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WATER RESOURCE DEVELOPMENT IN INDIA

JUNE 1980

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WATER RESOURCE DEVELOPMENT IN INDIA

ISSUES, PROBLEMS & PROSPECTS

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AMERICAN EMBASSY, NEW DELHI

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WATER RESOURCE DEVELOPMENT IN INDIA

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INTRODUCTION AND SUMMARY

The future of India will be to a significant degree determined by the success of water resource development over the remaining decades of this century. Water is the lifeblood of India. If used fully, it is a resource that would double the area of agricultural land now irrigated, triple existing electric generating capacity without burning oil or coal and concomitantly afford a means of beginning the local dispersion of a growing population that is concentrated along the lower reaches of natural watersheds.

The failure of the 1979 monsoon -- which produced one of the worst droughts of recent record and caused an eight to ten percent drop in agricultural production and near stagnation in the economy -- highlighted the stark fact of India's continuing absolute dependence on water. India's economy is becoming relatively more dependent on commercial energy, but it remains more critically affected by water supplies than any other single factor. Water is the single most important input to agricultural production. Agriculture contributes over 40 percent of national income, about 80 percent of the population lives in rural areas, and about 74 percent of the workforce is dependent on agriculture for their livelihood. Success in developing a well-managed, adequate supply of water will critically influence whether India -- the home of one-third of the world's poor -- will free itself from poverty and continue on its present course as the emerging dominant power in the South Asian region.

Yet provision of adequate water for crops and other uses in India is unusually complicated by the paradoxes of its climate and geography; although the average rainfall is about 120 cm (which is slightly more than the global terresterial mean of 99 cm), it is seasonal and often erratic in timing and geographical distribution, resulting in frequent catastrophic droughts or floods. Though the discharge of India's large river systems is quite high, they flow mainly in the Gangetic plain; the surface water resources of the Deccan, the largest arable land area, are significantly smaller. Ground water resources are likewise unevenly distributed. Ground water is abundant in the Ganga (Ganges) basin with its deep alluvial soils, while the rocky Deccan plateau has comparatively little ground water. Thus, the apparent abundance of water in India is illusory.

Surface water, estimated at 178 million hectare meters (m.ha.m)*, and about only 37 percent of which represents utilizable flow owing to limitations imposed by the country's geology and terrain,

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* Volume equivalent to covering 1 million hectares with one meter of water.

continues to be the principal resource. Potential ground water development attainable by the end of this century is estimated by the Central Ground Water Board at 57 m.ha.m. of which nearly 46 percent is useable.

Irrigation development continues to be given priority with irrigation potential estimated at about 58 million hectares at the end of 1979-80; this accounts for roughly 51 percent of the gross ultimate potential of 113.50 million hectares. Total investment in irrigation from the beginning of the planning era in 1951 to 1978 amounted to approximately Rs. 93 billion on major, medium and minor projects. Expenditure on irrigation in future plans, in order to reach the ultimate target potential by the year 2000, is expected to be substantial. But the considerable potential already created is, so far, underutilized; there is a sizeable gap between potential and actual utilization due to inefficient water management practices. The remedy is increased construction and improved operation of distribution.channels, including reduction of transit losses and provison of regulatory structures, and crop planning. Together these measures could increase utilization by as much as 25 percent. Rapidly escalating construction costs constitute a growing drain on state finances and increase the already high financial subsidy given to irrigation. Though they have been increased, water charge rates remain relatively low in terms of farmers' ability to pay.

Owing to the millieu of subsidies and price control in the agricultural sector, the economics of irrigation subsidy is a very complex subject which has not been rigorously studied. The water rate is only one element. Farmers receive only about 70 percent of the economic value of agricultural produce, for example, but this is offset somewhat by other subsidies.

With surface water in the Ganga basin now almost fully developed, irrigation in this region will depend on greater ground water use. Ganga ground water resources are among the largest in the world, but their current use and further development is constrained by fuel and power shortages. Diesel fuel to run small pumps is growing very scarce and prohibitively expensive while breakdowns in electric power generation with resultant load shedding frequently damage pumps and impair operating efficiency.

Expansion of the area under irrigation in this region will depend on increasing the availability of power to rural areas. Full realization of irrigation potential in the Ganga basin will require that the GOI assign a high priority to the rural electrification program.

With water sharing in the Punjab regulated by a 1960 treaty with Pakistan, India's international boundary water problems are now confined to the eastern region. India and Bangladesh are locked in a dispute over sharing Brahmaputra flows. India needs to augment low flows in the Ganga to provide sufficient water to keep Calcutta port from silting up. Although India and Bangladesh have conferred on this issue several times recently, no mutually agreeable solution of the problem is in sight. India has reportedly taken a hard line in these negotiations, rejecting out of hand efforts by Bangladesh to involve Nepal in the dispute, and has said that it will take unilateral steps to prevent damage to the port of Calcutta.

Continued progress in water resource development over the near term will depend on how much emphasis the GOI places on improving utilization of existing irrigation potential. Competing political priorities make it unlikely that the central government will try to force water law reforms aimed at improving water use practices through state assemblies, where there would be sharp resistance from landholders. Still, recently increased allocation in the Draft Sixth Plan (currently under revision) for constructing field channels and refurbishing existing works as well as for supplementary ground water development and rural electrification indicate that the GOI assigns a high priority to mobilizing resources to improve irrigation efficiency and extend its potential.

To make optimal use of water resources, provide effective flood control and achieve the long-term water development goal of Indian planners - doubling present irrigation capacity by the year 2000 - will require major inter-basin transfers via a national water grid. One such plan, the highly publicized "Garland Canal", has for all practical purposes been shelved by the GOI on technical and economic grounds. It seems likely that a national grid will be developed incrementally, with a series of projects gradually extending the system throughout the country. Many of the country's larger schemes underway or planned have required or will require interstate agreements, and negotiating inter-basin transfers has proven to be very time consuming. Legal battles between states over water rights will probably delay planning and implementation of inter-basin transfers but will not prevent their ultimately being implemented.

The Ganga and Brahmaputra river basins provide an excellent example of what could be accomplished in multi-state water resource development. Over three quarters of the non-irrigated land with irrigation potential lies in these two river basins (the northern states of Uttar Pradesh, Bihar and West Bengal which are directly south of the Himalayas and west of Bangladesh). The same region, together with India's two northern-most states (Jammu-Kashmir and Himachal Pradesh), is estimated to encompass undeveloped hydro-electric power sites with a total generating capacity of more than 23,000 MW the equivalent of the country's present installed electric generating capacity. Also, the country's most extensive coal deposits are located adjacent to the Brahmaputra delta region in the southern part of Bihar and contingent regions of West Bengal and Orissa. Thus, existing climatic and geographical elements for large increases in agricultural and industrial output of the Ganga-Brahmaputra heartland can be utilized by: a) construction of dams and reservoirs in the north and northwest to increase the reliable supply of water for irrigation and electricity generation, b) construction of a electric grid to connect the hydro-electric stations with coal-fired power stations in the southeast, diversifying the energy source of electricity generation, to provide reliable distribution of electricity to twenty-five percent of India's population.

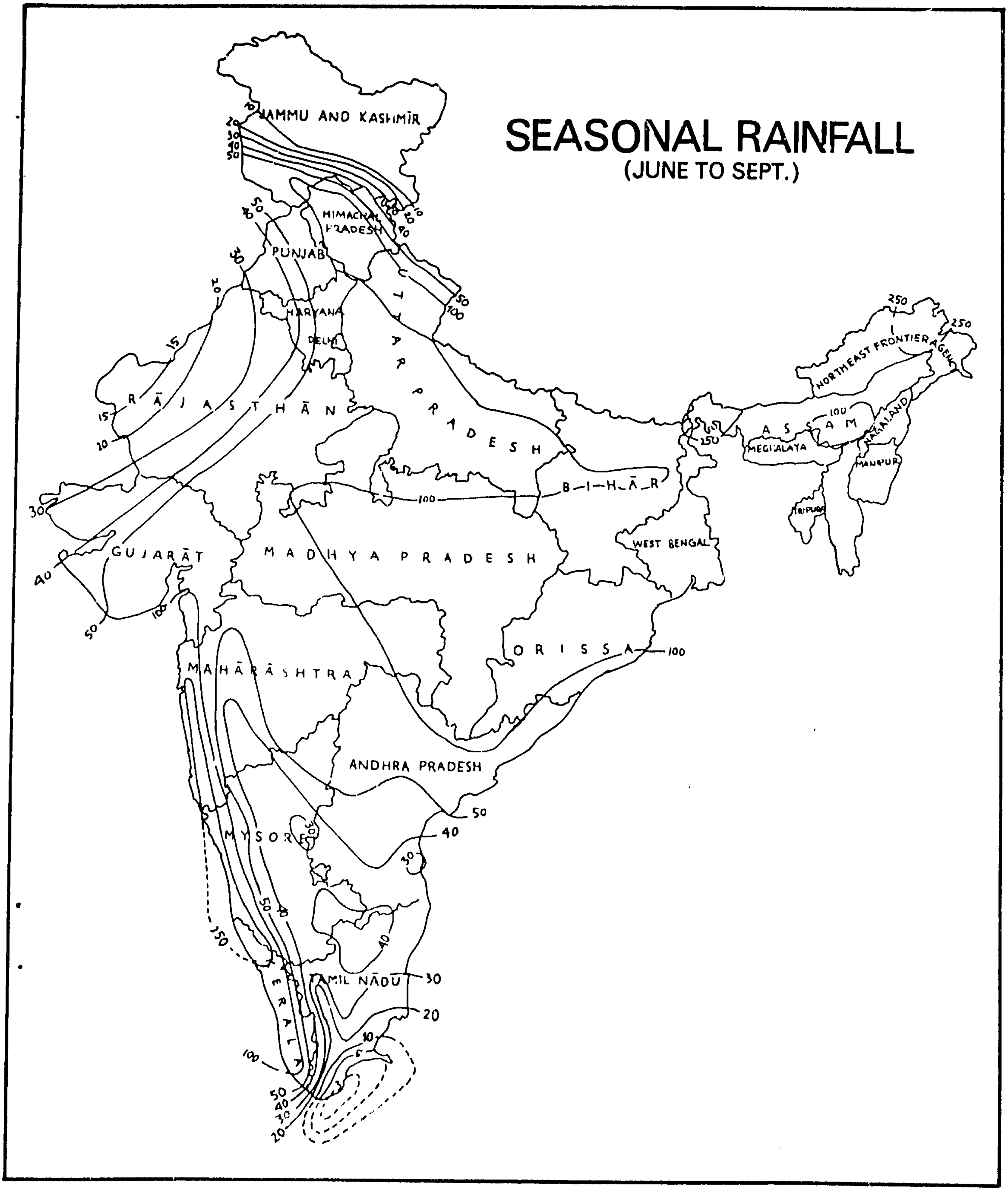
Mobilizing the investment resources for such major projects is, however, likely to become increasingly difficult in the face of escalating construction costs and growing scarcity of capital. Moreover, competing investment priorities will probably divert resources from these projects The issue will turn on whether scarce capital will be devoted directly to irrigation, or to industrial sectors, some of which also provide vital support to agriculture.

So without downplaying the vital importance of water to India's future, scarcity of capital, as well as other constraints in the economy will probably slow the rate of water resource development which India has demonstrated since independence, particularly the rate of expansion of the area under irrigation. END SUMMARY

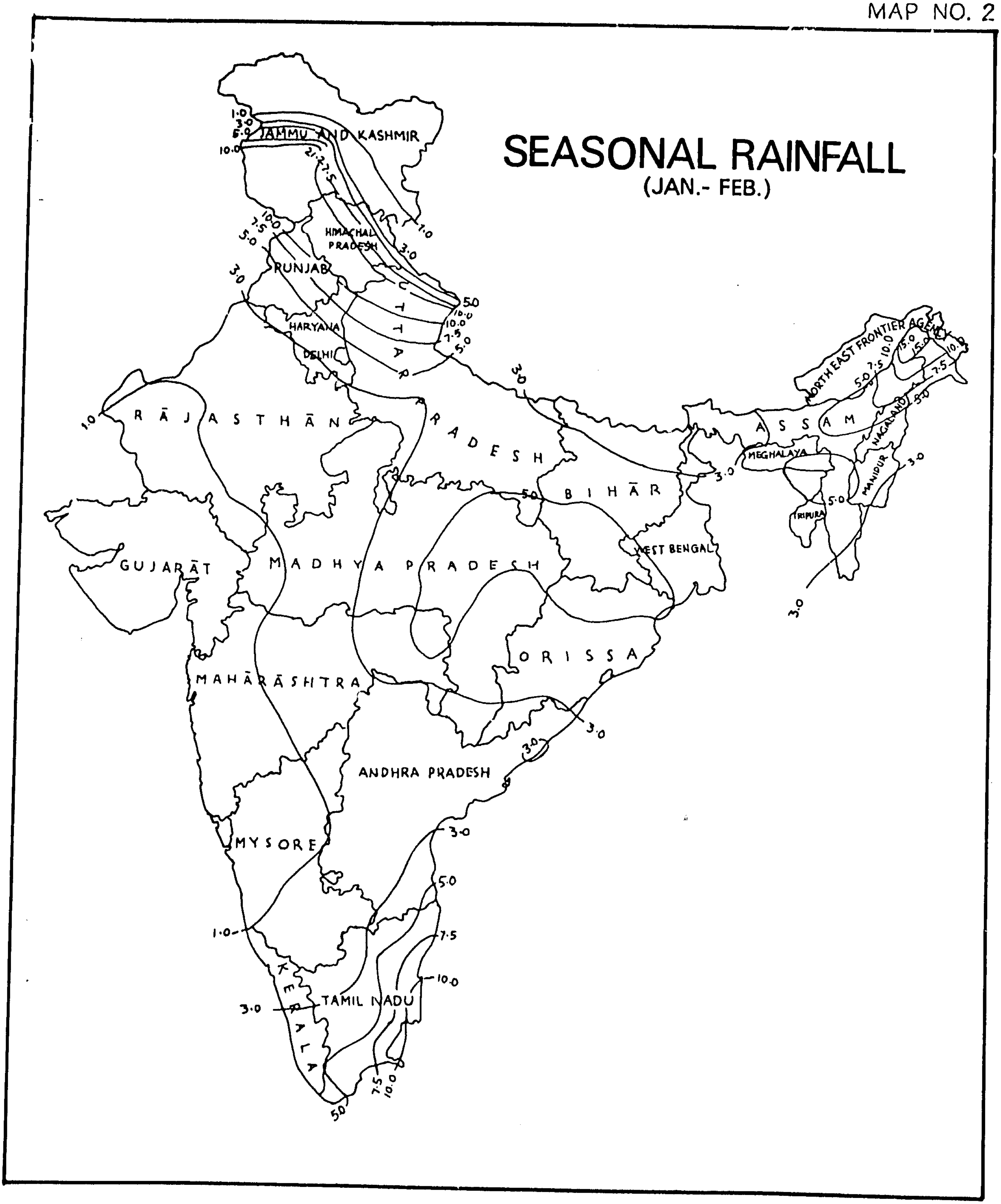
THE RESOURCE

Rainfall Patterns

The June to September southwest monsoon contributes from about 75 to 90 percent of rainfall in most parts of India. Rainfall occurs during October to December only in the extreme south and southeastern regions under influence of the northeast monsoon. Thunderstorms produce limited rainfall in some parts of the country during the hot weather between March and May. These rains are important only for the early spring rice crop in West Bengal and the Assam tea crop. The northern part of the country receives some irregular and unreliable rainfall during the winter which is significant for the wheat crop, particularly in unirrigated areas. As illustrated by Maps Nos. 1 and 2, about half of the country receives an annual average rainfall of 100 cms. or more. Large areas of the northeast and western coast receive rainfall of more than 200 cms. While some locations such as the Khasi Hills receive more than 1000 cms., parts of Rajasthan receive little if any at all. Since most rainfall occurs only during three months of the year, assuring a water supply to agriculture and industry for the remainder of the year poses a serious challenge to India's planners.


SEASONAL RAINFALL
(JUNE TO SEPT.)
JAMMU AND KASHMIR
HIMACHAL PRADESH
PUNJAB
HARYANA
DELHI
RĀJASTHĀN
UTTAR PRADESH
BIHĀR
NORTHEAST FRONTIER AGENCY
ASSAM
MEGHALAYA
NAGALAND
MANIPUR
TRIPURA
WEST BENGAL
GUJARĀT
MADHYA PRADESH
ORISSA
MAHĀRĀSHTRA
ANDHRA PRADESH
MYSORE
TAMIL NĀDU
KERALA

SEASONAL RAINFALL
(JAN.- FEB.)



Drought-Prone Areas

The complex system of monsoon winds, the arrangement of mountain ranges, the variability of rainfall and the erratic patterns of tropical storms produce well-defined regions and pockets of excessively low rainfall. Regions of water scarcity are defined by the Irrigation Commission as areas with rainfall of less than 100 cms. of which 75 percent is not received in 20 percent or more of the years and where irrigation is less than 30 percent of the cropped area. Rainfall in the northwestern drought-prone area is less than 75 cms. and as little as 40 cms. in some parts. Where it is not irrigated, this area is among the most famine-prone in the country. The second area is the so-called "shadow" of the Western Ghats where annual rainfall is less than 75 cms. and highly erratic. Because it is thickly populated, periodic drought conditions in this area cause much suffering and damage. In addition to these two main areas of water scarcity, represented by the cross-hatched area on Map No. 3, drought-prone pockets are scattered throughout the country.

Surface Water

An assessment by the Central Water Commission, based on analysis of stream flow data from eighty sources, places the total surface water resources of India at about 178 m.ha.m. This resource cannot be fully utilized due to the highly variable character of the flow and other limitations imposed by the country's geology and terrain. India's rivers and other major geographic features are shown on Map No. 4.

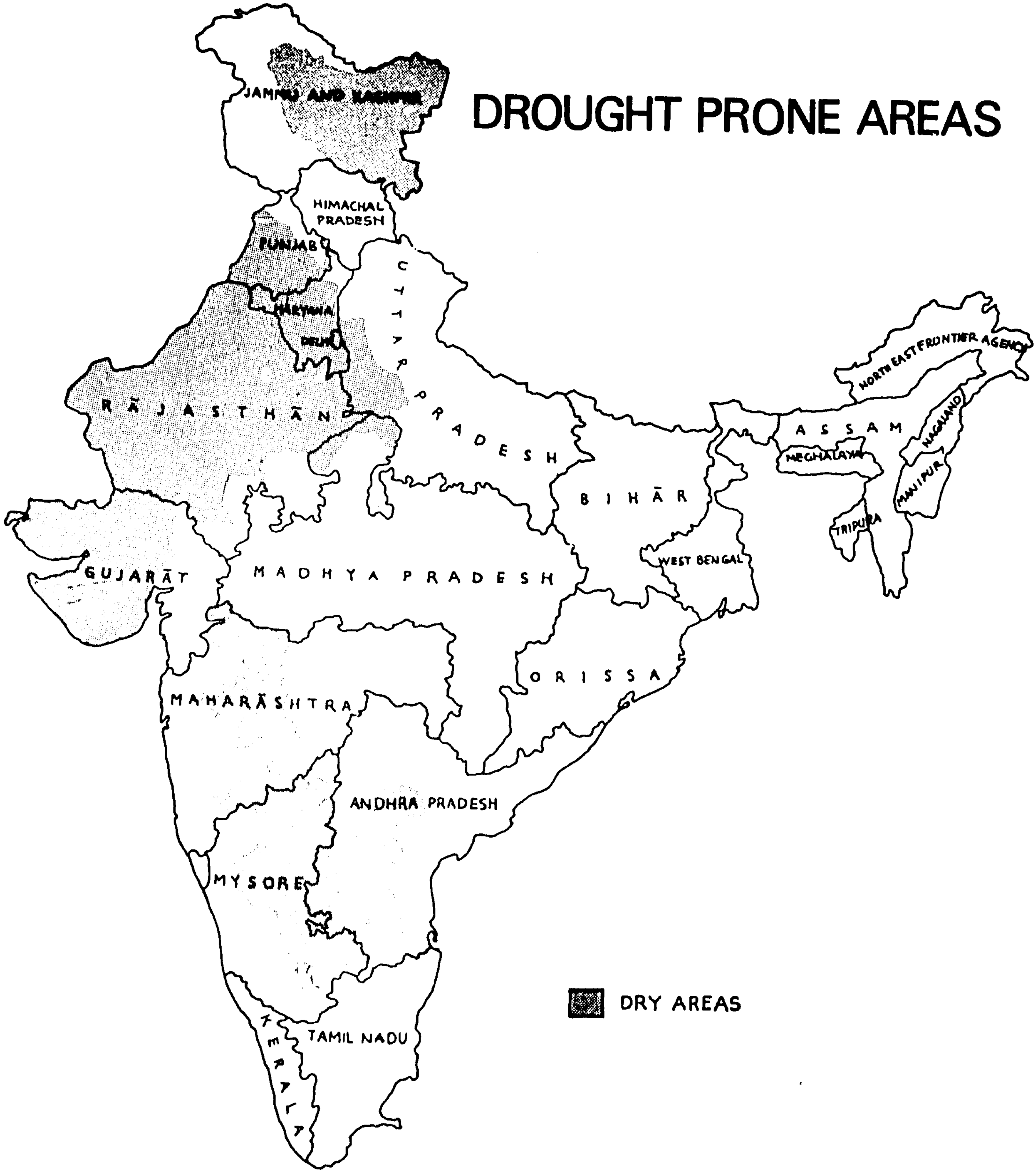
The bulk of river flows is concentrated during the four months when rain occurs. To conserve this water, construction of large storage works to hold flood flows passing to the sea would be required. However, suitable sites for construction of storage dams are limited. The utilizable quantity of river water also depends on the availability of suitable sites for its diversion, the quality of the water itself and the proximity of the flowing water to land fit for cultivation, as well as the dependability of flow. Given these limitations, the Irrigation Commission in 1972 estimated the total utilizable flow for irrigation at 66.6 m.ha.. The following table gives the details of this estimate region by region:

Estimate of Total Utilizable Flow for Irrigation
(in million hectare meters)

Basin	Average annual run-off	Utilizable Flow
Indus Basin	7.70	4.93
Ganga Basin	51.00	18.50
Brahmaputra Basin	54.00	1.23
West Flowing Rivers	28.80	6.92
East Flowing Rivers	34.80	33.80
Luni and Chaggar Basin	1.70	1.22
Total	178.00	66.60

MAP NO. 3

DROUGHT PRONE AREAS



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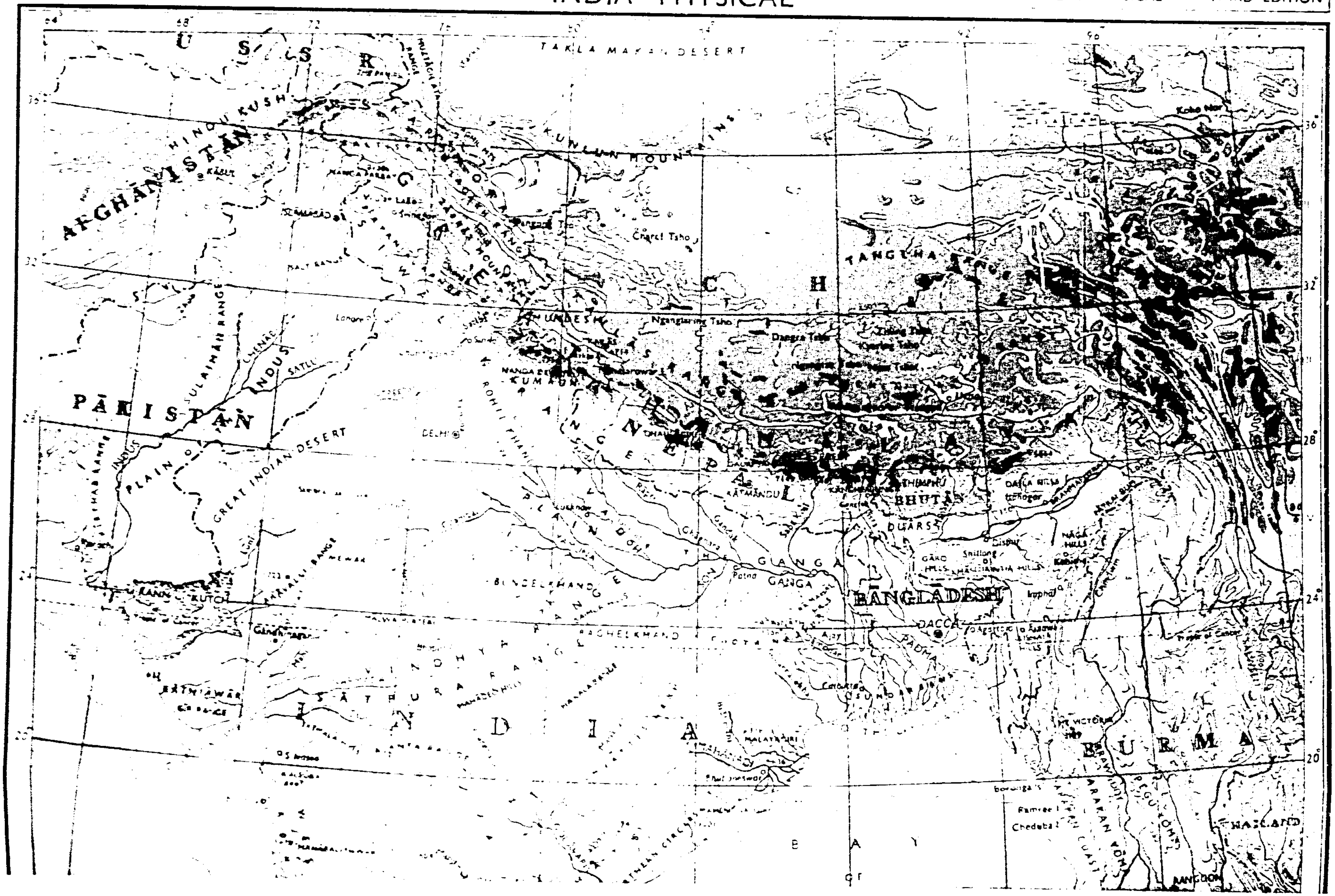
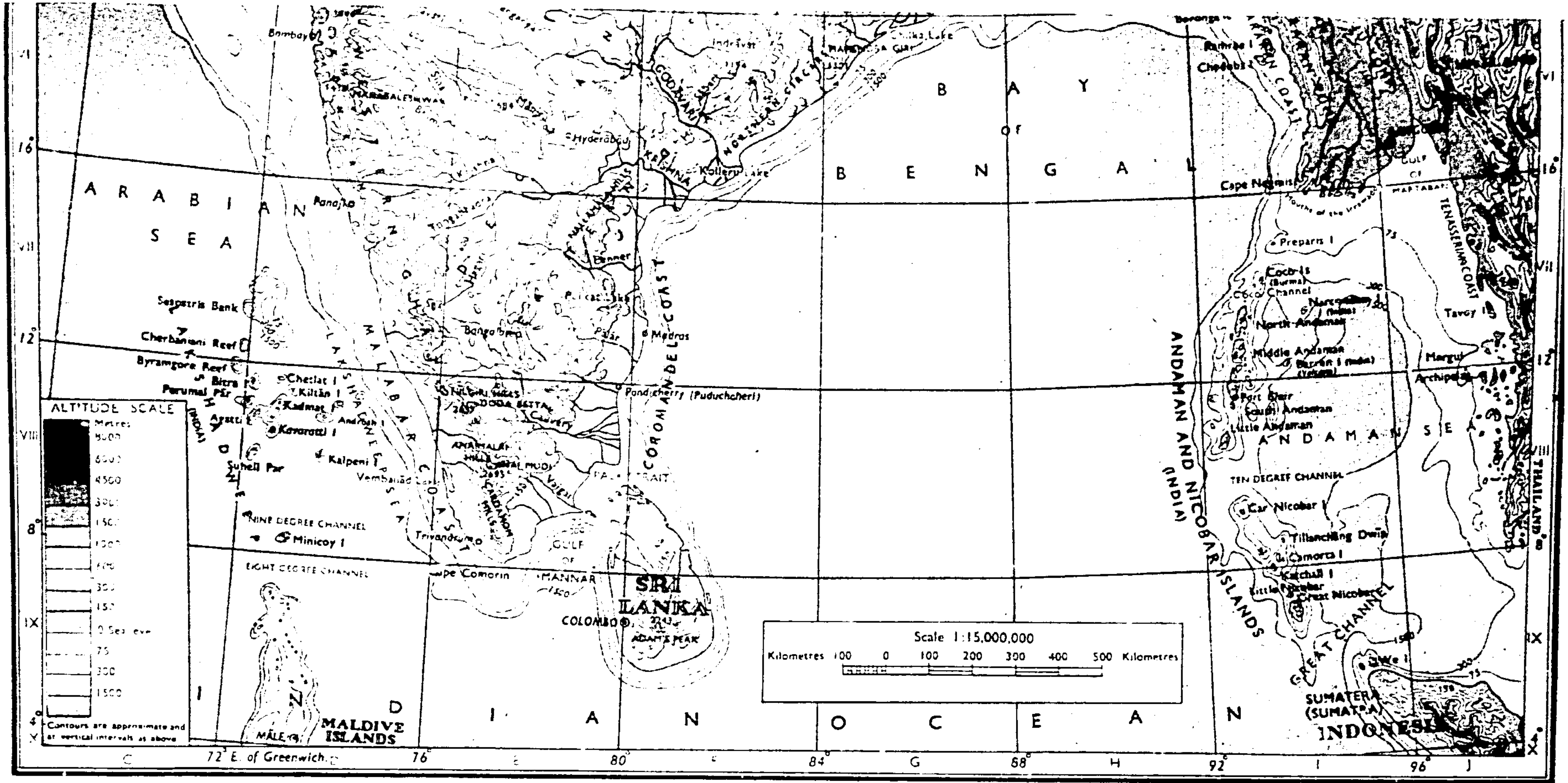
INDIA—PHYSICAL THIRD EDITION

INDIA - PHYSICAL





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1st Edition 1964 ; 2nd 1971 3rd 1974

Projection: Lambert Conical Orthomorphic.

Published under the direction of Dr. Hari Narain, M.Sc., D.Phil., Ph.D., *Surveyor General of India.*

1974.

The territorial waters of India extend into the sea to a distance of twelve nautical miles measured from the appropriate base line.

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INDIA—PHYSICAL	THIRD EDITION

Source: Irrigation Development in India - Tasks for Future, Indian Agricultural Research Institute, February, 1980

The National Commission on Agriculture estimates that this estimated usable flow will be sufficient for ultimately irrigating an area of 72 m.ha. by the end of 2025 A.D. Of the total usable flow, 58.5 m.ha. will be irrigated by major and medium irrigation projects and 15 million ha. from minor irrigation projects.

Ground Water

Ground water resources are dynamic: they are expanded by rainfall, seepage from irrigation canals and reservoirs, and the return flow from irrigation as well as inflow from rivers. The Central Ground Water Board has made the following estimate of total ground water resources of the country attainable by the end of the century.

Estimate of Ground Water Resources by 2000 AD
(in million hectare meters)

Contribution from rainfall	29
Seepage in return flow from canal systems	22
Seepage in return flow from ground water systems	6
Influent recharge from the drainage system including drains, streams, rivers, etc.	Negligible
Total	57

Source: Irrigation Development in India - Tasks for Future, Indian Agricultural Research Institute, February, 1980

Various factors, however, limit utilization of the total quantity of water stored in the ground: evaporation/transpiration losses from forest, water logged and marshy areas; inevitable afflux into rivers; and maintenance of a minimum base flow in the rivers for committed usage on existing canal systems and for ecological reasons. These factors reduce ground water usable for irrigation to an estimated 26 million ha.m. The National Commission on Agriculture estimates that this quantity is sufficient to ultimately bring an area of 40 million ha. under irrigation by 2025 A.D. The bulk of the estimated ultimate potential may, in fact, be realized by the turn of the century.

Distribution of ground water is governed by two factors: rainfall and geology. The greatest concentration of ground water is found in the alluvial plains of the Indus, the Ganga, the Brahmaputra and their tributaries; the inland valleys of the Narmada, Tapi and Purna rivers of central India; and the coastal alluvial plains. These formations comprise about one-third of the total land area in the country but contain 50 to 60 percent of total usable ground water resources. The next more productive source of ground water is the semi-consolidated sandstone formations, but these account for only 5 percent of total land area. Nearly 65 percent of total land area is covered by consolidated formations (about three-quarters crystalline rock and one-quarter basaltic rock) where ground water availability is limited and dependent on weathering and fracturing of the formation.

IRRIGATION

The Rapid Expansion of Irrigation Since Independence

Irrigation in India has been practiced from ancient times and has expanded steadily since then. Upon partition of the country in 1947, the area under irrigation stood at 19.4 million ha. Left with 80 percent of the prepartition population and having lost to Pakistan 17 percent of the irrigated area of undivided India on which the country was largely dependent for cereals, fibers, and oilseeds, the new Indian government was confronted with a massive food deficit. Irrigation was therefore given the highest priority at the beginning of the planning era in 1950. As a result, gross irrigation potential from major, medium and minor projects more than doubled from 22.60 million ha. in 1950 to 52.25 million ha. in 1977-78. The following table shows this rapid transformation of rain-fed to irrigated land.

Irrigation Potential
(gross million hectares)

Plan Period	Major & Medium	Minor Irrigation Ground	Minor Irrigation Surface	Minor Irrigation Total	Total Irrigation
1.Pre-Plan (1950-51)	9.70	6.50	6.40	12.90	22.60
2.End of 1st Plan (1955-56)	12.19	7.63	6.43	14.06	26.25
3.End of 2nd Plan (1960-61)	14.33	8.30	6.45	14.75	29.08
4.End of 3rd Plan (1965-66)	16.56	10.52	6.48	17.00	33.56
5.End of Annual Plans (1968-69)	18.10	12.50	6.50	19.00	37.10
6.End of 4th Plan (1973-74)	20.70	16.50	7.00	23.50	44.20
7.End of 5th Plan (1974-78)	24.77	19.80	7.50	27.30	52.25
8.Addl. Target (1978-79)	1.35	1.05	0.25	1.30	2.65
9.Addl. Target (1979-80)	1.10	1.25	0.25	1.50	2.60
10.Target (6th Plan)	6.50	7.00	1.50	8.50	15.00
11.Ultimate Feasible	58.50	40.00	15.00	55.00	113.50

Source: Irrigation Development in India - Tasks for Future, Indian Agricultural Research Institute, February, 1980

Total investment on major and medium projects during the 1950-51 to 1977-78 period was Rs. 54.54 billion. The area under minor irrigation increased during this period by 14.4 million ha. as a result of an outlay of Rs. 20.02 billion in the public sector and Rs. 18.12 billion of institutional credit extended to cultivators by the Land Development Banks, commercial banks, and cooperative banks, with refinancing through the Agricultural Refinance and Development Corporation (ARDC). There was an additional sizeable investment in minor irrigation projects from private sources by farmers themselves in achieving this total increase in minor irrigation.

The sixth Five Year Plan (now being revised) envisages creation of an additional irrigation potential of 15 million ha.: 6.5 million ha. from major and medium irrigation projects at an investment of Rs. 67.02 billion and 8.5 million ha. from minor irrigation projects with a public sector investment of Rs. 14.15 billion, about Rs. 22 billion of institutional investment, and Rs. 10 billion by farmers themselves. The emphasis is to be on: (a) higher utilization of existing potential; (b) speedy completion of ongoing projects; (c) efficient maintenance of the existing irrigation system, and (d) an assured supply of water to small farmers. Plans also call for monitoring water flows and use of remote sensing techniques. However, the long term goal is an increase in irrigation growth from 26.5 percent of total potential in 1977-78 to 33.4 percent in 1982-83 and increasing further to 39.4 percent in 1987-88 and 46.2 percent in 1992-93. This assumes doubling of the gross irrigated area from 45.31 million ha. in 1977-78 to 92.13 million ha. in 1992-93 which roughly works out to 81 percent of the maximum potential irrigated area based on presently known reserves of surface and ground water. Benefits flowing from irrigation by states are shown in Appendix A and B.

Investment figures during successive plan periods are shown in the following table:

Investment on Irrigation
(Rs. billion)

Plan Periods	Major & Medium	Minor: Plan Outlays	Minor: Institutional	Minor: Total	Total
First Plan (1951-52/1955-56)	3.80	0.76	Neg.	0.76	4.56
2nd Plan (1956-57/1960-61)	3.80	1.42	0.19	1.61	5.41
3rd Plan (1961-62/1965-66)	5.81	3.28	1.15	4.43	10.24
Annual Plan (1966-69)	4.34	3.26	2.37	5.63	9.97
4th Plan (1969-74)	12.37	5.13	6.61	11.74	24.11
5th Plan (1974-78)	24.42	6.31	7.80	14.11	38.53
Total	54.54	20.16	18.12	38.28	92.82
Sixth Plan (1978-83)	67.02	14.15	22.00	36.15	103.17
Likely during 1978-79	9.76	2.37	2.70	5.07	14.83
Approved for 1979-80	10.96	2.22	3.75	5.97	16.93

Source: Irrigation Department in India - Tasks for Future, Indian Agricultural Research Institute, February, 1980.

From the initiation of planned development in 1950 to the end of the fifth Five Year Plan, 146 major and 756 medium projects had been undertaken. Of these, 40 major projects and 447 medium projects were completed by the end of the Fifth Plan with 106 major and 309 medium schemes remaining to be completed in the Sixth Plan. Thus, most irrigation projects in India have been completed since independence.

The development of minor irrigation works in terms of physical units (excluding tanks and diversion projects for which precise figures are not available) is shown in the following table:

Development of Ground Water Structures
(in '000' nos.)

Plan Period	Dugwells	Pvt. Shallow TWs*	Public Deep TWs	Electric Pumpsets	Diesel Pumpsets
1. Pre-Plan (1950-51)	3,860	3	2.4	21	66
2. End of 2nd Plan (1960-61)	4,540	20	8.9	200	230
3. End of Annual Plan (1968-69)	6,110	360	14.7	1,090	720
4. End of IVth Plan (1973-74)	6,700	1,140	22.0	2,430	1,750
5. End of Vth Plan (1977-78)	7,425	1,700	30.0	3,300	2,500
6. During 1978-79	210	200	3.4	300	200
7. Target (1979-80)	280	250	3.9	400	200
8. Target VIth Plan	1,200	1,200	10.0	2,000	1,000
9. Ultimate Feasible	12,000	4,000	60.0	12,000	5,000

Source: Irrigation Development in India - Tasks for Future, Indian Agricultural Research Institute, February, 1980

Development of the Ganga Basin

Because in much of the irrigated area of India surface water resources have been harnessed to the maximum extent feasible, further development of irrigation will require maximum utilization of ground water to supplement supplies from surface sources. Much of this potential is in the Ganga basin which is among the largest ground water reservoirs in the world. The basin holds about 26 m.ha.m. of gross renewable ground water. The following table shows the ultimate irrigation potential, that already utilized, and that which is available for further development from ground water in the six states of the basin:

Development of Irrigation Potential in '000' ha.

State	Ultimate Feasible	Achievement up to 50-51	60-61	68-69	73-74	77-78	Balance
Bihar	4,000	170	260	500	800	1,200	2,800
Haryana	1,400	275	300	550	1,000	1,150	250
Madhya Pradesh	3,000	250	330	485	700	900	2,100
Rajasthan	2,000	950	1,020	1,250	1,400	1,450	550
U.P.	12,000	2,300	2,800	4,700	5,300	7,000	5,000
West Bengal	2,500	Neg.	Neg.	120	250	400	2,100
Total	24,900	3,945	4,710	7,905	9,450	12,100	12,800

Source: Irrigation Department in India - Tasks for Future, Indian Agricultural Research Institute, February, 1980.

*TW = Tubewell, the Indian term for a machine-drilled well

This data shows that, except for Haryana and Rajasthan, enormous ground water resources remain untapped. Estimates indicate that the four states of Uttar Pradesh, Bihar, West Bengal and Madhya Pradesh have ground water potential sufficient to sustain four million additional wells and tube wells capable of irrigating an additional area of 12 million ha. The slow progress of ground water development in these states is to some extent due to problems encountered in mobilizing institutional investment, but the chief problem is the lack of electrical power and shortage of diesel fuel as well as rising energy costs. Extension of power lines into rural areas is lagging, and in those areas where infrastructure exists power generation has been inadequate. Consumption of power for irrigation as a percentage of total power sold is only 9.8 in Bihar, 1.2 in West Bengal and 8.3 in Madhya Pradesh. The continuing lack of growth in the agricultural sector and power shortages have jeopardized the ground water development program in these states. Public tube wells designed to run almost around the clock in peak irrigation periods have been most seriously affected. Normally running 3,000 to 4,000 hours a year, power shortages have reduced their operation to as little as 1,000 hours per year.

The Critical Role of Rural Electrification in Irrigation Development

Rural electrification coupled with an assured supply of power will be a fundamental requirement of further expansion of the minor irrigation program, because electricity provides the most economical and efficient means of lifting ground water which offers greater potential for future expansion than surface water.

The use of diesel powered pumps and water lifting devices operated by draft animals are the alternatives. But they are cumbersome and comparatively much more expensive to operate. The scarcity and rapidly increasing price of diesel fuel has, in fact, significantly hampered the progress of minor irrigation programs in recent years. Rural electrificiation must, therefore, be assigned a high priority in future planning and supported by adequate programs for additional power generation.

Rural electrification projects are financed by the Rural Electrification Corporation, Ltd., (REC) set up by the Government of India in 1969-70 together with the Agricultural Refinance Development Corporation (ARDC). The REC promotes agricultural production through minor irrigation and extends favorable credit terms for electrification of remote backward areas. This will also help in utilization of untapped ground water potential in states where it has remained largely unused for want of capital financing. Financial resources of the REC consist of equities subscribed by the government, loans from the government, reserves and surpluses and market borrowing.

The REC has recently introduced a new program called the Special Project Agriculture (SPA) having a capital outlay of Rs. 3.60 billion to provide energy to 600,000 pump sets during the Sixth Plan. The sixth Five Year

Plan calls for energization of 2 million pump sets and electrification of 100,000 villages during 1978-83. Financed by commercial banks, the ARDC and the REC on an equal basis, this program envisages projects covered by eight year loans up to a total of Rs. 3 million for each project and 14 year loans up to Rs. 5 million for each project. There is a two-year moratorium on repayment of these loans. The REC financing component of these projects is at a nine percent rate of interest and the rest is at 10.5 percent. The program is expected to accelerate provision of energy for irrigation pumps.

The REC since its inception has approved 2,840 projects involving loan assistance of Rs. 10.52 billion for electrification of 189,000 villages and provision of energy to 1.19 million irrigation pumps. Nearly Rs. 6.95 billion have been dispersed up to September 1979, and 59,000 villages have been electrified and 424,000 pumpsets have been energized as of June 1979 under the REC program. The annual increase in electrification reached about 9,000 villages and 94,000 pumpsets during 1978-79.

Irrigation Project Administration

After independence irrigation development continued to be a state subject and public irrigation works, except for a few very large interstate projects, are designed, constructed and managed by state public works and irrigation departments. The Central Power and Water Commission (CPWC), now the Central Water Commission (CWC), was set up in the central government to set standards and review, to monitor plans and implementation of major and medium irrigation projects, and to deal with development of interstate rivers under the Ministry of Irrigation and Power. With more than 1,000 well-trained and experienced engineers, CWC is the country's primary technical authority for water resources. Funds for construction and operation and maintenance are budgeted to the state Irrigation Departments by the state governments. The source of funds is state revenues, and grants and loans from the Center. The latter are made contingent upon compliance with CWC technical standards and central government policies.

A program for administration of minor irrigation works was established in the Ministry of Agriculture for the country as a whole, including all private works such as well, tanks and channels and public works costing less than Rs. one million each. Minor irrigation works have recently been redefined as those having irrigated potential of less than 2,000 hectares. In 1973, major and medium irrigation under the Irrigation Department was transferred to a new Ministry of Agriculture and Irrigation (MOA) and hydro-power to the Ministry of Energy. The Irrigation Department, which was transferred out of MOA to the Ministry of Irrigation and Power in January 1980, is now a separate Ministry. Minor works continue under MOA. Much of this program is in the private sector and the GOI has developed means for substantially increasing the supply of credit for drilling and energizing wells and for rural electrification infrastructure both through cooperative and private banks, and the Agricultural Refinance and Development Corporation, in the public sector. Various departments in state governments, including public works, irrigation and agriculture as well as revenue, manage certain aspects of the program.

Ground water development was managed by the Exploratory Tube Wells Organization (ETO) set up in the Ministry of Agriculture in 1954 with USOM (now USAID) financing and technical assistance. In 1972 this organization became the Central Ground Water Board which also took over the former Hydrological Survey of India. The Central Ground Water Board is responsible for: macro-level hydrogeological investigations; deep exploratory drilling; monitoring water table behavior; developing methodologies for special problems encountered in planning assessment and development and management of ground water resources.

Development Costs and Water Rates

With the expansion of irrigation development throughout the country and the graudal increase in construction costs* after independence, the productivity criterion for financing irrigation projects followed under British rule was found to be inhibitive. Productivity was calculated as the ratio of receipts from water charges in any year to the unpaid capital and operation and maintenance costs plus interest up to that year. The rate of return test was initially lowered in 1949 from 6 to 3.75 percent, but eventually this rate was also found to be too high. Irrigation policy planners evolved the view that state investment policy should be determined by a broader criterion than that of direct revenue returned to the state. Studies by the Planning Commission between 1958 and 1961 showed that substantial direct and indirect economic and social benefits accrue from irrigation: double cropping, diversification and better quality of crops, higher yields, larger incomes, and greater employment opportunities for hired labor, and in addition there were indirect benefits like the establishment of processing industries, expansion of consumer industries, retail trade and transport and communications. On recommendation of the Nijalingappa Committee, the Government of India therefore accepted benefit-cost analysis as the basis for evaluating irrigation projects. A 10 percent annual rate of return (based on project life of 50 to 100 years) from direct benefits measured as increased income to cultivators is now used to calculate the benefit-cost ratio (B/C) ratio. Projects with a benefit-cost ratio of less than 1.5 are generally not considered for approval except in drought-prone areas or in areas where socially and economically disadvantaged groups predominate.

Water Rate Policy - Irrigation Subsidy

The water pricing issue raises three questions: (1) financial feasibility

* Average construction cost has risen from Rs. 2,000 per hectare in the late 1960s to a current level of about Rs. 10,000.

for farmers; (2) financial feasibility for government; and (3) economic feasibility for society.

Irrigation water pricing policy has been examined over the last twenty years by a number of authorities. There is a consensus among these studies that a policy for regulating water rates should have the following principal elements:

-- Water rates should in no case exceed 50 percent of the additional net benefit to cultivators and should vary from 20 to 50 percent depending on local socio-economic conditions.

-- Absent data regarding production of crops per unit of land before and after irrigation, the water rate may be related to the gross income from crops and should range between 5 and 12 percent of gross income with the upper limit being applicable to cash crops.

-- The rate should not vary from project to project except for quality of service. Any variation in rate should be small and irrigation works in a state should not impose a heavy financial burden on general revenues.

-- Water rates should be levied on a cropped area basis except where measurement of water for irrigation on a voluntary basis is feasible.

Implementation of these recommendations would help rationalize water pricing policy based on the principle of farmers' ability to pay; however, with a strong agriculture lobby, state legislatures are reluctant to raise rates. Nevertheless, water rates have risen as much as 100 percent over the past twenty years in many areas. Even if the recommendations were implemented, major and medium irrigation would continue to require heavy financial subsidies by government. The extent of economic subsidy, however is unclear. The B/C ratio used in India is based on financial returns rather than economic values. Because of price controls, farmers receive only about 70 percent of economic value (as set by world markets) for their crops, but this is partially offset by subsidies for production inputs. Correction for most of these distortions is made in feasibility studies for projects funded by the World Bank and USAID which require an economic B/C ratio of 1.0 based on interest of 12 percent, thus reflecting an economic subsidy equal to the difference between opportunity cost of capital and 12 percent or the calculated internal economic rate of return for projects having B/C ratios greater than 1.0.

Improving Water Management Practices

Despite the remarkable progress in harnessing surface water resources through the construction of large and small dams, headworks, regulators and canal systems since independence, the utilization of the enormous irrigation potential created by this infrastructure has been slow owing to failure to develop adequate water management techniques and policies. Of the total irrigation potential of 24.95 million ha. created by major-medium irrigation schemes through the end of the Fifth Plan, only 21.16 million ha. were actually being utilized. More significant is that the production benefit derived from utilized irrigation potential has been far below the optimum level. The following table shows the relative contribution from unirrigated and irrigated cropped areas to total foodgrains production potential in the country at the beginning of the planning era and at present (1977-78):

Production of Foodgrain from
Irrigated vs. Unirrigated Areas

	Units	1950-51	1977-78
Total area under foodgrains	million ha.	97.3	127.0
a) Unirrigated area under foodgrains	million ha.	79.0	90.0
b) Irrigated area under foodgrains	million ha.	18.3	37.0
Yield	kg/ha		
a) Unirrigated		500	700
b) Irrigated		900	1,700
c) Combined		522	988
Estimated production	million MT		
a) Unirrigated		38.5	63.0
b) Irrigated		16.5	62.9
c) Total		55.0	125.09
		(Actual	125.6)

Source: Irrigation Development in India - Tasks for Future, Indian Agricultural Research Institute, February, 1980.

According to this estimate, the average yield of irrigated foodgrain per ha. increased from about 0.9 metric tons (MT) in 1950-51 to about 1.7 MT per ha. during 1978-79. Experience in other countries shows that average yields of 4-5 MT per ha. from irrigated areas are quite common. Thus the priority task of irrigation development in India is to improve water management so as to obtain better yields and derive full economic benefit from the country's huge investment in irrigation.

Field Channels

The single most important requirement for quick and efficient utilization of irrigation potential created is construction and maintenance of field channels from the canal outlet to individual fields. On surface water projects the Irrigation Department constructs and operates at project cost, conveyance and distribution channels down to an outlet serving an area (called a chak) of firm usage as low as 10 to more than 100 hectares or even larger. From the outlet, farmers are expected to construct the channels and operate them to deliver water to individual holdings, often less than one hectare, a responsibility for which they have neither the organization nor technical capacity. The result is that these channels are unreliable and wasteful. In order to clarify responsibility, in the 1960s the Planning Commission issued a directive fixing chak size at 40 hectares. Out of a total command area of something over 25 million ha. covered under major-medium irrigation schemes, it is estimated that as much as 12-13 million ha. may be without field channels. Over the past two years, under World Bank and other donor pressure, the Central Water Commission and the Planning Commission have directed that field channels be provided for plots up to eight hectares in command areas as part of irrigation projects. The Center would provide 50 percent funds consisting of 25 percent loans and 25 percent grants with the remaining funds to be raised by states. These policies represent significant progress and it is now up to state governments to insure that the lag in creation of irrigation potential at the outlets and construction of field channels is reduced to a minimum.

Command Area Development

Realizing that optimum development of irrigation potential required careful, systematic administration of water distribution and water management practices, the GOI in 1973 called on the states to establish Command Area Development (CAD) authorities to plan on-farm works, modernize headworks, canals and other infrastructure such as warehousing, marketing and village to market roads, and generally to strengthen the organization of agricultural extension activities. Forty-three CAD authorities now coordinate services for almost all of the 60 major irrigation projects in India covering a cultivable area of 13 million ha.

Water Delivery Schedules

After construction and maintenance of field channels, the most important priority is establishment and enforcement of schedules for delivery of water to the fields, particularly for those less advantaged farmers at the tail ends of the distribution system.

Over the last fifty years, a turn schedule system has been developed in northern India which provides for delivery of water to each farmer in the command of an outlet for a specified period in proportion to the size of his holding and according to a turn schedule prepared in advance. For the most part, the schedules are established by the farmers themselves and if they are not satisfied, they can appeal to irrigation authorities. Since the quantity of water allocated to each farmer is fixed, this system induces the farmer to use water more efficiently. Unfortunately, the use and administration of turn schedules remains haphazard and water use is as a result less efficient than would be the case if they were formalized and carefully administered. Upon appeal by farmers or on its own initiative, when authorized by state governments, the Irrigation Department can establish and enforce a formal rotation on a prescribed schedule known as warabundi. Even in states where warabundi has been authorized for a number of years, progress towards full utilization has been negligible and the majority of states have yet to initiate it.

Crop Planning

Efficient water use is also significantly enhanced by planning crop patterns in irrigated areas based on soil types and regional agro-climatic conditions. Because water rather than land is the scarce resource, maximum production occurs through optimizing production per unit of water rather than per unit of land, thus crops are grown at less than full water supply and double and triple cropping gives way to single cropping of larger areas. Within the available water supplies, crop varieties should be selected to give equivalent yields with minimal amount of moisture over a short duration so that their growing period does not conflict with crops to be grown in the following season. Significant gains in production can result from double or multiple cropping if the sowing of such crops as rice, peanuts, arhar (pigeon pea) is advanced through use of ground water-irrigated nurseries. With crop patterns thus determined on the basis of available irrigation water and other factors, water distribution can be synchronized with crop requirements. In many irrigation systems where infrastructure is otherwise satisfactory, failure to match irrigation water supplies and cropping patterns is the main factor responsible for unsatisfactory levels of productivity.

Modernization

Most surface irrigation projects cannot meet crop requirements owing to excessive transit losses and inadequate regulatory structures on canals. On some projects canal capacities themselves are a constraint. Transit losses are particularly critical. Unlined canals lose between 20-50% of the volume of water they are designed to transport. GOI irrigation planners therefore have assigned a high level priority to remedying these defects, undertaking such measures as canal lining and construction of regulatory works, so that water requirements of crops during peak periods are met and application of fertilizers and other inputs is timely. Modernization of existing works ranks as a leading priority in the sixth Plan.

The Model Irrigation Bill

Concurrent with the expansion of irrigation works in India during the 19th century, the British colonial administration enacted a number of laws regulating and controlling water in state-owned canals and works. These laws varied considerably between states and within states. There grew up a multiplicity of laws covering various aspects of irrigation management and administration, often providing for multiple lines of authority and diversified control for operation and management of irrigation works which diffused responsibility and was ultimately against the best interests of the states as well as the irrigators. Moreover, these laws did not cover aspects of irrigation policy which assumed greater importance after independence: conjunctive use of surface and ground water, construction of on-farm development works including field channels, field drains, cropping patterns and drainage, and enforcement of proper maintenance of irrigation works previously maintained by ex-landlords and zamindars.

The Second Irrigation Commission therefore recommended in 1972 that the irrigation laws in each state be simplified and consolidated into a single statute uniformly applicable within all regions in the state. This recommendation resulted in drafting of the Model Irrigation Bill which has been circulated to the states for consideration and adoption with suitable modifications, if any, to accommodate prevailing conditions and practices in the states.

Since it would eliminate many long-standing practices and run counter to vested interests of larger land holders, the Model Bill is controversial. This and the complexity of the subject make it unlikely that many states will amend existing law along these lines in the foreseeable future.

The Model Ground Water Law

Increasing use of high yielding varieties has accelerated the over-development of ground water. Controls were needed to prevent overuse of ground water with the concomitant hazards of lowering the water table, well failure, saline infestation, and reduction in commited base flow in rivers. A model Ground Water Bill along these lines was prepared and circulated to the states by the Union Department of Agriculture in 1970. Because under Indian law all ground water vests in the government and there is no possibility of ground water being acquired by prescription, there are no legal barriers or constitutional problems preventing passage of such an act.

Thus, a comprehensive legal framework governing construction, maintenance, management and utilization of area irrigation works has been drafted; it is now up to the various state governments to take the required action to implement it. But, like irrigation law reform, this is a controversial, complex subject and not likely to be enacted soon.

FLOOD CONTROL

Flood control continues to be a major problem in India. Damage caused by floods over the last two decades has averaged about Rs. 1,500 million a year. In 1978, the country experienced some of the worst floods of recent record, affecting large areas of Haryana, Uttar Pradesh, Bihar and West Bengal while the states of Kerala and Tamil Nadu were hit by tropical storms which also produced flooding. Total damage amounted to Rs. 10.91 billion, a level of devastation only exceeded by the unprecedented floods of 1954.

Rivers causing serious floods fall into three groups. The first group consists of all the rivers below the Tropic of Cancer. In this group only the Narmada and the Orissa rivers - the Brahmani, Baitarni, Burhabalang - and the interstate river Subarnarekha have yet to be controlled.

The second group includes the Ganga and its tributaries. Of this group the areas most seriously affected are north of the Ganga and lying between the Ghaghra and the Mahanadi tributaries. The Ganga itself causes erosion at a number of places. Floods in this area affect the most densely populated areas of the country. As all these rivers are international and flow from Nepal, flood control requires to some extent cooperative planning between India and Nepal. The southern tributaries of the Ganga are the Yamuna and the Son. Sub-tributaries of the Yamuna such as the Chambal, the Sind, the Betwar are subject to serious flooding which has, however, diminished somewhat in recent years as flood control works are extended on these rivers.

The third group comprises rivers in the Brahmaputra valley in India. Here the prevalance of earthquakes, landslides and heavy silting seriously complicates the construction of flood control works. Since rivers passing through North Bengal, such as the Tista, Torsa, Jaldhaka, are international, their management will require cooperative planning with Bangladesh in order to be effective.

While considerable protection has resulted from works already constructed on rivers such as the Mahanadi, in the Indus and Tapi Basins, large areas of the country remain subject to serious flooding. Concerned by the magnitude of the flood control problem, the GOI established in 1976 the National Flood Commission to identify areas requiring immediate protection and to prepare a comprehensive plan for optimum multi-purpose utilization of water resources.

The National Flood Commission in its report submitted recently to the GOI has recommended a twenty-two point program for flood control as part of the strategy for optimal utilization of water resources. The program calls for setting up a central control agency under the chairmanship of the Prime Minister assisted by a strong technical group. Other major recommendations include (a) afforestation and soil conservation; (b) greater coordination among different agencies engaged in flood protection such as railways, national highways, and state irrigation/flood control departments: (c) establishment of a national council for mitigating disaster and (d) flood control tax. The Draft Sixth Five Year Plan (1978-83) (now under revision) estimates that the total area liable to flooding is 34 million ha. It is economically feasible to extend flood protection to about 80 percent of this area. The plan allocates Rs. 9 billion to various flood control projects and calls for preparation of master flood control plans. Major programs include construction of embankments, excavation of drainage channels, construction of storage reservoirs in upper river catchments and reservoir regulation to control flood discharges.

A NATIONAL WATER GRID

While most of India's immediate and near term water requirements can be met by surface and ground water development within river basins, inter-basin water transfers are necessary and will be increasingly so over the long term. Major interbasin projects have already been undertaken. These include the Periyar Diversion, the Kurnool Cuddappa Canal, the Beas-Sutlej link, and the Rajasthan Canal.

Indian planners have considered means by which some of the surplus water of the Ganga system can be pushed southward as far as the tip of the Peninsula. The idea of a national water grid was first proposed by Dr. K. L. Rao in 1972 when he was the GOI Minister for Irrigation and Power. UNDP conducted a preliminary feasibility study. The plan was not pursued further because of objections about engineering and environmental aspects of the project.

The highly publicized "Garland Canal", advocated by Dr. Dinshaw J. Dastur, a prominent engineer, would entail an investment of Rs. 150 billion and calls for the construction of two mammoth canals, the Himalayan Catchment Canal and the Central, Deccan and Southern Plateau Canal, to provide irrigation water throughout India. The GOI, though, appears to have shelved the proposal on grounds that it is not feasible either from an engineering or economic standpoint. GOI planners have not, however, abandoned the concept of a national water grid; they appear to favor an incremental approach rather than a massive, comprehensive project such as that proposed by Dr. Dastur.

The GOI is now considering a national water development plan which would link different rivers in the country and would undertake multi-purpose development of water for flood control, irrigation, drinking water, hydroelectric power generation and navigation.

The extension of such projects on a country-wide scale involves careful consideration of costs and benefits, possible alternatives, technical feasibility, and a firm, reliable assessment of ground and surface water resources. Long distance water transfer also involves careful consideration of long-term plans for industrial growth and urban development.

Most importantly, interbasin transfer requires a concensus among claimant states and regions regarding water distribution, and negotiation of agreements between states is only slightly less complicated and acrimonious than negotating international ones. The recently completed Narmada River agreement took several years and probably will be challenged in the courts. Interstate rivalry could thus be a major deterrent to achievement of this goal.

HYDROELECTRIC POWER

India's economically exploitable hydroelectric potential was assessed during a 1953-1960 survey by the CPWC at 41,100 MW. at a 60 percent load factor. This estimate was based on specific projects in various river basins for which topographical and hydrological data were available. Subsequent surveys indicate that the country's hydro potential is much larger if seasonal and secondary sources including micro-hydel projects are taken into account. Although a detailed updating of the earlier survey of potential has not been undertaken, the Central Electricity Authority (CEA) estimates that India's hydroelectric potential is 76,000 MW at a 60 percent load factor, equivalent to an annual generation of 400.5 TWH. (TWH = KWH X 10^9). The following table shows recent estimates of hydroelectric potential by region at a 60 percent load factor, the earlier CWPC assessment is shown for comparison:

Assessment of Hydroelectric Potential in MW

	CWPC (1953-60)	CEA	Percentage change in power potential
Total	41,000	76,200	85.4
Northern	10,700	27,800	159.8
Eastern	2,700	7,500	177.8
Western	7,200	7,600	5.6
Southern	8,100	13,100	61.7
North-Eastern	12,400	20,200	62.9

Source: Ministry of Energy, Department of Power, 1978-79 Report

Hydro potential now developed or currently under construction represents about 17 percent of the total potential of 76,200 MW. Most of the remaining potential is in the northern and northeastern regions. One of the factors contributing to slow progress in developing hydro potential appears to be the engineering problems entailed in dealing with large unstable rivers and active seismic conditions. A regional comparison of developed potential and potential is shown in the following table:

Hydro Potential Development and Under Development
(in MW at 60 percent load factor)

	Potential developed and under development (1)	Potential (2)	(1) as percent of (2) (3)
Total	12,804	76,200	16.8
Northern	4,226	27,800	15.2
Eastern	1,451	7,500	19.4
Western	1,330	7,600	17.5
Southern	5,554	13,100	42.4
North-Eastern	243	20,200	1.2

Source: Ministry of Energy, Department of Power 1978-79 Report.

Although electrical power development will continue to be assigned a high priority by the GOI and the Planning Commission, hydroelectric resources are not likely to be fully utilized because of the high initial cost and the long construction period required for hydro projects. This is borne out by projections in the draft Sixth Plan. Hydro capacity is projected to increase by 42 percent, from 10,010 MW to 14,240 MW over the Plan period compared to a 95 percent increase in thermal generation capacity from 13,059 MW to 25,526 MW over the same period. Although renewed emphasis is now being placed on development of India's vast hydro potential, and the GOI in cooperation with state governments is investigating possible hydro sites in Jammu and Kashmir, Arunachal Pradesh, Sikkim and the Andaman and Nicobar Islands, resource constraints may prevent significant development at this juncture. Nevertheless, the Government of India is thinking in terms of an integrated development plan for the northeastern states, which is a region of challenging geographical and geophysical characteristics. The dams proposed will not only produce much needed power but provide a measure of flood control during heavy monsoons. Because the area is seismically active, careful scientific studies will have to be conducted in connection with the design and construction of the high dams.

INTERNATIONAL BOUNDARY WATERS

India's international boundary water problems are now largely confined to the eastern region. A 1960 treaty with Pakistan governs water resource sharing in the Punjab and assures Indian access to flows in the Ravi, the Beas and the Chenab rivers.

The chief obstacle to management of water resources in the lower reaches of the Ganga and of the Brahmaputra rivers is the dispute with Bangladesh over low flows in the Ganga. For perhaps two centuries or more the discharge of the long, slow Ganga river has been shifting toward its eastern distributaries, which now lie in Bangladesh. Its westernmost outlet, the Bhagirathi-Hooghly, has been losing water, and also has been silting up, thus reducing the draft of ships that can come to Calcutta, now limited to about 26 feet, despite continuous dredging. The new bulk and container port, Haldia, south of Calcutta, offers only a little more draft. This situation is at its worst in the dry season, and to solve it a barrage and canal was finished by India across the river at Farakka in 1976, capable of diverting a flow of over 40,000 cusecs into the Hooghly. Dry season Ganga flows, however, can go as low as 15,000 cusecs and the removal of 40,000 cusecs would leave Bangladesh's districts on the Ganga without adequate water for maintaining navigation and preventing sea water infiltration. By embarrassing India through "internationalizing" the dispute in the UN, Bangladesh forced India to accept a split of the annual low water diverted at Farraka giving Bangladesh the greater part of it for the five years 1977-82, pending a long range settlement which would "augment the dry season flow of the Ganga".

There are two major proposals on the table to accomplish this: India wishes to link the far more voluminous Brahmaputra to the Ganga by a canal which would cross a portion of Bangladesh and enter the Ganga above Farakka. However, reduction of already low dry season flows in the Brahmaputra would aggravate the water supply situation in Bangladesh. Moreover, Bangladesh objects to the loss of a certain amount of her land which would be used by the canal, and counter proposes the impounding of monsoon water in a series of Ganga system upstream dams, many of which would be in Nepal, and releasing the water during the dry season. This would involve Nepal's joining the talks.

The concept of an internationally supported study of potential "eastern waters" development perhaps leading to a large-scale collaborative project across national frontiers was touched upon very lightly by President Carter during his February 1978 visit to New Delhi, and in effect seconded soon thereafter by the then U.K. Prime Minister Callaghan. There has been little concrete response from the South Asian countries actually involved, however, and in light of the unsuccessful Indo-Bangladesh Joint Rivers Commission meeting in February 1980, there is little current prospect of a positive response.

The Joint Rivers Commission also established a committee in December 1978 to examine sharing of flows in the Tista river. During the meetings in February the Bangladesh representative also objected to the construction of a dam on the Indian side of the Tista river in the absence of an agreement on water sharing. Prospects of an early settlement of these issues with Bangladesh, therefore, appear remote unless a high-level political decision is made.

CONCLUSION

Because India's economy is predominantly agricultural and agriculture depends on firm water supplies, continued economic growth in India will be heavily contingent on further development of irrigation. India has created vast irrigation potential since independence but has been much less successful in utilizing that potential effectively. Scarcity of financial resources, aggravated by rapidly escalating construction costs, will be the major constraint on creation of new irrigation potential in the future, but will be only one of several constraints in shifting emphasis to the more economically effective but politically less attractive task of achieving better water utilization. Field channels, land development, rural roads, warehouses, markets, credit, production inputs, and technical know-how effectively integrated into irrigation development schemes will be required to accomplish this task. But in addition to this heavy investment in rural infrastructure and technical training, improved organization and political commitment will be essential.

Uneven distribution of water resources presently denies irrigation to the majority of India's farmers. To extend irrigation to its maximum potential will require inter-basin water transfer on a substantial scale. While proposals for spectacular schemes to double present irrigation potential (113 million hectares by the year 2000) have generated a great deal of attention and comment, a national water grid is likely to be realized by increments rather than as a single grandiose scheme. The lengthy interstate negotiations and often acrimonious litigation which must precede large-scale inter-basin transfers will impede water development but will not be insurmountable obstacles. A balanced, Pareto-optimal allocation of the resource will probably be achieved in these negotiations, but they will proceed at a deliberate pace. On the international side, allocation and augmentation of low-season flows in the Ganga-Brahmaputra Delta in both India and Bangladesh are the basic issues. Their resolution will depend on the more political tone of the relationship between India and Bangladesh than on technical considerations.

The GOI seems prepared to assign a very high priority to mobilization of resources to improve water utilization. The Draft Sixth Plan shows substantially higher allocations for construction of field channels, modernization of existing works, development of ground water and rural electrification, and for Command Area Development programs designed to integrate rural infrastrucutre and services in major irrigation projects. But this program must compete for scarce resources with other investment priorities including large-scale inter-basin canals in the irrigation sector, and with requirements in industrial sectors, some of which - power, transportation and fertilizer - also provide vital support to agriculture.

While economically justified by benefit/cost analyses, irrigation is heavily subsidized by public financing. The direct charge rates for water set by state legislatures will continue to be difficult to increase. Generally, they are insufficient to reimburse any of the capital costs. On the other hand, low ceilings on commodity prices paid farmers and a less than simple system of subsidies make equitable repayment a complex, inadequately analyzed or understood problem. International donors continue to press the GOI and states to increase water rates but with limited success. It is clear that heavy financial subsidy of irrigation will continue.

Owing to basic principles in legislation enacted a century ago, subsequent state legislation, amplification by legal interpretation and adminstrative regulation, there is a great variation in fixing responsibility for water resource administration and in details of implementation among states and even among localities within states. Enactment of GOI-drafted model state laws on ground and surface water would implement a more orderly and uniform administrative process and strengthen authority to conserve water. However, to enact this legislation would require a sustained, energetic effort by the GOI to overcome resistance in state assemblies by landowners and others with a vested interest in the status quo. The GOI has other more pressing issues it must pursue with the states which will take priority over waterlaw reform. It is therefore unlikely that the model water bills will be enacted. But failure to pass them will probably not be a serious deterrent to irrigation development. Much has and can continue to be achieved simply through administrative interpretation of existing laws.

In sum, without gainsaying the strategic importance of water development to India's future, scarcity of economic resources and competing political and economic priorities, as well as constraints in other sectors, will likely slow the rate of water development, particularly expansion of the area placed under irrigation, which has prevailed from independence.

BENEFITS FROM MAJOR AND MEDIUM IRRIGATION SCHEMES
(000 hectares gross)

Name of State	Ultimate Irrigation Potential	Irrigation From Pre-Plan Schemes	Benefits from Plan Schemes to End of 1977-78		Target of Addl. Benefits During 1978-83		Potential to End of 1982-83 Including Pre-Plan Schemes	Percentage of Potential to End of 1982-83 of ultimate Potential
			Pot.	Ult.	Pot.	Ult.		
Andhra Pradesh	5,000	1,676	1,107	1,021	470	220	3,253	65
Assam	970	—	61	31	85	50	146	15
Bihar	6,500	404	1,898	1,151	670	620	2,972	44
Gujarat	3,000	33	924	501	340	300	1,297	43
Haryana	3,000	436	1,274	1,090	160	120	1,870	62
Himachal Pradesh	250	—	—	—	4	2	4	8
Jammu & Kashmir	250	43	57	49	39	15	130	52
Karnataka	2,500	308	700	645	361 +125 (a)	273	1,494	60
Kerala	1,000	158	274	252	160	140	592	59
Madhya Pradesh	6,000	513	743	493	640	560	1,896	32
Maharashtra	4,100	255	868	395	650	570	1,773	43
Manipur	135	—	—	—	37	20	37	27
Meghalaya	20	—	—	—	—	—	—	—
Nagaland	10	—	—	—	—	—	—	—
Orissa	3,600	455	871	871	250	200	1,576	44
Punjab	3,000	1,220	1,033	1,028	100	80	2,353	78
Rajasthan	2,750	320	1,056	846	570	350	1,946	71
Sikkim	20	—	—	—	—	—	—	—
Tamil Nadu	1,500	891	287	269	50	30	1,228	82
Tripura	100	—	—	—	—	—	—	—
Uttar Pradesh	12,500	2,553	2,919	1,846	1,407	1,400	6,879	55
West Bengal	2,310	440	980	960	380	350	1,800	78
Total States	58,315	9,705	15,052	11,448	6,489	5,300	31,246	53
Union Territories	160	—	10	10	14	2	24	15
All-India	58,475	9,705	15,062	11,458	6,503	5,302	31,270	53

(a) Benefits from non-plan

Source: Draft Sixth Five Year Plan, 1978-83 Revised, Planning Commission

BENEFITS FROM MINOR IRRIGATION SCHEMES
(000 hectares net)

Name of State	Ultimate Irrigation Potential	Irrigation From Pre-Plan Schemes	Benefits to End of 1977-78 Potential/ Utilization	Target for Additional Benefits During 1978-83 Potential/ Utilization	Benefits to End of 1982-83 Including Pre-Plan Schemes Target	% of Potential Estimated Ac At the End Of 1982-83 To Ultimate Potential
Andhra Pradesh	4,200	1,060	1,800	305	2,185	52.02
Assam	1,700	230	287	155	442	26.00
Bihar	5,900	1,020	2,100	1,440	3,540	60.00
Gujarat	1,750	440	1,355	195	1,550	88.57
Haryana	1,550	280	1,175	190	1,365	88.06
Himachal Pradesh	285	60	91	17	108	37.89
Jammu & Kashmir	550	270	314	19	333	60.54
Karnataka	2,100	1,545	925	250	1,175	59.95
Kerala	1,100	225	315	55	370	33.64
Madhya Pradesh	4,200	650	1,400	710	2,110	50.24
Maharashtra	3,200	810	1,505	265		55.31
Manipur	105	5	20	11	31	29.52
Meghalaya	100	7	18	17	35	35.00
Nagaland	80	5	35	24	59	~~73.75~~
Orissa	2,300	280	520	465	985	42.83
Punjab	3,550	814	2,830	234	3,064	86.31
Rajasthan	2,400	1,225	1,760	123	1,883	78.46
Sikkim	22	N.A.	7	6	13	59.09
Tamil Nadu	2,400	1,250	1,890	167	2,057	85.71
Tripura	115	10	33	18	51	44.35
Uttar Pradesh	13,200	2,900	7,590	3,095	10,685	80.94
West Bengal	3,800	800	1,300	700	2,000	52.63
Total-States	54,607	12,886	27,350	8,461	35,811	65.58
Total-Union Territories	250	15	90	35	125	50.00
Total-All India	54,857	12,901	27,440	8,496	35,936	65.51
or Say	55,000	12,900	27,300	8,500	35,800	65.00

Source: Draft Sixth Five Year Plan, 1978-83 Revised, Planning Commission