric supply extension	223·6	35·5	1950	In progress	...	...	...	16,400
Hyderabad thermal system ...	45·8	0·3	1952	Do.	...	...	...	...
Lyallpur steam (2 x 4,000 kw) ...	8·7	5·1	1950	Do.	...	...	...	...
Lyallpur diesel (10,000)	4·6	4·2	1954	Do.	..	...	...	...
Montgomery steam (2 x 3,000 kw) including transmission and distribution	16·9	11·6	1952	Do.	...	...	...	...
Dargai and Malakand hydroelectric project and extensions ...	69·7	59·3	1949	Do.	...	...	...	30,000
Rasul hydel scheme	93·9	74·3	1946	Do.	...	...	...	22,000
Interlinking N.W.F.P. and Punjab grid system	9·7	9·7	1952	Do.	...	...	...	...
Gujranwala-Daska-Sialkot extension	7·8	1·4	1952	Do.	...	...	...	...
Extension of local distribution system in Punjab towns	5·3	5·1	...	Do.	...	...	...	...
Abandoned electricity schemes ...	7·4	7·4	1947	Completed	...	...	...	6,325
Nationalisation of Sind electrical undertakings	9·8	1 5	1947	In progress	...	...	...	7,392
Distribution in area between Jhelum and Wah	3·0	0·5	...	Do.	...	...	...	...
Misc. power schemes	9·2	7·8	1953	Do.	...	...	...	1,225
Total ...	515·4	223·7	...	...	...	...	...	83,342
Grand Total ...	2294·0	900 2	...	...	770	185	...	83,342

91. The disparity between the cost incurred and the accomplishments achieved is occasioned by the fact that heavy initial investments have had to be made in the larger projects, such as the Ghulam Mohammad Barrage, the Thal Irrigation development, and the Rasul Tubewells, but some considerable time must elapse before the contemplated benefits can accrue.

92. In the Ghulam Mohammad barrage project, the headworks have been completed, but the construction and re-modelling of the canal network and the colonisation of the relative lands, have lagged behind, with the result that not only have the irrigation benefits been delayed, but the recovery of capital outlay through betterment levies, water rates etc., has been deferred.

93. In the Thal, while the canal system has practically been completed, colonisation work has not kept pace with the provision of irrigation facilities. Lands have to be prepared for irrigation farming, necessitating considerable investments, and it will be many years before the project is fully developed.

94. The Rasul tubewell scheme had originally been linked with the Rasul hydro-electric project, which was to supply the power for pumping. Unfortunately, owing to the extreme paucity of electrical energy in the country, Rasul power had to be diverted to urgent industrial uses. The project has, therefore, failed to serve its originally designed purpose, although, 1,551 out of a total of 1,860 tube wells have already been installed.

95. Only two multi-purpose projects were undertaken, *viz.*, the Warsak and the Kurram Garhi, estimated to cost Rs. 310 million of which Rs. 49 million were the estimated expenditure by March 1955. There was no substantial progress on the Warsak owing to changes in plans and delays in arriving at important decisions.

96. Supplies to the canals depending on the three eastern-most tributaries have been irregular and uncertain since independence. The Bambanwala-Ravi-Bedian Link was constructed to simplify delivery problems to the Central Bari Doab Canals.

97. The Sutlej valley canals have always experienced, from their very inception, acute shortages of supply at the times of sowing and maturing of the *kharif* crops. These deficiencies have been aggravated further by the short supplies in the Sutlej since independence. The completion of the Marala-Ravi and Balloki-Suleimanki links will increase the available supplies for the Sutlej valley canals by diverting some Chenab and Ravi waters into the Sutlej river, and will also make it possible to bring reclamation supplies to canals east of the Chenab.

98. The Ghulam Mohammad, Gudu and Taunsa barrage schemes were planned to assure regular supplies to the vast network of inundation canals taking off the main Indus and to bring further culturable waste land under irrigation. The Gudu barrage construction was delayed because the machinery did not arrive in time.

99. The demand for more cultivated land has grown with the increase in population. The Thal project was designed to draw water from the main Indus to irrigate an area of about 1.2 million acres. The Abbasia canal extension aims at developing the Crown waste areas of 274,000 acres, which had been abandoned in 1935. The main canals and feeders have been built but not yet lined, and were opened to permit the irrigation of 130,000 acres.

100. The total estimated cost of all power projects in progress in the pre-Plan period was Rs. 515 million, of which Rs. 224 million or 43 per cent was the estimated expenditure by March 1955. Of the total of 83,000 kw capacity installed, 52,000 kw is accounted for by the two hydro-electric projects, *viz.*, the Rasul (22,000 kw) on the Upper Jhelum canal and the Dargai and Malakand Extensions (30,000 kw) on the Swat canal. The estimated cost of these two projects is Rs. 164 million of which Rs. 134 million was the estimated expenditure by March 1955. The only other major addition to the installed capacity was 16,400 kw in Karachi, where an extension for generating 30,000 kw has since been completed, and another for 45,000 kw is planned for completion by 1960. Besides these, a new steam station with an initial installed capacity of 60,000 kw is also planned for early completion, possibly by 1962. The estimated cost of these, including the distribution system, is about Rs. 224 million of which Rs. 36 million was the estimated expenditure by March 1955. These figures do not include generating capacity installed by private industry, which in Karachi alone amounted to 28,000 kw by March 1955, and to

51,000 kw in the whole of the Indus Basin. Very little progress was made on schemes for the transmission and distribution of supplies. These are estimated to cost Rs. 60 million, of which only 21 million was spent by March 1955. The balance of Rs. 33 million was spent on miscellaneous small thermal projects and the acquisition of isolated or abandoned electricity schemes. With the installation of 83,000 kw since independence, the total capacity installed for public supply in the Indus Basin rose to 161,000 kw, representing 124,000 kw of firm power against 57,000 kw at the time of independence—an increase of more than 100 per cent. While the progress may appear to be satisfactory in terms of percentage increase, it was wholly inadequate to satisfy potential needs, or to keep pace with industrialisation. Normally, hydro-electric projects take years for investigation and implementation. To add to this, there were special causes which delayed the execution of the only major hydroelectric project in the basin, the Warsak. It was proposed to fill in the gap by installing thermal plants, but these also suffered from administrative delays.

101. Large areas of formerly productive lands have gone out of cultivation. It has been estimated that over 6 million acres have already been affected to such an extent that reclamation is necessary for bringing them back to normal production. The annual rate of deterioration is very large. The Chuharkana reclamation experimental scheme has been designed to reclaim certain badly-salted lands in a water-logged area, by establishing improved methods of irrigation and agricultural practices, but has not progressed as scheduled, owing to difficulties in the acquisition of land. The Punjab Soil Reclamation Board was constituted under the Punjab Soil Reclamation Act of 1952 to deal with the problem of salinity and water-loggnig, but has not yet been able to function effectively.

102. With nearly all the unregulated surface supplies of its rivers utilised, the Indus Basin now faces the final stage of its irrigation development—the construction of multi-purpose storage projects, which will also provide large blocks of cheap power, and the exploitation of its ground-water resources.

Programme in the Plan period

103. The Plan provides for (*a*) the maximum progress, consistent with efficiency, on projects already under execution, (*b*) starting work on certain important schemes, and (*c*) general water resource investigations as well as detailed investigations of specific projects. The total cost involved is estimated to be Rs. 4,296 million, of which Rs. 777 million was the estimated expenditure up to March 1955. A sum of Rs. 1,791 million, or 42 per cent of the total estimated costs, is proposed for expenditure during the Plan period. The figures are given in Table 6. These projects have been designed :

(*a*) To provide irrigation to 4.26 million acres of uncultivated land, of which 1.45 million will be attained by 1960 ;

(*b*) To improve irrigation facilities or reclaim from salinity and water-logging an area of 8.76 million acres, of which 4.04 million will be accomplished by 1960 ;

(*c*) To generate 841,000 kw of electrical power, of which 427,000 kw will be installed during the Plan period ; and

(*d*) To improve supplies for the areas commanded by the Sutlej Valley Canals.

Annual figures in the table below are based upon detailed discussions, scheme by scheme, with Provincial Governments and Central Ministries held in the latter part of 1956. These figures vary somewhat from those used in Chapter 2, which are based on 1957-58 budgets of Central and Provincial Governments as published in the spring of 1957.

TABLE 7

Expected results from water and power resources development, 1960.

Indus Basin

Name of scheme	Period of execution		Expected results during the Plan period				
	Commencement	Completion	Area irrigated new	Area irrigated old	Area reclimed	Area drained	Power
1	2	3	4	5	6	7	8
					(Thousand acres)		(kw)
I. GENERAL INVESTIGATION :							
Comprehensive investigations (first phase)	1956	In progress	...	...	...	...	...
Studies of reservior system (first phase).	1954	„	...	...	...	...	...
Ground water investigations.	1954	„	...	...	...	...	...
Investigations of specific schemes	1954	„	...	...	...	...	...
II. MULTIPURPOSE DEVELOPMENT :							
Mangla dam	1955	„	...	...	...	...	...
Warsak dam	1954	1960	...	...	...	...	160,000
Kurram Garhi	1950	1957	120	112	...	...	4,000
Swat storage	1955	In progress	...	...	...	...	...
Tributary storage on Jhelum...	1957	1960	...	...	...	...	...
Gilgit	1957	1959	...	...	...	...	...
Machinery pool	1957	1960	...	...	...	...	...
Hydraulics and soil mechanics laboratory.	1954	1956	...	...	...	...	...
Research	1956	1960	...	...	...	...	...
Studies and training ...	1957	1960	...	...	...	...	...
	Total ...		120	112	...	...	164,000
III. IRRIGATION :							
Ghulam Mohammad barrage	1947	1962	304	870	...	...	...
Gudu barrage	1953	In progress	...	950	...	...	...
Taunsa barrage	1953	Do.	70	1,255	...	...	...
Thal project	1939	1958	275	...	...	...	...
Warsak canals	1954	1960	...	...	...	...	...
Gomal Zam	1956	1960	...	...	...	...	...
Pehur development ...	1954	1958	48	12	...	...	...
Bara canals	1956	In progress	...	...	...	...	...
Small schemes	1954	Do.	130	5	...	...	...
Dams and reservoirs on hill torrents	1954	Do.	...	...	...	...	...

TABLE 7—*contd.*

1	2	3	4	5	6	7	8
Bambanwala-Sutlej link ...	1948	1960	...	...	...	...	...
Balloki-Suleimanki link ...	1951	1958		...	...	...	...
Marala-Ravi link	1953	1958	38	200	...	...	...
Tubewells, Drainage and Reclamation							
Tubewells	1944	In progress	267	28	150	...	...
Tubewells (subsidy) ...	1956	1960	33	...	...	...	...
Open wells (subsidy) ...	1956	1960	8	50	...	...	...
Reclamation schemes ...	1955	In progress	...	...	350	...	...
Sukkur drains	1955	Do.	...	...	...	...	...
Anti-waterlogging, Khairpur...	1954	Do.	10	27	...	...	...
Drainage Rechna chaj and Sind Sagar.	1957	Do.	...	...	...	...	...
Completed schemes ...	...	...	150	...	...	...	...
	Total	...	1,333	3,432	500	...	...
IV. FLOOD REGULATION	1956	In progress	...	...	...	...	...
V. POWER							
Karachi electric supply extension.	1950	1962	...	...	...	...	75,000
Natural gas power station, Multan.	1956	1960	...	...	...	...	140,000
Hyderabad thermal system ...	1952	1961	...	...	...	...	...
Sukkur thermal system ...	1958	1962	...	...	...	...	...
Lyallpur steam (6,000 kw) ...	1956	1958	...	...	...	...	6,000
Lyallpur steam (2x4,000 kw) ...	195)	1958	...	...	...	...	8,000
Lyallpur diesel (10,000 kw) ...	1954	1957	...	...	...	...	10,000
Montgomery steam (2x 3000 kw) including transmission and distribution.	1952	1957	...	...	...	...	6,000
Gujranwala hydel	1954	1961	...	...	...	...	...
Shadiwal hydel	1954	1961	...	...	...	...	...
Chichokimallian hydel ...	1954	1959	...	...	...	...	12,000
West Pakistan high tension grid.	1956	1961	...	...	...	...	...
Gujranwala-Daska-Sialkot extension.	1952	1958	...	...	...	...	...
Kurram Garhi transmission ...	1956	1958	...	...	...	...	...
Rasul hydel	1946	1959	...	...	...	...	...
Malakand rural extension ...	1949	In progress	...	...	...	...	...
Nationalisation of Sind electrical undertakings.	1947	1960	...	...	...	...	...
Small Schemes	1954	In progress	...	...	...	...	5,650
Total ...	...	...	...	...	...	...	262,650
Grand Total ...	...	...	1,453	3,544	500	...	426,650

105. An adequate appraisal of the available and related resources is of fundamental importance in planning for an orderly, efficient and integrated development of the basin. The formulation of policies for the conservation and full use of these resources will need to be based on the collection and interpretation of all relevant basic data, which, at present, are not adequate. A provision of Rs. 5·7 million has therefore been made in the Plan for the initiation of a long-term programme of comprehensive investigations, in order to make up this badly-felt deficiency.

106. The possibilities of utilisation of the existing natural and unregulated stream flows have already been more or less exhausted. The future development of irrigation will have to depend largely on the extent to which the surplus river flows can be conserved by storage. Moreover, to enable the exploitation of cheap and abundant supply of electrical energy, studies will have to be carried out in the upper reaches of the rivers and their tributaries, for the selection of suitable dam sites. A sum of Rs. 11·0 million has been provided in the Plan for the purpose.

107. Increasingly large quantities of ground water must be developed to replace the surface-water depletions, to augment supplies to the existing irrigated lands, and to meet new demands. The full development of this resource can proceed only if the main sources of ground water and their location, extent, nature, availability, behaviour, replenishment and quality are known with some degree of accuracy. An intensive and systematic investigation of ground water resources has been undertaken to determine the potentialities of development. The Plan includes Rs. 50 million for this purpose.

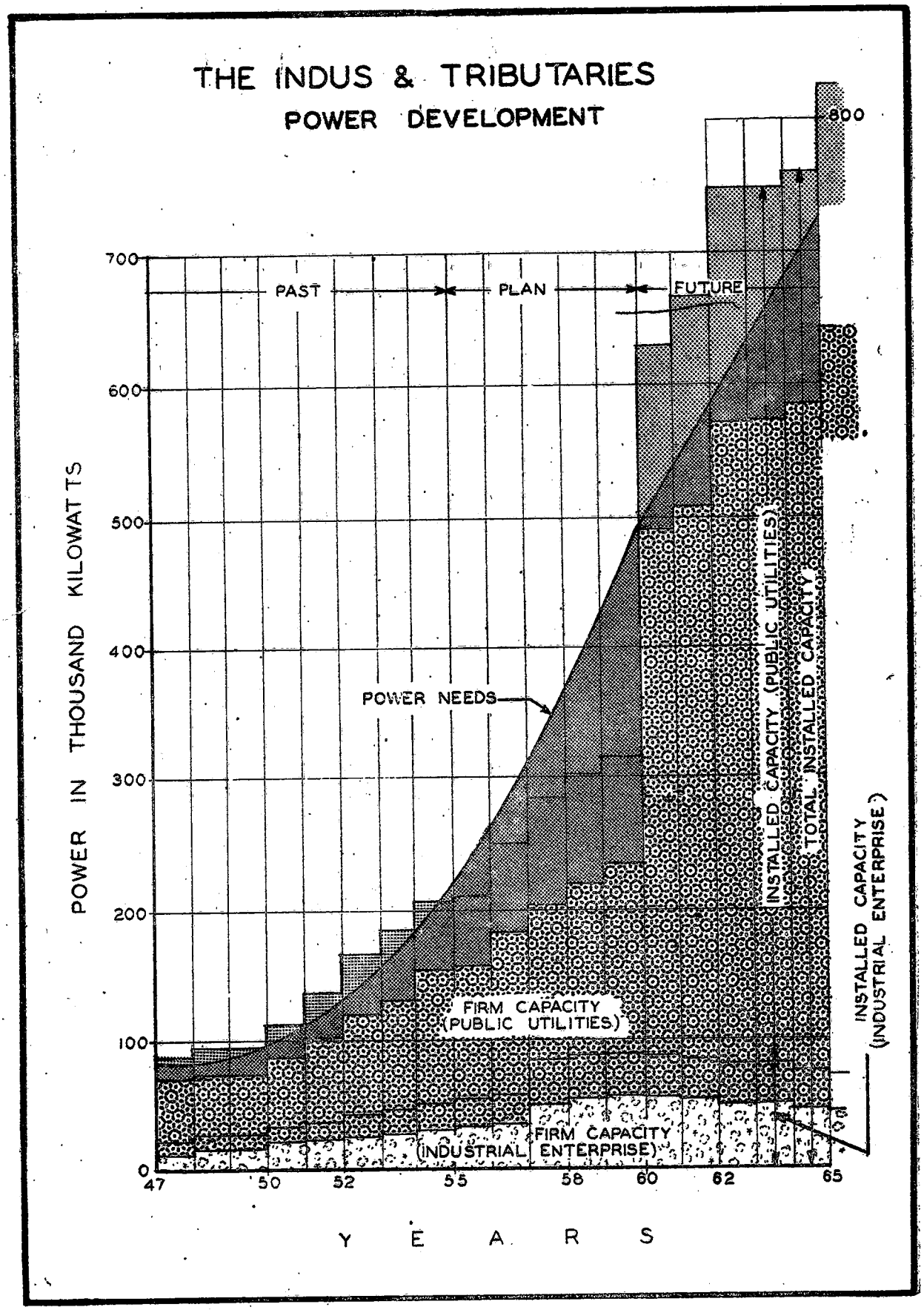
108. A sum of Rs. 10·3 million has been provided for the detailed investigations of 39 specific multipurpose and irrigation schemes, mostly small schemes to serve local needs in undeveloped areas, so that the construction of such projects as are found feasible can be started immediately after 1960.

109. The total estimated cost of multi-purpose developments is Rs. 1,370 million of which we estimate that Rs. 379 million (28 per cent.) will be spent during the Plan period. They are estimated to provide irrigation facilities for 120,000 acres of new land, improve irrigation facilities to an area of 112,000 acres, and add an installed capacity of 164,000 kw by 1960. Of the projects included under this head, the Warsak and the Kurram Garhi were under way at the beginning of 1955. The Mangla dam project is designed to have a live storage capacity of 3·5 million acre-feet, to yield about 9·5 million acre-feet of usable supplies for reclamation and improvement of existing irrigation, and to generate 300,000 kw of firm power on full development. Of the total power capacity proposed at the Mangla dam, the first unit of 75,000 kw is expected to be installed by 1965-66 to meet the growing power requirements expected by that date. The Upper Swat extension is scheduled to be started in the third year of the Plan, if the detailed investigations and surveys, to be conducted during the first two years, prove its feasibility.

110. The total estimated cost of the projects included under Irrigation is Rs. 1,757 million out of which an expenditure of Rs. 705 million or 40 per cent. will be incurred during 1955-60. They are expected to provide irrigation facilities for 1·33 million acres of uncultivated lands, and improve those on 2·43 million acres of lands already cultivated.

111. The Plan provides for the completion of all link projects underway. The Thal irrigation and Ghulam Mohammad, the Taunsa and the Gudu barrage projects were in progress at the beginning of the Plan period. The construction of the Upper Dera Ghazi Khan canal, heading at the Taunsa barrage, and of the re-modelling of the Gudu canals, have not been included in the programme, because of the lack of evidence of preparation of detailed colonisation and settlement plans. It is suggested that work on these be speeded up in the interest of economy, so that the investment on the barrages is not unnecessarily locked up for any avoidable length of time. The position will be reviewed on the receipt of such plans.

112. A number of hill torrents flood important towns and villages and damage valuable agricultural land. There are greater prospects of early results in improving the regime of these small streams as compared to the major river systems. The daming up of these streams for flood protection and for supplementing irrigation supplies is an urgent necessity. The execution of these schemes, with a reasonable assurance of success, can, however, be undertaken only after detailed investigations and surveys have been completed. The Plan provides for


THE INDUS & TRIBUTARIES
POWER DEVELOPMENT
PAST
PLAN
FUTURE
POWER NEEDS
INSTALLED CAPACITY (PUBLIC UTILITIES)
TOTAL INSTALLED CAPACITY
FIRM CAPACITY (PUBLIC UTILITIES)
FIRM CAPACITY (INDUSTRIAL ENTERPRISE)
INSTALLED CAPACITY (INDUSTRIAL ENTERPRISE)
POWER IN THOUSAND KILOWATTS
0
100
200
300
400
500
600
700
800
47
50
52
55
58
60
62
65
Y E A R S

51,000 kw in the whole of the Indus Basin. Very little progress was made on schemes for the transmission and distribution of supplies. These are estimated to cost Rs. 60 million, of which only 21 million was spent by March 1955. The balance of Rs. 33 million was spent on miscellaneous small thermal projects and the acquisition of isolated or abandoned electricity schemes. With the installation of 83,000 kw since independence, the total capacity installed for public supply in the Indus Basin rose to 161,000 kw, representing 124,000 kw of firm power against 57,000 kw at the time of independence—an increase of more than 100 per cent. While the progress may appear to be satisfactory in terms of percentage increase, it was wholly inadequate to satisfy potential needs, or to keep pace with industrialisation. Normally, hydro-electric projects take years for investigation and implementation. To add to this, there were special causes which delayed the execution of the only major hydroelectric project in the basin, the Warsak. It was proposed to fill in the gap by installing thermal plants, but these also suffered from administrative delays.

101. Large areas of formerly productive lands have gone out of cultivation. It has been estimated that over 6 million acres have already been affected to such an extent that reclamation is necessary for bringing them back to normal production. The annual rate of deterioration is very large. The Chuharkana reclamation experimental scheme has been designed to reclaim certain badly-salted lands in a water-logged area, by establishing improved methods of irrigation and agricultural practices, but has not progressed as scheduled, owing to difficulties in the acquisition of land. The Punjab Soil Reclamation Board was constituted under the Punjab Soil Reclamation Act of 1952 to deal with the problem of salinity and water-loggnig, but has not yet been able to function effectively.

102. With nearly all the unregulated surface supplies of its rivers utilised, the Indus Basin now faces the final stage of its irrigation development—the construction of multi-purpose storage projects, which will also provide large blocks of cheap power, and the exploitation of its ground-water resources.

Programme in the Plan period

103. The Plan provides for (*a*) the maximum progress, consistent with efficiency, on projects already under execution, (*b*) starting work on certain important schemes, and (*c*) general water resource investigations as well as detailed investigations of specific projects. The total cost involved is estimated to be Rs. 4,296 million, of which Rs. 777 million was the estimated expenditure up to March 1955. A sum of Rs. 1,791 million, or 42 per cent of the total estimated costs, is proposed for expenditure during the Plan period. The figures are given in Table 6. These projects have been designed :

(*a*) To provide irrigation to 4.26 million acres of uncultivated land, of which 1.45 million will be attained by 1960 ;

(*b*) To improve irrigation facilities or reclaim from salinity and water-logging an area of 8.76 million acres, of which 4.04 million will be accomplished by 1960 ;

(*c*) To generate 841,000 kw of electrical power, of which 427,000 kw will be installed during the Plan period ; and

(*d*) To improve supplies for the areas commanded by the Sutlej Valley Canals.

Annual figures in the table below are based upon detailed discussions, scheme by scheme, with Provincial Governments and Central Ministries held in the latter part of 1956. These figures vary somewhat from those used in Chapter 2, which are based on 1957-58 budgets of Central and Provincial Governments as published in the spring of 1957.

TABLE 6

Estimated expenditure on water and power resources development, 1955-60

Indus Basin

Name of Scheme	Total cost	Actual Expenditure upto March 1955	Expenditure estimates for 1955-56	1956-57	1957-58	1958-59	1959-60	1955-60	Balance to complete	Remarks
1	2	3	4	5	6	7	8	9	10	11
I. GENERAL INVESTIGATION :										
Comprehensive investigations (first phase) ...	5·7	...	...	1·0	1·2	1·5	2·0	5·7	...	To be continued.
Studies of reservoir systems (first phase)	11·7	0·7	0·6	1·4	2·5	3·0	3·5	11·0	...	Do.
Ground water investigations	65·0	0·9	3·7	6·0	10·0	15·0	15·3	50·0	14·1	
Survey of Pakistan ...	5·0	...	...	...	1·0	2·0	2·0	5·0	...	
Investigation of specific schemes	11·8	...	...	0·6	2·2	3·4	4·1	10·3	1·5	
Total ...	99·2	1·6	4·3	9·0	16·9	24·9	26·9	82·0	15·6	
II. MULTIPURPOSE DEVELOPMENT :										
Mangla dam	983·0	...	1·5	5·0	10·0	17·5	26·0	60·0	923·0	
Warsak dam	267·0	31·0	41·7	40·0	75·0	40·0	39·3	236·0	...	
Kurram Garhi	43·4	18·3	7·5	5·0	8·5	4·1	...	25·1	...	
Swat storage	38·0	...	...	0·2	0·3	5·0	14·5	20·0	18·0	
Tributary storage on Jhelum	20·0	...	...	...	1·0	5·0	14·0	20·0	...	
Gilgit	0·7	...	...	...	0·3	0·4	...	0·7	...	
Machinery pool	15·0	...	...	...	5·0	5·0	5·0	15·0	...	
Hydraulics and soil mechanics laboratory ...	0·8	0·3	0·5	...	...	...	...	0·5	...	
Research	1·5	...	...	0·3	0·4	0·4	0·4	1·5	...	
Studies and training ...	0·6	...	...	...	0·2	0·2	0·2	0·6	...	
Total ...	1370·0	49·6	51·2	50·5	100·7	77·6	99·4	379·4	941·0	
III. IRRIGATION :										
Ghulam Mohammed barrage	350·2	135·6	40·0	30·0	25·0	20·0	12·0	127·0	87·6	
Gudu barrage	304·4	11·0	20·4	25·0	40·0	40·0	24·6	150·0	143·4	
Taunsa barrage	209·6	38·1	34·7	42·5	40·0	6·0	4·0	127·2	44·3	
Thal project	154·5	145·9	2·3	3·0	3·3	...	...	8·6	...	
Warsak canals	19·6	0·3	0·1	2·0	5·5	6·1	5·6	19·3	...	
Pehur development ...	7·5	2·1	2·9	2·0	0·5	...	...	5·4	...	
Bara canals	9·0	...	...	...	0·1	4·0	4·0	8·1	0·9	
Gomal Zam	19·5	...	...	0·5	5·0	8·0	6·0	19·5	...	
Dams and reservoirs on hill torrents	9·8	0·4	...	...	0·8	3·4	3·9	8·1	1·3	
Bambanwala-Sutlej link ...	102·8	75·6	1·3	3·8	5·3	8·4	8·4	27·2	...	
Balloki-Suleimanki link ...	78·5	64·8	1·0	6·0	6·7	...	...	13·7	...	
Marala-Ravi link ...	95·2	49·0	19·0	15·9	11·3	...	...	46·2	...	
Small schemes	16·5	0·7	0·5	0·6	2·2	2·4	2·4	8·1	7·7	

TABLE 6—*contd.*

1	2	3	4	5	6	7	8	9	10	11
Tubewells, Drainage and Reclamation										
Tubewells	104·5	25·5	0·3	12·0	13·7	11·7	11·7	49·4	29·6	
Tubewells (subsidy) ...	5·0	...	...	0·2	1·0	1·8	2·0	5·0	...	
Open wells (subsidy) ...	9·0	...	...	0·6	1·9	2·5	2·5	7·5	1·5	
Reclamation schemes ...	42·7	...	0·2	2·2	7·1	6·6	8·5	24·6	18·1	
Sukkur drains	163·3	...	...	...	2·0	4·5	10·0	16·5	146·8	
Anti-water logging Khairpur	23·4	...	...	...	2·0	10·0	10·0	22·0	1·4	
Drainage Rechna, Chaj and Sind Sagar	32·0	...	...	...	2·0	4·0	6·0	12·0	20·0	
Total ...	1757·0	549·0	122·7	146·3	175·4	139·4	121·6	705·4	502·6	
IV. FLOOD REGULATION :	165·1	...	1·3	25·1	44·6	18·3	5·8	95·1	70·0	
V. POWER :										
Karachi electric supply extension	223·6	35·5	37·7	31·7	11·1	35·9	22·7	139·1*	49·0	
Natural gas power station, Multan	110·0	...	0·5	18·0	36·0	34·0	21·5	110·0	...	
Hyderabad thermal system	45·8	0·3	0·1	0·3	11·8	11·1	5·0	28·3	17·2	
Sukkur thermal system ...	35·8	...	...	...	0·2	4·0	8·0	12·2	23·6	
Lyallpur steam (6,000 kw)	6·5	0·1	0·2	0·2	2·0	2·0	2·0	6·4	...	
Lyallpur steam (2 × 4,000 kw)	8·8	5·1	2·2	1·5	...	...	...	3·7	...	
Lyallpur diesel (10,000 kw)	4·6	4·2	0·3	0·1	...	...	...	0·4	...	
Montgomery steam (2× 3,000 kw) including transmission and distribution	16·9	11·5	2·4	3·0	...	...	...	5·4	...	
Gujranwala hydel ...	34·0	1·2	1·0	3·2	5·6	6·5	6·0	22·3	10·5	
Shadiwal hydel	24·9	2·0	0·6	3·2	2·1	6·8	6·0	18·7	4·2	
Chichokimallian hydel ...	26·2	2·3	3·0	9·7	5·0	4·5	1·7	23·9	...	
West Pakistan high tension grid	120·0	...	...	8·0	25·0	23·0	24·4	80·4	39·6	
Gujranwala-Daska-Sialkot extension	7·8	1·4	1·1	1·0	1·1	3·2	...	6·4	...	
Kurram Garhi transmission	8·4	0·5	1·5	2·1	2·1	2·2	...	7·9	...	
Rasul hydel	93·9	74·3	2·5	8·1	5·0	4·0	...	19·6	...	
Malakand rural extension	40·4	32·3	2·2	2·3	2·6	1·0	...	8·1	...	
Nationalisation of Sind electrical undertakings ...	9·8	1·5	0·7	3·7	1·5	1·5	0·9	8·3	...	
Small schemes	87·5	4·5	0·9	7·9	9·3	6·5	3·4	28·0	55·0	
Total ...	904·9	176·7	56·9	104·0	120·4	146·2	101·6	529·1	199·1	
Grand Total ...	4296·2	776·9	236·4	334·9	458·0	406·4	355·3	1791·0	1728·3	

*Out of the total expenditure of Rs. 139·1 million, Rs. 77 million is proposed to be financed from the private sector.

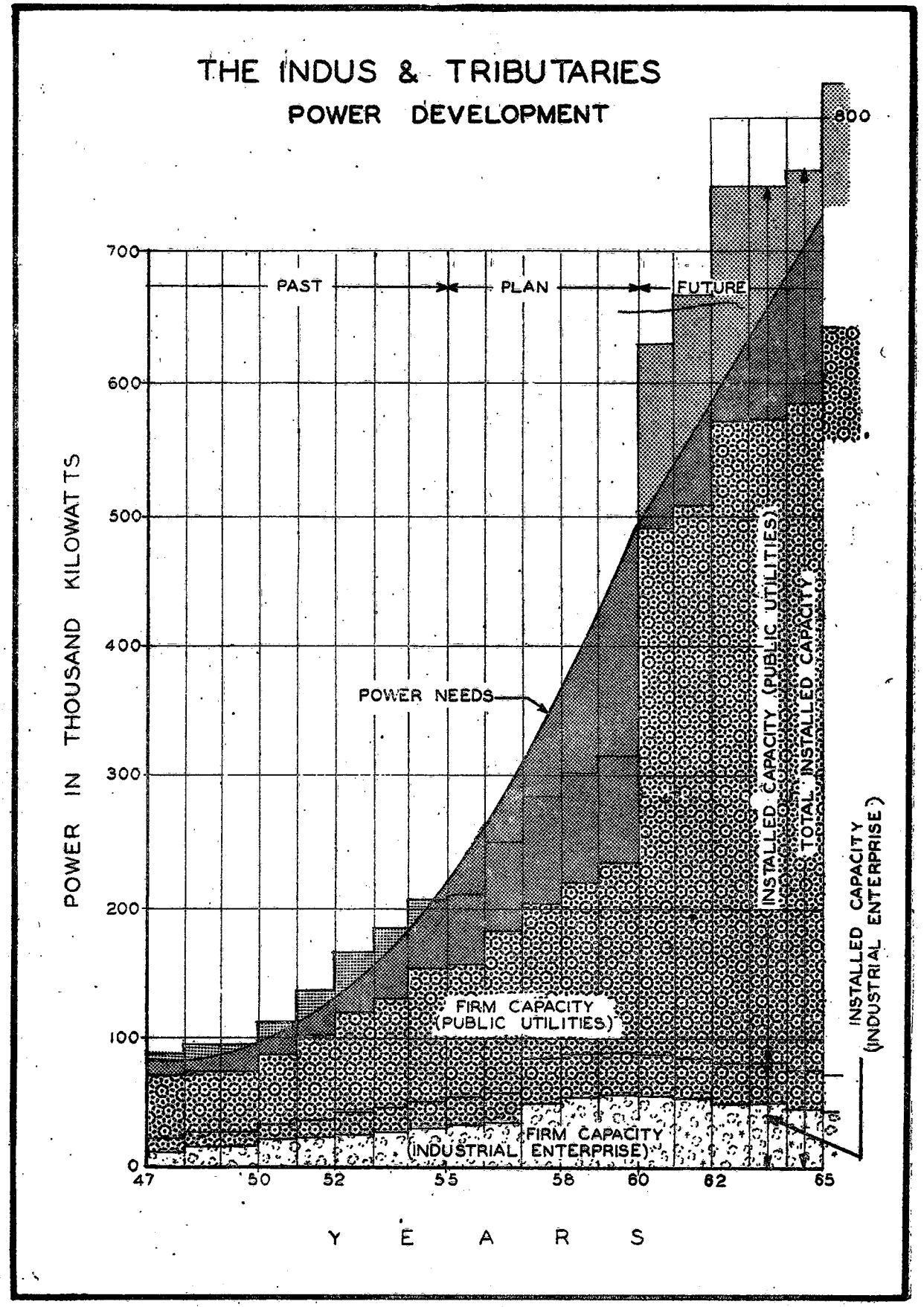
104. The expected results during the Plan period will represent (a) 34 per cent. (b) 49 per cent. and (c) 50 per cent. respectively of the designed goals. A substantial part of the proposed expenditure during 1955-60 on irrigation and multi-purpose developments are for maintaining and improving the productive capacity of the lands already irrigated. New lands will generally be served by schemes which had been started before 1955, and on which substantial expenditure had already been incurred, such as the Thal canals, and the Ghulam Mohammad, Taunsa, and Guddu barrage schemes ; on a large number of developments, expenditures previously made will produce results during the Plan period, and similarly, expenditure in the Plan will produce results after 1960. The expected results during the Plan period are summarised in Table 7.

TABLE 7

Expected results from water and power resources development, 1960.

Indus Basin

Name of scheme	Period of execution		Expected results during the Plan period				
	Commencement	Completion	Area irrigated new	Area irrigated old	Area reclimed	Area drained	Power
1	2	3	4	5	6	7	8
					(Thousand acres)		(kw)
I. GENERAL INVESTIGATION :							
Comprehensive investigations (first phase)	1956	In progress	...	...	...	...	...
Studies of reservior system (first phase).	1954	„	...	...	...	...	...
Ground water investigations.	1954	„	...	...	...	...	...
Investigations of specific schemes	1954	„	...	...	...	...	...
II. MULTIPURPOSE DEVELOPMENT :							
Mangla dam	1955	„	...	...	...	...	...
Warsak dam	1954	1960	...	...	...	...	160,000
Kurram Garhi	1950	1957	120	112	...	...	4,000
Swat storage	1955	In progress	...	...	...	...	...
Tributary storage on Jhelum...	1957	1960	...	...	...	...	...
Gilgit	1957	1959	...	...	...	...	...
Machinery pool	1957	1960	...	...	...	...	...
Hydraulics and soil mechanics laboratory.	1954	1956	...	...	...	...	...
Research	1956	1960	...	...	...	...	...
Studies and training ...	1957	1960	...	...	...	...	...
	Total ...		120	112	...	...	164,000
III. IRRIGATION :							
Ghulam Mohammad barrage	1947	1962	304	870	...	...	...
Gudu barrage	1953	In progress	...	950	...	...	...
Taunsa barrage	1953	Do.	70	1,255	...	...	...
Thal project	1939	1958	275	...	...	...	...
Warsak canals	1954	1960	...	...	...	...	...
Gomal Zam	1956	1960	...	...	...	...	...
Pehur development ...	1954	1958	48	12	...	...	...
Bara canals	1956	In progress	...	...	...	...	...
Small schemes	1954	Do.	130	5	...	...	...
Dams and reservoirs on hill torrents	1954	Do.	...	...	...	...	...


THE INDUS & TRIBUTARIES
POWER DEVELOPMENT
POWER IN THOUSAND KILOWATTS
700
600
500
400
300
200
100
0
PAST
PLAN
FUTURE
800
POWER NEEDS
INSTALLED CAPACITY (PUBLIC UTILITIES)
TOTAL INSTALLED CAPACITY
INSTALLED CAPACITY (INDUSTRIAL ENTERPRISE)
FIRM CAPACITY (PUBLIC UTILITIES)
FIRM CAPACITY (INDUSTRIAL ENTERPRISE)
47
50
52
55
58
60
62
65
Y E A R S

the investigations of 17 schemes in Kohistan and Dera Ghazi Khan regions. Besides the completion of Gomal Zam project it allows for the construction of 3 other schemes on a pilot-project basis.

113. Other irrigation schemes, mostly small, comprise :

(a) Diversion of stream flows into canals by gravity or lift ; and

(b) Improvement, extension and re-modelling of existing canals.

114. A provision of about Rs. 62 million has been made in the Plan for the development of ground-water resources. Of the schemes included under this head, the main object of the Punjab tube-well project is to reduce waterlogging in the Bari Doab, Bambanwala-Ravi-Bedian link area, and the Lower and Upper Chenab canal zones. It will also augment the supply of water to the existing irrigated areas. The Dera Ismail Khan tube-well project will provide irrigation facilities for new lands. The sum of 62 million rupees includes 12·5 million for the provision of technical services, materials, and equipment, not locally available to individual farmers for the installation and improvement of percolation and tube-wells.

115. The progress of the tube-well programme will depend on that of the ground-water survey and the availability of cheap power. Considering the serious physical, technical and ecomomic limitations, and particularly the lack of low cost power, the Plan presents a programme for ground water development which may reasonably be expected to be attained. Although the present cost of hydro-electricity is somewhat less than that of energy from thermal plants, the price is still not low enough to justify large-scale expansion of tube-well pumping.

116. No plan comprising irrigation works can be effective unless it includes schemes for arresting the deterioration of land already in use. We recommend that, as soon as detailed results of the pilot reclamation projects at Chuharkana and Jaranwala become known, concrete plans should be prepared for the extension of proven methods to other affected areas. A provision of Rs. 25 million has been made in the Plan for such reclamation works.

117. We recognise the urgent need for a comprehensive programme to stabilise and improve the yields of existing irrigated areas. The Plan includes a systematic programme for the drainage of irrigated lands in the Rechna, Chaj and Sind Sagar doabs and in the Sukkur barrage zone. The problem of waterlogging in the Khairpur division, attributed to the Rohri canal, is very acute. A provision of Rs. 23 million has been made in the Plan for the execution of remedial measures subject to the test of feasibility. It also provides for detailed investigations of the drainage problems of the tracts served by the Ghulam Mohammad, Gudu and Taunsa barrages.

118. It is realised that the great destruction caused by floods should be minimised. It must, however, be emphasised that flood control is a fundamental part of, and cannot be separated from, unified river basin development. An efficient and comprehensive system of flood regulation can be based only on reliable fundamental data. Detailed investigation would be necessary before suitable long-term schemes can be drawn up and implemented. A tentative programme comprising protective works of immediate nature has been prepared. Besides providing for flood regulation as a part of multipurpose projects, the Plan makes a separate allocation of Rs. 95 million for flood protection works designed primarily to improve conditions locally.

119. Small local water development schemes have been given higher priority in the Plan, because the interval between the construction of works and the accrual of benefits will be short and the increase in production quick, visible and local, stimulating local contributions, particularly in the form of labour and indigenous materials from the immediate beneficiaries. Small irrigation schemes can generally be undertaken by those directly benefited. Technical services, materials and essential equipment not available locally can be supplied by the Government.

120. Most of the schemes included under power are scheduled for completion before 1960. Of the total estimated cost of Rs. 905 million of such schemes, about Rs. 177 million or 20 per cent. was spent before the plan period and about Rs. 529 million or 58 per cent. is scheduled for expenditure during the Plan period. Among the major thermal generating schemes the Plan provides for the installation of a 140,000 kw steam station using

natural gas as fuel. It has been decided to locate this station at Multan. At Karachi, the newly completed 30,000 kw steam station based on natural gas will be extended by another 45,000 kw during the Plan period. Besides this, a new steam station, also based on natural gas, is proposed for early completion to meet the large unsatisfied demand of the Federal Capital and its suburbs. A sum of Rs. 80·5 million is included for expenditure on the high-voltage integrated transmission system which must be completed as soon as possible, perhaps by 1961, in order to make full and efficient use of all generating capacity linked to it. The Sukkur and the Hyderabad thermal systems are scheduled to be started during the Plan period and will be partially completed by 1960.

121. About 263,000 kw of generating capacity are proposed to be installed by 1960, in addition to the 164,000 kw to be installed as part of the multipurpose developments, giving a grand total of 427,000 kw to be installed by public utilities during 1955-60. Private installations made by industries, such as the 29,200 kw at Daudkhel, are expected to reach a total of 47,000 kw during the Plan period. The aggregate capacity expected to be installed during this period will, therefore, be about 474,000 kw.

122. The results expected during the Plan period include (a) the provision of irrigation facilities to 1·33 million acres of uncultivated land, (b) the improvement of irrigation service to 3·43 million acres of cultivated land and (c) the reclamation of 0·50 million acres of saline and water-logged lands. Assuming that the existing production on the lands, for which irrigation facilities are improved, will, on the average, be raised by about 25 per cent and the increase in production on the reclaimed lands will suffice only to offset the progressive deterioration due to salinity and water-logging in other areas, it is estimated that the net increased production will be equivalent to that of about 2 million acres of irrigated virgin lands. Of the 1·33 million acres of uncultivated land to be irrigated, about one million acres lie in large compact blocks and will need a major colonisation effort. The balance is in relatively small patches interspersed in developed areas. Although, on the basis of accomplishment since independence, and taking into account the complicated factors during that period, the proposed programme may appear ambitious ; it is, none the less, attainable.

123. The addition of 474,000 kw during the Plan period, will raise the total installed capacity to 685,000 kw in 1960. On the other hand, 52,000 kw of old thermal plant will become obsolete and have to be retired by that date, giving a net effective capacity in 1960 of 633,000 kw of which 492,000 kw may be considered as dependable capacity. Power requirements are estimated to be 495,000 kw by the same date. Hence the firm power available in 1960 is likely to be just about sufficient to meet the power demand existing at that time. During the Plan period itself, shortage of firm capacity will persist ; this can, as an emergency measure be overcome by using old plant normally held in reserve. This practice is tolerable for short periods of peak demand but adversely affects the quality of supply. The shortage in 1955 was about 30 per cent. and will still be of that order in 1958. The present generation by public utilities of 14 units per head of population is expected to rise to 40 by 1960, after taking into account the probable population growth.

124. Experience has shown that the most critical time of development is at the start of a new scheme. While most of the programme comprises schemes which have already been started, there are a few of vital importance which it is proposed to start during the Plan period. Responsible and convincing findings of feasibility, firm and immediate decisions by Government, prompt, effective and responsible implementation of the work in the field, and simplified procurement and financial procedures will be the best assurance of fulfilling the programme.

125. The attainment of the programme goals will not necessarily follow the fulfilment of the programme. In the field of agricultural accomplishments, provision of irrigation facilities will not, by itself, assure increased production. Establishment of farm units, colonisation, settlement and actual cultivation are necessary, before the full productive capacity of new lands can be realised. It must be recognised that the past record of land colonisation and settlement, following the initiation of the relative schemes, does not provide an assurance of early attainment of the programme goals. As most of the large developments are now under way, an all-out effort will have to be made to accelerate sound programmes for colonisation and settlement, if the requirements for increased agricultural production are to be met. In the field of power, the programme proposes to more than double the existing installed capacity during the Plan period. Assuming a prompt start the goal is capable of

reasonable attainment, but, again, it must be remembered that installed capacity by itself cannot serve power loads, until adequate and efficient transmission and distribution facilities have been provided. The early completion of the transmission systems, and more particularly the West Pakistan Grid, are essential, if the ever-growing power loads are at all to be served. Effective measures for colonisation, settlement improvement of cultivative practices and the perfection of facilities for the widespread distribution of electrical energy, are essential for the full implementation of the Plan.

COASTAL TRIBUTARIES AND DESERT STREAMS REGION

General description

126. The total area of the region is over 100,000 square miles, more than one-fourth of the whole country. For the most part, it is barren, with rugged mountains interspersed with semi-desert valleys and plains. The rocks are mainly sedimentary and highly folded, faulted and fissured. Many of the valleys are synclinal and have inland drainage. Only the Zhob river (a tributary of the Indus) in the north, and some streams in Mekran and Las Bela in the south, drain into the Arabian Sea.

127. Great aridity and large temperature ranges are the leading features of the climate. The uplands, between the elevations of 1,000 and 11,000 ft., experience intense cold, the minimum temperature ranging from —30° F to +30° F. The lowlands experience intense heat ranging from 90° to 130° F. The winds are strong for most of the year, both in the desert plains and the border valleys. The yearly average wind velocity at Quetta is about 6 miles per hour. Because of the high temperatures, low humidity and strong winds, the evaporation losses are very heavy, particularly from April to September.

128. The rainfall is scanty, badly distributed and exceedingly irregular. The number of really rainy days is extremely limited. The annual rainfall is hardly anywhere over 10 inches. In the plains the average is about 5 inches, going down, in some cases, to 2 inches. The average annual rainfall for the former Baluchistan Province is approximately 7·95 inches, and for the former Baluchistan States Union about 5·31.

Natural resources

129. The land is divided into small units by natural barriers, and pockets of good culturable land of variable extent, are scattered all over the region, aggregating approximately to 10 million acres, which represents 12 per cent. of the total land area. Of this, about 4 million are cultivated. Not all of this, however, is farmed at any one time. The actual acreage under crops varies from year to year, depending on the amount, intensitya nd time of occurrence of the rainfall. In an average year probably not more than 20 per cent. of the cultivated acreage is sown to crops.

130. The gravelly fans (*damans*) below the hills are mostly uncultivable, but are suitable as range for livestock. It has been estimated that 50 per cent. of the total land area could either be cultivated or developed as range land. Apart from the major river valleys the greater part of the area is perfectly arid and the only source of water is the uncertain and limited rainfall. There are innumerable small streams with insignificant flows and only in the larger ones does the flow continue for any considerable period of time. Perennial flow is found only in the lower reaches of the larger streams. Generally, flows are of a flashy character, the greater part of the run-off occurring at very high rates for very short periods. Most of the streams have steep bed slopes, carry a heavy load of silt, and traverse through young limestones, which are badly fractured and jointed. Practically no organised information exists for the proper assessment of the water resources of the region. As a very rough estimate, the stream flow in an average year may be placed at 4 to 5 million acre feet.

131. The geological formations and structures in the uplands favour the accumulation and transmission of ground water. There are a large number of springs, but the rate of flow in most of them is inconsequential. There appear, however, to be valuable and important ground-water supplies in certain areas, although they have not so far been precisely assessed. Pending completion of conclusive explorations and tests, firm estimates of their extent are not possible, but, as a rough approximation, the recoverable ground water may be said to be 2·5 million acre ft. per annum.

132. Fundamental data, which are a pre-requisite to drawing up a comprehensive programme of resource development, are completely lacking. The existing topographical maps are out of date, and lack in the details essential for the development of water resources. Accurate and precise levels are not available. The geology of the area has not been studied in any great detail, though a valuable series of aerial photographs, supplemented by ground geological reconnaissance surveys, have recently been completed.

133. At a number of stations, quite comprehensive meteorological records have been kept, some of which cover periods of 40 years or more. The number of rain-gauging stations, however, is insufficient to provide an adequate coverage, nor is there a systematic record of stream flows. Patchy and incomplete information is available in some cases, but no reliable data on floods, maximum and minimum flows, evaporation and percolation losses, silt loads, sub-surface yields, etc., exist.

Needs

134. The course, which land development should take in this region, is indicated below, in the order of importance :

(*a*) Conservation and development of range lands and forests ;

(*b*) Increased production of fodder ;

(*c*) Improvement in volume, quality and variety of fruit production ; and

(*d*) Production of foodgrains for local consumption.

135. Agriculture in this region is precarious, owing to the scarcity and the spasmodic nature of the rainfall and the unreliability of stream flows. The incidence of crop failure is therefore high and the yields low, while large fertile lands are lying barren, for want of adequate and regular water supply. It is estimated that 8·5 million acres could be placed under foodgrains and speciality crops, for which about 17 million acre-feet of water would be required annually, if it could be made available. At present only about 400,000 acres are under irrigated crops : at a guess, and allowing for prospective increases in productivity per acre, this acreage would have to be doubled by 1960 merely to provide present standards of consumption for the increased population.

136. Range lands and forests could be extended to cover 40 per cent. of the total land area. At present the area under forests is far from adequate for the needs of the region. It is estimated that 1·5 million acre-feet of water would be required for irrigated plantations and nurseries. For a balanced livestock economy, fodder supplies would have to be increased to provide for winter feeding and reserves for periods of stress. Allowing for an area under irrigated fodder crops, equivalent to 5 per cent. of the total range lands, the water requirements would be 4·25 million acre-feet per annum. Fruit culture is one of the region's greatest potential assets. The area under orchards could easily be increased by 200 per cent., and the total annual water requirements for the purpose would be 1 million acre-feet.

137. A reliable and perennial supply of drinking water to human settlements is necessary for any development in an arid region. This applies with greater force to range lands, where provision for adequate and well-spaced watering points is a basic need to enable a larger proportion of the range to be evenly grazed at all times of the year. It is estimated that 1 million acre feet of water would be required annually for this purpose.

138. The total water requirements of the region for ultimate development may, therefore, be placed at about 25 million acre-feet per annum, of which (a) 8 would be required for the urgent needs of grazing, forests, fodder and fruit culture and (b) 17 for food crops. This, as far as can be seen at present, is far in excess of the gross annual supplies available. Developments in category (a) will pay higher dividends in the long run and efforts should be concentrated on them. Category (b) can be spread over a longer period. The position can be reviewed afresh during every future plan period, as more and more data are made available.

139. The whole region being more or less a desert, it is naturally the most backward in industrial, and therefore power development. In 1955, the total electrical load was estimated to be 2,500 kw., of which 2,000 was concentrated in Quetta. For purposes of the industrial and agricultural development programme in the Plan, the power requirement has been estimated at 5,000 kw in 1960.

Long range development of the region

140. Such developments of the water and related resources, as have taken place in the region, are mostly of a local and indigenous character. There is evidence that some of the methods now practised were imported from Iran a long time back, and little or no improvements has taken place since, owing, chiefly, to the isolation from which the region suffered in the past. These methods are :

(*a*) Diversion of flows from perennial streams ;

(*b*) Detention of flood waters and flows of non-perennial streams ; and

(*c*) Tapping underground water source.

141. Perennial stream flows are limited, and the area irrigated by perennial canals very small, but relatively important because of the greater variety, larger yields, and higher value of the crop grown. The Nari and Pishin canals are provided with permanent works, and supply water to 17,500 and 5,000 acres of land respectively. Canals in the Lehri, Jhal and Tamboo areas, in Kalat Division, irrigate about 50,000 acres, and derive their supply from perennial flows by means of katcha bunds, which are washed away during the floods, and have to be replaced every year.

142. The purpose of detaining non-perennial flows is to convert short flood discharges into usable flows continuing over longer periods. This is done by simple detention reservoirs, diversion bunds of a semi-permanent type and canals, which require constant maintenance and frequent replacements. The water is conducted, as and when available, to the fields, which are bunded and terraced, in order to pond up the water and permit it to be stored in the soil for crop production. This method of irrigation, known as *sailaba*, is quite extensive, but entails very large expenditure in maintaining the bunds and terraces. About 650,000 acres are provided with these facilities, but the area actually irrigated in any one year does not exceed 10 per cent. of this.

143. Sub-surface weirs have been built for raising and diverting the underground flow in streams, but with indifferent success. Water stored in stream beds has also been drawn up by means of infiltration galleries, but, owing to lack of maintenance, the supplies made available have deteriorated progressively. Springs and *karezes* provide a substantial portion of the total perennial water supplies of the region. In the administered area of former Baluchistan alone, there were 1800 springs in 1908. Unfortunately, springs are allowed to flow without control. Although there are no dependable records, it is estimated, very roughly, that about 300,000 acres of land are irrigated annually by springs and *Karezes*. The latter are a distinctive feature of this region. The *karez* is specially adapted to the local geological conditions, in which water is stored in the coarse material of the alluvial fans which are deposited by hill torrents at the edges of the valleys. It consists of a collection gallery built in the water bearing fan, with an underground conduit for leading the water to the surface by virtue of the difference in the slope of the conduit and the ground slopes. This method of exploiting undergro und water has been practised for centuries, and is still the main source of perennial supply in the region, there being roughly 600 *karezes*.

144. At present wells do not play a significant role in the total water supply of the region, although, in certain areas, they constitute the only available source. Well water in the plains and desert areas is generally saline. Open wells are usually fitted with Persian wheels, worked mostly by camels. The tube wells, now being drilled, are powered by diesel engines, which are expensive in both first and recurring costs. Artesian wells are also found in a few places. The total area irrigated by wells in the region is only about 7,000 acres.

145. The total area irrigated in the region by all methods averages during the year to about 400,000 acres. Where perennial and dependable water supplies are available and the climate and soils favourable, high quality fruits, nuts, and vegetables are grown. Where the supply of water is variable and less dependable, it is used for production of food grains, watering livestock and domestic purposes. Lack of evenly distributed water supplies for livestock causes overgrazing and destruction of the range. Vagaries of rainfall and, as a consequence, of crop and range production, keep the population on the move.

146. Because of the scarcity of water, the conservation of supplies becomes obligatory, but the temporary nature and poor maintenance of the bunds and terraces built for the purpose, often result in failures at critical

times, and account for serious loss of water and damage to crops. Not much has been done to reduce excessive transportation losses in canal systems and *karezes*. The practice of allowing spring and *karezes* to flow throughout the year, regardless of demand, results in wastage of precious water.

147. The livestock industry requires extensive as well as efficient use of the range, and provision of dependable water supply. If watering places were well spaced, livestock would be able to graze broader areas, and destruction by over-grazing reduced. These would consist of wells as well as tanks to store surface run-off. Use of engine-driven pumps to raise water from wells would be expensive in initial and running costs, both of which involve foreign exchange, while the necessary fuels, machinery and spare parts would have to be transported over long distances in rough country. Also the technical skills required for maintenance would not easily be available. The practicability of wind mills, for pumping water into small storage tanks, should be explored, and simple devices for spreading surface run-off should be adopted, in order to improve the quality of the range. Water required for production of forage and food for the herdsmen may be supplied through the use of indigenous methods, improved in design, construction and maintenance. It would be reasonable to assume that, by the application of efficient methods, the carrying capacity of the range could be doubled.

148. Comparatively good opportunities exist for intensive cultivation along the Arabian Sea littoral, through the development of the coastal tributaries,—the Dasht, the Hingol, the Porali and the Hab, which have perennial flows, and on which weirs, dams, and reservoirs could usefully be built. Except these and possibly some of the others, such as, the Pishin Lora, and the Bolan water supplies should be developed or augmented in quantity and time by improved indigenous methods, and by the intensive use of contributed labour and local materials, supplemented by technical and professional skills, and the barest essential equipment and materials not available locally. Highly mechanised methods and sophisticated designs may prove costly and fruitless in the region. The efficiency and permanence of bunds and terraces should be improved by establishing proper alignment, section and grade, and through the construction of simple spillways of a permanent nature. Losses in canals should be reduced by construction to capacities required to reduce over-topping of banks, by the installation of permanent escapes, and by lining the channels in sections of the greatest loss with finely graded soil. Simply designed permanent diversion structures, constructed of native materials, would reduce water losses, and the high costs of maintenance and replacement of failures. Such methods should at least double the quantity of water now being put to beneficial use.

149. Lining infiltration galleries and sections of *karezes*, which are below the hydraulic gradient with permanent pervious materials, locally available, would increase water yields, while lining those above the gradient with impervious material would reduce transportation losses, and both would result in lower costs of maintenance. The installation of control gates above the impervious section of the *karez* would induce greater storage in the aquifer, increasing the efficiency of established control, and so result in the conservation of the water supply. Capping and regulating releases from flowing springs would accomplish the same purpose. It is estimated that the usable water supply from those sources could thus be increased three times.

150. Open and tube-wells, now being installed in the region, should be constructed well within the limits of the safe sustained yield of the aquifer, in order to reduce the possibility of over-expansion, and the consequent loss of investment and subsequent distress. Intensive investigations of ground-water resources should therefore be directed to define those limits. Efficient methods of recovery of ground water at a reasonable cost in tracts where low-cost power is not available, have yet to be explored. No estimates are at present available of the potential recoveries from ground water by open or tube-wells.

151. The possibility should also be explored of using part of the diverted flood waters for replenishing existing or potential aquifers, as a sure means of improving the underground source of water supply. The torrential nature of the run-off makes the control and conservation of flood flows extremely difficult, and it is very desirable to see that all catchment areas are protected, as early as might be feasible, with a suitable mantle of vegetation to produce steadier flows of streams and springs, and to retard the silting up of reservoirs and canals.

152. There are few areas of concentrated demand for electric power in the region, and future developments would consist of a number of relatively small isolated thermal generating plants, using improved local fuels. Because of the transmission distances involved, and the small power loads, the prospect for low-cost electric energy appears dim. Possibilities exist of medium-sized hydro-electric schemes on the coastal tributaries, for which a demand may be found in the development of ports and of the littoral generally.

153. In relation to the development already attained, the opportunities for further development are considerable. Since no exhaustive survey has been made, it is impossible to forecast, with any degree of accuracy, the ultimate extent of development, but, whatever this might be, it is imperative that the known resources should be conserved and used efficiently. Comprehensive planning requires the collection, investigation and analysis of a wide variety of meteorological, hydrological and geological data, the extreme paucity of which is a great bar to immediate progress. The actual extent of the available water resources, which could be used for irrigation, is not known in precise terms. The conservation of flood flows becomes difficult because of the undertermined nature of the run-off characteristics. Evaporation losses are not known, although it is certain they must be considerable. It can also be said with certainty that the area suitable for irrigation far exceeds the presently supposed availability of usable water, which has been placed, very roughly, at 7.5 million acre-feet. Allowing 1 million acre-feet for speciality crops such as fruits, nuts, etc., and another million acre-feet for domestic, commercial, industrial and stock-watering purposes, the balance of 5.5 million acre-feet would be available for food and forage crops. This would suffice to irrigate about 2.75 million acres, for one crop only. Considering that there is 10 million acres of culturable land in the region, it is obvious that a major portion of it must remain unirrigated, or depend on such poor and uncertain rainfall as it gets. It is equally obvious, therefore, that development must proceed on the basis of the most economical use of water on the best soil for the production of the most suitable and paying crops. Hence, any long range programme of development should comprise :

(*a*) Extensive reconnaissance of water and related resources ;

(*b*) Intensive investigations and plans for improving efficiencies of existing developments ;

(*c*) Improvement of works to increase efficiencies ;

(*d*) Preparation of plans for further development ;

(*e*) Construction of such feasible projects as emerge from (d) ;

The requirements of such a programme are primarily :

(*a*) Professional and technical skills ;

(*b*) Strong local leadership ; and

(*c*) Supply of essential items of equipment and materials, not available locally.

Development since Independence

154. The developments undertaken in the region since independence comprise :

(*a*) Storage reservoirs ;

(*b*) Diversion dams and weirs ;

(*c*) Sub-surface weirs ;

(*d*) Development of ground water ; and

(*e*) Miscellaneous minor irrigation schemes.

155. The estimated cost of the projects started since independence and completed by or in progress at the end of March 1955, totalled Rs. 7·2 million of which Rs. 5·0 millions was the estimated expenditure by that date. The projects are designed to provide irrigation facilities to about 60,000 acres. By March 1955 about 8,200 acres of land were brought under irrigation, representing 14 per cent of the designed accomplishments. The figures are given in Table 8. These Totals do not include expenditure on water developments financed entirely on non-Government account nor their accomplishments. No data relating to them are available, but they are a relatively small proportion of the total.

TABLE 8

Water and power resources development, 1947—55

Coastal Tributaries and Desert Streams

Name of scheme	Total estimated cost	Estimated expenditure up to March, 1955	Started in	Status	Results achieved by March, 1955		
					Area irrigated	Area reclaimed	Area drained
1	2	3	4	5	6	7	8
IRRIGATION :	(Million rupees)				(Thousand acres)		
Bolan dam project	4·7	2·1	1953	In progress	...	...	...
Anambar weir project	0·8	1·0	1948	Completed	...	...	...
Zargi Tangi	0·3	0·4	1946	Do.	1·2	...	...
Narechi irrigation	0·2	0·3	1949	Do.	0·5	...	...
Sub-surface weir at Brewery Quetta ...	0·1	0·1	1947	Abandoned	...	...	...
Duki water course	0·1	0·1	1949	Completed	0·8	...	...
120 minor irrigation schemes ...	1·0	1·0	...	Nearly completed.	5·7	...	...
Total ...	7·2	5·0			8·2	...	...

156. The actual cost figures have, in all cases, exceeded the project estimates, while not even a fraction of the expected benefits has been realised. This may be attributed to the fact that the basic data, essential for drawing up sound projects, were almost completely lacking, and most of the schemes were undertaken prematurely. Some schemes were either abandoned when half completed, like the sub-surface weir at the Murree Brewery, or ended in partial failure like the Zargi Tangi. In most of them, like the Anambar, the Narechi, and the Zargi Tangi the unwarranted expectations of high availabilities of supply were not realised, with the result that the schemes are not functioning as projected. In the case of the Anambar, even the available supply is not being fully utilized, as the final distribution of water is still in dispute. The execution of the Bolan Dam, project, designed to store and divert the flows of the Bolan river, was considerably delayed for various reasons.

157. Ground water is destined to play an important role in the future development of this region. It is necessary to delineate areas which show promise of development by tubewells. A few drilling rigs are actually in operation for experimental purposes, and, 31 bores have been hitherto drilled, of which 15 have proved successful. The cultivators were also encouraged to dig percolation wells, with the help of long-term " *taccavi* " loans.

158. The minor irrigation works consisted of :

(*a*) The improvement of the existing sources of supply by lining irrigation channels and water courses;
(*b*) The extension of sailaba cultivation ;
(*c*) The excavation of *karezes* and open wells ; and
(*d*) The improvement of springs, *karezes*, etc.

159. There was hardly any development in the field of power. The total installed capacity in 1955 was 2,800 kw, an increase of 600 kw since 1947, because of the addition of new diesel sets to the Quetta Power Station. The new woollen mill at Harnai has installed a small generating plant of its own.

Programme in the Plan period

160. The Plan includes comprehensive general investigations as well as detailed investigations of specific schemes, and the construction of small irrigation and power projects. The total cost of the schemes included in the Plan is estimated to be Rs. 157 millions, of which Rs. 2·5 millions was the estimated expenditure up to March 1955. A provision of Rs. 55 million (or 35 per cent of the total) has been made for expenditure during the Plan period. The figures are given in Table 9 below. The schemes are designed to irrigate 907,000 acres,

and produce 5,000 kw of power, in a coal-fired thermal station located at Quetta. It is expected that, by 1960, an area of 166,000 acres will be in receipt of the benefits of irrigation. The proposed 5,000 kw thermal station is, however, expected to be only partially completed by that time. These expected results are shown in Table 10. The Plan includes the completion of schemes that were in progress at the beginning of 1955, such as the Bolan Dam Project. It also provides for a start on the construction of such of the canals from the Gudu Barrage as serve lands in the region, although this item might, with equal propriety, have been included in the Indus Basin. Annual figures in the table below are based upon detailed discussions, scheme by scheme, with Provincial Government and Central Ministries held in the latter part of 1956. These figures vary somewhat from those used in Chapter 2, which are based on 1957-58 budgets of Central and Provincial Governments as published in the spring of 1957.

TABLE 9

Estimated expenditure on water and power resources development 1955—60

Coastal Tributaries and Desert Streams

(Million rupees)

Name of Scheme	Total Estimated Cost	Actual Expenditure up to March, 1955	Expenditure estimate for						Balance to complete	Remarks
			1955-56	1956-57	1957-58	1958-59	1959-60	1955-60		
1	2	3	4	5	6	7	8	9	10	11
I. GENERAL INVESTIGATION :										
Comprehensive investigations	2·8	...	0·1	0·3	0·5	0·8	1·1	2·8	...	
Survey of Sibi and Kachhi plains.	1·8	...	...	...	0·3	0·5	1·0	1·8	...	
Instruments and equipment	0·3	...	...	0·1	0·1	0·1	...	0·3	...	
Investigations of specific schemes.	0·8	...	...	...	0·3	0·3	0·2	0·8	...	
Total ...	5·7	...	0·1	0·4	1·2	1·7	2·3	5·7	...	
II. IRRIGATION :										
Flood irrigation schemes in Kalat Division.	55·3	...	...	...	1·0	1·5	2·0	4·5	50·8	
Canals from Gudu ...	23·2	...	...	0·3	3·0	5·0	8·0	16·3	6·9	
Ground water exploration and development.	40·4	...	1·0	1·6	2·0	2·5	2·5	9·6	30·8	
Lining of channels ...	7·8	...	...	0·1	0·3	0·4	0·5	1·3	6·5	
Bolan dam	4·7	2·1	1·9	0·4	0·3	...	...	2·6	...	
Small irrigation schemes ...	12·1	0·4	0·1	0·2	2·7	3·1	3·9	10·0	1·8	
Total ...	143·6	2·5	3·0	2·6	9·3	12·5	16·9	44·3	96·8	
III.—POWER :										
Quetta thermal power project.	8·0	...	...	...	1·0	2·0	2·0	5·0	3·0	
Grand Total ...	157·3	2·5	3·1	3·0	11·5	16·2	21·2	55·0	99·8	

TABLE 10

Expected results from water and power resources development by March, 1960

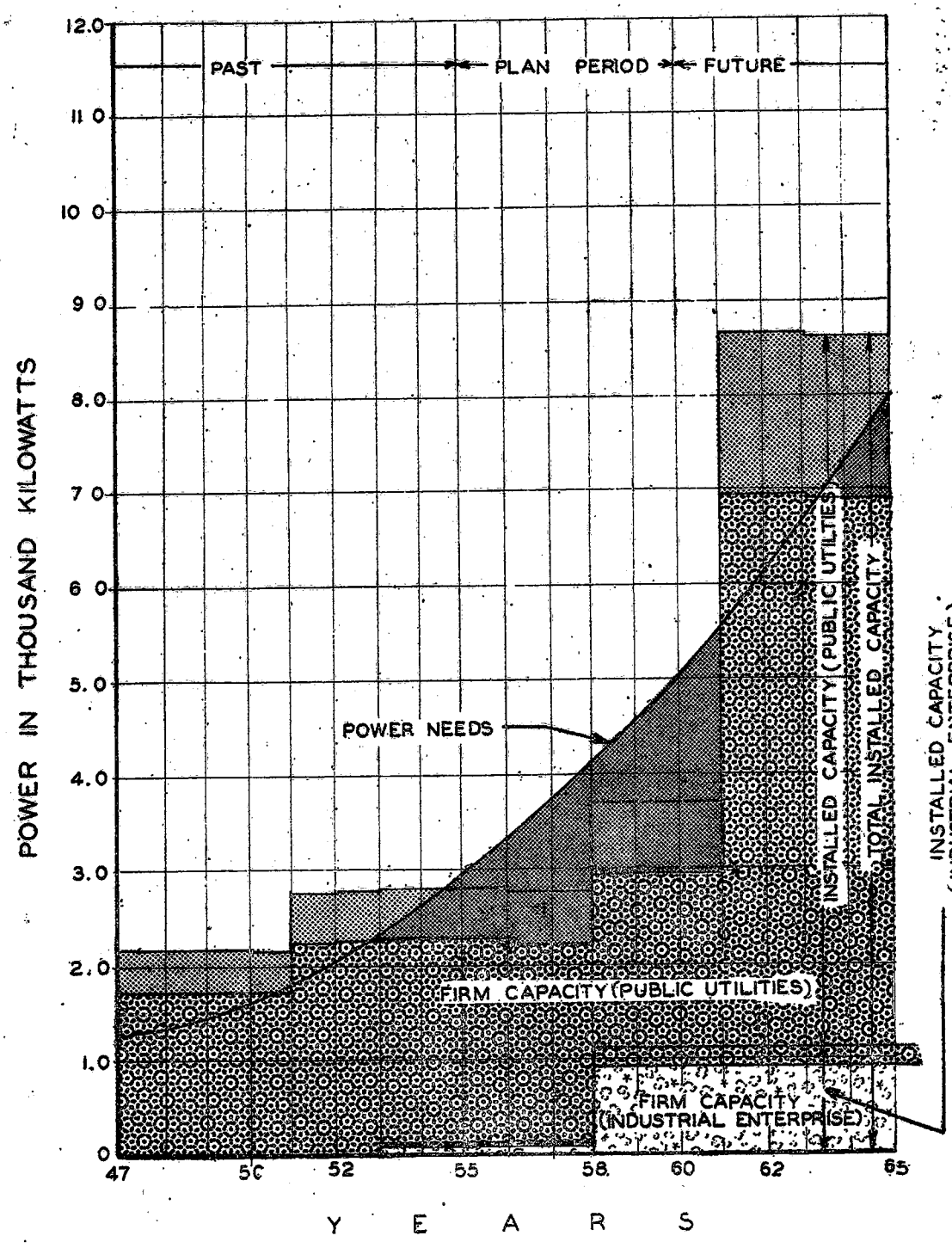
Coastal Tributaries and Desert Streams

Name of Scheme	Period of execution		Results expected during the Plan Period				
	Commencement	Completion	Area irrigated		Area reclaimed	Area drained	Power
			New	Old			
1	2	3	4	5	6	7	8
			(Thousand Acres)				(kw)
I. GENERAL INVESTIGATION :							
Comprehensive investigation	1955	1960	...	...	...	...	...
Survey of Sibi and Kachhi plains ...	1957	1960	...	...	...	...	...
Instruments and equipment	1956	1959	...	...	...	...	...
Investigation of specific schemes	1957	1960	...	...	...	...	...
II. IRRIGATION :							
Flood irrigation schemes in Kalat division	1957	In progress.	40	...	...	...	...
Canals from Gudu	1956	Do.	...	...	...	...	...
Ground water exploration and development	1955	Do.	11	11	...	...	...
Lining of channels	1956	Do.	3	...	...	...	...
Bolan dam ¶	1953	1958	24	10	...	...	...
Small schemes	1954	In progress.	40	27	...	...	...
Total ...			118	48			
III. POWER :							
Quetta thermal power project	1958	1961	...	...	...	...	...
Grand Total ...			118	48	...	...	...

161. The extreme paucity in this region of basic data, essential for projecting all water resources developments, is demonstrated by the number of schemes which have been abandoned, or have ended in failure in the past. Much more detailed and precise knowledge of the hydrologic, geological and other conditions of the region is needed to avoid the recurrence of such mistakes. The first requirements are a comprehensive survey of the water resources, topography, soils, land use, and the economic needs to be served by water and power resources development, and a logical and consistent general plan for the purpose, for which a sum of Rs. 3 million has been provided in the Plan.

162. The data on which the schemes submitted in the past had been based, were inadequate to enable the projects to be prepared in a satisfactory manner. In order to avoid this in the future, and to build up a reserve of complete schemes, a provision of Rs. 2·9 million has been included in the Plan, for detailed investigations of such specific schemes as show promise of feasibility. In a number of small schemes, investigations conducted hitherto indicate a reasonable chance of successful development. It is expected that the surveys and the preparation of the designs and plans will have advanced sufficiently to enable construction to be started on selected projects during 1955-60. Larger projects require several years of exploratory work to complete the geological and engineering surveys, the designs of structures and the studies of economic feasibility, before actual execution can start. While the construction of the smaller projects is in progress, it is intended that exploratory work on two large projects, the Aghor Hingol and Gharok should be undertaken during the Plan period, so that their eventual construction is not unduly delayed.

COASTAL TRIBUTARIES & DESERT STREAMS REGION
POWER DEVELOPMENT



163. The programme provides a sum of Rs. 9·6 millions for the exploration and development of ground water resources. Not till the investigations have been completed, can firm conclusions be drawn regarding the areas likely to offer good promise of development. Because of the large initial capital outlay involved, the high running costs, the lack of power at reasonable rates, the high costs of imported fuel, and the limitations of quality and quantity of water, the economics of tube-well pumping will have to be worked out very carefully before embarking on any large-scale programme of groundwater development. The possibility of the artificial recharge of groundwater resources, at times when the surface supplies are plentiful, should also be investigated. The Plan provides for three experimental schemes for the purpose. To minimise the losses in the conveyance and use of water, a provision of Rs. 1·3 million has been made in the Plan for an effective start on a programme of lining the least efficient sections of the existing channels.

164. The programme will require continuing appraisal, as specific plans are developed, and the inter-relationship between schemes becomes clarified. Most certainly would it require to be reviewed at the start of each year in which new construction is proposed. Adjustments may be necessary from time to time, as investigations may disclose the practicability of some schemes not included in the programme, and the impracticability of others, which had been included for construction in the later years of the Plan.

165. Had it not been for the serious physical and technical considerations limiting the size of the programme, the economic needs of this undeveloped area would have justified a larger programme than we now purpose. The first limiting factor is the lack of basic data, and the non-existence of projects that could be undertaken immediately with a reasonable assurance of success. The second is the absence of technical staff required for planning and supervising construction. Third, some time would necessarily be needed for recruiting, organising and training the staff. And fourthly, the total size of the programme has to be limited by the rate at which effective colonisation of the lands, proposed to be irrigated, can reasonably be expected to proceed. The programme outlined therefore represents the most optimistic rate of development that could be achieved under the circumstances. Its actual progress will, however, depend upon the completion of the necessary organisational arrangements, and the speed with which technical personnel and machinery can be made available. The programme further assumes that the requisite changes in the taxation structure, the land tenure system, and the existing water rights are effected in time to ensure its success.

166. The addition of 166,000 acres of irrigated land may be compared with the 400,000 or more acres which would need to be added by 1960 to provide food and clothing to the then population of the Region. But the exising programme is limited by available technical resources.

167. The power requirements of the region are mostly concentrated in the Quetta-Pishin district which is the centre of most of the industrial and agricultural development activity. The total demand of the region for 1955 has been estimated at about 3,000 kw against a total installed capacity of 2,800 kw, which represents a dependable capacity of 2,250 kw. The aggregate demand of about 3,000 kw in 1955 is expected to rise to about 5,000 kw by 1960, in view of the contemplated industrial and agricultural development of the region which includes the electrification of coal mines. The construction of the proposed 5,000 kw coal-fired steam station at Quetta should, therefore, be undertaken without further delay with a view to completing it in the shortest possible time.

SURVEY OF PAKISTAN

168. The main responsibility of the Survey of Pakistan is to prepare and keep up-to-date general purpose topographic maps of the whole country. Large arrears of work have accumulated due to paucity of technical staff, equipment and stores. For about one-third of the country no maps exist. Practically all the maps available for other areas are out-of-date. It is estimated that, at the present rate of progress, it would take about a hundred years to complete the survey and revision of the maps. Moreover, special maps are a pre-requisite in practically every sphere of development. Additional demands have been placed on the Department in connection with the development projects since Independence. The work to be entrusted to the Department will

increase considerably in view of the requirements of the projects included in the Plan. To enable the Department to carry on its normal functions efficiently and to meet expeditiously the requirements of development projects, we recommend that the Survey of Pakistan be suitably expanded and re-organised. An allocation of Rs. 5 million is made during the Plan period for the purchase of equipment and stores. It includes a provision for an aerial survey unit, establishment of photogrammetric and geodetic institutes, an additional triangulation unit and the expansion of the training facilities of the Department.

METEOROLOGICAL DEPARTMENT

169. Meteorological data are a pre-requisite to the drawing up of the comprehensive programme of resource development. There are serious deficiencies in the available data. The coverage of some parts of the country, for example, the upper regions of the northern tributaries of the Indus river system and some of the arid zones, is not adequate. We recommend that the needs in the different spheres of development be assessed immediately and a comprehensive programme prepared to meet these requirements. It will be necessary to install additional observation stations for the measurement of rainfall, temperatures, and evaporation, and to initiate snow surveys. It may require the expansion and re-organisation of the meteorological department. No specific provision has been made for this purpose but it is considered that sufficient funds could be made available from the allocations for ' General Investigations '.

170. The programme in the Plan Period is summarised in the following table by executing authorities. It reflects the position respecting the allocation of responsibilities among the different Governmental authorities as of June, 1957.

TABLE 11

Proposed allocations of water and power development, public sector, 1955-60, *by executing authorities.*

(Million Rupees)

Name of Scheme	East Pakistan Govt.	West Pakistan Govt.	Central Govt.	Total
1	2	3	4	5
GENERAL INVESTIGATIONS :				
Ground Water	...	50	...	
Other	20	26	12	
Sub-total ...	20	76	12	108
MULTIPURPOSE DEVELOPMENT :				
Karnafuli	217	...	...	
Warsak	...	...	236	
Teesta	50	...	...	
Ganges-Kobadak	85	...	...	
Mangla	...	...	60	
Other	2	82	1	
Sub-total ...	354	82	297	733

TABLE 11.—*contd.*

1	2	3	4	5
IRRIGATION :				
Taunsa Barrage	...	127	...	
Gudu Barrage	...	150		
Ghulam Mohammad Barrage	...	127	...	
Link Canals	...	87		
Other	38	256	3	
Sub-total ...	38	747	3	788
FLOOD REGULATION AND DRAINAGE:				
Comprehensive Drainage scheme for Faridpur ...	37	...	...	
Other	65	95	...	
Sub-total ...	102	95	...	197
POWER :				
Siddhirganj Thermal Power Station	32	...	...	
*Karachi Electric Supply	...	...	62	
West Pakistan Transmission Grid	...	...	80	
Natural Gas Power Station, Multan	...	...	110	
Hyderabad and Sukkur Thermal Systems	...	41	...	
East Pakistan Transmission and Distribution Schemes	48	...	...	
Other	34	164	...	
Sub-total ...	114	205	252	571
Total (Scheduled) ...	628	1,205	564	2,397
Reserve ...	300	...	...	300
Grand Total ...	928	1,205	564	2,697

* In addition to this amount about Rs. 77 million are provided against this scheme as private investment.

GPPK—H 3 P. B.—16-1-58—1,000.

SECTION C

INDUSTRY, FUELS AND MINERALS

Chapter 20

FUELS AND MINERALS

1. The development of modern industry, agriculture, transport and construction, such as has been taking place in this country, requires a rapid increase in supplies of fuels and mineral raw materials. At the time of independence nearly all the known sources of high grade coal and iron ore, bauxite and most other metallic minerals in the sub-continent were left in India. Known resources of fuels and minerals in Pakistan were negligible. Since then, there has been a considerable increase in the production of fuels and minerals within the country. There also has been some intensification of efforts to find additional deposits in large areas of the country which have never been thoroughly explored. The increase in domestic mining and production of certain fuels and minerals is shown in Table 1.

TABLE 1

Output of selected fuels and minerals in Pakistan, 1948—1956

Item	Unit	1948	1949	1950	1951	1952	1953	1954	1955	1956
1. Crude petroleum	Million imperial gallons.	17	33	45	47	55	62	68	72	74
2. Petroleum products :										
(*a*) Diesel oil	,,	1·34	1·33	2·30	2·82	5·85	9·06	12·28	13·96	15·2
(*b*) Motor spirit	,,	2·21*	6·11	10·42	11·16	15·10	16·95	19·08	19·41	19·8
(*c*) Kerosene oil	,,	0·30*	0·99	2·06	1·83	2·32	2·39	2·83	2·80	4·6
(*d*) Furnace oil	,,	6·52	15·19	24·50	25·19	23·75	27·67	25·85	25·48	25·1
3. Coal	Thousand tons.	241	332	437	506	599	584	554	533	646
4. Chromite	,,	18	17	18	18	17	23	22	29	23
5. Limestone	,,	347	279	303	344	672	879	822	887	756
6. Gypsum	,,	—	14	17	23	28	27	31	27	35

*Data relates to 9 months (April 1948 to December 1948).

Source : (1) Ministry of Finance : Economic Survey and Statistic

(2) Central Statistical Office.

2. Domestic production of fuels and minerals has not been enough to satisfy the demand. Many important minerals, including iron ore, have not been produced at all. Only about 33 per cent. of coal consumption and 20 per cent. of consumption of petroleum products in 1954 came from indigenous sources, the balance of the country's requirements being imported on the scale shown in Table 2. On the other hand, the country has been nearly self-sufficient in salt, ceramic clay, limestone and gypsum. Chromite has been exported, but very few other minerals, and no fuels at all. Consequently very heavy net expenditures of foreign exchange have been made to import coal, petroleum products, metals, chemicals and many other needed materials not mined or produced in the country.

6. The Geological Survey has a sound tradition of professional work, and a well-trained staff. Its current operations, however, need to be greatly expanded. The Survey should be required to prepare and execute well-defined programmes of work, intended to explore rapidly the most promising areas and to prospect for the most important minerals. For example, the Survey should concentrate for the next few years on (a) the unexplored mountainous portions of West Pakistan; (b) important minerals needed for the development programme, such as ores of non-ferrous metals; coal and lignite, oil and gas, potassium salts and phosphates, and high grade clays; (c) ores of metals which have promising export markets, such as tungsten, titanium, antimony, cobalt, columbium, beryllium and monazite.