Managing the Wealth and Woes of the River Brahmaputra

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Prof Dulal Goswami in response to our request was kind enough to write this article on the mighty river Brahmaputra. We are very happy to carry this article in the present issue of* Ishani*. Our understanding about the North-eastern region and even its neighbourhood cannot be complete till we have the correct understanding about the river Brahmaputra. It is a river which passes through four countries, namely India, China, Bangladesh and Bhutan. Dr Goswami has given a hint in the title of the article itself that Brahmaputra contains both wealth as well as woes. He makes an attempt in his article to consider how the wealth and the woes of river Brahmaputra should be judiciously managed.

This article is particularly valuable because it succeeds in mobilizing a wealth of information on the river at one place. The author has dealt with different dimensions pertaining to this river such as its properties, about the people inhabiting the basin of Brahmaputra, the economic potential of the river, its potential as an important waterway and with many other factors. Any serious student of the people and the region of Assam in particular and the people in the neighbourhood of Assam cannot ignore the way or the manner in which this mighty river has influenced the lives of the people in the region.

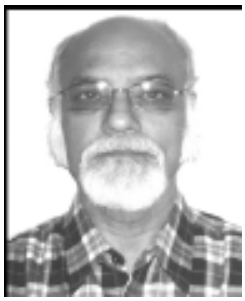
Professor Goswami has described the misery that the river creates year after year. He also describes the way the largest river island Majuli, which is also the highly revered centre of Neo-Vaishnavite faith, is gradually shrinking in size as erosion plays havoc with it during each rainy season. He tells us at one place of the article that, "An extremely dominant monsoon rainfall regime interacting with a unique physiographic setting, fragile geological base and active seismo-tectonic instability together with anthropogenic impacts have moulded the Brahmaputra into one of the world's most intriguing and gigantic fluvial system".

Professor Goswami also sounds a note of warning about undertaking construction of large dams. He tells us, "In the last few years there has been a spurt of activities in identifying more than hundred mega dams in the eastern Himalayas especially in Arunachal Pradesh.... These are presently at various stages of planning and development. There is growing concern about the possible negative impact of the proposed large dams in terms of their viability and sustainability vis-à-vis the delicately poised geo-environmental base, ecological balance, ethno-cultural heritage and the extreme dynamism of geo-physical processes in the region."

....The wisdom behind constructing big dams in the Eastern Himalayas raise more questions than can possibly be answered at the present stage of our knowledge and development. We invite readers to go through more details in the article. These are all highly important.

There is also mention of two devastating earthquakes that had taken place in the region in the past and this is an important factor influencing the destiny of the region. A major portion of the region falls within sensitive seismic zone.

Professor Goswami has also dealt with the mention of Brahmaputra in ancient texts as well as different legends governing it.



Author

A river extraordinaire, the Brahmaputra in Assam presents a picture of awesome expanse, enchanting grandeur, overwhelming sobriety, and immense vigour. Its 580,000 sq. km basin spreads over China (50.5 %), India (33.6 %), Bangladesh (8.1 %) and Bhutan (7.8 %). The Indian part of the basin is shared by Arunachal Pradesh (41.9 %), Assam (36.3 %), Meghalaya (6.1 %), Nagaland (5.6 %), Sikkim (3.8 %) and West Bengal (6.3 %). A unique river, the Brahmaputra drains such diverse environments as the cold dry plateau of Tibet, the rain-drenched Himalayan slopes, the landlocked alluvial plains of Assam and the vast deltaic lowlands of Bangladesh.

Originating from the great glacier mass of Chema-Yung-Dung, south east of the Mansarovar lake in the Kailash range of southern Tibet at an elevation of 5300 m, it traverses 1625 km in China, 918 km in India and 337 km in Bangladesh before emptying into the Bay of Bengal through a joint channel with the Ganga. Flowing eastward for 1625 km over the Tibetan plateau, the Brahmaputra, known there as the Tsangpo, enters a deep narrow gorge at Pe (3,500 m.) close to the eastern extremity of its course in Tibet, skirts around the Namcha Barwa Peak (7755 m) forming a sharp hairpin (or syntax) bend and continues southwards across the east-west trending ranges of the Himalayas, viz., the Greater Himalayas, Middle-Himalayas and sub-Himalayas before debouching onto the Assam plain near Pasighat. These different geo-ecological zones have distinctive assemblages of topographical, geological, climatological, floral, faunal and ethnological characteristics. The gradient of the Brahmaputra River is as steep as 4.3 to 16.8 m/km in the gorge section upstream of Pasighat, but near Guwahati it is as flat as 0.1m/km. The dramatic reduction in slope exhibited by the Brahmaputra as it cascades through one of the world's deepest gorges in the Himalayas before debouching on to the Assam plain explains the sudden dissipation of immense energy locked in it and the resulting unloading of large amounts of sediments in the valley downstream. Two rivers, the Dibang and the Lohit, join the upper course of the Brahmaputra, known as the Dihang (or Siang) river, a little south of Pasighat, and the combined flow, hereafter called the Brahmaputra, flows westward through Assam for about 640 km. until near Dhubri, where it abruptly turns south and enters Bangladesh.

Rank of the Brahmaputra among large rivers of the world in terms of discharge and Sediment yield

River	Average discharge at mouth (103.m3s-1)	River	Sediment yield(tons km-2yr-1)
Amazon	99.15	Yellow	1403
Congo	39.66	Brahmaputra(at Bahadurabad, Bangladesh)	1128
Yangtze	21.80	Brahmaputra (at Pandu,Assam)	804
Brahmaputra	19.83	Irrawaddy	616
HwangHo	19.83	Yangtze	246
Yenisei	17.39	Mekong	214
Mississippi	17.30	Orinoco	212
Orinoco	17.00	Colorado	212
Lena	15.49	Missouri	159
Parana	14.90	Amazon	46
Irrawaddy	13.56	Indus	103
Ob	12.49	Mississippi	64
Ganga	11.67	Nile	37

In the plains of Assam and Bangladesh, the Brahmaputra flows in a highly braided channel marked by the presence of numerous mid-channel and lateral bars and islands. An extremely dominant monsoon rainfall regime interacting with a unique physiographic setting, fragile

geological base and active seismo-tectonic instability together with anthropogenic impacts have moulded the Brahmaputra into one of the world's most intriguing and gigantic fluvial systems.

In the course of its 2880 km journey, the Brahmaputra receives as many as 22 major tributaries in Tibet, 33 in India -- mostly in the NER (20 of these coming from the north and 13 from the south), and 3 in Bangladesh. The Subansiri, Jia Bharali and Manas are the major trans-Himalayan tributaries of the Brahmaputra with the first two having their origin in Tibet (China) while the last one in Bhutan. The Dibang and Lohit are two other large tributaries emerging from the extreme eastern flank of the Himalayas. The Jiadhal, Ranganadi, Puthimari, Pagladiya, etc., are major rivers having their sources in the sub-Himalayas, the latter two in Bhutan. Among the south-bank tributaries, the Burhidihing originates at the Nagaland-Myanmar border, the Dhansiri and Dikhow in the Naga Hills, the Kopili in the Karbi plateau, while the Kulsi and the Krishnai flow from the Meghalaya hills.

A major river covering a large part of southern Assam which eventually joins the Brahmaputra river in Bangladesh is the Barak which is known there as the Meghna river. The Barak with its network of tributaries is the second largest river system in the NER and is a part of the Ganga-Brahmaputra-Meghna system. The river Barak rises in the Manipur hills south of Mao bordering Nagaland and Manipur, south east of mount Japvo. After traversing the Barak Valley in a westerly direction upto Karimganj, it bifurcates into two branches known as the Surma and the Kushiyara which reunite near Bhairab Bazar in Bangladesh, the joint stream being called the Meghna which later meets the Brahmaputra, known locally as the Padma, and eventually flows into the Bay of Bengal. The Barak has a total length of 902 km from its origin to its outfall with the Meghna in Bangladesh, of which the Indian reach is 564 km long. Out of the total basin area of 42,455 km2, about 62 % lies within India (NE India). The principal tributaries of Barak in Assam are Jiri, Chiri, Madhura, Jatinga in the north and Sonai, Rukni, Dhaleswari, Katakhal, Singla and Longai in the south. Average discharge of the Barak river is 694 cumec at Badarpur which may occasionally rise upto 7764 cumec during the flood season.

Its mythology and history

The Brahmaputra has been a subject of great mystery and reverence since the early days of our history and civilization. The river is mentioned as 'Lauhitya' in classical Indian literature like the Mahabharata, Purana and Hasta-yurveda. However, Kalika Purana and Jogini Tantra mention the name Brahmaputra for the first time. According to Padma Purana (Sristi Khanda), the Brahmaputra's birth is linked to Brahma, the creator of the world. Hence, the name Brahmaputra meaning the 'Son of Brahma'. As the legend goes, the lake Brahmakunda was the original source of the Brahmaputra. Lord Parasurama cut a way for the rising waters of Brahmakunda to flow down. From the Brahmakunda, waters entered Lake Lohita in the Kailash valley. Again, Parasurama cut a channel to the east. Thereafter, these waters broke down through the mountains and entered Kamrupa (ancient name of present Assam), and finally flowed down to the South Sea. The river got the name Lauhitya due to rising from Lake Lohita. The Brahmaputra was referred to as a masculine river (Nada) as it is a river flowing from east to west, unlike others that flow from west to east, besides being vast and powerful. The name Lauhitya was found in many other classical literature like Kalidasa's Raghuvamsa, Kalhan's Rajtarangani and in stone pillar inscriptions as well as copper plates. Some of these ancient plates pay eloquent homage to the sea-like river 'Lauhitya' ('Lauhitya-Sindhu'). In the Smriti works, the Brahmaputra is referred to in the following Sanskrit verse:

'Brahamaputra Mahabahu Santanu Kulanandana

Amoghagarbhasambhuta papam Lauhitya me hara'

('O Lauhitya, the large-armed son of Brahma, born as a son in the family of Santanu, from the womb of Amogha; Kindly remove my sin')

The Brahmaputra remained an enigmatic and mysterious river all through human history. However, there had been sustained efforts to unravel its hidden mysteries by countless monks, explorers and travellers from India, China and a few western nations. The most significant ones among these early explorers were Swami Pranavananda of India (1830's), Kintup of Sikkim and a Chinese Lama (1881), Sven Hedin (1905), Col. F.M. Bailey and Capt. H. Morshead (1913), Frank Kingdon Ward and Jack Cawdor (1924). However, the most stunning, and probably the last major

discovery in regard to the Tsangpo (Upper Brahmaputra) was made in 1998 when an expedition sponsored by the National Geographic Society, led by two Americans, Tibet-Scholar Ian Baker and Tsangpo-expert Kenneth Storm Jr., ultimately unveiled the riddle of the Tsangpo gorge by surveying and measuring the spectacular 30 metre high Hidden Falls. However, Chinese geographers claimed to have been exploring the gorge since 1973 and had photographed the Hidden Falls from a helicopter in 1987. The Tsangpo Grand Canyon is now the deepest, longest and most treacherous canyon of the world with a depth of 5382 metres. The mammoth river-linking plan conceived by the Government of India has been a cause of considerable concern for the people of this region in view of the serious and far-reaching environmental, human and socio-economic implications it may have for the region. Although the era of discovery may be over in regard to the course of the Tsangpo, but the potentiality of political and strategic adventurism and unsustainable mega interventions in the eastern Himalayan region seem to be assuming increasingly ominous proportions in recent times.

Basin rainfall

The Brahmaputra basin, excluding the Tibetan portion, forms an integral part of the monsoon regime of eastern Asia with a mean annual rainfall of 230 cm having a variability of 15-10 per cent. Distribution of rainfall over the basin shows marked spatial variation, for example, from as low as 175 cm in the Kopili basin located in central Assam to as high as 410 cm in the Jiadhal basin in the north-eastern part. The Himalayas exercise a dominating influence on the prevailing weather of the basin due to their location directly on the path of the moisture bearing southwest monsoon. Rainfall in the Himalayan sector averages 500 cm per year with the lower ranges receiving more than the higher ranges. A gradual increase of rainfall from the valley bottom towards the lower ranges followed by a decrease towards the higher ranges is evident from the observed annual rainfall at Dibrugarh (285 cm) in the far eastern part of Assam valley, Pasighat (507cm) in the foothills, and Tuting (274 cm) further up in the Himalayas. Monsoon rains from June to September account for 60-70 per cent of the annual rainfall in the basin, while the pre-monsoon season covering the period March through May produces 20-25 per cent of the annual rainfall caused primarily by depressions moving from the west and by local convectional storms. Precipitation in the Meghalaya plateau to the south of the valley is of the order of 1000 cm per year. Snowfall is experienced in the Brahmaputra basin in most areas with elevations of 1500 metres and above.

The summer rains are primarily controlled by the position of a belt of depressions called the monsoon trough (axis) extending from north-west India to the head of the Bay of Bengal. In the course of its north-south oscillations in summer when this axis moves closer to the foothills of the Himalayas, heavy precipitation is caused in Assam and adjoining highlands. Intense rainfall activities triggered by cloud burst occasionally cause devastating flash floods and landslides in the region.

Earthquakes and their impact on the river

Due to their strategic location in regard to colliding Eurasian (Chinese), Indian and Indo-Myanmar tectonic plates, the Brahmaputra valley and its adjoining hill ranges are seismically very unstable. The earthquakes of 1897 and 1950, both of Richter magnitude 8.7, are among the most severe in recorded history. These earthquakes have caused extensive landslips and rockfalls on hill slopes, subsidence and fissuring of ground in the valley, and changes in the course and configuration of several tributary rivers as well as the mainstream. The earthquake of 1950, for example, raised the bed level of the Brahmaputra at Dibrugarh by at least three metres leading thereby to increased flood and erosion hazard potential of the river. Lowering of the Himalayas as a result of erosion (i.e., denudation) and raising of the ground level of the Brahmaputra Valley in Assam through accelerated sedimentation (i.e., aggradations) are related phenomena. There appears to be phases of rapid aggradations of the Brahmaputra channel associated with earthquakes, mainly as a result of deposition of sediments received from landslides, followed by relatively slower removal of accumulated debris over longer time periods. Active seismicity of the NE region has a very significant impact on the hydrologic characteristics and channel pattern (i.e., morphology) of the Brahmaputra river including its host of tributaries and other water bodies (e.g., wetlands) strewn over the floodplains. Occurrence of these episodic events led to

intensification of flood hazards, especially in the aftermath of the two great earthquakes of 1897 and 1950.

Basin biodiversity and ecology

The Brahmaputra basin in North-east India belongs to the Indo-Burma biodiversity hotspot, one of the 25 hotspots of mega bio-diversity on earth recognized by the World Conservation Union (IUCN). The outstanding feature of the region is the great diversity of flora and fauna and their enormous variation in both vertical and horizontal distributions. While extraordinary luxuriance and great diversity in vegetation mark the monsoon-dominated wetter parts, the ice-covered mountain-tops and other rain-deficient areas with thin soil cover exhibit vegetation that is strikingly sparse or completely absent. Its unique physiographic and climatic characteristics make it the richest reservoir of floristic and faunal diversity in India. All the states in the basin have more than the mandatory forest cover of 33 % of their respective geographical area except Assam which has 22 % forest cover. Arunachal Pradesh, with 69,350 km2 of forested area, remains the greenest state of the region. The Brahmaputra basin in North-eastern India has 59 % forest cover, the highest in the country. The region supports all types of vegetation right from the cultivated plains to grasslands, meadows, marshes, and swamps, scrub forests, mixed deciduous forests, humid evergreen forests, temperate and even alpine vegetation. About 600 plant species from NE India are listed as rare, endangered or threatened. Further, over 800 species of orchids are reported from this region which are included in the Appendix-II of the CITES (Convention on International Trade in Endangered Species) and considered endangered. The NE region is reported to have about 7233 animal species that include 195 mammalian, 607 bird, 115 reptile, 54 amphibian, 267 fish and 4953 insect species. About 67 of these species (32 mammalian, 28 birds, 6 reptiles and 1 amphibian) are considered endangered.

The north-eastern region, especially the floodplains of the Brahmaputra, is dotted with a large number of wetlands or beels, which possess tremendous ecological significance as unique habitats for an exquisite variety of flora and fauna (Goswami and Das, 2003). These beels function as flood water retention basins and traditional fisheries. Over 3,500 such wetlands have been identified in Assam, of which 177 are more than 100 ha. in size. Most of the wetlands are now in degraded condition while a considerable number have been totally destroyed due to siltation, eutrophication, harmful land use practices and encroachment for settlement, construction of roads, railways, embankments, etc. Equally significant is the cultural diversity of the Brahmaputra basin with its great multiplicity of ethnic, social and linguistic groups occupying their unique habitat in the basin.

River hydrology

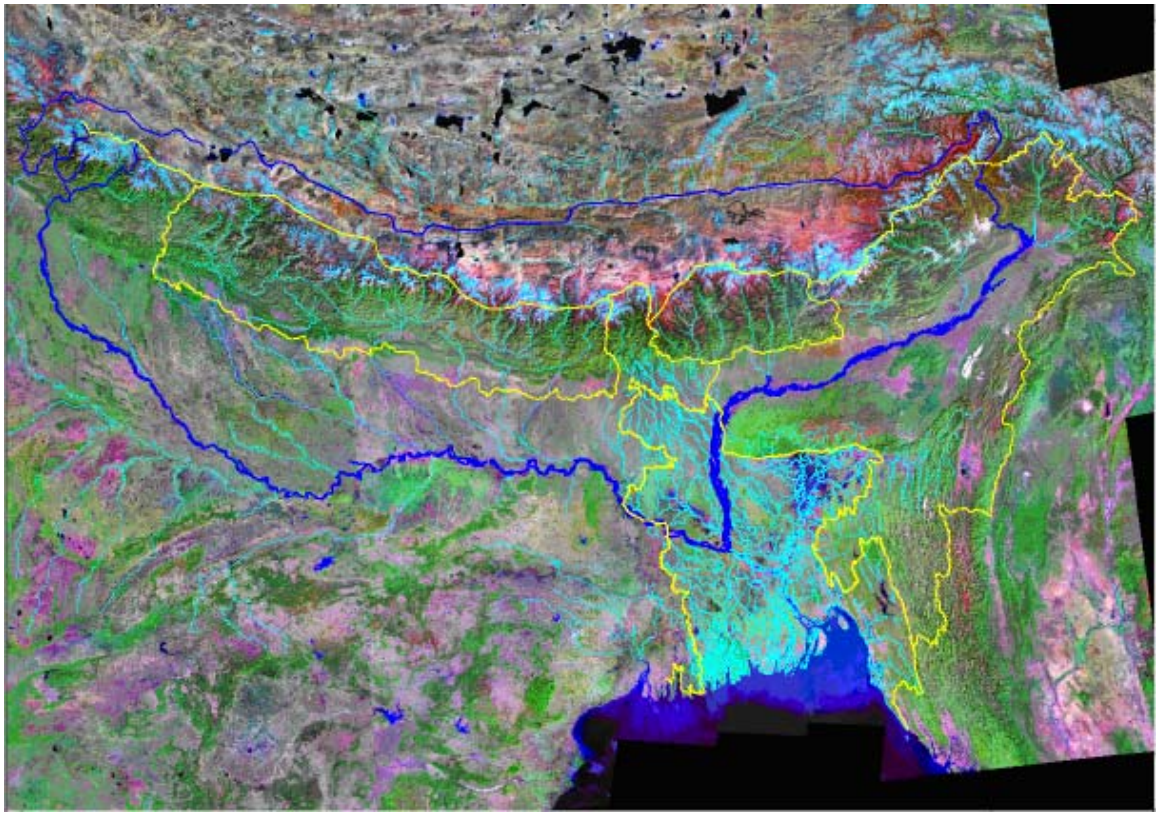
The flow regime of the Brahmaputra that responds to the seasonal rhythm of the monsoon and freeze-thaw cycle of the Himalayan snow is characterized by an extremely large and variable flow, enormous rates of sediment discharge, rapid channel aggradations, accelerated rates of basin denudation and unique patterns of river morphology. With an average annual discharge of 19,830 cubic metre per second (cumec) at its mouth, the Brahmaputra ranks fourth among the large rivers of the world (Table 1). Water yields (volume of water drained by unit area of the basin) of the Brahmaputra and some of the tributaries like the Subansiri, Jia Bharali and Manas are exceedingly high, surpassing most of the world's major rivers. High monsoon rainfall in the upper catchments and their steep gradients are considered to be the major factors responsible for the high rates of unit discharge which in turn help generate the high sediment yield from the basin and contribute significantly towards causing drainage congestion in the valley. The highest recorded daily discharge in the Brahmaputra at Pandu was 72,726 cumec in August 1962, while the lowest was 1757 cumec in February 1968. The discharge in the river between summer high flows and winter low flows fluctuates, on an average; by 12 times although in certain years it has been as high as 20 times. The mean annual flood of the river viz., 48,200 cumec, has a recurrence interval of 2.2 years, while the maximum recorded flood discharge of 72,726 cumec has a return period of 133 years. The enormously large variations in the river's daily discharge over different seasons are a remarkable feature of its flow regime. High intensity flash floods with enormous damage potential constitute another significant phenomenon more frequently observed in recent years in the case of some of the tributary rivers of the Brahmaputra.

The Brahmaputra is one of the most heavily sediment-laden large rivers of the world, second only to the Yellow (Hwang Ho) river of China in terms of the amount of sediment transported per unit drainage area, viz., 1,128 metric tons per sq. km. per year at Bahadurabad in Bangladesh. The river carries an average annual suspended sediment load of 400 million metric tons at Pandu (Assam) with an average daily rate of 2 million tons in the flood season (May through October) accounting for 95 % of the annual sediment load. Daily sediment discharge rates as high as 26 million metric tons are recorded during exceptionally high peak flows. The Brahmaputra is a classic example of braided river with multiple channels twinning around numerous mid-channel and lateral sandbars, locally known as chars. The banklines of the river in the erosion-prone areas undergo drastic changes during the flood season causing massive erosion hazard.

Flood and erosion hazards

The Brahmaputra and Barak basins, particularly the portions in Assam, have earned notoriety for the awesome hazards of annual flood and erosion that create mayhem every year, bringing misery to the people and shattering the fragile agro-economic base of the region. The valleys of the Brahmaputra and the Barak, which together account for 24.9 % of the surface area of NER and 80.8 % of Assam, are two worst flood ravaged regions of India receiving, on the average, 3-4 waves of flood every year. These floods cause extensive damage to agriculture, environment, human life and property, thereby affecting severely the economy of the state. With over 40 % of its land surface (3.2 million ha) susceptible to flood damage, which is 9.4 % of the country's total flood prone area, the Brahmaputra valley in Assam represents one of the most acutely hazard-prone regions in the country.

Floods in the NE region are caused by a combination of natural and anthropogenic factors. The unique geo-environmental setting of the region vis-à-vis the eastern Himalayas, the highly potent monsoon regime, weak geological formation, active seismicity, accelerated erosion, rapid channel aggradations, massive deforestation, intense land use pressure and high population growth especially in the floodplain belt, and ad hoc type temporary flood control measures are some of the dominant factors that cause and/or intensify floods in the Brahmaputra and the Barak basins (Goswami, 1998). The scenario is further exacerbated by a myriad of social, environmental and economic factors that make populations increasingly vulnerable.



Satellite Image showing the Brahmaputra and Ganga Rivers

Assam, the most flood prone and flood ravaged state of the region, has experienced major floods in the years 1954, 1962, 1966, 1972, 1977, 1984, 1986, 1988, 1998, 2000, 2002 and 2004, 2007 and currently in 2008. In the aftermath of the Great Earthquake of 1950, the damage potential, intensity and frequency of floods have increased significantly. The floods of 1988 and 1998 and 2004 were the worst ones in recent history. However, the flood hazard of 2004 broke all previous records of flood damage, affecting 28.5 million ha. of land, 12.3 million people, 12.57 million ha. of cropland, and 10,560 villages besides claiming 251 human lives and innumerable cattle and wildlife. All the 27 districts were affected by the flood and the total damage was estimated at Rs. 6500 crore. As many as 336 nos. of breaches had occurred in the embankments that aggravated the flood, erosion and sedimentation problems. Several tributaries of the Brahmaputra had undergone drastic channel avulsion causing heavy erosion, extensive sedimentation and severe flooding. Exceedingly heavy, incessant and concentrated rainfall in the upper catchments of flashy rivers like Pagladiya, Puthimari, Pohumara, Beki-Manas-Aie, etc., synchronization of flood peaks in the tributaries and the main stream, breach of a natural dam upstream of Kurichu Hydel Project in Bhutan and release of excessive amount of water by the Kopili Hydel project together with long-continued human depredations in the watersheds are cited as the major causative factors of the flood havoc. In the current flood season beginning mid-July 2008 massive flash floods have devastated large areas in Lakhimpur district due to breaching of embankments and overtopping of riverbanks by rivers like Dikrang, Ranganadi and Singora caused reportedly by sudden release of excess waters from the Ranganadi river project, and also breaching of the Brahmaputra embankment at Matmara. Breaching of embankments has been a major cause of intensification of the flood hazard in recent times. Erosion hazard posed by the Brahmaputra is also extremely severe in several vulnerable sections like Majuli, Palasbari, Rohmoria, Bhuragaon, Bokuwal, etc. Majuli, the world's largest inhabited freshwater island and the legendary nerve centre of Neo-Vaishnavite cultural heritage of Assam, has already lost as much as 371 sq km of its

landmass to the river in the last 50 years with a reduction in area from 1246 sq km in 1950 to 875 sq km in 1998.

A grim flood scene

Utilization of Water Resources

The Brahmaputra and its tributaries carry more than 30 % of the total water resources potential of the country. Besides, this region has the highest per capita and per hectare availability of water in the country and possesses as much as 41 per cent of the country's total hydropower potential. Similarly, as against an ultimate irrigation potential of about 4.26 million hectares, the area presently under irrigation is only 0.85 million hectares. Likewise, only 4.3 % of existing groundwater potential has been developed thus far although availability of ground water at relatively shallow depth (within 20 m) is very high in the region, especially in the valley areas. River navigation in the 890 km long reach of the Brahmaputra from Sadiya to the Bangladesh border which is now the 'National Waterway No. 2' of the country has also not been utilized to its potential.

Agriculture, the mainstay of most of the basin dwellers, suffers the most as a result of gross underutilization of existing water resources and the impact of ravaging flood and erosion hazards. In view of the extensive flood damage to paddy crops, there seems to be an urgent need to adjust the crop calendar by increasing the emphasis on winter (rabi) crops. However, development of sustainable, localized irrigation facilities that safeguard environmental and social concerns is a prerequisite for effecting any such change. For this, there needs to be a significant improvement in the power availability scenario in the state based on sustainable energy sources.

In the last few years there has been a spurt of activity in identifying more than hundred mega dams in the eastern Himalayas especially in Arunachal Pradesh. Several of these like the Lower Subansiri (2,000 MW), Dibang (3000 MW), Kameng (600 MW), Tipaimukh (1500 MW) and Ranganadi (405 MW) are presently at various stages of planning and development. There is growing concern about the possible negative impact of the proposed large dams in terms of their viability and sustainability vis-à-vis the delicately poised geo-environmental base, ecological balance, ethno-cultural heritage and the extreme dynamism of geophysical processes in the region. In view of the inadequate knowledge base, lack of systematic data over an adequate time

span and across diverse terrains and considering the intense dynamism and immense scale of the geophysical processes of the Himalayas, the wisdom behind constructing series of big dams in the eastern Himalayas raises more questions than can possibly be answered at the present stage of our knowledge and development. Besides, given the raging controversies over issues like inappropriate assessment of environmental and social impacts, lack of transparency and public participation in the decision-making processes and displacement of local communities, loss of their lands and livelihoods, the question assumes further complexity. The increased frequency and magnitude of catastrophic flash floods in Assam in recent years that are associated with upstream dams in neighboring states and countries has been a strong pointer in regard to the urgent need for a change in the policy so far followed in the case of harnessing the water resources of this geophysically, ecologically and socio-culturally hypersensitive region without ascertaining the probable impacts on the lower riparian states like Assam.

The policies and practices for utilisation of these resources in the future need to have a broader outlook and a changed paradigm and philosophy of development. As against the ad hoc, piece meal, short-term structural measures that are being adopted now, an integrated basin management approach for the rivers based on the principles of soil and water conservation as well as sustainable development needs to be adopted. It is high time we go beyond the confines of techno-centric management to a broader notion of resource utilisation and disaster management. Proper assessment and reduction of vulnerability, empowering of local populations, and strengthening of existing institutions are essential for this. Especially for the Brahmaputra and the Barak rivers with their diverse background of natural and human heritage, such a plan may contribute immensely towards ensuring food, health and ecological security. As a long-term strategy for resource utilization and hazard management, a judicious mix of structural and non-structural measures with a greater emphasis on the latter, should form the core of the watershed based regional plan. The water resources of the North-east region must be planned on zonal basis to ensure optimal resource utilization, hazard management, and welfare maximization. Networking of hydro-meteorological data centres across State, national and international boundaries can play a key role in the management of water resources and flood hazards in the Brahmaputra basin. Being an international river of immense size, huge resource base and high hazard potential, only effective cooperation and coordination among the basin countries together with persistent efforts at the national and regional levels will be able to create an effective response mechanism to the problems of flood and erosion and usher in an era of progress and prosperity to the region.

It will, therefore, be apt and proper for us to first fully explore the potential of using time-tested, well-regarded and environmentally more benign methods of water resources management such as watershed management and rainwater harvesting which fit well into the newer paradigm of water development. The stakes seem to be too high and risks too great in any venture of immense dimension having potential for far-reaching consequences to call for any hasty decision.

Socio-economic and Cultural Scenario

The Brahmaputra basin is extraordinarily rich in its cultural diversity with a large multitude of ethnic, social and linguistic groups occupying their unique ecological niche and exhibiting varying scales of underdevelopment. The basin carries a total population of more than 80 million. The spatial distribution as well as density of population is quite uneven in the basin. The highest density of 828 persons/sq. km is recorded in the Bangladesh portion of the basin followed by India (143 persons/sq. km), Bhutan (26 persons/sq. km) and Tibet (6 persons/sq. km). In fact the general pattern of population distribution in the Brahmaputra basin follows the physiographic and climatic zones from north to south with a very sparsely populated greater Himalayan region in the north succeeded by the zone of relatively modest density in the middle Himalayan valleys followed by the more densely populated south zone occupying the submontane belt and the floodplain areas. The Brahmaputra basin in India is home to 200 indigenous multi-ethnic communities each with its distinct history, culture and geographic space. These are widely scattered from the Tibetan highlands through the Arunachal mountains to the Assam plains and its adjoining hills.

The Brahmaputra valley in Assam represents the most urbanized and industrialized part of the basin. Assam is richly endowed with petroleum and natural gas and is famous for production of tea. The tea industry was first established by the British in 1833. Robert Bruce, an official of the British Empire, is credited with the discovery of tea in Assam in 1823. However, Maniram Dewan, an illustrious son of Assam, is credited with the emergence of tea plantation in the state. At present, there are altogether around 40,000 tea gardens in the state out of which about 800 are large gardens with their own factories. This industry has an annual production of 454,000 metric tons accounting for more than 52 per cent of the country's total. However, the industry now faces stiff competition in the international market from countries like Sri Lanka and Kenya, besides having managerial problems at home. The Brahmaputra valley in Assam is also richly endowed with vast reserves of petroleum and natural gas. Oil was first struck at Digboi in upper Assam in 1889 and its commercial production started in 1899 after the formation of the Assam Oil Company. At present, oil fields in the Brahmaputra valley in Assam produce about 5,145,000 metric tons of crude oil and 1890 M.C.M of natural gas. Besides, the state produces 701,000 metric tons of coal and 487,000 metric tons of limestone. The region is also known for its traditional silk products and has tremendous potential for development of handicrafts based on indigenous resources like cane, bamboo, bell-metal, etc. With its extremely scenic landscapes, rich biotic resources, colourful ethnic communities, unique cultural heritage, historical monuments and majestic water courses, the Brahmaputra basin in North-east India carries immense potential for development of nature-based, people-centered industries like eco-tourism, cottage and handloom, horticulture, floriculture, etc.

In the course of its long and arduous journey from the snowy heights of the Tibetan Plateau through the precipitous slopes of the Eastern Himalayas to the landlocked valley in Assam and the deltaic lowlands of Bangladesh until it meets the sea, the Brahmaputra and the host of tributaries joining it en route sustained through millennia a variegated socio-religious and cultural milieu on both banks enriched with colourful legends and rituals, traditions and ethos. These include Buddhist monasteries, Hindu temples, Churches, Mosques, Gurudwaras, besides numerous other institutions of traditional and ethnic faith and culture. The Buddhist monastery at Tawang and the Parasuram Kunda on Lohit river in Arunachal Pradesh, the Siva doul (temple) and other monuments of the Ahom rule in upper Assam, Biswanath temple, Nagsankar temple, Da-Parbatia and Mahabhairav temple near Tezpur, Barpeta Satra and Kirtan Ghar, Batadrawa Satra, Haigrib-Madhab temple and Poa-Mecca at Hajo, Kamakhya temple in Guwahati, Gurudwara and Rangamati mosque in Dhubri district are some of the ancient monuments of great repute and reverence on the banks of the Brahmaputra river and its tributaries.

Guwahati, the capital city of Assam and gateway to the Northeast, known as Pragjyotishpura in ancient times, has the earliest reference in the great epic Mahabharata. A number of legendary temples of great antiquity and eminence adorn this ancient city. The most outstanding among these is the Kamakhya temple on the Nilachal hill overlooking the Brahmaputra river. It is revered by devout Hindus as one of the holiest Shakti Peeths in India. The present temple was constructed by king Naranarayana and his brother Chilaraya in 1565 A.D. Other temples of significance in and around the city include the Nabagraha temple -- one of the earliest centres of ancient astronomy and astrology, Umananda temple perched on a rocky island in the Brahmaputra, Ugratara temple, Chatrakar temple, Viswakarma temple, Basistha Ashram temple, Sukreswar temple, Dol Govinda temple, Dirgheswari temple, Ashwaklanta, Manikarneswar temple and Kama Deva temple.

Majuli island in the middle of the Brahmaputra river, off Jorhat town in Upper Assam, is the most venerated and thriving nerve centre of the Neo-Vaishnavite religio-cultural heritage of Assam. The foundation of this great institution was laid in the mid-15th century by Srimanta Sankardeva, one of the country's greatest Vaishnavite Gurus, religious preachers, social reformers, litterateurs and artists. The hallmark of this unique religio-cultural tradition is the institution of Satras (monasteries) anchored on the cult of monotheism and dedicated to the propagation of Neo-Vaishnavism through the medium of devotional songs, dramas and dances. These are powerful centres for dissemination of knowledge and the art of harmonious living.

Further, the Brahmaputra was witness to and associated with one of the most glorious moments in the history of Assam, when in the fierce naval battle of Saraighat fought on the Brahmaputra

near Guwahati in April 1671, the Great Ahom General Lachit Barphukan defeated the invading Moghul army led by Raja Ram Singh and safeguarded the sovereignty of the state. The unparalleled valour, patriotism and supreme sense of devotion to duty displayed by this great warrior was exemplified by his act of beheading his own uncle for dereliction from his assigned duty in the war, saying what has come to be an immortal catch phase and soul elevating memory for countless generations in this part of the country - "my uncle is not greater than my country."

Conclusion

Having two major international rivers passing through three of the most populous countries in the world, the management of the NER's vast water resources needs adequate regional as well as international cooperation and pooling of resources and expertise at the national and global level. Strengthening of the scientific and technical information base, assessment of available technologies vis-à-vis the unique nature of the region and induction of more appropriate strategies are other aspects that need to be emphasized. What is most needed, of course, is a strong political will both at the state and national levels and a sustained popular zeal to convert the water resources of the region into a force for sustainable development of the region through an integrated, multi-disciplinary approach that covers not only technological aspects but also social, economic and environmental aspects. What bothers one the most today is the level of trade off between a multitude of seemingly valid concerns raised by critics and the apparently legitimate societal needs that the structural measures are capable of satisfying in an underdeveloped region like the North-East. Under the existing circumstances, any intervention if at all required for the interest of society, ecology and economy of the region, must be on a modest scale with least possible impact on the environment and society in the downstream direction as well through adoption of judicious mitigative measures adopted on the basis of dialogue and discussion. Any deviation from this is fraught with uncertainties that may lead to grave consequences. On how humanity at large and our country in particular face up to the formidable challenge posed by the Brahmaputra and use its vast resources as a vehicle of economic change and social transformation will depend the peace and prosperity of the entire region.

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