Journal of the
IRRIGATION AND DRAINAGE DIVISION
Proceedings of the American Society of Civil Engineers

IRRIGATION IN INDIA: PAST AND PRESENT

By Asit K. Biswas,[1] A.M. ASCE

SYNOPSIS

Approximately 450,000,000 acre-ft of surface water are available annually for irrigation in India. In addition, another 300,000,000 acre-ft of water can be tapped from underground. With a rapidly growing population, the food problem will become more and more acute in the future. However, to 1960-1961 only 120,000,000 acre-ft of water, i.e., 27% of the usable surface water flow, was used for irrigation. Hence, in order to be self-sufficient, India must harness all available water both surface and underground—even if government subsidation of some irrigation projects is necessary.

With a mean annual rainfall of approximately 46 in., India has used irrigation from time immemorial. Because there is substantial variation in quantity, incidence, and duration of the annual precipitation, famines and floods have occurred with severe regularity. Hence, both irrigation and flood control must be undertaken if prosperity is to be brought to the country.

Man is indeed fortunate that both irrigation and flood control can be successfully incorporated in a river valley scheme. Soon after independence in 1947, the Government became aware of the problem, and irrigation received 27.2% of the total financial allocation of the First Five-Year Plan (1951-1957). However, the writer feels that more emphasis should have been placed on both irrigation and flood control in the present Third Five-Year Plan.

INTRODUCTION

Irrigation practice in India can be traced to prehistoric times. Water from wells, tanks, and canals was intensively used for irrigation practices. India

Note.—Discussion open until August 1, 1965. To extend the closing date one month, a written request must be filed with the Executive Secretary, ASCE. This paper is part of the copyrighted Journal of the Irrigation and Drainage Division, Proceedings of the American Society of Civil Engineers, Vol. 91, No. IR1, March, 1965.

[1] Lecturer in Civ. Engrg., Univ. of Strathclyde, Glasgow, Scotland.

has immense resources in terms of land and water, but until 1960-1961 only 9% of the total annual surface water flow available had been tapped for irrigation. Out of nearly 467,000,000 acres of arable area available, only 70,000,000 acres were irrigated during 1960-1961. Today (1964), food production is the most important problem, and, consequently, irrigation plays a major part in the national economy and welfare. Hence, top priority was given to irrigation and power in the First Five-Year Plan, 1951-1956. The broad allocation of resources in the Plan is shown in Table 1.[2]

RAINFALL

The outstanding feature of rainfall in the vast subcontinent is its unequal distribution over the country. It varies from less than 10 in. in the northwest deserts of Rajputana to approximately 460 in. at Cherrapunji, in the

TABLE 1.—ALLOCATION OF RESOURCES IN THE FIRST FIVE-YEAR PLAN

Program	Outlay, in million rupees[a]	Percentage of total outlay
Irrigation and power	5,614.1	27.2
Transport and communication	4,917.0	24.0
Agriculture and community development	3,604.3	17.4
Social services	3,398.1	16.4
Industry	1,730.4	8.4
Rehabilitation	850.0	4.1
Miscellaneous	519.9	2.5
Total	20,687.8	100.0

[a] 1 dollar is equivalent to 4.76 rupees

Assam Hills (Fig. 1). Cherrapunji has perhaps the greatest amount of rainfall in the world and as much as 102 in. of rain have been recorded in a period of four days. The mean annual rainfall is slightly less than 50 in. and is remarkably constant. The maximum recorded rainfall variation is approximately 15%. However, substantial variations in the quantity, incidence, and duration of rainfall in individual tracts from year to year, make irrigation of supreme necessity in the country. In some areas, even less than 25% of the annual average rainfall has been recorded.

The bulk of the precipitation falls during the months of June to October because of the southwest monsoon sweeping over the country from the Indian Ocean and the Arabian Sea. Rainfall is quite scarce—from 1/2 in. to 2 in.—during the winter months of November to February, and practically nil in the

[2] "First Five-Year Plan," Planning Commission, Govt. of India, New Delhi, India.

scorching summer months, March to May. Only the southeastern part of the country experiences heavy rainfall from October to December.

Although the over-all pattern of rainfall is generally constant, most parts of the country can expect an average dearth of rainfall every 5 yr and a serious drought every 10 yr. Variation of annual rainfall from 5 in. to approximately 500 in. gives rise to three types of areas, i.e., where irrigation is (a) extremely necessary, (b) necessary as a factor of safety, and (c) unnecessary. The foregoing data illustrate the importance of irrigation in India's economy and perhaps explain why the history of irrigation in India can be traced to the dawn of civilization.

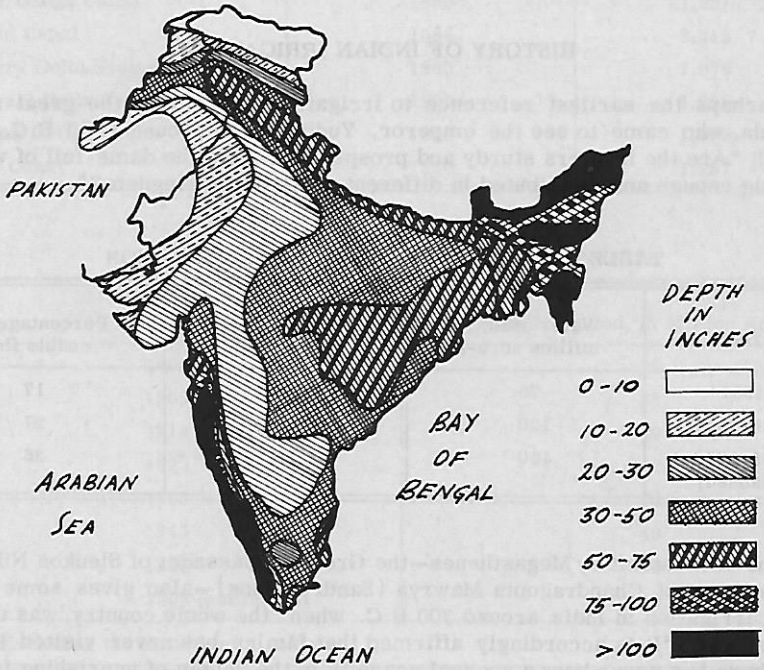

FIG. 1.—DISTRIBUTION OF RAINFALL IN INDIA

WATER RESOURCES

The total annual rainfall over the country is slightly more than 3,000,000,000 acre-ft of water. Because most of the rainfall is during the summer months nearly 1,000,000,000 acre-ft, i.e., 33 1/2% of the total, is immediately lost as a result of evaporation. Approximately 650,000,000 acre-ft is lost because of percolation—thus leaving 1,350,000,000 acre-ft available as surface water.

But because of physiographical conditions, i.e., flow characteristics, topography, climate, and soil conditions, only 450,000,000 acre-ft of water can be used for irrigation. However, to 1947—when India became independent—little of the usable water was tapped. Table 2 shows the total surface water used for irrigation since 1951.

Of the 650,000,000 acre-ft of percolated water, 350,000,000 is absorbed in the topsoil, thus leaving 300,000,000 that can be tapped annually for irrigation. Without extensive exploration it is not possible to estimate the total underground reserve of water and, hence, it is a difficult problem at present (1964) to determine a national plan.

HISTORY OF INDIAN IRRIGATION

Perhaps the earliest reference to irrigation is given by the great sage, Narada, who came to see the emperor, Yudhishtira, around 3150 B.C., and asked: "Are the farmers sturdy and prosperous? Are the dams full of water and big enough and distributed in different parts of the kingdom?"

TABLE 2.—SURFACE WATER USED FOR IRRIGATION

Year	Water used, in million acre-ft	Percentage of total flow	Percentage of usable flow
1951	76	6	17
1960–1961	120	9	27
1965–1966 (planned)	160	16	36

The account left by Megasthenes—the Greek Ambassador of Sleukos Nikator to the court of Chandragupta Mawrya (Sandrokothos)—also gives some idea about irrigation in India around 300 B.C. when "the whole country was under irrigation." "It is accordingly affirmed that famine has never visited India, and there has never been a general scarcity in the supply of nourishing food." However, a few years after the departure of the Greek Ambassador, during the reign of the same emperor, a severe famine befell the country.

Rock inscriptions found in the state of Kathiwar also credit Chandragupta with the construction of "Sudarsana" Lake (300 B.C. -457 A.D.). An excellent description of this "pleasant looking" dam is found from the inscriptions, as well as from inscriptions recording two major disasters that befell it, in one of which "by a breach, four hundred and twenty cubits long, just as many broad (and) seventy-five cubits deep, all the water flowed out, so that (the lake), almost like a sandy desert, (became) extremely ugly (to look at)."[3] The history of this interesting dam can be traced to 457 A.D., but nothing is known about its final destruction.

The ancient Indian was an expert in the art of sinking wells in brick masonry in sandy soils. Tanks were used extensively in central and southern

[3] Diskalkar, D. B., "Selections from Sanskrit Inscriptions," Vol. I, Part II, p. 15.

TABLE 3.—MAJOR IRRIGATION WORKS COMPLETED FROM 1820-1930

Project	Year of completion	Area irrigated, in Thousand Acres
Western Jamuna Canal	1820	1,018
Ganga Canal	1856	1,620
Lower Ganga Canal	1880	1,251
Sirhind Canal	1884	2,312
Cauvery Delta System	1889	1,070
Godavarl Delta System	1890	1,229
Krishna Delta System	1898	1,002
Sarda Canal	1930	1,297

TABLE 4.—TOTAL IRRIGATED AREA IN INDIA

Year	Area Irrigated, in Million Acres[a]
1895	29
1905	33
1915	40
1925	43
1935	44
1945	49
1955	56
1965 (estimated)	90

[a] Excluding the area now in Pakistan

TABLE 5.—PRODUCTION OF MAJOR CROPS

Crop	Unit, in millions	Year		
		1950-1951	1955-1956	1960-1961
Cereals and pulses	Tons	52.2	65.8	76.0
Sugarcane	Tons	5.6	6.0	8.0
Oilseeds	Tons	5.1	5.6	7.1
Jute	Bales	3.3	4.2	4.0
Cotton	Bales	2.9	4.0	5.1

India; some rivers were even crudely dammed for irrigation. However, state-controlled irrigation works have begun to play a major role only in the last 100 yr. It may be worthwhile to note that during the middle of the nineteenth century two private irrigation companies were formed, but because of subsequent financial troubles, the government took possession of these works.

In the nineteenth century the "British Raj" was more concerned with the improvement of existing irrigation works than with building new ones. "India,

TABLE 6.—AREA IRRIGATED BY VARIOUS METHODS—1958-1959

	Area, in acres
Canals	23,900,000
Wells	16,700,000
Tanks	11,700,000
Other resources	5,600,000
Net area	57,900,000

TABLE 7.—MAJOR IRRIGATION SCHEMES AFTER 1947

Project	Area to be irrigated on completion, in million acres	Total Cost,[a] in million rupees[b]
Bhakra Nangal	3.604	1,018.9
Gandak	3.138	494.5
Hirakud	2.158	933.4
Nagarjunasagar	2.060	911.2
Chambal	1.400	548.5
Kosi	1.397	248.2
Damodar Valley	1.273	346.8
Mahi	0.751	417.8

[a] Estimated cost of irrigation part only
[b] 1 dollar is equivalent to 4.76 rupees

. . . . . , in a great measure owes to her former rulers the first inception of her present unrivalled systems of State Irrigation Works."[4] Sir Proby Cautley, and Sir Arthur Cotton were perhaps among the leaders who laid the foundation of modern irrigation engineering in India. Cautley's finest work is the aqueduct over Solani river.[5] The 170-ft wide and 10-ft deep channel with roads on each side crosses the river over fifteen brick masonry arches, each of 50-ft span, and is supported by massive piers on the sandy river bed.

[4] "Report of Indian Irrigation Commission," Part I, 1903, p. 9.
[5] Newhouse, Ionide, and Lacey, "Irrigation: British Council," London, 1950, p. 45.

Cautley was responsible for the Great Ganges Canal and the Eastern Jamuna Canal. However, these projects were not exactly perfect. The Ganges Canal, of which Solani aqueduct is a part, was given a much steeper slope than necessary and consequently there was heavy scour; but this is understandable because the analogy was based on considerable smaller canals. Subsequently the errors were rectified.

While Cautley was working in Northern India, Cotton was working on the southern side of the sub-continental peninsula. Cotton built the Upper Anicut across Coleroon, a tributary of the Cauvery River. He also developed the Godavari and Krishna deltas. Considering that Godavari has a catchment area

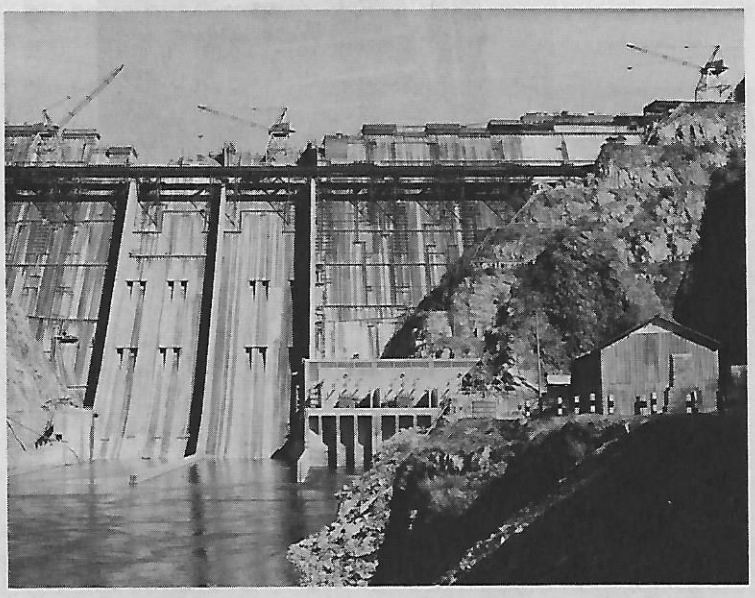

FIG. 2.—BHAKRA, INDIA'S HIGHEST DAM (740 FT) ON RIVER SUTLEJ (COURTESY: INFORMATION SERVICE OF INDIA)

of 115,000 sq miles and maximum discharge slightly more than 1,500,000 cfs. it was not an easy job.

Major irrigation works completed from 1820 to 1939 are shown in Table 3.

IRRIGATION AFTER 1947

After independence (1947), the Government of India was concerned with the need for food for a vastly growing population and irrigation was given a much needed impetus. Nearly 27.2% of the total outlay in the First Five Year Plan (1951-1956) was set aside for irrigation and power. Table 4 shows the growth of irrigated area over the years from 1895 to 1956, and the estimated

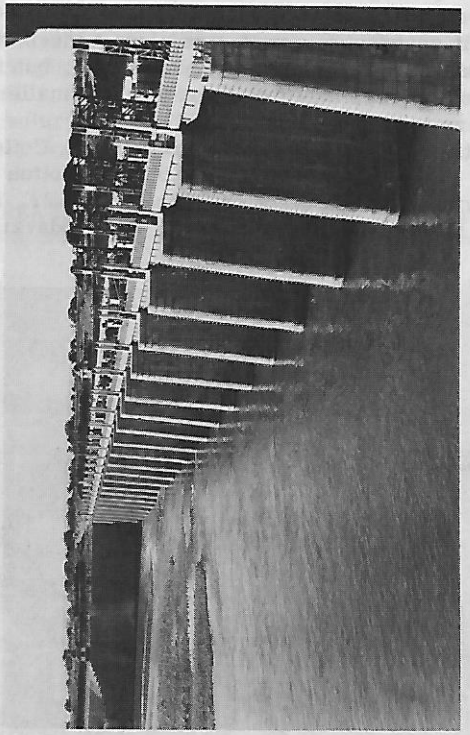

FIG. 4.—A VIEW OF THE HEADWORKS OF NANGAL DAM (COURTESY: INFORMATION SERVICE OF INDIA)

FIG. 3.—THE INSPECTION GALLERY OF NANGAL DAM, USED FOR CHECKING DAMAGES AND LEAKS, RUNS UNDER RIVER BED (COURTESY: INFORMATION SERVICE OF INDIA)

growth for 1965. Table 5 indicates improvement of production of major crops since 1950-1951.

Canals are still the major source of irrigation, closely followed by wells and tanks. The areas irrigated by various methods in 1958-1959 are shown in Table 6.

Brief details of the major irrigation schemes are given below and some statistics are tabulated in Table 7.

Bhakra-Nangal Project.—The highest dam in India is the 740-ft high concrete gravity structure built on the Sutlej River near the village of Bhakra (see Fig. 2). Eight miles downstream is the 90-ft high Nangal Dam. The Bhakra reservoir has a total capacity of 7,400,000 acre-ft of which 5,700,000 acre-ft[6] can be used for irrigation. The Nangal Dam (Fig. 3) regulates the

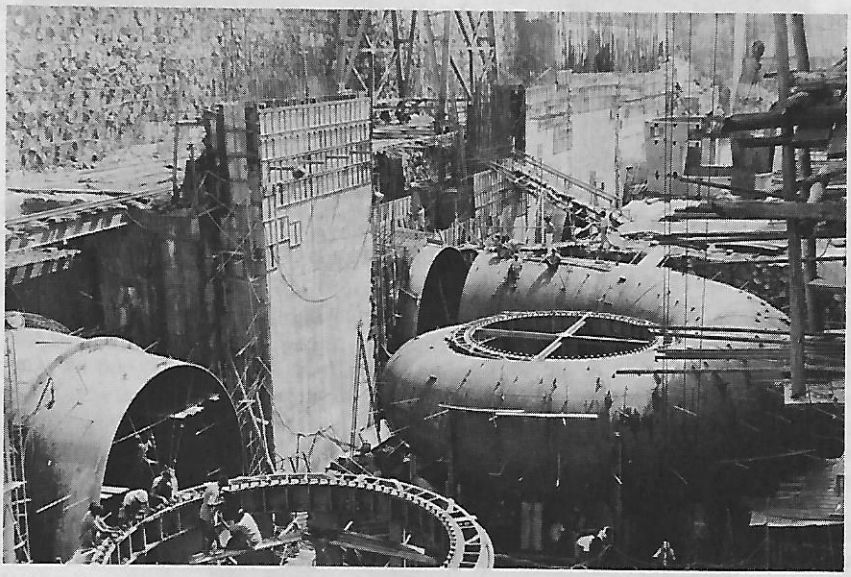

FIG. 5.—SPIRAL CASINGS AND SPEED RINGS FOR THE TWO ENGLISH ELECTRIC 52,000 HP WATER TURBINE GENERATING SETS DURING THE COURSE OF ERECTION AT HIRAKUD PROJECT (COURTESY: ENGLISH ELECTRIC COMPANY LTD.)

Nangal Hydel Canal (Fig. 4) which is nearly 40 miles long and has a full supply discharge of 12,500 cfs. The canal is fully lined and has two falls of 93 ft and 100 ft that are used for power generation. The project is expected to irrigate an additional 3,604,000 acres and generate 400,000 kw at 100% load factor. The total estimated cost was 1,510,000,000 rupees.

Hirakud Project.—The 195-ft high Hirakud Dam (Fig. 5) is on the River Mahanadi in the state of Orissa and has 67,775 ft of earthen dikes. When fully

6 "New Projects for Irrigation and Power in India, 1954," Leaflet No. 3, 4th Edition, Central Bd. of Irrigation and Power, New Delhi, India.

FIG. 6.—TILAYA DAM—ONE OF THE MAJOR DAMS OF DVC (COURTESY: INFORMATION SERVICE OF INDIA)

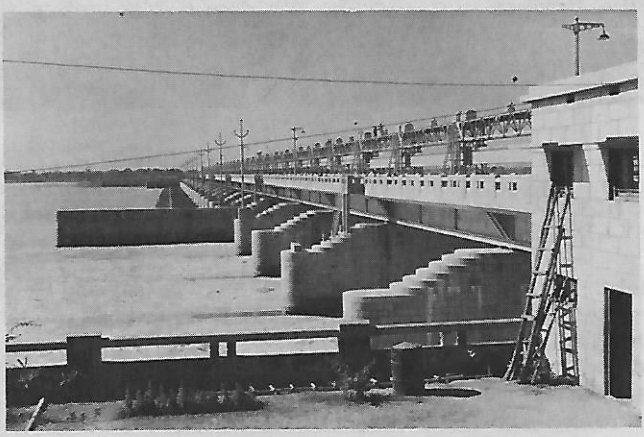

FIG. 7.—A VIEW OF THE DIRGAPUR BARRAGE OF DVC (COURTESY: INFORMATION SERVICE OF INDIA)

completed it will have a total gross area use of 1,337,000 acres[7] and the total cost of the irrigation part will be only 933,400,000 rupees.

Damodar Valley Project.—Begun in July, 1948, it is perhaps the most important multipurpose project in India. The project consists of eight dams (Fig. 6) and a barrage (Fig. 7) across the River Damodar and its tributaries. The work is being conducted by the Damodar Valley Corporation (DVC which has a structure similar to the Tennessee Valley Authority (TVA). When completed it is expected to provide (a) permanent irrigation for 1,273,000 acres, (b) flood control of the Damodar River and its tributaries, (c) 85 miles of navigational canal, and (d) 1,000,000,000 kw-hr of energy per annum distributed over 25,000 sq miles.

Tungabhadra Project.—Inaugurated in February, 1945, the project aims at harnessing River Tungabhadra, a tributary of the Krishna River. It consists of a 160-ft high straight gravity stone masonry dam. The dam is 5,942 ft long with a central spillway of approximately 2,300 ft.[6] There are two canals, one on each side, serving a total area of 2,000,000 acres. Water is distributed in the states of Mysore, Andra Pradesh, and Hyderabad.

CONCLUSIONS

The total topographic area of the country is 806,270,000 acres, of which 467,000,000 acres are arable. Approximately 75% of the cultivable land is currently (1964) in use. Availability of cultivable land per capita in India is 0.82 acres, compared with 2.68 in the United States, 2.59 in the USSR, 0.48 in Germany, and 0.42 in the United Kingdom.

Food production reached a record peak in 1960 but in subsequent years the growth could not be maintained—in fact, there was a steady decline. In 1960-1961, 70,000,000 acres of land were under irrigation. If India is to become self-sufficient in the growing of food, more and more land must be irrigated, even if government subsidies are required for certain projects. In the Third Five-Year Plan, 6,000,000,000 rupees were to be spent on irrigation, of which 4,360,000,000 were intended for continuing schemes and 1,640,000,000 for new projects.

The writer feels that the objectives in irrigation and power for the Third Five-Year Plan were not capable of fulfillment by the end of the period. Undoubtedly, the Chinese-Indian conflict threw the entire plan into disarray by diverting to defense funds that India could have used for stabilizing her economy. But, with some shrewd planning and vigorous execution of the plan, perhaps some of the main problems facing India can be solved in the future.

ACKNOWLEDGMENTS

The writer wishes to thank William Frazer, Professor and Head of Civil Engineering of the University of Strathclyde, Winifred K. Thorne and the information Service of India of the Indian High Commission in London, and the English Electric Company for their kind cooperation in the preparation of this paper.

---

7 "The Third Five Year Plan," Planning Commission, Govt. of India, New Delhi, India.

KEY WORDS: dams; India; irrigation; reservoirs; water resources

ABSTRACT: Practice of irrigation in India can be traced to prehistoric times. Water from wells, tanks, and canals was used intensively for irrigation practices. India has immense resources in terms of land and water, but until 1960-1961 only 9% of total annual surface water flow available had been tapped for irrigation. Out of nearly 467,000,000 acres of arable area available, only 70,000,000 acres were irrigated during 1960-1961. Today (1964) food production is India's most important problem and, consequently, irrigation plays an important part in the national economy and welfare. Hence, top priority was given to irrigation and power in the First Five-Year Plan 1951-1956.

REFERENCE: Biswas, Asit K., "Irrigation in India: Past and Present," Journal of the Irrigation and Drainage Division, ASCE, Vol. 91, No. IR1, Proc. Paper 4277, March, 1965, pp. 179-189.