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.

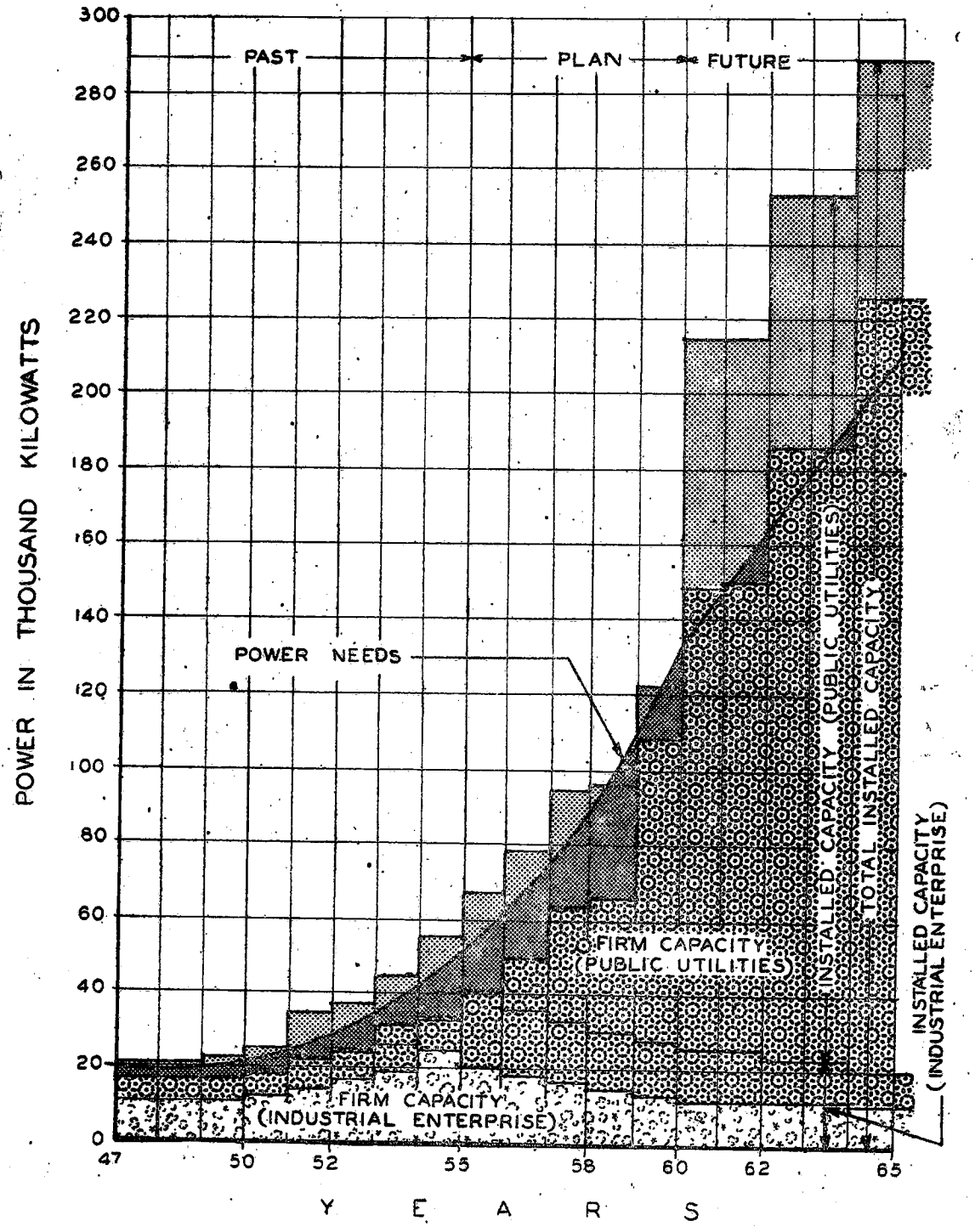
(*c*) Investigations for harnessing the power potential of wind velocities, solar and atomic energy etc., not only for the generation of electricity but also for other useful purposes.

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.