Chapter 14
Necessity of Regional Co-operation

India's three major rivers– the Ganga, the Brahmaputra (called Yamuna in Bangladesh) and the Meghna– are common to India and Bangladesh, an undivided terrain before 1947(except from 1905 to 1911 when it was first divided by Lord Curzon).

A large delta, spread over India and Bangladesh, known as the Bengal basin, was formed by these three major rivers. Throughout the geological quaternary ages, these three rivers flowed on numerous existing and abandoned courses, leaving behind a large, low-lying, flat alluvial plain. The delta, formed by the Ganga and the Brahmaputra is the largest in the world, spread over 59,600 sq. km (23,000 sq. miles). The Ganga, primarily a meandering stream, has a maximum normal discharge of the order of 70,780 cumecs, or 2.5 million cusecs and the Brahmaputra, primarily a braided river, has that of the same volume too. The Meghna, the smallest of the three, has an approximate flood discharge of 14,170 cumecs, or 0.5 million cusecs. Thus, during floods, the Ganga and the Brahmaputra accumulate about 141,600 cumecs, or five million cusecs of water at Goalanda in Faridpur district of Bangladesh and about 155,000 cumecs or 5.5 million cusecs near Chandpur, also in Bangladesh; this combined discharge flows into the Bay of Bengal. The average annual discharge of the three rivers, which is about 42,470 cumecs or 1.5 million cusecs, is nearly the same as of the Mississippi in the USA. This huge discharge flows through Bangladesh after merging at a single point, making it the largest in the world.

The hydrological features of the three rivers are summarised below.

The Ganga

The main stream comprises the combined flow of two rivers–Alakananda and the Bhagirathi – which meet at Deva Prayag in Garhwal district of Uttarakhand, a new Indian province, carved out of Uttar Pradesh in the Himalayan range in 2002. The original course flowed southward, then easterly and finally in its lap, flowed southward again and debouched into the sea. During its eastward middle course, a number of big and small tributaries join it from the north i.e. the left bank which also originate from the Himalayan range in Nepal. Therefore, these tributaries flow from

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Nepal as well as from the Indian soil on the south of Himalayan foothills. The major tributaries from the north are the Rama Ganga which joins the Ganga much above the confluence with the Yamuna at Allahabad, the Gomati, the Ghagra with its three tributaries – the Sarda, the Karnali and the Rapti, the Gandak and the Kosi with its two tributaries – the Buri Gandak and the Bagmati, the Kamala, the Sun Kosi and the Arun Kosi. The Gomati flows entirely within the Indian territory; the Sarda flows in India except a small portion in Nepal, the Karnali, the Rapti, the Gandak and the Kosi and their tributaries originate in Nepal. On the south, Yamuna joins the Ganga at Allahabad where its total annual run-off is more than that of the Ganga. The average annual run-off of the Ganga is about 0.06 trillion (10^{12}) cubic metre against 0.09 trillion (10^{12}) cubic metre for the Yamuna. Thus, the combined run-off of the Ganga below the confluence is about 0.15 trillion (10^{12}) cubic metre. With the contribution from the tributaries on both sides the average annual run-off of the Ganga at Farakka increases to about 0.4 trillion (10^{12}) cubic metre, owing to contribution of the tributaries from both sides. Out of this total run-off, the contribution from Nepal is approximately 20% only, which flow through tributaries originating in Nepal.

As stated, the catchment area of the Ganga basin between the Himalayan (northern side) and the peninsular sub-basins (southern side) is in the ratio of about 60:40, but the discharge contribution is just the reverse, i.e., about 40:60 owing to more intense rainfall in the Himalayan range and also over the foothills than that of the peninsular region. Thus, hydrologically, the Himalayan rivers contribute more to the management of water resources than the peninsular streams. Of the Himalayan streams, the Ghagra with its tributaries contribute maximum run-off – about 94,500 Mm^3 and the Gomati up to about 7,400 Mm^3 cusecs. Of the peninsular streams, the Sone contributes run-off up to 32,000 Mm^3 and the Kosi gives at least 5,000 Mm^3 run-off. The Yamuna is not a peninsular stream, as it originates in the Himalayan range, not far from the origin of the Ganga. The details of catchment area of the tributaries are shown in Table 14.1 below.

Average annual run-off of the Ganges at Farakka varies from 0.35 to 0.40 trillion (10^{12}) cubic metre.

Above the confluence with Yamuna at Allahabad-
Run-off of the Ganges — 0.053 trillion (10^{12}) m^3 — 13%
Run-off of the Yamuna — 0.098 trillion (10^{12}) m^3 — 25%
Total — 0.151 trillion (10^{12}) m^3 — 38%

Therefore, the average annual run-off between Allahabad and Farakka is (0.40 – 0.151) 0.249 trillion (10^{12}) m^3.

Now, contribution from Northern side is about 60% and that from Southern side is 40%.

Therefore, contribution from Northern side is 0.149 trillion (10^{12}) m^3.
Say, 0.150 trillion (10^{12}) m^3.

Considering 50% run-off from Nepal, contribution from Nepal is 0.075 trillion (10^{12}) m^3. This is about 19%, or say, 20% of the annual run-off available at Farakka, or about one-fifth of the average annual run-off at Farakka. A schematic diagram of the Ganges river with its tributaries on either side and of other rivers of India and the neighbouring countries is shown in Fig. 14.1.

Table 14.1 Tributaries of the Ganga river (up to Farakka)

Name of tributary	Name of sub-tributary	Country from which originated	Catchment area covering the Country	Average annual run-off (Mm^3)	Remarks
1	2	3	4	5	6
A) Northern side					
i) Ramaganga	–	India	India	15,300	–
ii) Gomati	–	India	India	7,400	–
iii) Ghagra	a) Sarda	India	India + Nepal	Total-94,500	Small contribution from Nepal
	b) Karnali	Nepal	Do		
	c) Rapti	Nepal	Do		
iv) Gandak	–	Nepal	India + Nepal	52,000	
v) Kosi	a) Buri Gandak	Nepal	India + Nepal	Total-69,000	–
	b) Bagmati	Nepal	Do		–
	c) Kamala	Nepal	Do		–
	d) Sun Kosi	Nepal	Do		–
	e) Arun Kosi	Nepal	Do		–
					–
B) Southern side					
i) Yamuna	a) Chambal	India	India	Total-98,000	–
	b) Sind				
	c) Betwa				
ii) Ken	–	India	India	11,500	–
iii) Tons	–	India	India	6,000	–
iv) Sone	–	India	India	32,000	–
v) Kiul	–	India	India	5,000	–
vi) Punpun	–	India	India	4,000	–
vii) Gumani	–	India	India	2,000	–

No dams have been constructed on any of these tributaries and the passage of water has not been fully blocked, but other types of control structures, such as barrages, anicuts etc. have been constructed across most of the tributaries and the parent river Ganga for diversion of some discharge for irrigation and other purposes.

The average monthly discharge of the Ganga river at Farakka point is shown in Table 14.2.

James M. Coleman recorded an average annual discharge of 412,000 cusecs, or 11,665 cumecs and maximum high-flood discharge of 2.585 million cusecs, or 73,190 cumecs in September 1961 near the Hardinge Bridge. The lowest flow, as he recorded, in the river as 42,000 cusecs, or 1189 cumecs. From the Table 14.3, it is observed that the average annual discharge in the river between 1979 and 1988 was 393,000 cusecs or 12,120 cumecs. The highest discharge, recorded in September 1998 was about 2,650,000 cusecs, or 75,000 cumecs and minimum discharge was about 1,050 cumecs, or 37,000 cusecs, in April 1980. In the Ganga, the flow goes down from October, hits the minimum between the last weeks of March and April, then rises from May-end, or the first part of June and hits the maximum between

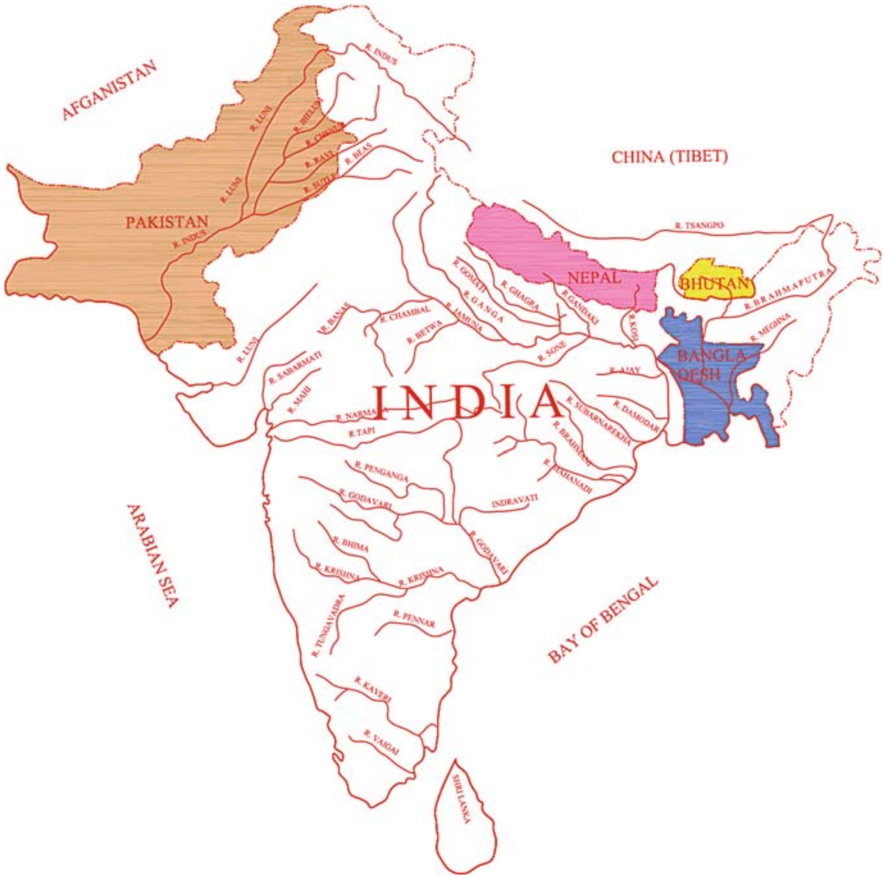

Fig. 14.1 River systems of India and neighbouring countries (See also Plate 10 on page 372 in the Colour Plate Section)

the last week of August and the first week of September. The first flood-peak occurs generally in India in July-end, or in the first week of August. Both the rising and falling stages are quite sharp, as can be seen from the Table 14.2. This is clear from the water-level hydrographs of a few years, as shown in Fig. 14.1.

The Ganga's left arm enters Bangladesh after flowing about 50 km from Farakka; the Mahananda joins it from the left. This river has its origin in India and about 10,000 sq. km of its catchment area is also in India's north-eastern States. Its average annual run-off is about 5,000 million cubic metres. A small portion of its lean-season flow has been held by barrage near Siliguri in Darjeeling district of West Bengal for irrigation purpose. Other tributaries of the Ganga-Padma in north Bangladesh are the Purnarbhaba, the Atrai (Boral) and the Karatoya which also originate in India. Their catchment area – about 20,000 sq. km – sprawls in India and Bangladesh. Taking their average annual run-off to be between 4,000 and 5,000 million cusecs,

Table 14.2 Average monthly discharge of the Ganga at Farakka (1979–1988)

Month	Discharge in cusecs	Discharge in cumecs	Remarks
January	57,430	1,630	1) Low discharge below 1132 cumecs (40,000 cusecs) recorded in 1981, 1983, 1984, 1985, 1986, 1987 and 1997.
February	46,020	1,300	
March	37,620	1,070	
April	37,330	1,060	2) High flood occurred in August during 1979, 1981, 1984, 1985, 1986, 1988, 1996 and 1998.
May	48,460	1,370	
June	125,000	3,560	3) High flood occurred in September during 1980, 1982, 1983, 1987, 1996 and 1998.
July	734,500	20,800	
August	1,386,000	39,250	4) In none of these years high flood crossed 56,625 cumecs (2,000,000 cusecs) for one month.
September	1,382,000	39,150	
October	569,800	16,130	
November	188,700	5,340	
December	97,330	2,760	
Average	392,650 Say, 393,000	11,118 Say, 11,120	

Table 14.3 Average monthly discharge of Bangladesh rivers (in 1000 cumecs)

	Ganges at Hardinge bridge (1934–1963)			Brahmaputra at Bahadurabad (1956–1962)			Meghna at Bhairab Bazaar (1957–1962)		
Month	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean
January	5.10	2.29	3.11	6.60	4.36	5.21	0.65	0.51	0.59
February	4.76	1.90	2.75	4.98	3.40	4.33	0.54	0.37	0.48
March	3.60	1.61	2.35	5.97	3.77	4.67	1.10	0.51	0.62
April	2.97	1.25	2.04	8.61	5.15	7.13	1.13	0.74	0.91
May	3.14	1.39	2.12	24.04	7.98	17.81	2.49	1.39	1.93
June	9.68	2.35	4.36	38.65	26.50	32.22	5.38	3.37	4.19
July	29.59	10.76	18.09	45.36	33.55	40.15	9.12	5.69	7.28
August	52.58	23.61	39.44	55.52	30.72	44.00	9.14	6.68	7.76
September	56.03	25.03	36.64	48.50	24.35	35.33	9.51	6.43	7.73
October	42.30	8.35	17.72	32.28	14.07	21.49	8.10	5.27	6.68
November	16.53	4.39	7.19	14.98	8.49	10.59	5.01	1.78	2.77
December	6.74	2.86	4.19	9.37	5.66	6.65	1.27	0.79	0.99
Mean (Annual)	16.36	7.81	11.66	21.74	17.98	19.20	3.94	3.00	3.51

the total contribution by the Mahananda and these tributaries is about 15,000 million cusecs; about 50% of it comes from India. No control structure exists across these rivers. The total catchment areas of the Mahananda (over India and Bangladesh) and its tributaries are about 10,000 sq. km and 20,000 sq. km, respectively.

The catchment area of the Bhagirathi-Hooghly sprawls over about 60,000 sq. km but unlike the Ganga's tributaries in the upper and lower reaches, which started from the Himalayas, its tributaries have their origins in Rajmahal and Chhoto-Nagpur hills which are much lower than the Himalayas and therefore, have very little, or no discharge in dry season. Therefore, dams had to be constructed over a few of these for irrigation and generation of hydro-electricity.

Thus, the total drainage area of the Ganga-Padma for a length of about 2,515 km is about 1.03 million sq. km (their length within Bangladesh is about 380 km), out of which 450,000 or 0.45 million, sq. km is on its north and 580,000 or 0.58 million sq. km is on the south. Northern tributaries, like the Ghagra, the Gandak and the Kosi together drain about 190000, or 0.19 million sq. km in Nepal (which is about 20% of the total drainage basin of the Ganga) and 30,000 sq. km in Bangladesh. However, the total drainage area of the Ganga along the Bhagirathi-Hooghly for a length of about 2,620 km up to the Sagar island is about 1.07 million sq. km, out of which 430,000 sq. km is on the northern and eastern sides and the balance 640,000 sq. km is on the south and the west. Here, the northern and eastern catchments include the areas of two small eastern tributaries – Jalangi and the Mathabhanga (about 10,000 sq. km) and 60,000 sq. km from western tributaries on the west.

The Brahmaputra

The Brahmaputra has its origin on the northern slope of the Himalayas in Tibet, where it is called Tsan Po. It flows eastward for a length of about 1,430 km (900 miles) along the foothills of the northern Himalayas and then turns southward and enters Arunachal Pradesh, an Indian State at its north-easternmost point and flows for about 180 km (110 miles). Then it turns west and flows through other Indian State, namely, Assam – for about 650 km (400 miles) and then enters Bangladesh. At the border, the river curves southward and continues on this course for about 240 km (150 miles) to its confluence with the Ganga. After this, the combined river flows for about 100 km (60 miles) and joins the Meghna. After about another 240 km, the combined discharge joins the Bay of Bengal. The total length of the river from source to sea is about 2,840 km (1,760 miles). Within Bangladesh, the channel varies considerably in width, ranging from less than two to more than 15 km. The Brahmaputra is a braided channel, unlike the Ganga, basically a meandering channel. During low flows, it becomes a multiple channel stream with sand bars in between and the channels shifting back and forth, between the mainstream banks which are often 6 to 12 km apart an aerial view of the river shows many channels, shoals and islands, which indicate a river of low hydraulic efficiency and of heavy sediment load.

The discharge of the Brahmaputra is mostly derived from the snow-melt in Tibet on the northern side of the Himalayas until it enters Arunachal Pradesh. Rainfall is very heavy in Arunachal Pradesh, Assam and Meghalaya in India and in Dinajpur and Mymensingh districts in Bangladesh, adding substantial flows in the river. The reach between Dhubri where its leaves India and enters Bangladesh and Aricha where it joins the Ganga is popularly known as Yamuna in Bangladesh. The old Brahmaputra course which is now a distributary of the main river and joins the

Meghna near Bhairab Bazar, used to be the main Brahmaputra, once upon a time; the present course, insignificant at that time, was known as Yamuna. Further down, there is one more distributary, Dhaleswari which leaves the left bank of the Brahmaputra and joins the Meghna, south of Dhaka city.

As stated, the Tsan Po/Brahmaputra is about 2840 km, or 1760 mile, long – longer than the Ganga in any of its courses. Up to Aricha, where it merges with the Ganga, the total drainage area is about 581,000, or 0.581 million sq. km, of which 293,000 sq. km is in Tibet, 241,000 sq. km is in India and only 47,000 sq. km is in Bangladesh. The catchment area of the river above Bahadurabad is about 536,600 sq. km. The discharge observation station at Bahadurabad recorded the highest flow of 71,320 cumecs, or 2519,000 cusecs, in 1958 and the lowest of 3,280 cumecs, or 116,000 cusecs, in 1960. The average annual discharge is about 19,200 cumecs, or 678,000 cusecs, which is nearly twice that of the Ganga. The first flood-peak occurs generally in mid-June and carries huge sediment load in both monsoon and lean seasons. During floods, the channel transports nearly 5 million tonnes of sediment in a day. The annual silt run-off Bahadurabad is about 735 million tonnes.

The Meghna

The Surma-Meghna flows on the east of the Brahmaputra through Bangladesh. The Surma rises as the Barak on the southern slope of the Nagaland-Manipur watershed in India. The Barak divides into two branches within Cachar district of Assam. The northern branch is called Surma which flows through east of Bangladesh beside Sylhet town and flows southward. The southern branch is called the Kushiara which flows through India and then enters Bangladesh. At first, the northern branch joins the Meghna near Kuliarchar and then the southern branch also joins the Meghna, near Ajmiriganj. The upper Meghna up to Shaitnol is a small river, whereas the lower Meghna below Shaitnol is one of the largest rivers in the world, as it is the mouth of three long rivers – the Ganga-Padma, the Brahmaputra and the Meghna. The last receives the old Brahmaputra on its right bank at Bhairab Bazar. Its total length is about 930 km, or 580 miles. It is predominantly a meandering channel, but in several reaches, especially where small tributaries leave sediment, braiding is evident and sand islands divide the river into two or more channels.

The maximum flood discharge, recorded in the Meghna, is of the order of 12,220 cumecs, or 431,500 cusecs, in 1960; the average annual discharge is of the order of 3,510 cumecs, or 124,000 cusecs, i.e. about one-third the Ganga's. Even though the river has a lower discharge than of the Ganga and the Brahmaputra, it leaves about 0.20 million tonnes of sediment in a day during floods.

There are about 50 other small and medium-size rivers which flow through both the countries and with which the interest of both the countries are involved. However the hydrological data of most of these rivers are available. Therefore, the following discussion on regional cooperation will be confined to these three major rivers. A schematic diagram of them when they are in spate is shown in Fig. 14.2.

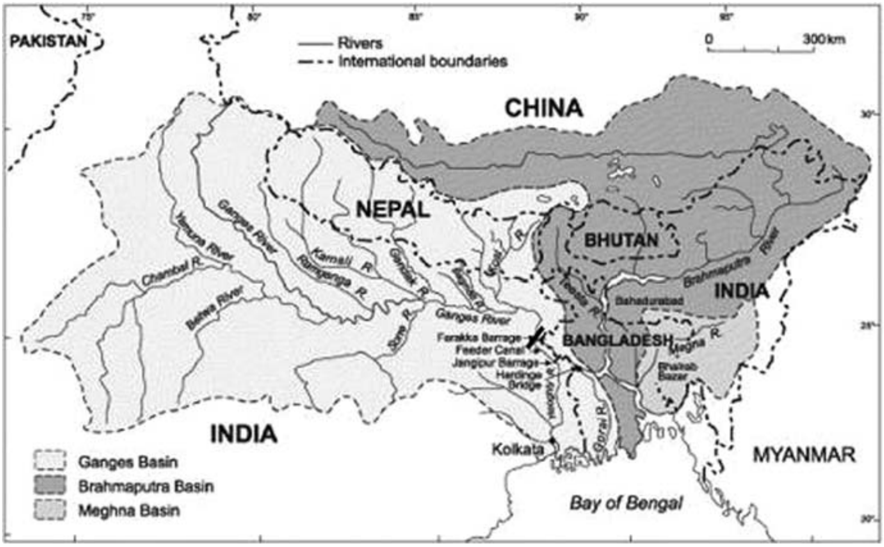

Fig. 14.2(a) GBM basin

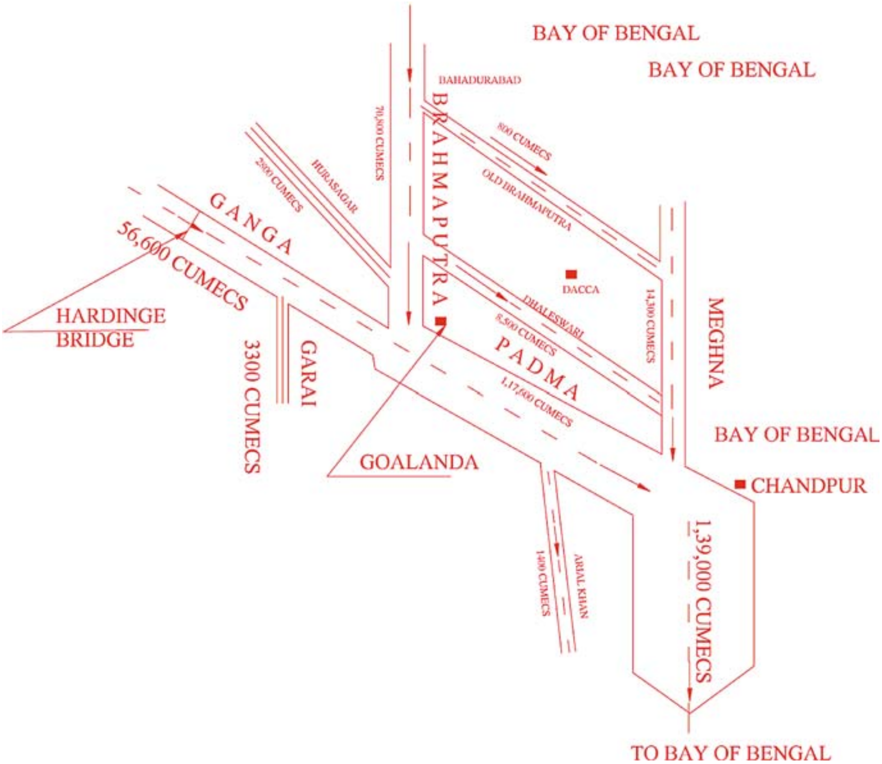

Fig. 14.2(b) Schematic line diagram of three major river system with normal flood discharge in Bangladesh

The minimum discharge of the Ganga normally falls to about 1,275 cumecs, or 45,000 cusecs, in mid-April. In the Brahmaputra, it goes down to about 3,170 cumecs, or 112,000 cusecs, and in the Meghna to about 370 cumecs, or 13,000 cusecs, in mid-February. The discharge in the Ganga rises appreciably from mid-June and falls appreciably from mid-October, every year but in the Brahmaputra and the Meghna, the flow rises appreciably from mid-April and falls from mid-September. For a comparative study of the average monthly discharge in the three rivers, the location of discharge observation sites within Bangladesh, as reported by James M Coleman in 1968 were considered. These are the Hardinge Bridge site for the Ganga, Bahadurabad for the Brahmaputra and Bhairab Bazar for the Meghna as shown in Table 14.3.

The Table 14.3 shows that whereas the Ganga starts rising from May, the Brahmaputra and the Meghna do so from March. Thus, there is a minimum time-lag of two months for flood in the Ganga and the other two rivers, the former follows the latter. Also, there is a time-lag of one month for the high flood, which comes in the Ganga in September and in the Brahmaputra in August. The minimum discharge in the Ganga, about 1,275 cumecs, occurs in April and that in the Brahmaputra, about 3,170 cumecs, about two months ahead, in February. Thus, the minimum discharge in the Ganga is over $2\frac{1}{2}$ times less than that of the Brahmaputra, leaving plenty of water in the latter, even in lean season. From the schematic diagram shown in Fig. 14.3, it is seen that over 138,700 cumecs, or 4.9 million cusecs of water flow into the Bay of Bengal during floods through a single outlet of the three combined rivers, namely the Ganga, the Brahmaputra and the Meghna in Bangladesh. This is the largest in the world for a single outlet to the sea and exceeds even the Amazon by about $1\frac{1}{2}$ times.

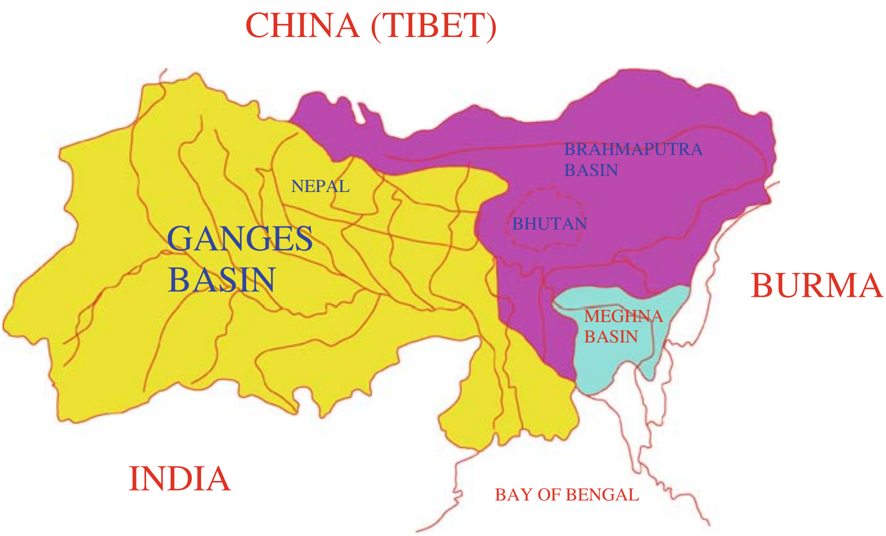

Fig. 14.3 The Ganges, Brahmaputra and Meghna basins (See also Plate 11 on page 373 in the Colour Plate Section)

Of the total volume of water, brought into Bangladesh, nearly 85% is carried by these three rivers, making them the primary causative factors for floods in Bangladesh. Flood flows of about 56,600 cumecs, or 2,000,000 cusecs, in the Ganga and the Brahmaputra and about 8,490 cumecs, or 300,000 cusecs, in the Meghna are generally sufficient to make the rivers and their tributaries/distributaries go into spate and overflow their banks. Thus, almost every year, water-levels in these rivers rise, spill over the banks and cause devastating floods. Bangladesh farm land is flooded, almost every year, plunging people in misery. Parts of Bihar and West Bengal in India are also affected in some years following the flood in the Ganga. The main characteristics (length, drainage area & discharge) of the three rivers follow in the Table 14.4.

The Table 14.5 shows that the maximum drainage area of the two rivers lay in India. The Ganga and the Brahmaputra get maximum water from the Indian soil. It is quite legitimate, therefore, for India demanding the maximum of its share for the benefit of its own soil and irrigation, drinking water, navigation and power generation. All the rivers are 'international' as they flow through more than one country. In respect of the Ganga and the Brahmaputra, India is a mid-riparian country and in that of Meghna, an upper one. Whatever may be the percentage of length, or of the drainage area in the two countries, international law dictates that the interests of the upper and the lower riparian countries have to be protected, as far as practicable.

Discussions are under way among India, Nepal and Bangladesh on issues of regional cooperation and development of water resources. Being poor and of uneven development, these South-Asian countries are considering many proposals of developing and effectively using water resources. Some of these are:

I. Storage of surface and sub-surface water for irrigation and mitigating or moderating flood;
II. Inter-basin transfer of water from India to Bangladesh and vice-versa;
III. Generation and distribution of hydro-electric power at suitable locations in Bhutan, India and Bangladesh;
IV. Improvement of navigation as well as other communication and transit facilities among Nepal, India and Bangladesh;
V. Financing and promotion of engineering expertise to secure the above; and
VI. Securing minimum guaranteed flow from India to Bangladesh.

Water resources abound in South-Asian countries, much of which flow, unutilised, into the sea. Rainfall and its distribution are not uniform in different months of the year. Therefore, judicious storage, transfer and utilization can only help their all-round development. Keeping this and proposals from various agencies in view, the potential of regional development etc. is shown in the Table 14.5 below.

These potentials for regional cooperation and exchanges cannot be achieved without mutual understanding and good neighbourly relation. Though the primary concern of each country is protection and promotion of its own interests, or the benefit of their own people, some sacrifice is necessary for regional development. Storage reservoirs may cause submergence of land and invite evacuation and resettlement

Table 14.4 Main characteristics of the rivers

River	Length (km)	Source	Drainage area (1000 sq.km)					Discharge (Cumecs)		Remarks
			China	India	Bangladesh	Nepal	Total	Max	Min	
1	2	3	4	5	6	7	8	9	10	11
Ganges	2,645 along Bhagirathi-Hooghly 2,650 along Ganga-Padma	India India	– –	880 (82%) 810 (79%)	– 30 (3%)	190 (18%) 190 (18%)	1,070 (100%) 1030 (100%)	75,000	1,275	Maximum discharge in Sept. Minimum discharge in April
Brahmaputra	2,840	China (Tibet)	293 (54%)	241 (45%)	47 (1%)	–	541 (100%)	71,320	3,170	Maximum Discharge in Aug. Minimum discharge in Feb.
Meghna	930	India	–	20 (20%)	80 (80%)	–	100 (100%)	12,220	370	Maximum discharge in Sept. Minimum Discharge in Feb.

Table 14.5 Potential for regional development

Countries involved	Potential possibilities	River basin
i) Nepal and India	a) Construction of storage reservoirs. b) Irrigation c) Hydro-power generation d) Grant of engineering expertise and finance	The Ganga and its tributaries
ii) Bhutan and India	a) Construction of storage reservoirs b) Hydropower generation c) Grant of engineering expertise and finance	Tributaries of Mahananda and Tista
iii) Bangladesh & India	a) Construction of storage reservoirs b) Flood mitigation/moderation c) Hydropower generation d) Guaranteed minimum flow e) Navigation and other transit facilities f) Inter basin transfer of water g) Granting engineering expertise and finance	Ganges, Meghna, Brahmaputra and the tributaries of Brahmaputra and Meghna
iv) Nepal and Bangladesh	a) Communication and transit facilities b) Transfer of Hydropower	Tributaries of the Ganges
v) International Organizations (in case of extreme necessity)	a) Provision for engineering expertise b) Provision for financing c) Arbitrating the disputes, if any.	–

of affected people, hydro-power has to be affordable. Inter-basin transfer of water may affect arable land. Engineering expertise and financial help may be inescapably required from other countries. All these can be sorted by detailed discussions among the concerned countries. Happily, a process is under way and following an understanding between the governments of India and Bhutan, a hydro-electric power project has been set up at Chukha in the Himalayan kingdom. The Kosi barrage project has been possible because of Indo-Nepal goodwill and joint endeavour. Negotiations are also on between Nepal and India for construction of storage reservoirs on other tributaries of the Ganga and for hydro-power generation and irrigation. The Ganga Water Treaty of 1996 between India and Bangladesh was the result of mutual understanding and cooperation on water sharing and minimum guaranteed flow to Bangladesh. However, only a few have been achieved and many more remain to be done. Though the national water policy envisages it, the water resource management of river basins as a whole has not made much headway, even in India which is the largest and more developed amongst these South Asian countries.

Negotiations for development of regional water resources should be initiated, either on its own, or bilaterally between the two countries. Most of the issues being bilateral, the government of India desires that all issues, be they on water resources, transit, transport, border dispute, or any other, are to be settled between the affected parties who are directly or indirectly involved, through discussions and with mutual trust and understanding. This is the policy, adopted by India since Independence and many problems were solved accordingly.

It is established that the combined discharge of the inter-connected river basins of the Ganga-Brahmaputra-Meghna (GBM) have enough water for the countries through which they flow and to meet their needs by optimal and integrated planning. Being land-locked and mountainous, Nepal and Bhutan have very little scope for irrigation except in some pockets but they have it amply for building reservoirs, generating hydro-power for their own use, or just for sale to India and Bangladesh. Therefore, a bilateral process is necessary between India and Bangladesh to explore the possibilities of cooperation on specific projects, involving inter-basin transfer of water for irrigation, navigation and hydro-power generation etc. However, joint discussions by India and Bangladesh with Nepal in 1986 on augmentation of the Ganga water at Farakka did not make much headway, as Nepal insisted on assurance of its benefits before exchange of information about storage facilities in its own territory. Moreover, floods in three river basins of Bangladesh occur in monsoon months, every year. In 1987–1988 and 1998, the floods were unusually severe, causing huge devastation. The Government of India, the USA, France, Japan and the UNDP rendered massive help in relief and rescue operations in 1987 and 1988 spates. Therefore, an understanding between India and Bangladesh on the vital issue of river-basin management is absolutely necessary.

The total water available from the basins of the Ganga, the Brahmaputra and the Meghna is a huge mass, much of which runs into the sea without any use. Only a miniscule of this prodigious water resource is utilized at present for irrigation, navigation and hydro-power generation etc. by the three countries. Droughts and floods have been occurring with increasing frequency and intensity all over the eastern and north-eastern parts of the subcontinent for several decades. The entire surface water irrigation of non-peninsular India, Nepal, Bhutan and Bangladesh depends on the water of these three river basins, leaving aside the huge ground-water potential of the region which is also indirectly contributed by the Himalayan rivers.

The annual available discharge of the three river basins is shown in Table 14.6 below.

As shown in the above table, the huge water mass, before coming down to the plains of India and Bangladesh, descends through steep Himalayan slopes in high falls at several places within Nepal and India. Some World Bank studies show that the hydro-power potential of the upper Ganga basin is about 13 million kw (Mkw) at 60% load factor, of which 4 Mkw are within India, 2 Mkw on the borders between Nepal and India and the rest within Nepal. Nepal's own potential for hydro-power is 83 Mkw, equivalent to the combined installed capacity of Canada, United States and Mexico. Nepal's geographical features permit massive hydro-power generation in three major sub-basins of the Ganga. According to the report of His Majesty's Government of Nepal, titled 'Hydro-power potentiality in Nepal, 1971', the Karnali basin generates 32 Mkw, the Gandak basin 21 Mkw and the Kosi basin 22 Mkw. Nepal's undulating land, covered with thick forests and numerous rivers, rivulets, creeks and Nullas(drains) has very little scope for waterway communication. Transport and communication through a network of roads and highways, or by railway, though not impossible, would be very costly as well as highly technical and time-consuming. Therefore, a viable mode of transport which is a crying need for

Table 14.6 Average monthly flow volume of three river basins (in million cusecs – Mm^3)

Month	Average monthly flow			
	Ganges at Hardinge Bridge	Brahmaputra at Bahadurabad	Meghna at Bhairabbazar	Total discharge
1	2	3	4	5
January	8,335	13,910	1,590	23,835
February	6,560	10,420	1,200	18,180
March	6,190	12,615	1,700	20,505
April	5,330	17,680	2,430	25,440
May	5,280	42,430	5,180	52,890
June	11,170	84,190	9,900	105,260
July	47,855	118,035	20,925	186,815
August	100,540	120,785	22,170	243,495
September	95,805	94,055	21,305	211,165
October	46,175	58,790	16,710	121,675
November	18,420	27,150	7,980	53,550
December	11,235	18,040	2,650	31,925
Annual	362,895	618,100	113,740	1,094,735
Say,	0.363 million Mm^3	0.618 million Mm^3	0.114 million Mm^3	1.095 million Mm^3

Nepal and Bhutan, can be a network of electrically-operated ropeway system across their mountainous territories and also with adjacent places in India and Bangladesh. As Nepal does not have high technical capability, such development is possible only if it generates and sells hydro-power to India in bulk, for which bilateral negotiations and understandings with Delhi are necessary. Trilateral or multilateral negotiations on this issue will be very difficult and may not succeed, unless a bilateral accord is reached. Already, India has stated the process with both Nepal and Bhutan and understandings on a few projects have been reached and yielded good results. The construction of barrages across the Kosi and the Gandak has been possible with such bilateral understanding between India and Nepal for the development of irrigation in two countries. Negotiations are also going on for construction of high dams in the San Kosi, the Tamur, the Kali Gandaki, the Chisapani etc., all of which would be located within Nepal. As stated, the Chukha hydro-power project would not have materialised but for technical and financial assistance by India. The work of the Tala hydro-power project is now in progress (2008) in Bhutan with also India's technical assistance.

Nepal and Bhutan suffer from enormous land erosion owing to the steep ground contour and large-scale deforestation, causing a veritable ecological disaster. Torrential rivers aggravate erosion in monsoon months, making their governments export eroded soil. If this continues unabated, Nepal will, some day, embrace ecocide, bringing in its trail widespread hunger and starvation of an increasing population. Nepal's economy was precarious for a long time because of political instability. It can never balance its trade with India unless it is able to produce and sell hydro-power to India and Bangladesh in a big way. An index plan of three river basins is shown in Fig. 14.3. On the other hand, as stated, Bangladesh has excess water, especially in monsoon months, which go waste, as it flows into the sea. High floods damage the crop and cause shortage of food and power for an exploding population and tardy industrial growth. Inter-basin transfer of water in a large scale to boost agriculture, transport and generation of hydro-power can materialize with bilateral negotiations and understanding with India. Unless this is done, Bangladesh can never achieve a balance of trade with India. The Ganga Water Treaty of 1996 was possible through such bilateralism. As it is, the Ganga basin is already developed and water available to it may not be in excess of the future requirement of India and Nepal. Therefore, the water resources of the Brahmaputra and the Meghna, which are almost untapped, can be gainfully utilized by constructing storage dams, barrages at suitable locations and also by inter-basin transfer of water from the Brahmaputra to the Ganga, as proposed by Indian representatives of the Joint River Commission (JRC) for augmenting the Ganga flow at Farakka. Construction of dams across the tributaries of the Brahmaputra, such the Subansiri, the Dihang and the Lohit in Indian soil and at Tipaimukh across the Meghna will help produce massive hydro-power for use by both countries.

The Working Group of ESCAP (earlier ECAFE) in Bangkok reported in 1968 that as the Brahmaputra during her long journey through Tibet into India goes through seven major falls and along precipitous gradients, it has potential for huge hydro-power which would have been equal to the total global production of electricity in that year. Harnessing of this massive potential would also help mitigate the flood hazards that Brahmaputra leaves on the Assam valley in India and Bangladesh, almost every year.

This would be possible through regional co-operation between India and China at the first instance and with Bangladesh, Bhutan and Nepal at a later stage, with technical and financial assistance by the USA, Japan, Russia, Canada, Britain and some international agencies under the United Nations. There has not been much progress in this direction and as it appears, Bangladesh which will benefit the most from such cooperation with India and other concerned countries is not much interested.

Augmentation of the Ganga flow at Farakka by inter-basin transfer of water from the Brahmaputra basin to that of the Ganga, as proposed by India, will not only revive Calcutta Port, improve navigability, but will be an immense source of irrigation, increase crop yield along its banks, generate ample hydro-power and mitigate flood hazards in the Brahmaputra valley in Assam and Bangladesh. The World Bank is of the view that such diversion would be a more logical and better economic solution of the problems of water scarcity in both countries, but the merits of the diversion and its timing need careful examination. Some 566 cumecs, or 20,000 cusecs to 1,132 cumecs, or 40,000 cusecs, can be transferred from the Brahmaputra to the Ganga without creating much problem in the river. The World Bank adds that there could be potentiality to use almost the entire dry-season flow of the Ganga which would boost agriculture and industry in India's upper riparian States.

On the other hand, Bangladesh held that there would be enough water in the Ganga basin for India, Nepal and Bangladesh; therefore, augmentation must be confined to the Ganga alone. It suggested 12 possible storage dams on the Karnali, the Sapta Gandaki and the Sapta Kosi, besides two more on the Arun and the Tamur (in Nepal). Together with those proposed on India's rivers, these would raise the dry-season flow of the Ganga from 1,557 cumecs, or 55,000 cusecs, to 5,096 cumecs, or 180,000 cusecs. Water stored in reservoirs in Nepal could be released to the Ganga through natural rivers. Besides, a canal constructed along the Terai in Nepal could carry water from the Gandak and the Kosi to the Mahananda, the Karatoya and the Atreyi, to augment their dry-season flow. It could also become a cross-country ('international') navigation route which Nepal, a land-locked country, needs badly. Nepal appears to be keenly interested in developing her irrigation, hydro-power and navigation facilities, but whether they have to be sorted out, bilaterally between Nepal and India, or trilaterally among Nepal, India and Bangladesh, has to be decided by Nepal. India's offer of bilateral dialogue with Nepal on these issues has merit. Being directly involved in the matter, it would be easier for them to take a quick decision. India and Nepal need almost the whole of dry-season flow of the Ganga. On the other hand, it is a fact that the water of the Brahmaputra is almost untapped and both India and Bangladesh would need huge quantity from its basin. According to a World Bank report, the total gross demand of water from the Brahmaputra basin in Bangladesh in the dry season is around about 2,265 cumecs (80,000 cusecs) and in Assam around 1,700 cumecs (60,000 cusecs) in the long run; therefore, there would be hardly any water left in the Brahmaputra for inter-basin transfer. However, much of this flow would be utilized for irrigation during the transfer also. It would thus not be difficult to transfer between 1,130 cumecs (40,000 cusecs) and 1,700 cumecs (60,000 cusecs) to the Ganga basin, even in the long run, after meeting the needs of both countries. Moreover, this volume of transferred water could be utilized by the two countries only. Seismically and in respect of other effects, the two proposals have their demerits too, which should be addressed while drawing the schemes. Thus, considering the pros and the cons, it appears that the Indian proposal has more merits but both countries should agree for overall development of the region.

The GBM basin has a diverse climate and a time-space variation of precipitation. Because of this, accommodation of the needs of the basin countries by a negotiated settlement is essential. Thus, inter-basin transfer of water from the Brahmaputra basin to that of the Ganga supports the storage of monsoon flow and its utilization for irrigation and hydro-power generation. Before going in for a multi-lateral understanding, or agreeing for it, bilateral understanding between the directly affected countries is absolutely necessary. Some progress has taken place, but it is quite slow when a vast population in the river basins suffers. There is thus a need to create public opinion in the basin countries for encouraging regional cooperation between, or among, the governments for harnessing river-water resources.