WATER MANAGEMENT IN SOUTH ASIA

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CERTIFICATE

Certified that this dissertation entitled "WATER MANAGEMENT IN SOUTH ASIA", submitted by MR. SOMNATH MITRA in partial fulfilment of the requirement for the award of the degree of MASTER OF PHILOSOPHY, has not been previously submitted for any degree of this or any other University. This is his own work.

We recommend this dissertation be placed before the examiners for evaluation.

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CHAPTER 1

CHAPTER 1

INTRODUCTION

The significance of water resource in South Asian region lies in the fact that the rivers form the backbone of the agrarian system as well as they are rich in terms of hydroelectric power potential. The economy in this region being subsistence type, is largely dependent on the natural water resources. Another important factor is the of physical characteristics mighty river systems of this region. Among them, the most interesting is the alignment of two of the most important transnational rivers - the Ganga and the Brahmaputra, which form, what could be called a twin basin in the eastern part of the South Asian mainland. Unlike the Indus system in the west, the water of which have been conclusively divided under an agreement between the two riparian states (India and Pakistan), the Ganga and Brahmaputra offers a problem of much larger magnitude. The two rivers are spread over four countries - India, Nepal, Bhutan and Bangladesh and offer no scope for clear cut division of the vast resource they offer. The water resource in this twin basin region has to be shared.

The concept of exploiting water resources, carries within it, the idea of transforming nature for the human benefit. As on one hand it has strong positive attributes of sustaining the economy, it also needs to be confronted on account of floods which are common in this twin basin region. Hence political decision making on sharing of water resources not only have international significance of establishing bilateral relations between the concerned nations, it has also implications of establishing an environmental balance through rational policy measures. This research hence attempts to focus on the point that the importance of a joint venture on water management in the twin basin region of South Asia is enormous and of immediate necessity. It not only removes the existing problems such as flood and environmental degradation but also revitalizes the economy. Hence the conventional area of tension on water sharing needs political rethinking in the context of challenges of tomorrow. In the Ganga Brahmaputra plain, live one of the largest concentration of population. Managed well, the land can feed the entire sub-continent. Otherwise there can be mass hunger. If the neighbouring nations attempts to identify the manner in which policy measures on either side of the border can act as meaningful remedy for frequent natural calamity and poverty, the people of the region experience, it would benefit all. Otherwise in a spatial framework, piecemeal measures in isolated pockets will only have a limited return of benefit. The research hence proposes to study programmes of water management for the Ganga and Brahmaputra basin taking into consideration physical, economic and political parameters of concern, common to the four basin States.

The Region

The twin basin of the Ganga and Brahmaputra is shared by four nations - India, Bangladesh, Nepal and Bhutan. The eastern and northeastern states of India are drained by these two river systems, namely Uttar Pradesh, Bihar, West Bengal, Sikkim, Assam, Meghalaya, Arunachal Pradesh, Nagaland, Mizoram, Manipur and Tripura. These states together has a population of over 324 million or 38% of the total population of India. The basin of the Ganga and Brahmaputra together holds a population of about 150 million. The country-wise breakup has been shown in the following table.

The economy of the region is predominantly agricultural and more than 70% of the total workforce of this region is dependent on agriculture. In the Indian portion of the basin

Population in the Ganga-Brahmaputra Basin

Country	Population (in million)
Bangladesh	106.7
Bhutan	1.4
India	843.1
Nepal	18.9
Indian part of the basin	324.8

Source: World Development Report 1992

industries have been developed in a number of pockets but the other three states have a very low degree of industrialisation.

Agriculture is the mainstay of the population. Since the region receives a medium to high rainfall and characterised by a vast alluvial plain in the southern part, it is one of the traditional rice growing regions of the world. Besides the plains of the twin basin produce most of the jute of the world. In the northern part, tea is an important cash crop, grown mainly in north-Bengal and Assam.

The most characteristic physical feature of this twin basin of Ganga and Brahmaputra is represented by the Himalayan mountain system in the north. In fact the Nepal and Bhutan are the two countries which are actually mountain kingdoms. The rivers in the twin basin flows from the Himalayan region carrying enormous load of waters and carry vast quantities of glacier melt as well as the rainwater, which make them perennial throughout the year and has phenomenal irrigation and hydroelectric potential. The river systems, here, which offer vast and rich resource demand a special mention.

The Ganga is the product of two major headstreams - the Bhagirathi and Alaknanda rising in the Garhwal Himalaya, which meet at Devaprayag. The Ganga flow eastwards and divides into a number of streams below Farakka in West Bengal is again known as Bhagirathi and finally becomes Hooghly, on which stands Calcutta, and joins Bay of Bengal. The main branch flowing southwest and enter Bangladesh. After meeting Jamuna (Brahmaputra) near Goalando it takes the name of Padma and joins Meghna before falling into the sea.

The Brahmaputra originates in Tibet near Mansarvar lake and is known as Tsangpo till it enters India where is takes the name of Dihong in Arunachal Pradesh. Near Sadia the Dihang is joined by two tributaries - Dibong and Lohit and the combined river becomes Brahmaputra as it flows through Assam. After entering Bangladesh, Brahmaputra branches out near Bahadurabad Ghat. The main channel assume the name Jamuna till it joins Ganga to form Padma. The other channel, move towards east through Mymensingh is called Old Brahmaputra and joins Meghna at Bhairav Bazar.

A number of small streams rising in Manipur form Barak which meet Surma in Bangladesh to form the Meghna. The major river systems of Nepal from west to east are Karnali (Gaghra), Narayani (Gandak) and Kosi which are three major tributaries of the Ganga and join it in the north Indian plain. Kosi actually has seven arms in Nepal of which the major ones are the Sun Kosi, the Arun and the Tamur. There are also three important rivers which rise in midlands of Nepal and drain the Mahabharat and the Siwalik range in southern Nepal. These are Rapti, Bagmati and Kamla.

The principal rivers of Bhutan are from west to east - Amo chu or Torsa, Wong chu or Raidak, Mo chu or Sankosh and Manas. The first three drains western Bhutan, while Manas and its tributaries drains the east, when they emerge into the Duar. All these finally joins the Brahmaputra.

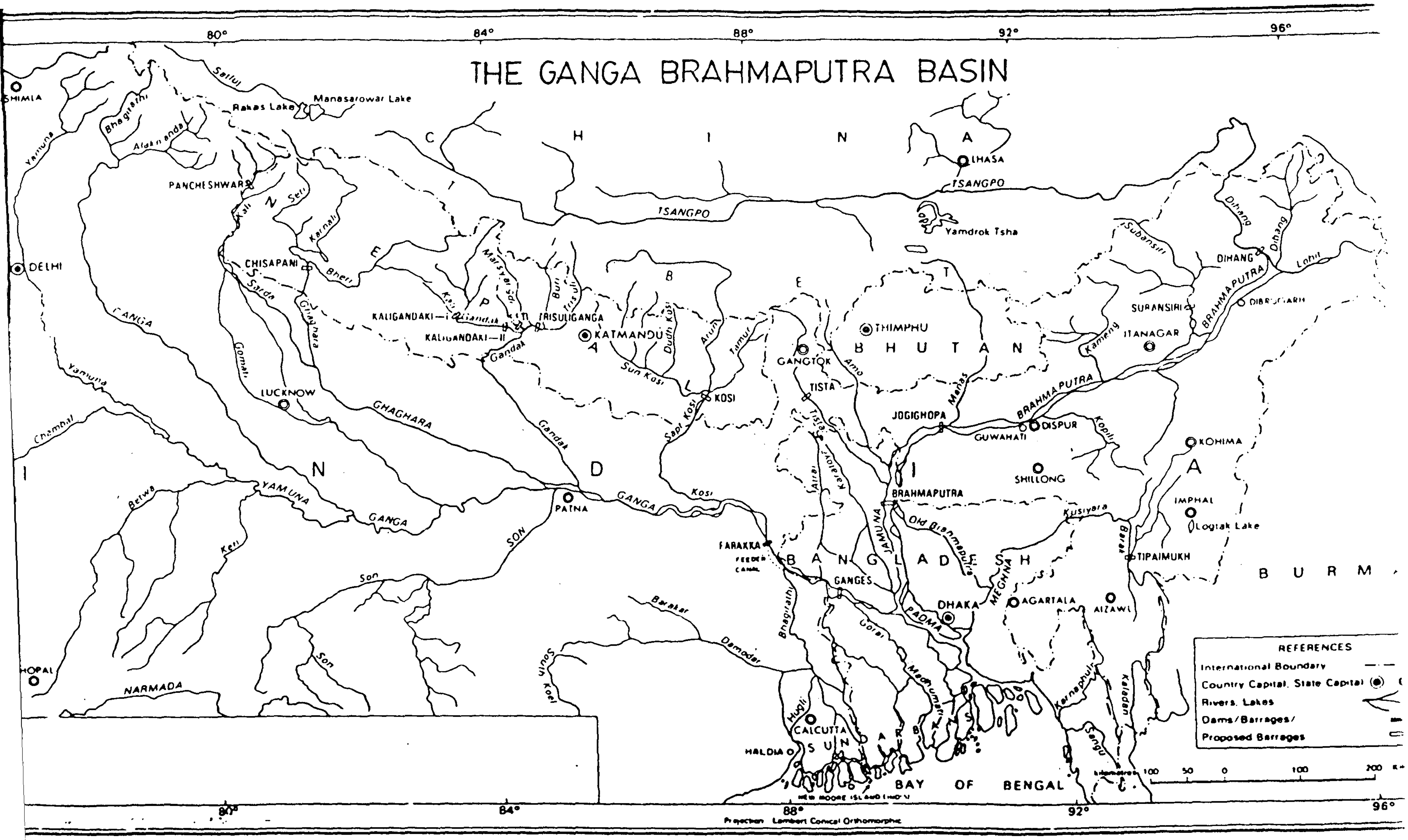
The introductory note with a brief introduction of the Ganga-Brahmaputra basin with special reference to the rivers, is followed by four more chapters that unravels the various aspects of water management.

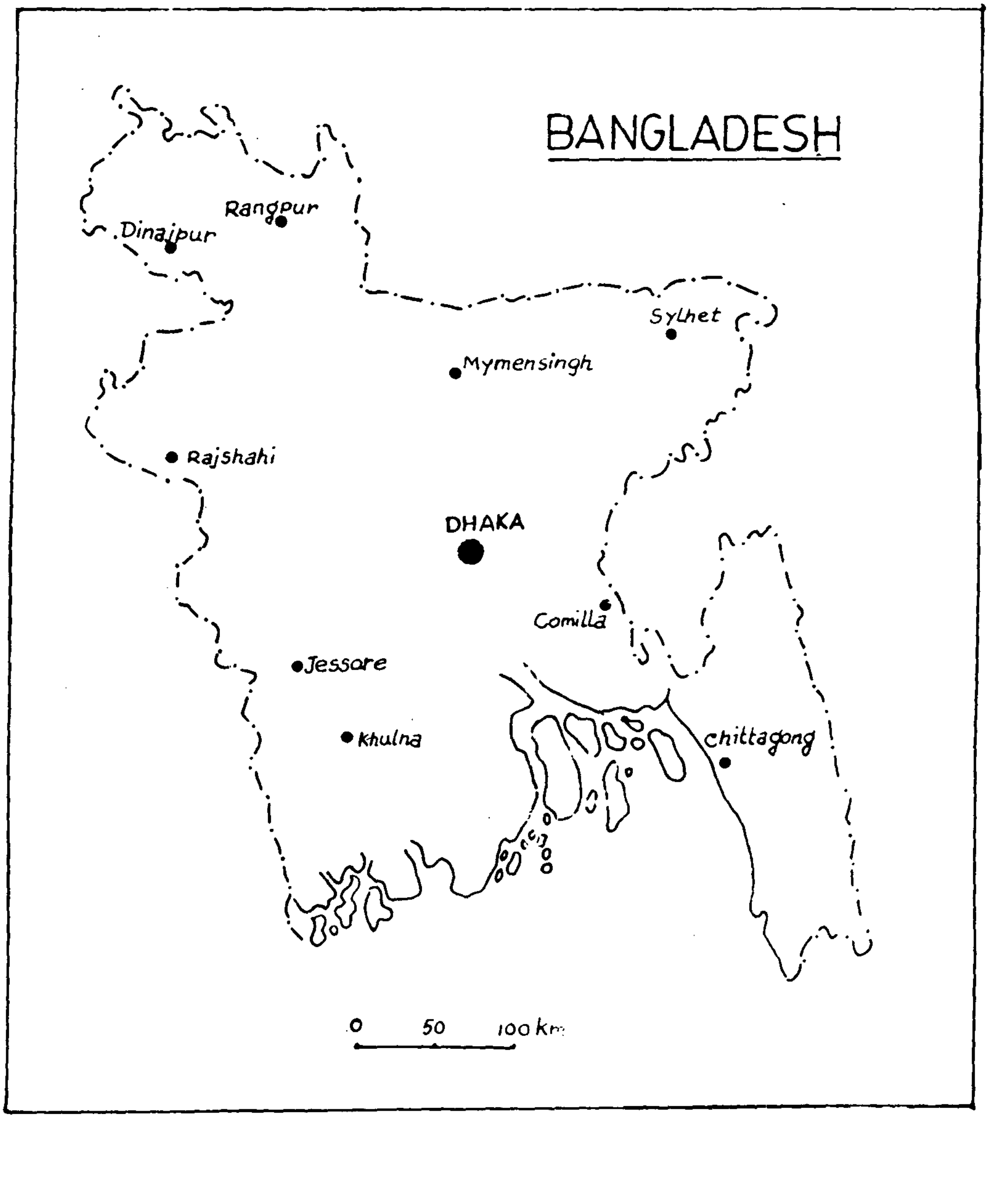
Chapter 2 deals with the water resource availablility in this region. An overall assessment of water resource has been attempted which incorporates the water budget of the region, the total availability of the surface flow and groundwater and the seasonal flow of the Ganga and Brahmaputra (river regime). The water budget assessment incorporates the climatic factors which have a direct bearing upon the availability of water from the nature - that has been attempted using a suitable methodology.

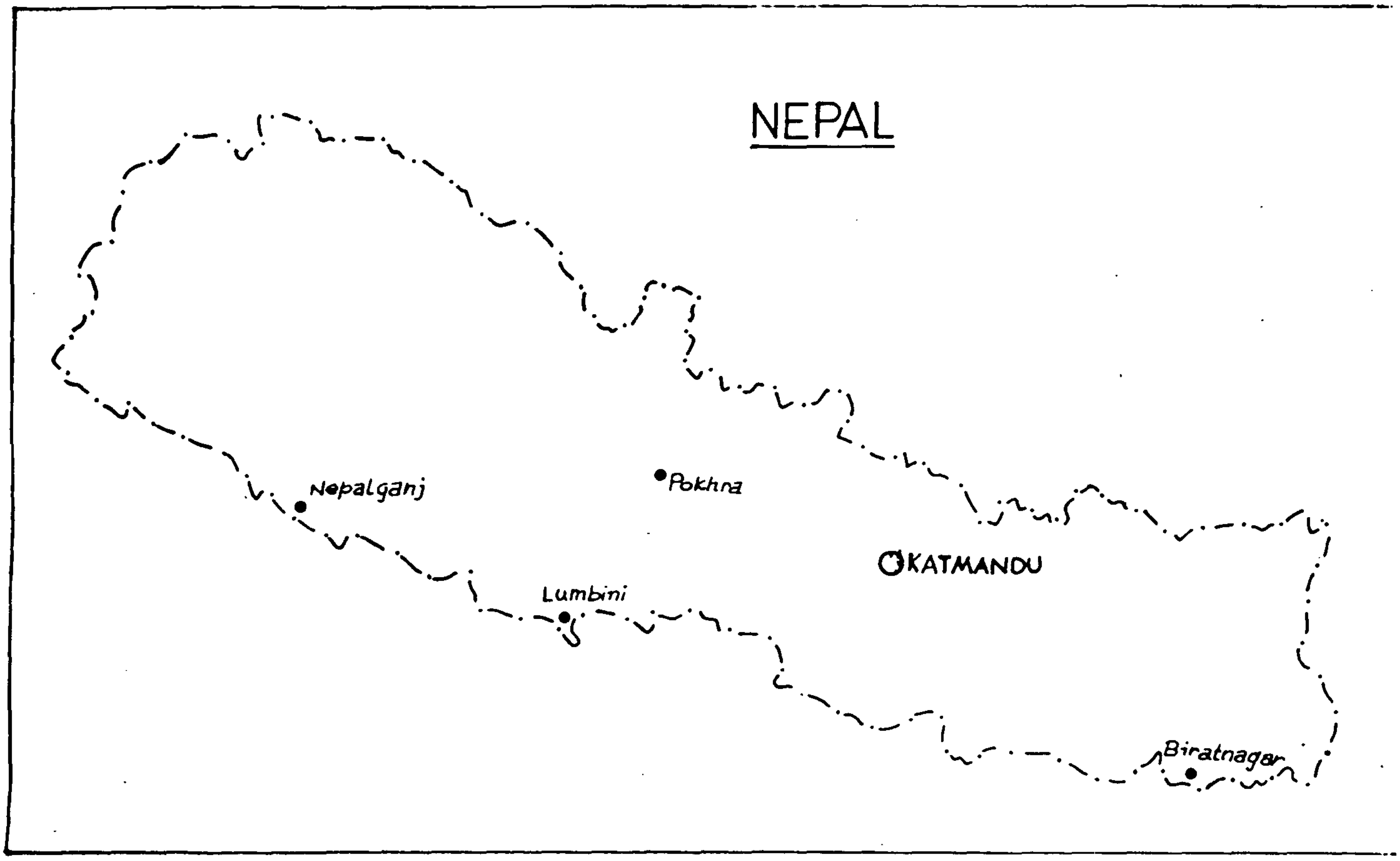
Chapter 3 looks into the different areas of water management (flood control, irrigation, hydelpower generation) in this region. It elucidates the relative importance of the four basin States in different areas of water management and also their policies and programmes in those areas. Further the chapter tries to identify the areas of cooperation among the basin states as also their individual perception of cooperation.

Chapter 4 looks into the crucial questions of law and points of agreement and dispute in the management of transnational water resource. In the process, disputes and agreements in this regard among the countries, since last century has been reviewed, along with different approches towards codifying water laws and compact as attempted by a number of international forums from time to time. Finally, the scenario in the Ganga-Brahmaputra basin in this regard has been examined as it is shared by four sovereign States.

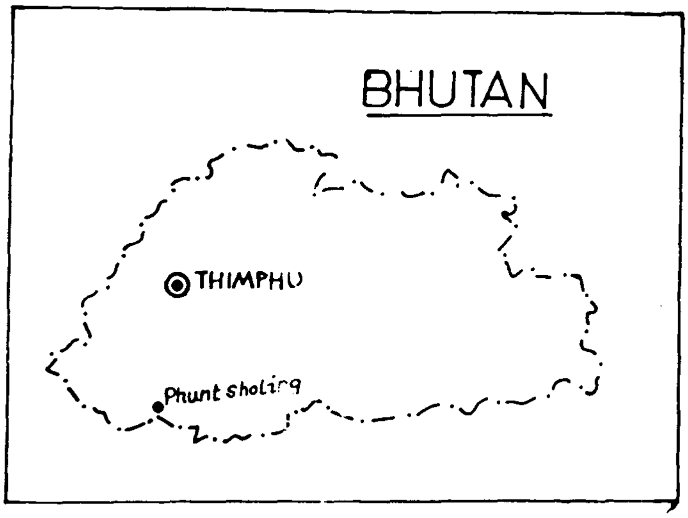
The final Chapter (5) concludes the entire exercise with some findings and suggestions.


THE GANGA BRAHMAPUTRA BASIN
80°
84°
88°
92°
96°
CHINA
NEPAL
BHUTAN
TIBET
INDIA
BANGLADESH
BURMA
SHIMLA
DELHI
LUCKNOW
PATNA
KATMANDU
THIMPHU
LHASA
GANGTOK
DISPUR
GUWAHATI
SHILLONG
KOHIMA
IMPHAL
ITANAGAR
DIBRUGARH
AGARTALA
AIZAWL
DHAKA
CALCUTTA
HALDIA
Manasarowar Lake
Rakas Lake
Yamdrok Tsha
Logtak Lake
TSANGPO
BRAHMAPUTRA
GANGA
YAMUNA
GHAGHARA
SON
NARMADA
GANGES
PADMA
MEGHNA
JAMUNA
PANCHESHWAR
CHISAPANI
KALIGANDAKI—I
KALIGANDAKI—II
TRISULIGANGA
KOSI
TISTA
JOGIGHOPA
DIHANG
SUBANSIRI
FARAKKA
FEEDER CANAL
TIPAIMUKH
BAY OF BENGAL
REFERENCES
International Boundary
Country Capital, State Capital
Rivers, Lakes
Dams/Barrages/
Proposed Barrages
Projection Lambert Conical Orthomorphic


BANGLADESH
Rangpur
Dinajpur
Sylhet
Mymensingh
Rajshahi
DHAKA
Comilla
Jessore
Khulna
Chittagong
0 50 100 Km


NEPAL
Nepalganj
Pokhra
Lumbini
KATMANDU
Biratnagar

0 50 100 Km


BHUTAN
THIMPHU

CHAPTER 2

CHAPTER 2

AN ASSESSMEMT OF WATER RESOURCES IN GANGA-BRAHMAPUTRA BASIN IN SOUTH ASIA

The Ganga and Brahmaputra offer a vast interlinked basin. The basin is spread over more than one-fourth the area of India - the largest country in South Asia - and the whole of Nepal, Bhutan and Bangladesh. Moreover part of this interlinked basin lies in Tibet, to the north of Himalayan divide.

In any region, there are usually two major sources of water namely surface and ground waters. However these two sources depend greatly on precipitation which determine the volume of available water. The twin interlinked basin of Ganga and Brahmaputra lies in the subtropical monsoon region where rainfall is an important determinant of a predominant agricultural economy. The availability of rainfall over time and space assumes great importance in the study of water management in this region of South Asia. Hence the following exercise looks into the aspect of water balance in the Ganga-Brahmaputra basin of South Asia.

2.1 Water Balance in the Ganga-Brahmaputra Basin in South Asia

The variation of the water surplus or water deficiency amounts from place to place and time to time is a fact of great agricultural, biological and geographical importance. Water balance of any region could be deciphered from the mean monthly rainfall and mean monthly potential evapotranspiration. The method of estimating mean monthly evapotranspiration is as follows:

2.1.a The Methodology

The combined influence of the evaporation and transpiration process is usually designated as evapotranspiration. It represents the transport of water from the earth back to the atmosphere, that is reverse of precipitation. The concept of Potential evapotranspiration (PE) was first introduced by Thornthwaite (1948). It is an index of the amount of water that would evaporate and transpire if it were always available from the soil and the plants.

Thernthwaite's formula for unadjusted PE (in cm/month) is

$PE = 1.6\ (10.T/I)^a$ where,

T = monthly temperature, °C

I = annual heat index i.e. sum of 12 monthly heat index values i determined from

$i = (t/5)^{1.514}$

a = non linear function of heat index approximated by expression,

$a = 6.75 \times 10^{-7/3} - 7.71 \times 10^{-5/2} + 1.79 \times 10^{-2} + 0.49$

A further development over Thornthwaite's method by Crowe (1957) offers both clarity of measurement and computational ease. Crowe suggests "since evaporation occurs mainly during the day, a relationship with temperature will be more likely to emerge if mean daily maximum temperatures are used in preference to the means for the whole 24 hour period employed by Thornthwaite"*. Also since evaporation is greatest in summer, it is thought wise to explore this relationship, in the first instance, for the warmest month of the year at any given station.

The relationship which emerged from a number of stations in both hemispheres took the simple form:

----

* Crowe, P.R. (1957) 'Some further thoughts on evapotranspiration a new climate' Geographical Studies 4, p.56-75.

$$Etr = 7.3\ (Tmx - 6)°C \text{ in mm}$$

or $Etr = 0.16\ (Tmx - 43)°F$ in inches; where

Etr = evapotranspiration of the warmest month

Tmx = mean daily maximum temperature of the warmest month

The values are then adjusted according to the table 1 which takes some account of the mean precipitation during the warmest month. Stage I thus yields an absolute value as an estimate of PE of the warmest month.

Stage II. The appropriate values for the other 11 months are considered to be proportionate to this figure. In view of the number of factors which have to be taken into account, the proportion is derived from a number of indices. These involve

a) The difference between the saturation vapour pressure at mean daily maximum and minimum temperatures (table 2).

b) A correction necessary because the mean maximum - mean minimum range is often well in excess of the true periodic diurnal range of temperature (table 3).

c) A further adjustment for day-length like that proposed by Thornthwaite but carried logically beyond 50°N (table 4).

The method thus proceeds: subtract the values appropriate to the mean daily minimum temperatures from

TABLE 1 : Correction for precipitation during key month

(Reduce values derived from the above formula by the following proportions)

Precipitation In	Precipitation mm	Proportion
0	0	100
1		96
2	50	92
3		88
4	100	84
5		80
6	150	76
7		72
7.5 or over	190 or over	70

TABLE 2 *Indices for monthly evapotranspiration*

I. Celsius scale

C		-9	-8	-7	-6	-5	-4	-3	-2	-1
-40	0.19	0.21	0.23	0.26	0.28	0.31	0.35	0.38	0.42	0.46
-30	0.51	0.56	0.61	0.67	0.74	0.81	0.88	0.96	1.05	1.15
-20	1.25	1.37	1.49	1.62	1.76	1.91	2.08	2.25	2.44	2.64
-10	2.86	3.10	3.35	3.62	3.91	4.21	4.55	4.90	5.28	5.68
°C	0	1	2	3	4	5	6	7	8	9
0	6.11	6.57	7.05	7.58	8.13	8.72	9.35	10.01	10.72	11.47
10	12.27	13.12	14.02	14.97	15.98	17.04	18.17	19.37	20.63	21.96
20	23.4	24.9	26.4	28.1	29.8	31.7	33.6	35.6	37.8	40.1
30	42.4	44.9	47.5	50.3	53.2	56.2	59.4	62.8	66.3	69.9
40	73.8	77.8	82.0	86.4	91.0	95.8	100.9	106.2	111.7	117.4

(Since this table gives saturation vapour pressure over water in millibars it is of some value for general reference.)

TABLE 3 *Correction factors for variation in relative magnitudes of maximum-minimum range and the periodic diurnal range of temperature (%)*

S. HEMIS. / N. HEMIS. (°Lat.)	JULY / JAN.	AUG. / FEB.	SEPT. / MAR.	OCT. / APRIL	NOV. / MAY	DEC. / JUNE	JAN. / JULY	FEB. / AUG.	MAR. / SEPT.	APRIL / OCT.	MAY / NOV.	JUNE / DEC.
72	0	5	20	70	100	100	100	100	75	20	0	0
68	0	25	65	90	100	100	100	100	85	55	10	0
64	20	45	80	95	100	100	100	100	90	70	30	15
60	35	65	90	95	100	100	100	100	90	80	45	25
56	50	70	90	95	100	100	100	100	95	85	60	40
52	[illegible]	75	90	95	100	100	100	100	95	85	70	55
48	[illegible]	80	90	95	100	100	100	100	100	90	75	65
44	80	85	90	95	100	100	100	100	100	95	85	75
40	85	90	90	95	100	100	100	100	100	95	90	85
36	90	90	95	95	100	100	100	100	100	95	95	90
32	90	95	95	100	100	100	100	100	100	95	95	90
28	100	100	100	100	100	100	100	100	100	100	100	100

Equatorward of about 30° N and S no systematic correction emerges.
Interpolate for intermediate latitudes.
Local correction factors may be obtained for any area near a station providing hourly temperature values but latitude appears to be the dominant control. Note that it is only seasonal changes in the *ratio* of the two ranges which affect the method

TABLE 4 *Mean possible duration of sunlight expressed in units of 30 days of 12 hours each (%)*

	JAN.	FEB.	MAR.	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
°S						*Southern hemisphere*						
50	137	[illegible]	108	89	77	67	72	88	99	119	129	141
40	127	107	107	93	86	78	81	92	100	115	120	129
30	120	[illegible]	106	95	92	85	90	96	100	112	114	121
20	114	[illegible]	105	97	96	91	95	99	100	108	109	115
10	108	[illegible]	105	99	101	96	[illegible]	101	100	106	105	110
						Equator						
0°	104	95	104	101	104	101	104	104	101	104	101	104
°N						*Northern hemisphere*						
10	100	92	103	103	108	106	[illegible]	107	102	102	98	99
20	95	91	103	105	113	111	114	111	102	100	93	94
30	90	88	103	108	118	117	120	114	103	98	89	88
40	84	84	103	111	124	125	127	118	104	96	83	81
45	80	82	102	113	128	129	[illegible]	121	104	94	79	75
50	74	79	102	115	133	136	137	125	106	92	76	70
52	71	78	102	116	135	139	139	126	106	92	73	67
54	68	76	102	117	137	142	[illegible]	128	106	91	71	64
56	66	75	102	118	140	146	[illegible]	130	106	90	69	[illegible]
58	62	74	102	120	144	151	[illegible]	132	107	89	66	56
60	58	72	102	121	147	157	155	135	108	88	63	51
62	53	70	102	123	152	164	161	137	108	87	59	44
64	47	68	101	125	158	174	169	141	109	85	55	37
66	38	64	101	128	166	200	183	146	110	82	49	24
68	26	61	99	131	174	200	[illegible]	151	112	80	41	0
70	0	56	99	134	197	200	206	156	112	78	33	0
72	0	51	99	140	206	200	[illegible]	170	113	75	4	0
74	0	45	99	146	206	200	[illegible]	183	115	70	0	0
76	0	31	97	154	206	200	206	206	117	65	0	0
78	0	8	96	168	206	200	[illegible]	206	119	56	0	0

Table 5. Potential Evapotranspiration and Rainfall (in mm)

Month	PE	Rainfall	PE	Rainfall	PE	Rainfall	PE	Rainfall	PE	Rainfall	PE	Rainfall	PE	Rainfall	PE	Rainfall
	Dibrugarh		Patna		Varanasi		Dinajpur		Dhaka		Jessore		Biratnagar		Phunt Sholinog	
Jan	121	19.3	83	16.8	56	20.1	105	9.1	99	8.2	91	9.4	99	8.8	87	6.4
Feb	103	25.4	95	13.8	74	15.1	115	15.4	120	31	113	33.0	113	9.7	92	5.2
Mar	151	74.7	155	10.9	122	9.8	187	17.5	160	60	156	49.0	177	16.8	149	4.1
Apr	142	174.4	210	15.2	176	5.2	188	54.3	152	137	187	89.6	189	117.7	165	61.7
May	134	324.1	149	49.1	186	17.1	160	186	152	245	140	206.2	192	147.3	171	97.2
June	120	453.7	153	180.6	139	96.9	99	346	101	315	107	285	113	384.4	132	189.6
July	132	406.7	98	303.1	76	302.9	101	393	86	329	88	285	106	422.7	106	312.9
Aug	126	344.5	76	305.1	60	305.7	97	348	82	349	71	280.4	87	416.2	102	279.8
Sep	110	255.5	81	225.1	73	201.3	88	331	75	298	78	228.0	88	361.1	89	192.7
Oct	105	120.1	94	64.5	96	55.2	118	120	107	134	108	109.0	97	271.2	88	141.1
Nov	132	22.5	101	7.7	71	4.9	109	11	93	24	90	24.1	101	10.2	87	11.6
Dec	127	9.2	86	2.6	61	6.5	94	1.5	92	5.0	82	4.6	94	8.1	81	7.2

those at the corresponding maxima in table 2 for each month of the year; multiply by the correction factor given in table 3 for selected latitudes, then multiply again by the appropriate factors for day length given in table 4. Equate the index thus derived for the warmest month with the absolute value obtained in stage I and read off the values for the other months in the proportions indicated.

2.1.b The Water Balance

The water balance graphs of the few selected stations in the Ganga-Brahmaputra basin reveals that in spite of the incidence of medium to fairly high rainfall, there are distinct periods of surplus and acute shortage. Moreover the pattern of the water balance graphs are the obvious reminder of the monsoon climate prevailing in the region. The rainfall mainly occurs during the period from June to September, the period of surplus water, while the preceding and following months water deficit is marked where potential evapotranspiration exceeds the amount of precipitation received.

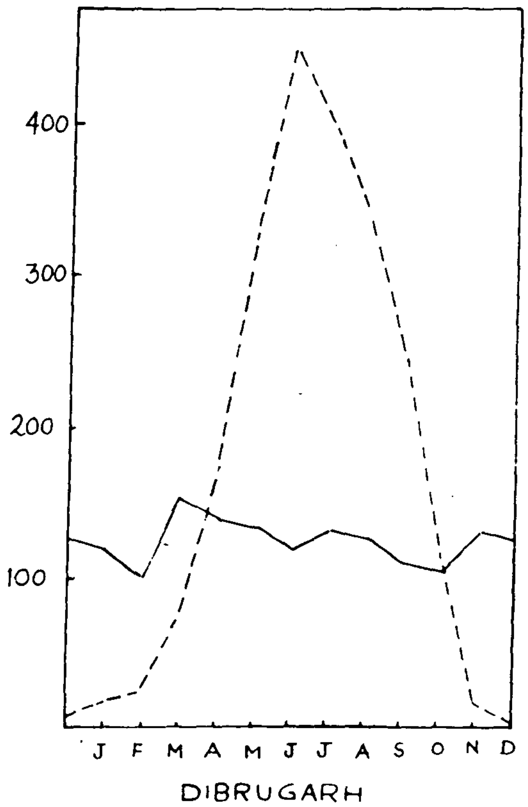
It is, however, noted that there are marked regional variation in water balance. The graphs for Dibrugarh, Varanasi and Patna reveal that an overall annual surplus of annual moisture availability in the first case whereas a deficit in Varanasi and a balance in the third region. It is, however, noticed that most of the rainfall occurs during the period of June to October. 86% of the total rainfall occurs during this five month period in the Varanasi region whereas for Patna and Dibrugarh the figures stand at 84% and 65% respectively. Hence it follows that precipitation is somewhat more spread out throughout the year in the northeastern part of the Ganga-Brahmaputra valley.

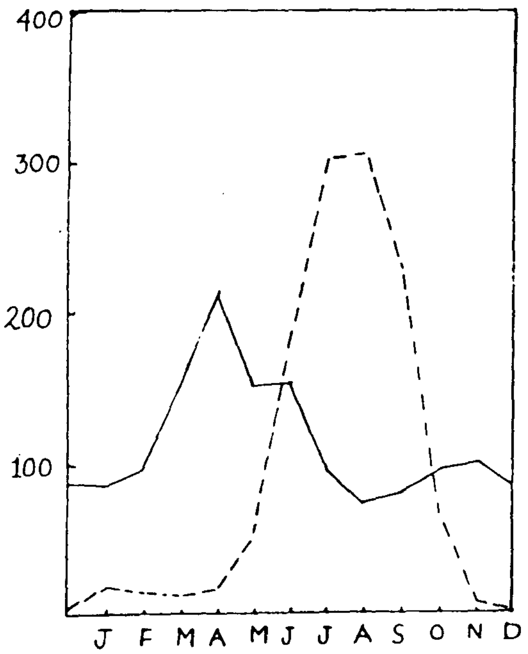
Bangladesh, lying in the lower part of the Ganga-Brahmaputra basin shows a similar kind of variation of moisture availability. However, the general pattern shows that about 80% of the total annual rainfall occurs during May-September period. There is an overall annual surplus of moisture availability but distinct disparity of the distribution of rainfall over time leaves behind a long six to seven month period of water deficit.

Similar condition prevails in Nepal and Bhutan. In the southern part of the Nepal forms the flat terai region, during the six month of May to september precipitation figure remains much above the evapotranspiration, indicating a huge surplus. Moreover the remaining months show a small to medium deficit.

In Bhutan the characteristic water balance shows low to medium in deficit months resulting out of low potential

Water Balance





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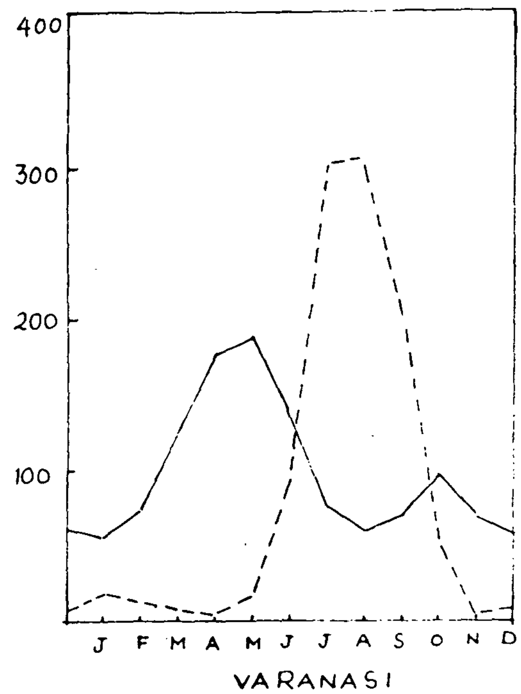

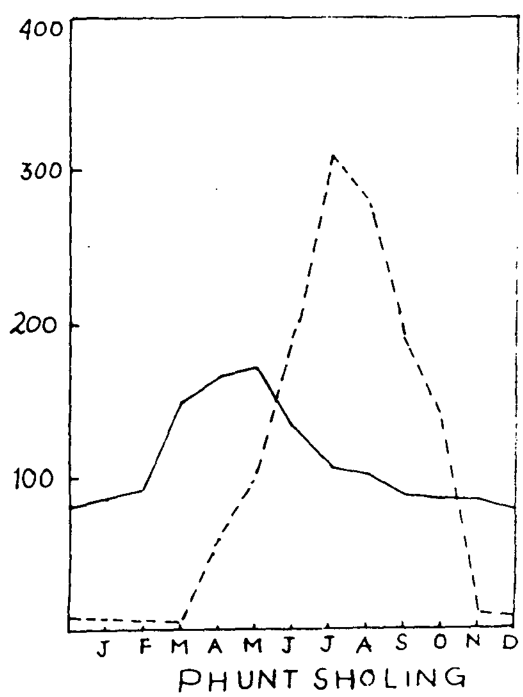

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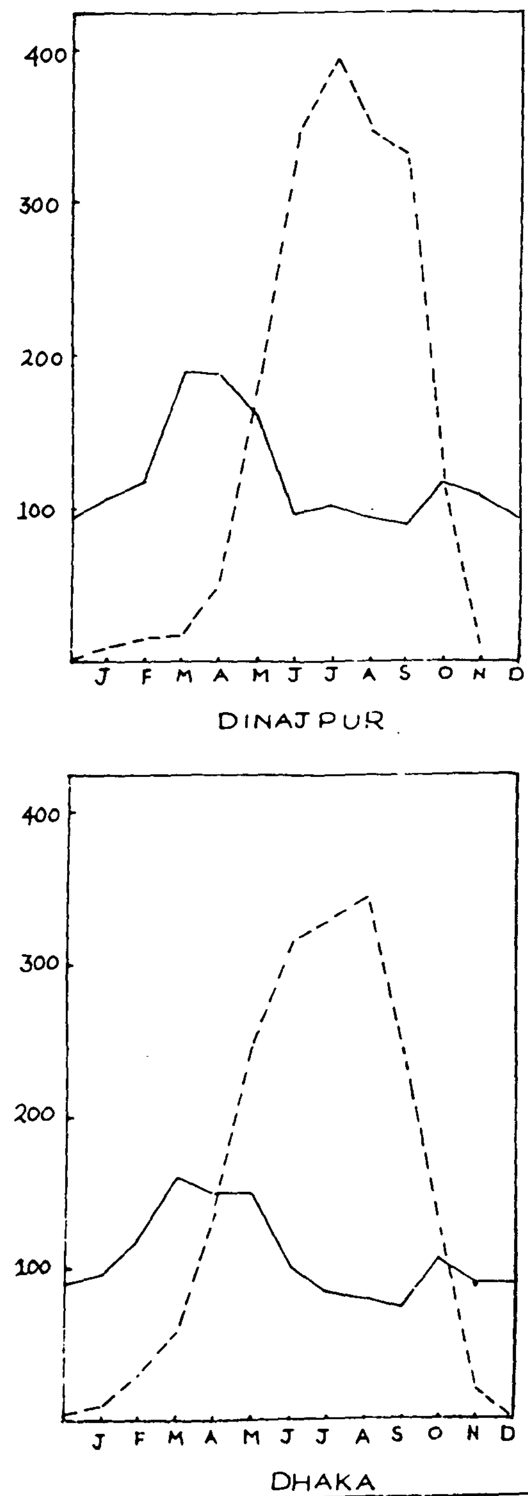

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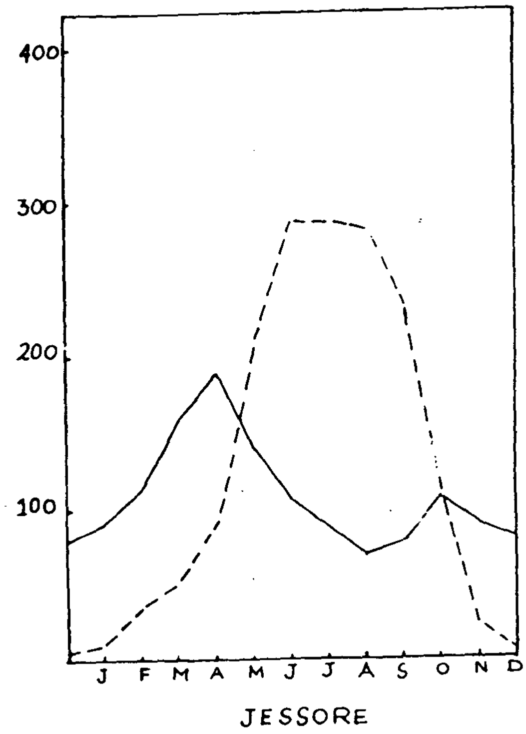
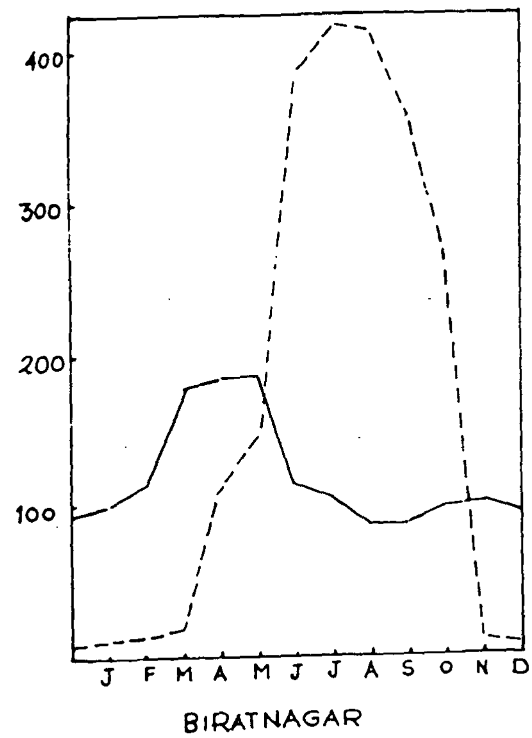




evapotranspiration and low precipitation during the winter months, higher deficit during summer and Surplus during the June-September period.

The overall scenario in this twin basin region of south Asia reveal the seasonal imbalance of moisture availability. This is also evident from the fact that the region is prone to the flood and drought conditions. Being one of the most densely populated region of the world with a dominant agrarian economy proper management of water assumes great importance for the development of the region. The analysis of water balance also reveals that this twin basin of the the Ganga-Brahmaputra, spreading over eastern India and the three neighbouring countries, offers a geographical unity that cut across the national boundary.

2.2 Water Resource of the Basin

According to the report of Central Water Commission (1980) the estimated water resource of Ganga-Brahmaputra basin within India is 115.32 million hectare-meters (total surface flow). This account for over 60% of the country's surface flow, though only a part of the surface flow is utilisable, because the utilisable quantum is determined by the cultivable area and storage and diversion possibilities. In this respect utilizable flow and ground water recharge in the Ganga basin is far greater than the Brahmaputra basin, though in terms of actual surface flow, the Brahamputra system carries water in far larger quality. The table 6 shows the water resources of this twin river basin.

One important aspect of the Ganga system is that about 21% of the basin flow in India comes from non Himalayan river and nearly two thirds from the rivers with catchment in Nepal. The table 7 shows the average annual flow of Ganga and its tributaries.

The Brahmputra river is 2900 Km long and rises in Tibet. After flowing 1700 Km parallel to the main range of Himalaya, it enters India, and after passing through 120 Km in Arunachal and Assam, enters Bangladesh below Dhubri and after traversing 279 Km joins Ganga at Goalundo. The combined flow of the two rivers is known as Padma. The total catchement area is 580000 sq.km of which the drainage area in India is 187110 sq.km. The average annual flow of the river is shown in the table 8.

Bangladesh receives an annual average inflow of 107 million hectare meter of surface water all of which virtually comes from India. The estimated annual rainfall is about 25 m.ha.m. allowing for evaporation, this gives a runoff of 115.3 m.ha.m. and part of which is utilizable. In addition to it has a groundwater potential of 1.81 m.ha.m.

Table 6. Water Resource in Ganga-Brahmaputra Basin (in million hectare meter)

Basin	Total surface flow	Utilizable flow potential	Ground water utilizable water	Total (3+4)
(1)	(2)	(3)	(4)	(5)
Ganga	52.50	25.00	17.20	42.40
Brahmaputra (incl. Barak)	59.72	2.40	2.23	4.63
Total	112.22	27.40	19.43	46.83
Others	3.10	0.30	0.30	0.33
Grand Total	115.32	27.70	19.46	47.16

Source: Central Water Commission, April 1988.

Table 7. Average annual flow in the Ganga and its tributaries

Sl.No.	Name of the sub-basin	Average annual flow (in million cu.m)
1.	Yamuna at Allahabad	43020
2.	Ganga at Allahabad	58980
	(a) Ramganga	(15258)
3.	Ganga at Allahabad after confluence with Yamuna	152000
4.	Ganga at Patna	364000
	(a) Tons	(5910)
	(b) Son and other basins between Tons and Son	(31800)
	(c) Gomti	(7930)
	(d) Gahgahra	(94400)
	(e) Gandak	(52200)
5.	Ganga at Farakka	459040
	(a) Buri Gandak	(7100)
	(b) Kosi	(61560)

6.	Ganga at confluence below the Haldi	493400
	(a) Dwarka	(4687)
	(b) Ajoy	(3207)
	(c) Damodar	(12210)
	(d) Rupnarayan	(4400)
	(e) Haldi	(5300)

Source: India's Water Wealth (1979).

Table 8. Average Annual flow in Brahmaputra

Sl.No.	Name of the sub-basin	Average annual flow (in million cu.m)
1.	Brahmaputra	322800
	(a) Dihong	(200000)
	(b) Dibang	(62800)
	(c) Luhit	(60000)
2.	Brahmaputra at Gauhati	455000
	(a) Subansiri	(54270)
	(b) Kameng	(25900)
	(c) Buri Dihang	(13670)
	(d) Dham Siri	(20000)
	(e) Kalong	(28000)
3.	Brahmaputra at Dhubri	510450
	(a) Manas	(32000)
	(b) Sankosh	(17270)

Source: India's Water Wealth (1979)

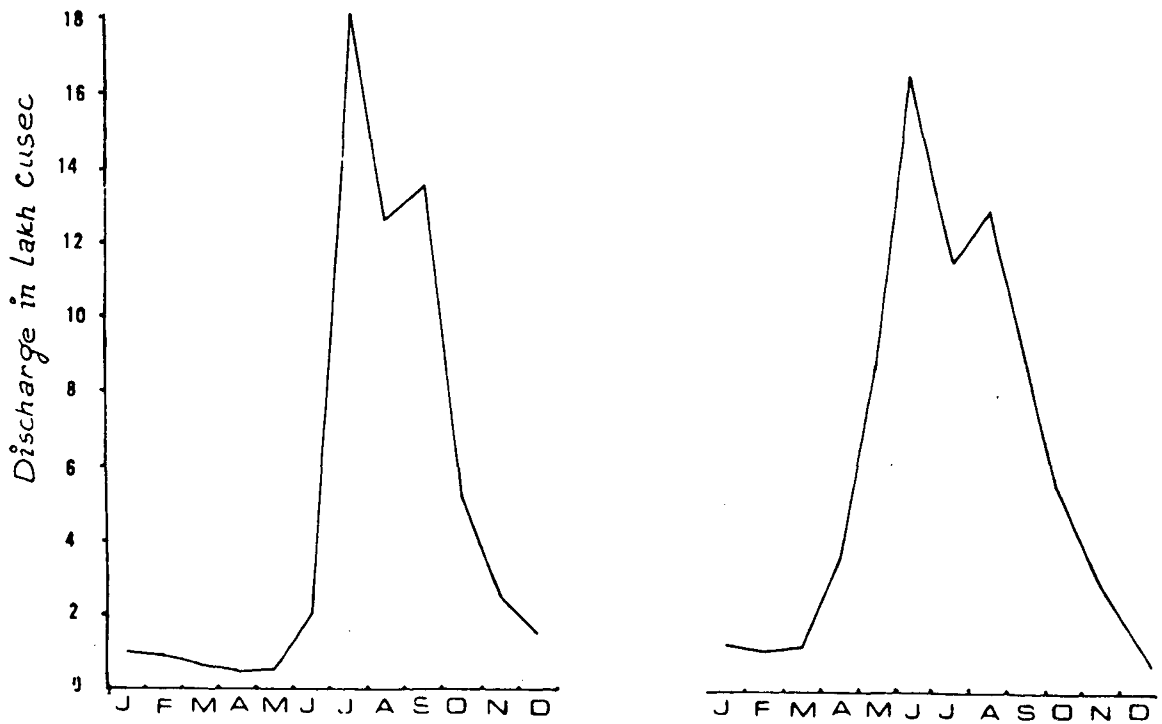
as assessed by UNDP (1992).

Nepal and Bhutan has abundant surface water resources, but the amount that could be used for irrigation is limited to the mountainous terrain. The groundwater resources of these two countries has not been scientifically assessed. Nepal, however, has a rich acquifer along the Sub-Himalayan springline that runs laterally along the Terai. Recently, the Gomdak basin study has been done by the Australian Showy River Authority and a Kosi basin study by the Japanese. However these studies are primarily focused on energy aspects. However for Bangladesh and India the study of water resource has been done by government agencies and the studies project long term water requirement upto 2005 for Bangladesh and upto 2025 for India.

2.3 River Regime

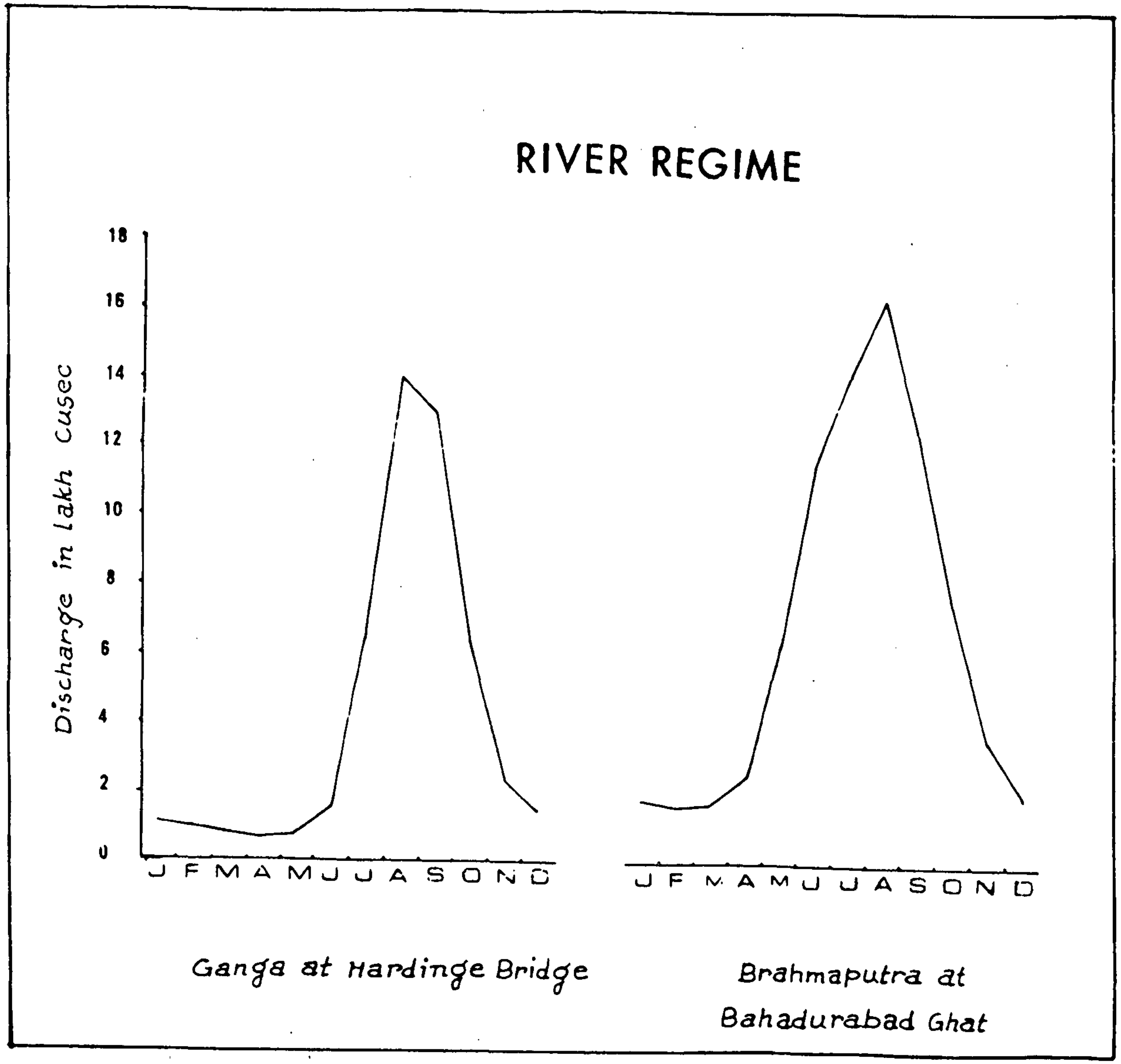
The regimes of the Ganga (at Farakka and Hardinge-bridge) and Brahmaputra (at Pandu and Bahadurabad-Ghat) are shown in the following diagrams. The regimes are basically similar, showing a rapid rise to a peak and somewhat gentler fall, but there are significant minor differences. At Farakka Ganga rises its peak in July from a minimum in April-May whereas at Hardinge bridge it attains peakflow in August. Moreover in both the areas in ganga the rise is

RIVER REGIME



Ganga at Farakka

Brahmaputra at Pandu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Ganga at Hardinge Bridge
Brahmaputra at Bahadurabad Ghat

sharp. The Brahmaputra in contrast rises more gradually and peak flow is reached in June at Pandu and in August in Bahadurabad Ghat. The differences reflect the later onset of monsoon rains in the Ganges catchment compared with the easterly areas drained by the Brahmaputra.

In general the peak discharge record at Hardinge bridge in Bangladesh is about 2.5 million cusces, whereas the minimum which occured in 1976 is only 23200 cusces (Less than one percent of the peak discharge). Again the maximum peak discharge at Bahadurbad in north eastern Bangladesh, just above the old Brahmaputra tributary is 2.7 million cusces. The minimum flow at Bahadurabad is about 110,000 cusces (about four percent of the peak discharge. This extremely variable flow pattern of the Ganga river results in a major challenge in surface water resource planning.

CHAPTER 3

CHAPTER 3

WATER MANAGEMENT IN THE BASIN

The previous chapter unravels the fact that water is in abundance in this twin-basin region of the Ganga and Brahmaputra. However, managing and developing this vast source offers a big challenge to the nations sharing the basin. It involves a great deal of effort. The major areas of the water resource management in this twin basin region includes flood control, irrigation and hydl-power generation, though they have got relative importance to the four basin states. For example, irrigation and flood control are the two major areas of concern to Bangladesh whereas the development of hydro power becomes Nepal's immediate area of interest. However, the problems and prospects of water management could never be studied in isolated manner confined in the territory of each basin state, rather the problems and their remedy often transcends the national boundaries of the four basin states.

3.1 Flood and Flood Control

The Ganga-Brahmaputra basin is one of the few highly flood prone areas of the world. The entire Bangladesh and the four major states of India falling in this region are inundated every year with varying intensity. On an average about 2.75 million hectares of Bangladesh are flooded annually. However, in an abnormal year if heavy rainfall occurs just in time of peak discharge period the magnitude of the flood devastation seems to appear awesome. This has happened in 1955 and 1974 when about 35 percent of the total area was inundated. Moreover, in recent past, there was an unprecedented 100 year return flood in Brahmaputra and a 50 year return flood in the Meghna which severely affected two thirds of the country. The official figures also show that about 8.28 million hectares in Bangladesh is vulnerable to floods of which 3.4 million hectare had been protected by 1991 leaving 4.88 million hectare at risk.

Bangladesh is prone to severe flooding because

a) 80% of its total land surface falls into the flood plain of Ganga Brahmaputra basin,

b) a high monsoon discharge, draining about 1.5 million square kilometers in five countries, flows into the sea through Bangladesh which is occupying 7.5% of the total basin.

In India the area vulnerable to floods is about 24 million hectares in Ganga basin and 3.5 million hectares in the Brahmaputra basin of which some 4.4 million hectares and 1.4 million hectares respectively had been protected by 1978 according to Rashtriya Barh Ayog Report 1980. The table 9 shows the major flood prone areas (statewise) in the Ganga-Brahmaputra basin in India.

Table 9

State	**Chronically flood prone area**	**Rivers**
Assam and Northeast	Brahmaputra and Barak Valley	Brahmaputra Barak
Uttar Pradesh	Basins of Ganga and its tributaries	Ghagra, Rapti, Gandak and also Ganga and Yamuna
Bihar	North Bihar Plain	Ganga, Kosi, Gandhak, Son
West Bengal	North Bengal South Bengal	Mahananda, Teesta Damodar, Saraswati, Roopnarayan, Silabati Ajay, Kangsabati etc.

Among these regions the Assam and northeastern sector has been frequented by severe flood intermittently. The very high rainfall often coupled with peak discharge times of the Brahmaputra and Barak cause havoc in this region. In the north Bihar plain Kosi is the most destructive on account of its extremely high silt content. In lower part of the Ganga basin in West Bengal, Hooghli and its small tributaries inundates vast areas every year. Nepal, though being a mountain kingdom, also has a flood problem in parts of Terai. Most of the medium rivers like the Rapti, Bagmati and Kankai inundates a considerable area in the terai region every year.

The flood control strategies in this region has envisaged a wide range of measures. In a report on "Water Resource Development and Flood Control in Bangladesh" which dates back the very year, the Bangladesh was born, it has been stated that the overall flood control in long term would include three basic elements: first a system of embarkments to protect the flood plains from overflow; second a channel rectification programme to arrest the meandering of the rivers and the third diversion of flood flows from the main rivers into other channels where feasible.

Bangladesh's strategy towards flood control could be studied in two phases - before and after 1971. During the Pakistani regime, the strategy was more or less revolved around the finding and recommendations of a UN Technical Assistance Mission which came after the devastating floods of mid fifties. The Mission's report submitted in 1957 pointed out that the contribution of Brahmaputra, Ganga and Meghna to the flood discharge during June-October period was in the ratio of 5:4:1. The Mission recommended:

a) building up of embarkments to confine the rivers with a reasonable range of their channels,

b) proper settlement, planning by relocating them on mounds or beyond embarkments,

c) clearing and strenghtening of smaller rivers,

d) cooperation with India in the field of discharge data exchange and better flood forecasting.

However, the Mission ruled out the idea of building flood storages on Ganga and Brahmaputra within Bangladesh. A Water and Power Development Authority (WAPDA) was set up in 1959. In 1964 WAPDA presented a master plan with international consultancy. The master plan identified 51 major projects to provide flood protection and drainage to 3.2 million hectares by 1985.

After 1971, the new independent Bangladesh looked for a more comprehensive strategy and the emphasis shifted from flood control to irrigation for self-sufficiency in food. The strategy shifted from flood control to a long term water development programme. This obviously resulted into looking beyond the national boundary while formulating a long term national plan, hence a regional approach found an important place in the strategy of Bangladesh. Hence, during the SAARC

Table 10 Flood Affected Area in Bangladesh since 1954

Year	Flood affected area (sq. km)	Percentage of total area
1954	36920	25.64
1955	50700	35.21
1956	35620	24.74
1960	28600	19.86
1961	28860	20.04
1962	37440	26.00
1963	43160	26.97
1964	31200	21.67
1965	28600	19.86
1966	33540	23.29
1967	25710	17.87
1968	37440	26.00
1969	41600	28.39
1970	42640	29.61
1971	36475	25.33
1972	20800	14.44
1973	29900	20.76
1974	52720	36.61
1975	16590	11.52
1976	28418	19.73
1977	12548	8.71
1978	10832	7.52
1980	33077	22.97
1982	3149	2.19
1983	11112	7.72
1984	28314	19.66
1985	11417	7.93
1986	4589	3.19

Source: BWODB.

Summit in Kathmandu in December 1987, a special initiative from Bangladesh has been taken and a joint study of natural disaster including flood and drought in South Asia has been agreed upon.

In India flood control strategies comprise a number of components. Damage due to inundation can be reduced by confining the flood flows within embarkments or by limiting the flood discharges at the damage centre. Reservoirs, detention basis, diversions and soil conservation measures help in reducing the magnitude of flood flows. All these have been taken care of in varying degrees in different conditions to mitigate the flood damage to a considerable extent in India. Major attention has been given to tame the Brahmaputra in Assam and Kosi in Bihar, an elaborate strategy has been undertaken to take care of Ganga flood, and some measures taken to control flood in Damodar Valley and Yamuna flood, that is considered to be one of the most successful flood control programmes.

The Brahmaputra with Barak, cause havoc in Assam valley every year. Any measure to tame these rivers not only help the region to be saved from the wrath of the flood havoc, but it has a direct implication to the flood control programmes in Bangladesh. Because it has already been discussed that the answer to the question of flood protection transcends its national boundary to a considerable extent. The strategies taken to mitigate floods in Assam and northeast are

a) to control soil erosion, various programmes have been taken up to stop Jhum cultivation, which choke the rivers with additional sediment,

b) the Brahmaputra and Barak are jacketed within embarkments extending over 3400 km and 700 km in India respectively.

Besides proper institutional measures have also been taken up. Initially flood control was looked after by Assam Administration. In 1970, a three-tiered Brahmaputra Flood Control Agency was set up which was later replaced by statutory Brahmaputra Board in 1981. The Board looks after the entire northeast. The Board submitted two master plans in 1986 and 1988 pertaining to flood control and bank erosion and improving drainage in Brahmaputra and Barak. Of a cultivable area of 34 million hectares in Assam, some 3.1 million hectares are flood prone. Only 270,000 hectares are protected so far. The Brahmaputra Board has recommended two giant multipurpose dams on Dihang and the Sabansiri, both in Arunachal which are estimated to store 5.70 m.ha.m and 1.34 m.ha.m respectively. These two dams if built, will reduce flood peak by well over a meter below Pandu (Guwahati) and a far larger degree in upper Assam and even moderate flood peak in significant areas of Bangladesh. However, the Tiparmukh dam, proposed to be built on the Barak on Manipur Mizoram border, will similarly protect the Cachar plain and greatly benefit the Meghna basin and Sythet in Bangladesh.

The Ganga and its tributaries are also responsible for flooding a vast area. There is a short storage facility in the basin. The Tehri and some other dams are being built in the Ganga Yamuna basin. Moreover, talk are on to build two more dams in Nepal at Chisapani (on Karnali or Ghagra) and Pancheswar (Mahakali or Sharda).

The Ganga Flood Control Commission which was set up in 1970 to prepare a basin master plan was completed in 1980. The final plan, submitted in 1986, has divided the entire basin in 23 sub basins and the plans concerned to them have been sent to the respective states to develop specific investment proposal s for specific projects and proposals.

The most problematic among the tributaries of Ganga is Kosi, which is most destructive on account of its high silt content. Over a span of 130 years the Kosi had swung 120 kms west in the arc from Purnea to Saharsa in north Bihar. It is notorious as Bihar's River of Sorrow. Hence it remained at top in the agenda of the flood control programmes since the early days. The building of embarkments with a barrage was started as early as 1955 and the barrage was complete by 1964 which provided a flood protection over an area of 210,000 hectares.

The embarkments also provided protection to 51,000 hectare in Nepal. However, a major part of the Kosi project, a high dam at Barakshetra in Nepal, could not be implemented due to lack of enthusiasm on the other side of the border. However after the devastating flood of 1987, Kosi dam came back on agenda and is being discussed between the two neighbours currently.

Among other flood control programmes Damodar Valley Corporation (DVC) remained one of the most successful projects set up under an act of Parliament in 1948. It envisaged building up of eight dams to moderate a 100 year return-flood of 28000 cumecs to 4500 cumecs. However only four dams have been built so far, but even eight floods have been successfully regulated which were in excess of 1943 flood (9910 cumecs) which turned the attention towards Damodar flood seriously for the first time. Again the unprecedented 1978 flood of 24,100 cumecs was moderated to 4500 cumecs (DVC, December 1986). Moreover DVC has a wireless based flood forecasting system. However, the most advanced flood forecasting has been introduced in upper Yamuna catchment with the control in Delhi which is fully computerised.

Nepal and Bhutan being mountainous kingdoms do not have much problem of flood inundation but are prone to glacial lake outburst which cause immediate devastation in the upper catchment areas of the rivers and has a long term effect on the course of the river further down. There are quite a few recorded cases of such phenomena. In this regard both these mountain states could provide with valuable data useful for the river basin planning. India is now assisting Nepal for strengthening and upgrading its data collection and forecasting infrastructure.

Soil conservation has a strong bearing upon flood control. India has made considerable progress in this regard from the inception of Sixth Plan period (1980). Presently National Landuse and Watershed Development Council is coordinating various programmes. Integrated Water Development Programme has been launched since 1988.

Nepal also faces an acute problem of soil and water conservation. A modest Indo-Nepal soil conservation programme was taken up in the Kosi catchment in mid 1950s as a follow up to Kosi project. Sixteen integrated watershed management programme are under implementation in Nepal of which four central schemes and the rest district level programme.

3.2 Irrigation

The largest consumptive use of water is in irrigation. The previous chapter revealed that in spite of abundance in moisture availability, 80% of the rainfall occurs during June-October period in the Ganga Brahmaputra region. Being densely populated with high population growth, increased food production has always been remained at top in agenda of economic planning in the region. In this context irrigation assumes great importance in this twin-basin region of South Asia. The table 11 show the surface water resource development in the Ganga-Brahmaputra basin in India.

Table 11 Surface Water Resource Development of the Ganga-Brahmaputra Basin

Basin	Average annual runoff km^3	Utilisable flow km^3	Storage completed km^3	Under construction km^3	Major projects Completed No.	Major projects Completed Potential (m.ha)	Major projects Under construction No.	Major projects Under construction Potential (m. ha)
Ganga	501	250	37.40	16.79	67	8.26	47	7.22
Brahmaputra	537	24	1.09	2.71	1	0.03	4	0.15

Source: India 1991

Irrigation has been developed in India since historical time. During British period quite a few irrigation schemes were taken up. However the essential feature of the earlier schemes was building diversion or river lift schemes without storage. However, after independence, the emerging need to become self sufficient in food production, irrigation activities received the due impetus. In the eastern part of India a number of projects have been built. The Damodar Valley Corporation (DVC) multipurpose water resource development programme was taken up in Bihar and West Bengal. Then a number of storage and diversion schemes were followed - the most important of them are Kosi (Bihar and Nepal), Gandak (U.P., Bihar and Nepal), Ramganga (U.P. - the first major Himalayan storage in Ganga basin at Kalagarh in Garhwal), Mayurakshi and Kangsabti (West Bengal), Chandan and Badua (Bihar). The Teesta dam projected in Sikkim for power generation, will also augment lean season irrigation supplies for Teesta barrage project in West Bengal.

In Uttar Pradesh over 12 of the 17.5 million hectares of net cropped area in the state were under irrigation in 1988-89. One third of this comes from ground water utilizing about 30 percent of the total ground water potential. The state has drawn up a perspective plan for developing its water resources to the fullest extent by 2020. In Bihar, in spite of an abundance of water resource, the rate of irrigation development remained low. The state has an identified irrigation potential of 12.4 million hectares, two-thirds of which is from surface water resources. Out of an estimated 2.86 million hectare meter of ground water only 21 percent has been utilised so far. Moreover, North Bihar and Nepal constitute a single hydrolic entity but there is no water planning. The state has a net cropped area of about 7.7 million hectares of which only 2.7 million hectare receive irrigation.

West Bengal has a net sown area of 2.25 million hectares and an ultimate irrigation potential of 6.1 million hectares. However, presently about 40 percent of the total cropped area is irrigated. Though the Jangipur canal in West Bengal draws out 1132 cumecs from the Farkka Barrage, to flush out Bhagirathi-Hooghly and control salinity, the state receives no irrigation supply from Ganga though the state has sought an allocation of about 425 cumecs during the dry season from January to May.

The net sown area in the northeastern regions about 3.30 million hectare of which 2.56 million hectare lies in Assam. All the seven states put together has an ultimate irrigation potential of about 3.61 million hectare. Assam has already developed an irrigation potential of 1 million hectare. It only uses about 3 per cent of its underground water. The table 12 shows ground water potential of the region basin-wise.

Table 12 . Basin-wise Ground Water Resource Potential

Basin	Total replenishable ground water resource (million hectare meter / year)	Utilisable for irrig. (million hectare meter / year)	Net draft (million hectare meter / year)	Level of ground water dev. (%)
Ganga	17.1725	14.5901	4.4931	30.79
Brahmaputra	2.7857	2.3678	0.0503	2.12
Northeast composite	2.2788	1.9370	0.2621	13.53

Source: India 1991

Irrigation became the most important component in the overall water resource development strategies in Bangladesh after its independence. In this respect a major change of focus could be envisaged from the earlier years under Pakistani regime when flood control attracted the attention most.

By the year of 2000 Bangladesh will need to increase food production to 25 million tonnes in order to remain self-sufficient. To achieve this target, it will have to bring atleast 3.75 million hectares under irrigation by that date as against a maximum potential of 4.45 million hectares. By the end of 1980s irrigation in Bangladesh extended over 2.44 million hectares almost equally divided between surface and ground water system. The UNDP undertook a groundwater study (1982) and identified three aquifers - an upper and a large main aquifer, both interconnected at depths varying from five to 75 meters and a lower aquifer. The country was divided into 15 potential groundwater development zones. However there are two cautions inherent to the use of groundwater use for irrigation purposes. They are

a) since upper and main aquifers are interconnected, drawdown from the later should be limited to six meters, otherwise the numerous dugwells and stand pipes providing drinking water to the millions of people would dry up;

b) drawdown should be regulated to prevent saline intrusion where the coastal streams are affected by saline intrusion from the sea.

Bangladesh National Water Plan, 1985-2005 makes a realistic estimate of the needs and possibilities. For purpose of this study the country was divided into following five planning regions:

1. Northwest (Ganga, Mahananda, Teesta)
2. Northeast (Meghna-Brahmaputra)
3. Southeast (Meghna-Karnaphuli)
4. South central (Ganga-Brahmaputra)
5. Southwest (Ganga)

The National Water Plan envisages irrigation of 72 per cent of irrrigable area of 6.90 million hectare by 2005 using both surface and groundwater. The long term strategy of the NWP is the development of the three main rivers with the construction of barrages and gravity schemes. Moreover, an immediate strategy to enlarge the area under irrigation at a moderate cost, envisages small diversion of large rivers into their distributaries. Besides, the NWP of Bangladesh has mentioned the possibilities of significant storage potentials to resolve long term problems in the upper catchment of the Ganga and Brahmaputra basins in Nepal, Bhutan and India.

In Nepal, public irrigation works were limited to Chandra canal constructed in 1927 and a small diversion scheme, and the Judda canal prior to 1950, though an estimated 120,000 hectares were commanded by small works undertaken by farmers.

India's National Perspective plan, proposed by Central Water Commission, however envisaged enhancement of irrigation potential by close cooperation between the neighbouring countries, which would be beneficial to all. A Brahmaputra Ganga link canal (based on stored monsoon diversions) would facilitate upstream withdrawals from Ganga without affecting uses in lower Ganga and Brahmaputra. An estimated 14.8 m.ha.m of additional water would be available to irrigate 22 m.ha. in Nepal, Bangladesh and India. The cooperation of Nepal and Bangladesh would be essential for the proper functioning of this project.

3.3 Development of hydlpower in the Twin Basin

The Ganga-Brahmaputra basin has a vast hydroelectric potential in the tune of 200,000 to 250,000 MW of which at least half could be viably harnessed today. However, only a small part of this vast resource, have been developed till date. Large volumes of monsoon flow and snow and glacier melt flowing down the Himalaya and other ranges are a gift of gravity, which has a far reaching role in the development process of this otherwise developing region.

Nepal and Bhutan have huge hydro-electric reserves which constitute their largest single resource endowment and source of wealth. These two countries have the potential of emerging as a significance hydl-power exparte to India and Bangladesh and receive considerable exporter earning.

The first hydl station in this region was built near Darjeeling (400 KW) in 1897 for municipal use. The Mussoorie (1909), Simla (1913) and Nainital(1922) municipalities followed with mini hydel-projects. In Nepal, the Pharping hydel station was commissioned in 1911 with a capacity of 500 KW. In U.P. falls of one to two meters on the Ganga canals were tapped in 1930s through a series of microhydel projects that generate almost 70 MW today.

Hydl-power generation, however, was in a very low level at the time of independence, in the Indian part of the basin. Damodar valley project was first taken up which developed a total capacity of 140 MW in stages. Other projects followed - Chambal (380 MW), Rihand (300 MW) and lessser schemes in West Bengal, Assam and U.P. Of the total hydél-potential only about 13% has been harnessed in India of which, the Ganga basin contributes 12% and Brahmaputra only 1%.

In the north east 150 MW Kopili hydel project has been commissioned in 1988. Besides two more projects are in the pipeline -Doyang Hydro Electric Project (75 MW), Nagaland and Ranganandi Hydro Electric Project (405 MW), Arunachal Pradesh.

There is a potential of almost 3000 MW available in the Yamuna basin and may be double that in the upper Ganga basin from Hardwar to the glaciers. The rivers flowing into Ganga from middle India may be having another 5000 MW potential. Sikkim and North Bengal have a potential of between 2000-3000 MW. U.P. also shares a potential of over 2000 MW with Nepal on the Mahakali river. Of the 41000 MW potential of the Brahmaputra, less than 500 MW has been commissioned or is under construction in Assam and Meghalaya. Other giant schemes mooted in discussions with Bangladesh since 1978 but so far only some medium-large projects have been cleared for construction. Ranganadi (405 MW) and Kameng (600 MW) in Arunachal Pradesh being the two largest. The Loktak project (105 MW) is currently the only major hydel scheme in the southern tier of India's northeast.

After 1951, some initiative was taken to develop hydel power in Nepal with international assistance. The Trisuli (21 MW) and Daighal (14 MW) projects were financed and built by India and Sunkosi (10.5 MW) by China. Water Energy Commission was set up in 1976 and by mid 1980s the total generation capacity had grown to 126 MW. Arun III (402 MW) on one of the seven arms of Kosi, expected to come on stream by 1996.

In Bangladesh Karnaphuli hydel station in the

Chittagong Hills has remained the country's only hydel station with an augmented capacity of 130 MW. Another potential source on the Sagu, also in Chittagong Hills (87 MW) is yet to be harnessed. Of the 57 rivers flowing through this country only one originates within its territory, leaving headwaters of the rest of all beyond its boundary. This is significant from the point of view of Nepal and Bhutan which could expect a potential market for hydel-power.

In the entire gamut of water management in the Ganga-Brahmaputra basin, Bhutan comes to be very prominent given its vast hydel power potentials which is estimated at 20,000 MW. Its first major hydro-scheme, the 336 MW run of the river Chukha project is now fully commissioned. It is built with Indian assistance. The bulk of the Chukha power is exported to India. The gross earning of Bhutan from this source was in the order of Rs. 34 crores in 1989.

Nepal's progress towards building projects which would ensure considerable export earning from the sale of power to India has been rather slow. It has shown interest in the Chisapani project on the Karnali river since long and also it posed the Pancheswar project (2000 MW) on the Mahakali to Nepal only relatively recently. The Karnali project has been under study since 1964 by various international consultants.

In addition, another US-Canada consortium was invited in 1986 following an understanding with India, to prepare a feasibility report. A preliminary report settled the site and proposed to raise the height of the dam to generate 10,800 MW as against 3600 MW earlier contemplated. Moreover, if storages on the Bheri and Seti rivers feed into the Karnali reservoir, total capacity could ultimately go up to 16,000 MW. Now an agreement is to be worked out between India and Nepal to ensure international funding. Hopes of accomplishing the main project by 2001 at a cost of $ 4.4 billion may seem to appear rather optimistic. But it could transform Nepal's economy and energy scene in the northern India, the potential market of this huge block of power.

The discussion of the water management scenario in the Ganga-Brahmaputra basin elucidates that there is a long way to go to develop all the three aspects of water management to accomplish the full potential. The economy in this water rich region can be boosted up if proper attention and effort is given to develop the water resource in a comprehensive manner. However, involvement of all the four basin states to their respective capacity is needed to reach this goal. Realistic assessment and balanced appraisal of the cost benefit of the entire water resource development process by the four basin states is must for the translation of any project into reality. The misunderstanding, mistrust and diverse interest will be detrimental to the resource development process. The following chapter examines the perception of the basin states and point of disputes and agreements among them in this regard.

CHAPTER 4

CHAPTER IV

DISPUTE, CO-OPERATION AND QUESTIONS OF LAW IN TRANSNATIONAL WATER MANAGEMENT

From time immemorial water assumed a great importance in the life of human beings. Hence it seems to appear that water remained a major point of discontent and conflict in its use, among individuals, groups of individuals, states of a country and between countries. Initial issues related to water, was mainly confined in the areas of inland water transport. A number of conventions between Austria and Turkey (1619) involving Rhine could be traced as some of the earliest attempts towards making of international law on navigation.

The issues relating non-navigational use of water gradually started gaining importance from the later part of nineteenth century. Since the most important use of inland water is for irrigational purpose and rapid population growth creating an acute demand for increased food production, the issues involving water use became a major point of conflict between countries as well as different political units of the countries. The last two centuries have seen numerous conflicts in this regard. This has prompted the governments and international forums to search for a plausible solution to meet this end. 1 This chapter elucidates the question of law that emerged in the realm of water management in the world in the past two centuries in three parts. The first part contains an account of the major conflicts in different regions of the world, the second part highlights some attempts to codify water laws and compacts by different international forums and the third part deals exclusively with the points of disputes and agreement among the four basin states of Ganga and Brahmaputra in South Asia.

4.1 Water in National and International Politics Since Nineteenth Century

It has already been stated that most of the conflicts of the recent time involve non-navigational use of inland water. The earliest clash on international water rights occurred between the US and Mexico over the Rio Grande in 1896. Initially the US took refuge of what came to be known as Harmon Doctrine by rejecting a Servitude which makes the lower country dominant and subjects the upper country to the burden of arresting its development and denying to its inhabitants the use of a provision which nature has supplied entirely within its own territory. However she finally conceded some of its interests by accommodating Mexico's interests under U.S.-Mexico convention on Rio-Gromde in 1906. The treaty divided and assigned proportionally the waters of the Rio-Gromde in the uppermost 140 Km reach of the river taking into account Mexico's existing irrigation use.

In the course of time to meet the challange of huge increase in demand of water for irrigation and other consumptive use on the both sides of the border a comprehensive Treaty was signed in 1944 by the US and Mexico on both the Rid-Grande and the Colarado river. The salient features of the treaty are as follows:

a) delimitation of rights of the two countries;

b) building of two storage dams, the cost being divided in proportion to their respective benefits and jointly operated by the US-Mexico International Boundary and Water Commission;

c) equal division of hydl-power generated;

d) a guaranteed delivery of 185,000 ha.m of water of the colorado to Mexico plus and additional 25,000 ha.m in a surplus year, and an average amount of 43,000 ha.m per annum to Mexico from the Rio-Grande.

Rio-Grande problem and its subsequent settlement set a precedent in the sphere of legality in water management of Great Lakes and St.Lawrence river which make much of the boundary between the U.S. and Canada. A boundary water Treaty was signed between them in 1909. An International Joint Commission (IJC) was constituted as an instrument to address both boundary and trans-boundary water issues, equally represented by the both countries.

In the Treaty of 1909, trans-boundary St. Mary and Milk Rivers were considered for special provision, which were to be treated as a single unit for purposes of equal apportionment.

The IJC recommendations in 97 cases has been invariably accepted by the two Governments till late. IJC on a self appraisal, set out a series of principles at a Conference in 1981 at Dakar. They advocated:

a) an on going permanent joint commission with absolute parity in terms of representation between countries inspite of any disparity between their population and economy,

b) creation of a network which enables a great deal of information flow, formally and informally between governments, to make both sides aware of each other's problems and experience,

c) the Commission to act as a buffer with a common data base thus discouraging undue politicization of the issues, and

d) the commission as an exogenous agency to alert the governments to matters of concern which may be overlooked by them.

The Columbian River Treaty signed in 1961 between the U.S. and Canada provides another example of successful mutual cooperation in the management of transboundary river. Though about 12% of the Columbia basin lies in Canada, the bulk of the hydroelectric potential is located here. The treaty provides for the construction of three major dams in Canada of two million hectare meters of storage capacity. The objective was to increase power production and flood control benefit in the downstream reaches in the U.S. The U.S. in return provides half of the additional power generated in its territory and a sum equivalent to one half of the estimated flood damage prevented in the U.S. Moreover Canada provides an additional flood protection upto a certain limits if it is called for and in return is paid by the U.S. a pre-determined sum as well as a further amount equal to the loss in hydel-power generation in Canada to meet the U.S. exigency.

The last two cases brings out an important contribution in the field of evolving water law. This contribution came to be known as the "principle of downstream benefit" which was actually, authored by the U.S.-Canada International Joint Commission. Under section 15(4) of the Indian River Boards Act of 1956, this principle was implicit which was made explicit by the Yadav Mohan Committee appointed by the Government of India in 1961 to examine the levy of charges for utilisation of water on a downstream project. Later this principle has been duly appreciated and adopted by the Narmada Water Disputes Tribunal, 1978. The Tribunal concluded that Madhya Pradesh is entitle to payments for such benefits from Gujarat for regulated release of water from Narmada Sagar dam (in M.P.) for the Sardar Sarovar project downstream (in Gujarat) and also for flood control benefits, if any, obtained by Gujarat due to the construction of upstream reservoirs in Madhya Pradesh.

One of the landmarks in the international cooperation in managing transnational river has been set in Africa. The agreement on Nile between Egypt and Sudan was reached in 1929 and the process continued for 30 years more to reach the point of agreement on the Full Utilisation of Nile Waters. The agreement envisaged:

a) construction of Aswan High dam in Egypt and a reservoir (Lake Nasser) which submerged a part of Sudanese territory against due compensation by Egypt,

b) Construction of various projects in Sudanese territory to increase the river yield, the cost being equally shared by the two riparian states,

c) a permanent Joint Commission to develop the basin, oversee the projects and prescribe fair arrangement for sharing low river flows.

A further dialogue has been opened between all the nine co-riparians to provide means for further rational planning, conservation, development and future allocation of basin waters.

Among other cases a nine nation agreement on navigation and economic cooperation in the Niger basin (1963) and the Organization for the Development of the Senegal River set up by Mali, Mauritania and Senegal in 1972, are notable.

In Asia one of the most important example of river basin development in Mekong committee first established in 1957. The committee intends to develop lower Mekong basin involve Laos, Thailand, Vietnam and Kampuchea. However, in recent years due to internal political destability, Kampuchea's seat is lying vacant.

The committee functions through National Committees and a Bangkok based Mekong Secretariat. It has so far prepared an indicative plan for the short-term (1971-80) and long term (1981-2000) development of the basin. The plans projected both the water storage on hydro-electric potential of the lower Mekong basin. It has been envisaged that Laos and Kampuchea has the major hydro-electric potential and could become important hydroelectric exporter like Nepal and Bhutan. The projects and proposals developed by the Committee enjoys national acceptance among the basin partners and also international credibility.

The Indus Water Treaty of 1960 between India and Pakistan, which could be seen as a matter being negotiated with the good offices of the World Bank, is the most important example in the South Asian region.

The Treaty allocated the waters of Sutlej, Beas and Ravi for unrestricted use except for a 'transition period' of assured supply to Pakistan (from April 1, 1960 to March 31, 1970). Moreover the existing irrigation needs from Indus, Jhelum and Chenab has been appreciated in the Treaty. Moreover the right to develop irrigation for additional 700,000 acres from these rivers has been conferred to India subject to certain conditions. India on its part contributed 62 million pound in ten equal instalments towards the development of alternative facilities in the lower basin in Pakistan. The Treaty provided for regular exchange of canal data and for future cooperation. A Permanent Indus Commission has been set up, which in the following years of the Treaty has met and resolved a number of difficult problems referred by either side.

The Latin American experience in managing transnational rivers presents one of the most outstanding case of recent times. The Del Plata agreement between Argentina, Uruguay, Paraguay, Brazil and Bolivia, which culminated in the Brasilia Treaty 1986, presents a variety of principles and mechanisms for fostering mutual cooperation.

The Brasilia Treaty set up two major institutions. An Inter Government Coordinating Committee (CIC) with a permanent secretariat in Buenos Aires represented by the Ambassadors and Foreign Ministers, has been authorised to take policy decisions. The CIC has a Secretary with two year term, assisted by expert groups drawn from the staff of the respective governments. A Funding agency Fonplata has been set up in 1976 with a capital that had grown to $200 million in 1986. Fonplata is empowered to grant 15 year loans at seven to eight percent interest in the directions of the annual Foreign Ministers' meeting of CIC. So far 38000 MW of hydroelectric power had been developed on the system.

4.2 Attempts to Codification of Water Laws

All the case involving transboundary water management have dealt with some common problems. These are in fixing the quantity of water, allocation between conflicting status and regulation or implementation of the decision. However, in the disputes settled upon these questions has been solved in different ways between the riparian parties involved. In the process different principles and mechanisms has been evolved which have been followed or referred in solving different other cases. However there have been some consorted efforts by certain world forum where some attempts to codify the international water law, has been made time to time.

4.2.a Helsinki Rules

The subject of International Law in the sphere of water resource has long been in the agenda of International Law Association (ILA) - since 1954. At its session at Helsinki in 1966, ILA has laid down a set of principles which are still widely acclaimed all over the world. The Helsinki Rules are laid down in a number of articles. It refers to general rules of international law and their implication to the use of waters of an international drainage basin.

Moreover the basin of the river flowing through two or more countries has been envisaged as a geographical unit. Moreover the Rules of Equitable Utilization of the waters of an transnational drainage basin has been set out. The rules of allocations could be briefly summerised which consider the following factors.*

i) the geography of the basin in general and the extent of drainage area in each basin state in particular;

ii) the hydrology of the basin and the contribution by each basin state in particular;

iii) the climate of the basin;

iv) the past utilization of waters of the basin including, in particular, existing utilization;

v) the economic and social needs of each state;

vi) the population dependent on water in each basin state;

vii) the comparative costs of alternative means of satisfying the economic and social needs of each basin state.

viii) the availabilibity of other resources;

ix) the avoidance of unnecessary waste in the utilization of the waters of the basin;

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* Rao, K.L. (1979) India's water wealth; Orient Longman, New Delhi.

x) the practicability of compensation to one or more of the co-basin states as a means of adjusting conflicts among users and xi) the degree to which the needs of a basin state may be satisfied without causing substantial injury to a co-basin state.

It can however be noted that the above factors are not exhaustive. For example fixing of the priority of use may change overtime. In past navigation was the most important use of rivers, but with the increased population and technological change large scale appropriation of water for irrigation became more and more important. Moreover priority changes over space like in tropical and subtropical countries irrigation comes into forefront as against temperate regions where generation of hydropower is more important use of water. However Helsinki Rules have been widely appreciated as guidelines in many places.

4.2.b Recommendations of the United Nations

The U.N. Conference on the Human Environment held at Stockholm in June 1972 made a number of recommendations (Recommendation 51) which could serve as guiding principles in settlement of water issues between the riparian countries, with particular reference to their environmental implications. The Recommendation 51 suggested:

a) In accordance with the UN Charter and the principles of international law the right of permanent sovereignty of each country concerned to its resource development must be appreciated,

b) the following principles should be considered by the States concerned when appropriate -

(i) when major water resource development is envisaged, its environmental impact must be taken into consideration, hence the other co-basin country should be notified well in advance.

(ii) From environmental point of view the basic objective should be to ensure the best use of water and avoid pollution in each country.

(iii) The net benefits of transnational basins should be shared equitably.

c) Such arrangements when appropriate by the states concerned, will permit undertaking on a regional basis:

(i) Collection, analysis and exchange of hydrological data through some international mechanism agreed upon by the states concerned.

(ii) Joint data collection programme to serve the planning requirements.

(iii) Environmental implication assessment of the existing water uses.

(iv) Joint study of the causes and symptoms of problems related to water resources, taking into account the technical, economic and social consideration of water quality control.

(v) Quality control of the water considering it as an environmental asset.

(vi) Provision for the judicial and administrative protection of water rights and claims.

(vii) Prevention and settlement of disputes with reference to the management and conservation of water resources.

d) Regional conferences should be organised to promote the above considerations.

The Stockholm recommendations though elucidated the problems in the settlements of water disputes from an environmental point of view, the spirit of the guiding principles laid down in various treaties and conferences are contained in it.

4.2.c Role of the International Law Commission

The International Law Commission (ILC) an U.N. organ has been assigned to codify the rules of international water courses, in 1971 in its 23rd session. The procedure has been to appoint a special Rapportuer to frame draft articles in this regard. There has been a major shift in the working hypothesis.

It's charter is enjoined it to frame a law for "International Watercourses" rather than international drainage basin which the Helsinki Rule has adopted. This has been done due to the apprehension of some that the basin concept might be extended to include the territories falling within the basin rather then on the water and their relationships. Hence "a watercourse system is formed of hydrological components such as rivers. Lakes, canals, glaciers and groundwater constituting by virtue of their physical relationship a unitary whole".*

The 36th session of ILC in 1984 a complete draft convention consisting 41 draft articles in six chapters has been presented. The draft presents a whole range of guidelines regarding general principles, rights and duties of watercourse states, co-operation and management of international watercourse, environmental protection, pollution, health hazards, natural hazards, peaceful settlement of disputes and final provision. However the ILC

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* Schwebel, Stephen M. Special Rapporteur: Third Report on the Non-Navigational Uses of International Watercourse. ILC 34th session, New York, 1981.

is yet to adopt a final draft for presentation in General Assembly.

4.2 World Bank Manual

World Bank is one of the most important lending agency projects in waterways. In recent times many contentious issues cropped up among the developing nations regarding water management. The World Bank accordingly attempted to formulate guidelines for their own funding activities in relation to projects that involve such issues. The guidelines cover rivers and their tributaries, Canals and Lakes which form boundary, or flow through two or more countries and all types of projects whether irrigation, hydroelectric, flood control, navigation, drainage, sewerage or involving industrial uses or possible pollution. In the opinion of the bank, cooperation among riparians ensures best and efficient utilization of international waterways.

4.3 Disputes and Co-operation in the Ganga Brahmaputra Basin

The twin basin of Ganga and Brahmaputra is shared by four sovereign nations. The very physical set up of the region reveals the fact that water of the basin has to be shared not divided. Unlike the Western part of the Sub-continent, where the water of three indus tributaries has been assigned to India completely and the rest of them left untouched for the downstream country of Pakistan, the Ganga-Brahmaputra basin offers no scope for any clear cut division of water. This, also, partly support the fact that there has been no comprehensive understanding among the nations so far in the area of water management.

There are three important areas of water management - power production, irrigation and flood management. In the areas of hydl-power, the two mountain kingdom of Nepal and Bhutan assumes great importance, whereas in the areas of irrigation and flood management there is enormous scope for cooperation between India and Bangladesh. There have been piece-meal efforts between the countries for joint management of water but in an atmosphere of mutual distrust any meaningful approach towards a comprehensive water management programme is yet to take off.

(a) Indo-Nepal contentions

Nepal lying in the northern mountainous region of the basin has a huge hydl-power potential. Moreover the two major tributaries of Ganga the Kosi and Gandak originate here and flows through a large point of north Bihar plain which causes major flood in this region. There is enormous scope for joint water management beneficial to both countries. Firstly Nepal has a potential to grow as a hydl-power exporter to India and secondly India could be endowed with downstream benefits in the field of flood management and irrigation from a joint water management programme.

The first study in 1971 by the Department of Electricity assessed Nepal hydel potential to be 83000 MW. However a more recent study (1983) by Nepal's Water Resource Ministry estimated a feasible power potential of 27000 MW. Moreover a number of international agencies has done quite a few feasibility studies in Nepal and identified possible sites for the development of hydl-power projects. However, in spite of these great possibilities, actual progress has been limited.

There have been a number of projects envisaged between Nepal and India, which remained far from being translated into reality. The issues have been periodically raised and shelved. The two cases involving the Kosi and Gandak could be cited in this regard. The first initiative to develop Kosi basin taken by Indian Central Water and Power Commission in 1950. It proposed to build a High Dam at Barakshetra and a barrage further down at Chherta, both within Nepal to regulate the river control silt flow, generate 1800 MW of power and irrigate large tracts of Nepal and Bihar. Moreover the proposed storage of 8.5 lakh hectare feet would have neutralized a peak flood of 24050 cumecs to a more manageable 5660 cumecs. But the idea failed to concretise. It was believed that the marketing of such irrigation and power potential would be difficult and even a flood of 5660 cumecs would require embarkments in Bihar. Hence the first attempt towards this end failed to take off.

The first tangible achievement in joint river management has been made in 1954 between India and Nepal. The agreement on Kosi realised

(a) a regulating barrage below Chherta and a pair of embarkments;

(b) a 10 MW of hydl-power generation facility at a canal drop in Nepal,

(c) a bridge over the barrage to open an important west-east communication in Nepal, and

(d) some irrigation facility to Nepal (12150 ha).

The cost of the barrage and subsidiary works was borne entirely by India which got a fair measure of flood protection and irrigation facility from the agreement. The total irrigation potential of the project has been about 1.055 million ha.

The Gandak project, another important scheme between India and Nepal has been the result of agreement between the two countries in 1959. The agreement provides for

(a) construction of a barrage across the river at Balmikinagar, and

(b) a 15 MW hydl-power station in Nepal at canal drop.

The project provides irrigation for 1.15 m. ha in Bihar, 0.27 m.ha. in U.P. and 0.05 m.ha in Nepal. The entire cost of the project has been borne by India. However, it failed to satisfy the upper riparian state as it has been pointed out that Nepal got only 0.15 m.ha of irrigation and 15 MW of hydl-power while India has been endowed with a huge irrigation facility.

There have been many instances of diverse political opinion across the border which have halted the development of many projects which could become extremely beneficial in this region. The Kankai multipurpose project planned by Nepal with West German consultancy has failed to take off as Asian Development Bank which was approached for project funding suggested consultation with India because it was already using Kankai water for irrigation. India in turn asked for a formal project report from Nepal on the basis of which it could study the impact of Nepalese project. Nepal did not comply with India proposal, instead turned to Mulaghat-hydroelectric project on the Tamur, an arm of the Kosi. But India objected on the ground that the Mulaghat dam would be submerged, if the Kosi High Dam in which it had once again become interested, be constructed. This in turn made Nepal reluctant to discuss the Kosi project and the entire exercise reached to an impasse. Similarly two proposed mega-projects on Karnali (at Chispani) and Mahakali (at Pancheswar) river failed to make any progress due to difference of opinion on either side.

Some progress could be seen on the Tanakpur hydl-cum irrigation project on Mahakali river though it was not free of controversy. The rupees 403 crore Tanakpur project has been entirely funded by India. Sanctioned in October 1984, it was completed in March 1991. Though, its installed capacity is 120 MW, it produces a maximum of 94 MW in July when the water level reached the highest level in the reservoir. In the second Indo-Nepal Joint Commission signed in New Delhi in 1991, it was decided that India would give annually 10 million units of power free of charge to Nepal out of the 400 million units produced as a gesture of close relationship with Nepal.

However, the agreement is yet to be ratified in the Nepal's Parliament as the Nepal's Supreme Court ruled, as the treaty was challenged by the opposition parties, that the matter should be passed by a two-third majority in a joint session of the two Houses. The ruling Nepalese Congress did not have such a majority. Subsequently, a Joint

Parliamentary Committee (JPC) has looked into the matter. The JPC Report has been examined by the expert committee, headed by Professor Lokraj Bural. The expert committee agreed with the Government's view that India was not making any consumptive use of the Mahakali river. It had, therefore, no grave and long term effect. But the opposition rejected this report and demanded for proper appraisal of the Nepali's contribution to the project in terms of land and water and its due share of power. To dispel the mistrust a joint communique was signed between the two heads of the Governments in October 1992. It clearly declared that the natural resources of Nepal, in particular the land used for the construction of the left afflux bund of the Tanakpur barrage (about four hectares) will remain under continued sovereignty and control of Nepal and that Nepal is free to exercise all attendant rights thereto.

Apart from internal political pressure leading to failure to reach a well balanced agreement which has been inherent in the relationship between the neighbours in the subcontinent, there has been differences on the sharing of cost and benefits of the projects. The fixing of price at which Nepal would sell electricity to India has been a constant source of discontent. In the area of irrigation, Nepal often demanded the ownership of water stored within its territory which is again, against the spirit of International law. Moreover the calculation of downstream benefits in respect of both irrigation and flood control has always been a arduous process often marred by divergent opinions.

b. Sharing of water between India and Bangladesh

The sharing of the Ganges water has been the primary issue in the transnational water management between Bangladesh and India. The discussion in this matter have been taking place for the 25 years. The discussion with Pakistan and with Bangladesh has indeed been torturous. The dispute was mainly concerned with the allocation of waters in dry months, when water flow of the Ganga is low, which generally occurs between March 15 and May 15. India's necessity during this period is for irrigation and flushings out silt from the river Hugli to keep the port of Calcutta alive. Bangladesh states that it requires water in the lean season to meet her irrigation requirements, check salinity and maintain navigation. During all those years, the problems has been vigorously discussed, world bodies have been approached but any specific agreement remained a far cry. Agreement was reached in November 1977 and the main points are as follows:

1) The water to be released by India to Bangladesh from Farakka, in the quantum shown in the table 13 based on the 75% of the flows recorded at Farakka from 1948 to 1973. The water to be shared from 1st January to 31st May, by 10-day periods in quantum shown in the table;

provided further, if the actual availability at Farkka during a 10 day period is higher or lower from the quantum shown in the column 2 of the table it shall be shared in the proportion applicable to that period, but the release of water to Bangladesh shall not fall below 80% of the quantum shown in column 7 of the table in any particular 10-day period if the Ganga flow is such a low during that 10 day period.

2) The water released to Bangladesh, Farakka shall not be reduced below Farakka except for reasonable uses of water, not exceeding 200 cusecs by India.

3) A Joint Committee consisting of the representatives of the two Governments shall oversee the sharing of water and the disputes, if any, will be referred to the two Governments.

4) The long term arrangements will be for augmenting the flows of Ganga during the dry season. The Indo-Bangladesh Joint River Commission set up in 1972, will carry out the investigation in connection with augmentation of dry season

Table 13 Sharing of Waters at Farakka between the 1st January and the 31st May every year

Period		Flows reaching Farakka (based on 75% availability from observed data 1948-73) (Cusecs)	Withdrawal by India at Farakka (Cusecs)	Release to Bangladesh
January	1-10	98500	40000	58500
	11-20	89750	38500	51250
	21-30	82500	35000	47500
February	1-10	79250	33000	64250
	11-20	74000	31500	42500
	21-28/29	70000	30750	39250
March	1-10	65250	26750	38500
	11-20	63500	25500	38000
	21-31	61000	25000	36000
April	1-10	59000	24000	35000
	11-20	55500	20750	34750
	21-30	55000	20500	34500
May	1-10	56500	21500	35000
	11-20	59250	24000	35250
	21-31	65500	26750	38750

Source: India's Water Wealth (1979).

flows.

5) The agreement will be reviewed by the two governments at the expiry of three years. This agreement will be enforced for a period of 5 years and may be extended further in the light of the reviews.

With the approaching of expiry of the 1977 agreement, the accord was given an ad hoc extension with this difference that the guarantee of 80% of the flow values earlier allocated to Bangladesh was omitted. Meanwhile the negotiation on the augmentation proposal took off in March 1978. The augmentation proposals updated and exchanged from time to time between India and Bangladesh, which focus on the modalities to increase lean season flow in Ganga.

The augmentation proposals that have been revised from time to time by Bangladesh envisage

i) A canal along the Terai, "conveying water from the Gandak and the Kosi to augment the dry season flows of the Mahananda in West Bengal in India and the Korotoya in Bangladesh as well. Such a waterway and its connecting route through India and Bangladesh thus created for increased dry season flow could also serve as an international water route".*

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*Power, Water and Flood Control Ministry, Govt. of Bangladesh. Proposals for augmentation of the Dry Season Flow of the Ganges. Dhaka. March 1978

ii) The updated proposals of Bangladesh following negotiations augmentation in 1983 entailed the construction of 12 dams in Nepal including storages at Chisapani (Karmali), Kali, Gandaki I and II, Trisul Ganga, Seti, Sapta Kosi (Kosi High Dam) and Pancheswar (on Mahakali). The proposal claimed that it would be technically feasible to raise the height of the seven dams named to augment dry season flows at Farakka by 70000 million cubic meters.

The Indian proposals on the dry season augmentation has two components -

i) A barrage across the Brahmaputra at Jogighopa in Assam combined with a 324 Km long link canal (with an capacity of 100000 cusecs) across Bangladesh to a point just above Farakka in West Bengal. The link not only augment the lean season flow at Farkka but also offers a vast irrigation facility in Bangladesh besides opening a direct waterway between Assam and West Bengal.

ii) Construction of three dams on the Dihang, Subamsiri (both in Arunachal Pradesh) and Barak (on Mizoram-Manipur border). The first two dams were estimated to lower the flood peak in Bangladesh by 1.3 meters while the third would significantly reduce the intensity of flood in the Meghna-basin in Bangladesh. However India would be in a position to offer large blocks of cheap power to Bangladesh.

Unfortunately the reaction of each country to the augmentation proposals of others has been always negative. Both remained septic to each others proposals. The emphatic rejection of each other proposals created an atmosphere of deadlock. India remained opposed to any involvement of Nepal in the augmentation process between India and Bangladesh as it has already entered into bilateral relationship with Nepal in different areas of water management. To bypass the deadlock, the proposal put forward by Bangladesh of a new forum has been accepted by India after the signing of a MOU in November 1985. As a result the Joint committee of Experts (JCE) was created alongside JRC. However JCE could make little headway. Though India agreed that the JCE might approach Nepal for the limited purpose of eliciting data on the feasibility of augmenting lean season flows at Farakka from storages of Nepal, it was not keen at all in a multilateral effort beyond it. Nepal's response to JCE has also been lukewarm as it was found that the JCE mechanism unsuited to their purpose, moreover, as an obvious reason Nepal was keen to know the extent of nepal's participation in and benefit from the storage dams, and they sought time to respond to the request of data. However despite the extension of the term of JCE, there have been little headway in further communication regarding this matter.

Indo-Bhutan co-operation

The co-operation between India and Bhutan joint management of water resource has been limited to a single project so far, but it exemplifies one of the most successful cases of mutual cooperation in this region though its scope is limited to the harnessing of hydlpower only.

The country has an abundance of hydroelectric potential estimated at 20000 MW. Its first major hydroelectric scheme, the 336 MW run-of the river chukha project is now fully commissioned. Since Bhutan is not able to absorb more than about 7 MW of chukha power, the bulk of it is exported to India.

The chukha project, on the Wangchu river was first investigated in 1961 and taken up under an agreement signed in 1975. The project has been built and funded by India. Of the total project cost, 60 percent was given as grant to Bhutan. The balance is treated as loan at five percent interest repayable over 15 years from the commissioning of the project (1988).

The project is overseen by Chukha Project Authority, an autonomous body with high level representatives on both sides. Operating at 60 percent load factor, the Chukha hydro station generate 1944 million units of salable power. India has guaranteed to purchase all the energy that is available for export. A powerline communication system connects Chukha to Silliguri in North Bengal. The power is shared within India by West Bengal, Sikkim, Assam, Orissa and DVC. It has been integrated to the Northwestern and Eastern regional grid of India. It is the first international grid in the subcontinent linking Bhutanese and Indian power systems.

CHAPTER 5

CHAPTER 5

CONCLUSION

The water remained the most important issue among the basin states of the Ganga-Brahmaputra region. The diplomatic relationship between the basin states has often guided by the issues of water sharing as well as its development. This signifies the importance attached to water resource in the twin-basin region. The earlier chapters has clearly pointed out that the water resource to this region cannot be clearly divided among the basin states, rather it has to be shared in a manner whereby the benefits accrued out of its development percolate to each basin state in a balanced way.

A jointly coordinated effort is need of the hour between the basin states in the water management areas. In this regard the role of South Asian Association for Regional Cooperation (SAARC) could be highlighted. The subject of water resource has been kept out of the SAARC mandate, since it has always been dealt with on a bilateral basis. The very charter of the SAARC which was adopted in Dhaka in 1985 kept all matters of bilateral issues among the member states, out of its agenda. However the organisations subtle progress in other fields such as exchange of experts and technological information among the member states has a direct bearing upon the issues of water management among the co-riparian states of the Ganga Brahmaputra basin.

The terms of reference set by the SAARC group of expert on the study of "Causes and Consequences of National Disasters and the Protection and Preservation of the Environment" could be seen as a step forward towards a multilateral approach for the resource development of the region. The terms of reference incorporated among others - a countrywise identification and study of natural disasters, identification of specific areas of national priority and common areas of regional cooperation. This kind of approach could provide a back up to the mutual cooperation in the field of water management though it remains a area of bilateral concern.

Looking from the other way round, the very approach towards regional cooperation in the sub-continent provides for a greater participation in socio-economic field of the region. Since the countries of this region do not share a common strategic perception, greater interaction in the socio-economic field could thus come as a panacea to remove the misunderstanding and distrust which is evident in the political atmosphere of the subcontinent. Hence a meaningful joint approach towards water management by the basin states of the Ganga and Brahmaputra, which would involve a huge population with a common interest, would strengthen the regional cooperation and dilute the political tensions prevailing among the states in the region.

Another significant finding of the present exercise is that failure to reach a balanced agreement time and again, in different projects, envisaged bilaterally has been proved self-defeating. There has always been scarcity of funds and the international funding agencies did not show much interest in many projects on a transnational river due to the absence of any agreement between the riparian states.

The disputes in the region regarding water management cropped up time and again because the measures currently being contemplated in a disjointed manner in India, Bangladesh and Nepal are fought with disturbing consequences. Perhaps the most damaging of these was Bangladesh's suggestion that 12 storage dams built in Nepal to impound the monsoon rains for release in summer. The move fell through because of Nepal's objection on grounds of environmental and other hazards. But it showed how each country in this region looking at issues in a highly selfcentric manner without paying heed to the danger of such piecemeal tempering with mighty rivers. Moreover impoundment of the rivers in their mountainous catchment pose a number of other problems. There are national sensitiveness over sharing of water of the common river and such a large scale impoundment would incur huge cost that none of the countries could bear. On the other hand it can be suggested that proper attention should be given to develop groundwater resources which have a two-fold advantage. Firstly, it would incur small overhead costs and stream flow diversion through canal could be avoided and second, that diversion amount will be available for downstream use or to augment the flow of the river. This suggestion could be useful for the upper Ganga basin.

In the field of hydlpower generation the basin states can take lesson from the commissioning of highly successful Chukha hydlpower project in Bhutan, with close collaboration with India. More and more such ventures should follow where the two mountain states of Nepal and Bhutan have a significant role to play. In the past many projects with vast hydlpower potential were not considered viable on the ground that it would be difficult to find a market for it. But despite the lesson of Bhakra - that power generation creates its own demand - and the emerging energy shortage, nobody had the vision to seize the opportunity.

Internal political pressure coming in the way of fruitful cooperative endeavor is common in the region. It is more so in the smaller neighbouring countries of India. The need is to create adequate political will among the leadership and the public. The stress should be on the need to give priority to economic goals rather than political postures; the realisation that delay results in the enormous escalation of costs; that there is a need for reliable data which can be upgraded on the basis of third world priorities of sustainable development. India, as the largest country, has to be most generous, though this cannot mean concessions which leave the 370 million inhabitants in the basin region of India, substantially worse off than their neighbour. Then only the water in the Ganga-Brahmaputra basin could provide badly needed inputs for the development of the poor sections of the subcontinent.

To achieve this goal the foundation of the international cooperation in this region has to be made stronger. In respect of Nepal and Bangladesh as well as in the case of Bhutan suitable instrumentalities and corporate our inter-governmental mechanisms will have to be established. The existing structure have failed either because they were too narrowly conceived or were not given a fair trial. The institutional basis of bilateral and multilateral cooperation must be laid and backed by treaties, self-actuating procedures for conflict resolution and a strong and agreed data base. Ultimately something like a Himalayan River Commission might emerge. Every imperative therefore is to tap more fully its vast unexploited potential within a framework of sustainable development. This opportunity to uplift the marginal man, in what remains the largest concentration of global impoverishment despite being blessed with great gifts of the nature, has to be seized.

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