ENSO CLIMATE CYCLE AND SEASONAL FORECAST

An alternative for flood management in Bangladesh

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Following the dissipation of the 2005-06 weak La Nina (cooler than average SSTs) in October-November-December 2005, sea surface temperatures across the central and eastern tropical Pacific continued to increase in January-February-March, and are currently running average. There is now a significant possibility that ENSO-neutral condition exists for next 3-months. Based on the behaviour of past ENSO-neutral conditions, Bangladesh is likely to experience normal flooding during the monsoon.

AT present, Bangladesh has a flood forecasting lead-time of only three days or so. Due to short lead-time and outdated dissemination network, these products are not often very useful for long-term planning purposes. Neither the national (i.e., government agencies) nor the individual (i.e., farmers) decision makers can really use these products for any kind of responses related to planning purposes. Unfortunately, these deterministic forecasts have further limitations due to nonlinearity in the climate system and the growth of numerical forecasting model errors over time. Therefore, it is difficult to increase the lead-time of these forecasts after 6-days and almost impossible to increase the lead-time after 10-14 days. While these limitations are effective in many developed countries, it is therefore unlikely that, the lead-time of the present short-term deterministic forecasts in Bangladesh can see any dramatic change in the foreseeable future.

For any type of response planning (i.e., relief operation at the government level and crop plantation at the individual level), there is a demand for long-range (month to season) flood forecasts. The seasonal forecast is a type of long-range forecast. Seasonal forecasting is the outcome of a shift from deterministic predictions (e.g., 0.2 mm of rain will fall tomorrow) to probabilistic forecasting schemes. Here the emphasis is on forecasting the probability that a particular climate variable will be significantly above or below a mean state over a time-averaged period (usually ranging from a month to a season) (e.g., there is a 20% probability that the seasonal flooding in the northern part of Bangladesh will be higher than normal). Primary observations revealed that there is teleconnections between the strength of El Nino/La Nina and the climate variability (magnitude of flooding, for example) in Bangladesh.

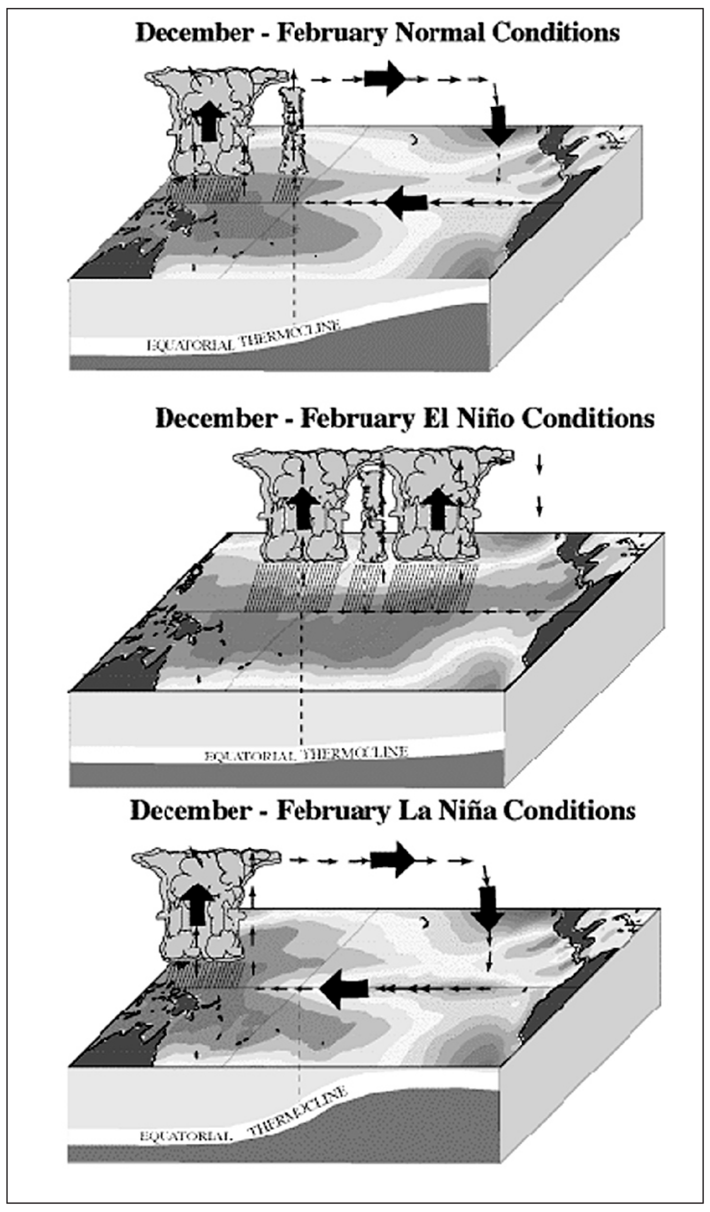
What is El Nino/La Nina?

The term El Niño was first coined more than 100 years ago to describe the unusually warm waters that would occasionally form along the coast of Ecuador and Peru. This phenomenon typically occurred late in the calendar year near Christmas, hence the name El Niño (spanish for "the boy child", referring to the Christ child). Today the term El Niño is used to refer to a much broader scale phenomenon associated with unusually warm water that occasionally forms across much of the tropical eastern and central Pacific. The time between successive El Niño events is irregular but they typically tend to recur every 3 to 7 years.

La Niña is the counterpart to El Niño and is characterised by cooler than normal sea-surface temperatures (SSTs) across much of the equatorial eastern and central Pacific. A La Niña event often, but not always, follows an El Niño and vice versa. Once developed, both El Niño and La Niña events tend to last for roughly a year although occasionally they may persist for 18 months or more. El Niño and La Niña are both a normal part of the earth's climate and there is recorded evidence of their having occurred for hundreds of years.

Although El Niño and La Niña events are characterised by warmer or cooler than average SSTs in the tropical Pacific, they are also associated with changes in wind, pressure, and rainfall patterns. In the tropics where El Niño and La Niña form, rainfall tends to occur over areas having the warmest SSTs. Under normal conditions (see figure 1) the warmest water is found in the western Pacific, as is the greatest rainfall. Note that the dark arrows in the figure indicate the direction of air movement in the atmosphere with upward arrows associated with clouds and rainfall and downward-pointing arrows associated with a general lack of rainfall. Notice that under normal conditions winds near the ocean surface travel from east to west (these winds are called "easterlies") across the Pacific. Under El Niño conditions, the easterlies weaken, warmer than average SSTs cover the central and eastern tropical Pacific, and the region of heaviest rainfall has moved eastward as well. La Niña conditions could be thought of as an enhancement of normal conditions. During these events unusually cold ocean water extends westward to the central Pacific, the easterlies near the ocean surface are stronger than usual, and the warm SSTs in the western Pacific are accompanied by heavier than usual rainfall.

Figure-1

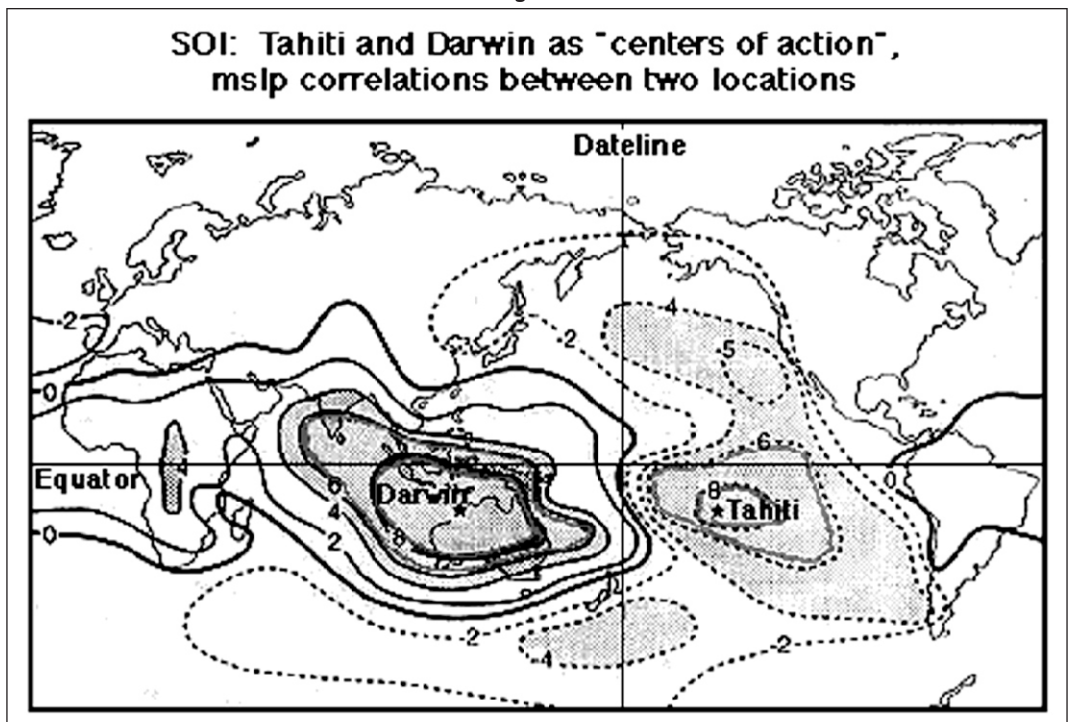


Schematic view of sea surface temperature and tropical rainfall (Figures courtesy of NOAA, Climate Prediction Centre).

What is El Nino-Southern Oscillation (ENSO)?

While the tropical ocean affects the atmosphere above it, so too does the atmosphere influence the ocean below it. In fact, the interaction of the atmosphere and ocean is an essential part of El Niño and La Niña events (the term "coupled system" is often used to describe the mutual interaction between the ocean and atmosphere). During an El Niño, sea level pressure tends to be lower in the eastern Pacific and higher in the western Pacific while the opposite tends to occur during a La Niña. This see-saw in atmospheric pressure between the eastern and western tropical Pacific is called the Southern Oscillation, often abbreviated as SO. A standard measure of the Southern Oscillation is the difference in sea level pressure between Tahiti and Darwin, Australia (see figure 2). Since El Niño and the Southern Oscillation are related, the two terms are often combined into a single phrase, the El Niño-Southern Oscillation, or ENSO for short. Often the term "ENSO Warm Phase" is used to describe El Niño and "ENSO Cold Phase" to describe La Niña.

Figure-2



Tahiti and Darwin are at opposite ends of the Southern Oscillation's seesaw, and so the difference in pressure between them is used to measure the Southern Oscillation. The numbers represent a statistical measure called the correlation coefficient. The figure shows that the pressure variation at Tahiti is as closely related to Darwin as are locations near to Darwin, but with the opposite sign (i.e., if the Pressure is high at Darwin, it is low at Tahiti and vice versa). (After Rasmusson, 1984.)

Why do we care so much about what goes on in the tropical Pacific with El Niño and La Niña?

Once developed, El Niño and La Niña events typically persist for about a year and so the shifted rainfall patterns associated with them typically persist for several seasons as well. This can have a significant impact on people living in areas of the tropical Pacific since the usual precipitation patterns can be greatly disrupted by either excessively wet or dry conditions. In addition, the shifting of tropical rainfall patterns during El Niño and La Niña not only affects the tropical Pacific region but areas away from the tropical Pacific as well. This includes many tropical locations as well as some regions outside the tropics in both the Northern and Southern Hemispheres. Why this occurs is related to how rainfall (associated with sea surface temperatures) in the tropics affects wind patterns in the atmosphere. In the tropics, air that rises to form clouds and precipitation at a certain location must subside somewhere else (what goes up must come down). This is how one tropical region that is persistently wet, for example, can lead to another region being persistently dry. Shifts in tropical rainfall and winds can also affect regions outside of the tropics by altering prevailing wind patterns that circulate around the globe.

How El Nino/La Nina years are defined?

Given that there are typical characteristics of El Nino and La Nina, how are specific 'ENSO events' defined? How large must the value of the index be, and for how long must it persist in order for an El Nino or La Nina to be identified as strong or moderate? Any definitive objective procedure for classifying intensity is yet to be explored. However, a common method used for this purpose is based on the Nino 3.4 sea-surface temperatures (SST) index. (see figure-3)

In this method, an El Nino or La Nina event is identified if the five-month running average of the Nino 3.4 index exceeds +0.5Êdeg. C (for El Nino) and 0.5 deg. C (for La Nina) for at least six consecutive months. According to this multivariate ENSO index, seven major El Nino years are 1997-98, 1991-92, 1986-87, 1982-83, 1972-73, 1965-66 and 1957-58, and seven major La Ni-a years are 1998-99, 1988-89, 1975-76, 1973-74, 1970-71, 1964-65, 1954-55 and 1949-50.

This ranking may even vary if based on an averaged Nino 3.4 index over different seasons. Also, it was observed that the relative ranking of events would vary if the ranking were based on an index other than Nino 3.4. For example, the classification system in the Western Regional Climate Centre (WRCC) that is based on the average value of SOI for the months of June-November provides a different ranking of events. With this WRCC approach, the ENSO phase is determined by atmospheric quantities (SOI) (value of SOI = -1.0: Strong El Nino, SOI = -0.5: Moderate El Nino, SOI = + 0.5.: Moderate La Nina, and SOI = +1.0: Strong La Nina). Another classification that is based on cold (La Ni-a) and warm (El Ni-o) episodes is also available. This has been compiled to provide a season-by-season breakdown of cold and warm conditions in the tropical Pacific. However, as compared to other methods, the Nino 3.4 SST ranking method is said to be the most reliable and widely used.

El Nino/La Nina and seasonal flooding in Bangladesh

Approaches to seasonal forecasting can broadly be divided into two categories: empirical/statistical techniques, and numerical/dynamical modeling, of which the former have historically been more widely (developed. Unfortunately, research in Bangladesh relating to seasonal flooding has just begun. Therefore, considering the present research level in Bangladesh, Bangladesh can be benefited by using simple statistical methodology to develop seasonal flood forecasts. It can be added here that, based on the global mean atmospheric response to different large-scale modes of oceanic variability, (e.g., El Nino-Southern Oscillation (ENSO) and associated teleconnections), it may then be possible to predict how the flooding in Bangladesh will respond to certain oceanic situations from the knowledge of how the atmosphere (here Bangladesh flooding) has responded in the past to the variation of sea-surface temperatures (SST) in the tropical Pacific Ocean, with a variety of lag times. This predictability can be enhanced with the information achievable from monitoring the downstream stream-flows -- that are generated mainly from upstream rainfall conditions -- in advance of the flooding season.

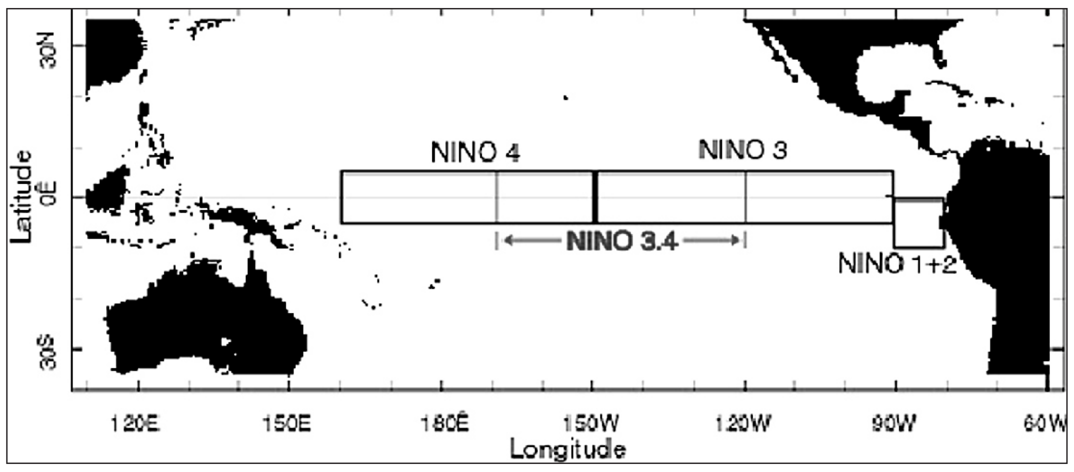
The SOI-rainfall relation in the greater Ganges-Brahmaputra-Meghna (GBM) basin systems shows strong casual connection to SOI extremes indicating negative value to dry and positive value to wet. Therefore, when SOI is negative (i.e. strong El Nino years) the whole basin experiences less rainfall. The deficiency of rainfall causes Bangladesh rivers to be drying because of low-flow and, as a result, the country faces severe drought. Please note that the moderate El Nino years don't always cause a similar atmospheric response (drought).

On the other hand, when SOI is positive (both in strong and moderate La Nina years) there is significant increase of rainfall along the greater GBM basins causing flooding along the whole catchments. This, in turn, severely floods Bangladesh, as it is the lowest riparian country in these basins.

ENSO-2005/06 and Bangladesh floods

Following the dissipation of the 2005-06 weak La Nina (cooler than average SSTs) in October-November-December 2005, sea surface temperatures across the central and eastern tropical Pacific continued to increase in January-February-March, and are currently running average. There is now a significant possibility that ENSO-neutral condition exists for next 3-months. Based on the behaviour of past ENSO-neutral conditions, Bangladesh is likely to experience normal flooding during the monsoon of 2006. This is a probabilistic type of picture that is based on monitoring of the ocean and knowledge of how the atmosphere has responded in the past to similar SSTs in Bangladesh, with a variety of lag times.

Figure-3



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GROUNDWATER RECHARGING

Is there a link to transboundary water conflicts resolution?

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Experts have begun to realise and question the competence and capability of the Joint River Commission (JRC) in dealing with issues relating to transboundary water conflicts resolution in the region. A cursory evaluation may surface that the commission is more a talker by shivering shoulders than really understanding the issues by depth required in facing its counterparts across the talking table. The role of JRC as such must shift from 'eating and meeting' to substantially 'acquiring and achieving' the national benefits and interests.

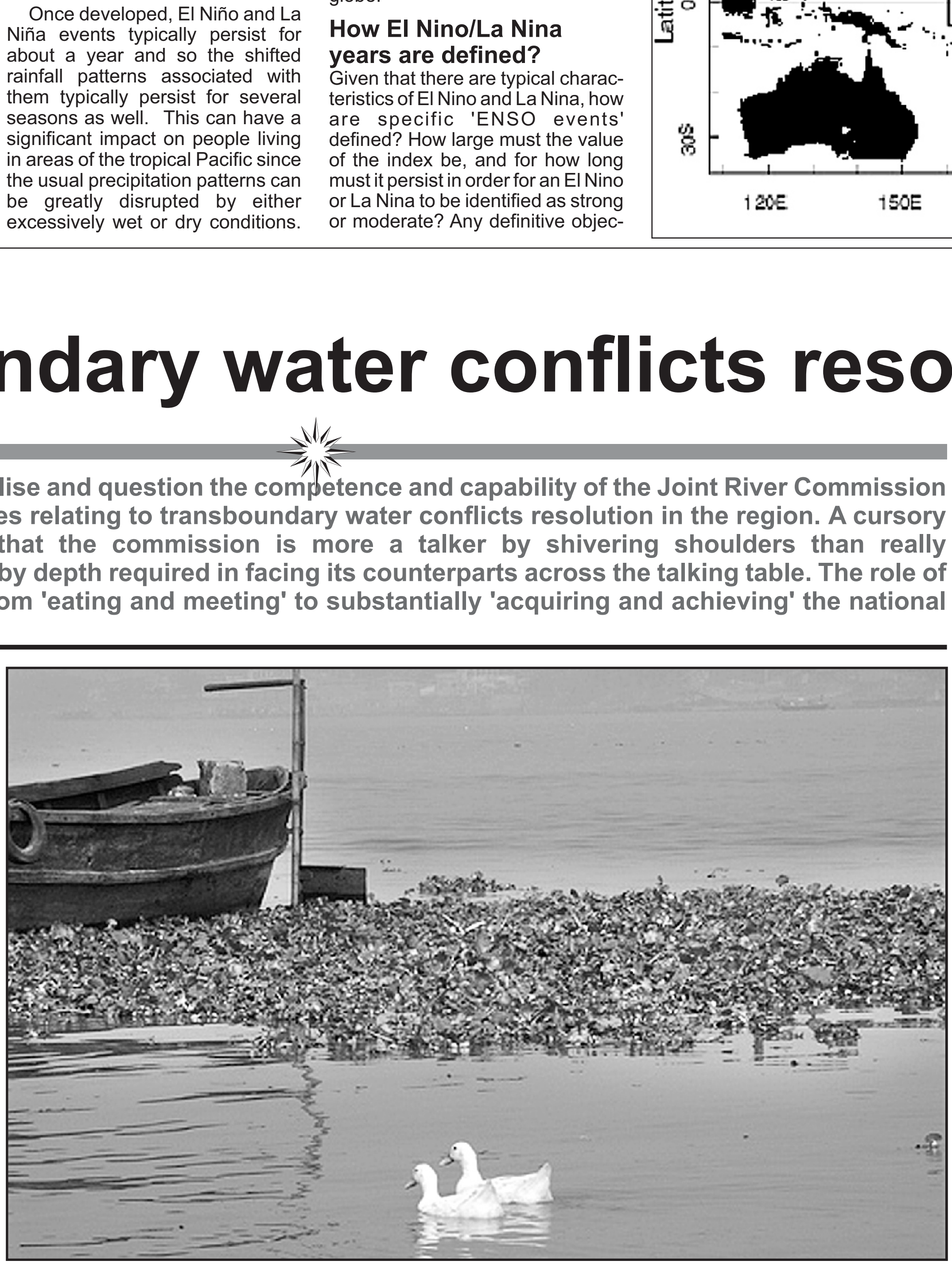
OVER 97 percent of water in totality on this planet is saline and undrinkable. Only 0.5 percent of the remaining less than 3 percent is accessible for human use and ecosystem. Of this accessible total, 10 million km3 is stored in underground aquifers, 21,120 km3 in natural streams, 119,000 km3 in rainfall on land after accounting for evaporation, 91,000 km3 in natural lakes and, little over 5000 km3 in man-made storage. Such huge amount of water within the nature is justifiably unevenly distributed for maintaining ecological balance in general and hydraulic equilibrium in particular over the planet. Human intervention on water resources for use and actions that pollute it faster than nature can correspondingly replace and recycle, has yielded over-sagging stress and culminated in rupture in many parts of the world. This does not mean that world is running out of water but it is not available or required when and where people need it. The known four ways of contributing to such water stress phenomenon are namely (i) over abstraction of groundwater, (ii) excessive withdrawal of surface water, (iii) pollution of fresh water and, (iv) inefficient use of water resources.

Notably 50 percent of all drinking water, 40 percent of industrial water and 20 percent of irrigation water in the global perspective are sourced from underground aquifers, the largest fresh water source of supply. About one-third of the world population's water needs are met by groundwater supplies. Over-abstraction principally for irrigated agriculture resulting in drawdown of the water table has thus primarily affected its quality particularly in the shallow aquifers and further because of widespread indiscriminate withdrawal in many parts of the world in quantities greater than the nature's ability to renew, the hydraulic conditions have been disrupted. The disruption has led to seawater intrusion along shorelines, causing salinisation of coastal agricultural lands. The water table has dropped by tens of meters in many places. Falling water tables have also exacerbated land subsidence in many regions causing land fissures and damages to roads, railways and housing including many other settlements.

In the face of continuous stretching of the water stress worldwide, agriculture accounts for 70 per cent of freshwater consumption, mainly for irrigation of agricultural crops, as against 82 per cent by the developing and the underdeveloped.. Agricultural demand for water is projected to continuously increase, since much of the additional food that will be needed to feed the increased population is expected to come from an increase in irrigated agriculture.

In Bangladesh the distribution of water use by sectors is, in agriculture 59 percent, municipal 10 percent, industry 11 percent, navigation 15 percent and, environment 2 percent. Such use-distribution by sector over time has not developed in composite manner rather one has little or no link to the other in water use planning resulting in hydraulic disruption of streams. In this backdrop of the total use for agricultural purpose, ground water accounts for 70 percent and surface water 30 percent. Quality-wise arsenic contamination of ground water is a challenge for ensuring drinking water supply in the rural areas. According to a recent news (The Daily Ittefaq, May 18, 2006) 1.5 million tubewells are contaminated by arsenic mixed water threatening about 70 million rural population. Groundwater depletion is the major threat for domestic supply in urban areas particularly in known major cities.

Another official statistics published in the recent past (The Daily Star, March 23, 2006) revealed that 890 thousand out of 3.15 million hectares of irrigated lands in the peak season went almost beyond irrigation for excessive drawdown of groundwater table making 300 thousand shallow tubewells virtually redundant. The report further revealed that the south-west part of the country is reportedly empty of underground aquifer. Water resource management for meeting the needs of different sectors is severely stressed. Apart from other needs, only 2 percent annual increase in food production for 40 percent absolute increase in population by 2025, to the extent based on underground aquifers, may as such severely stress-batter the nation's groundwater reliability.



Land development has seriously impacted the underground aquifer storage. The closed water bodies in Bangladesh are estimated at 351,000 ha that includes ponds, baors and costal low lands. Further the haor area measures about 114,000 ha and the Kaptai hydro-power dam storage is 68,000 ha. Water bodies are rapidly shrinking primarily by upstream withdrawal and then from corresponding invasion by agriculture. The groundwater recharging phenomenon in the system is thus being destroyed.

Estimation of groundwater availability in Bangladesh has remained as a source of considerable controversy differed by opinions of experts within the country. National Water Management Plan, 2003 failed to apprehend any probability of nation-wide deficit in groundwater resources by 2025 except in a limited area on the west. It has been evidenced that at the point the river Ganges entering into Bangladesh, along the western border the underground aquifers depletion is gradually advancing easterly. Experts are of the opinion that upstream withdrawal of surface water has ceased refilling the underground aquifers. The concerns for same phenomenon in case of barrage at the upstream of Teesta and the hydro-power dam planned to be built soon across the river Borak in India upstream of the Meghna basin may sustain. The process of recharging underground aquifers at the west, central, and east at some point of time may thus culminate in total hydrologic disruption drying up the subsurface water storage within the country.

The geologic formations of aquifers differ from place to place. Uncertainty over the physical properties of aquifers is a primary problem for its management. Furthermore the difficulty of ground water management often relates to transboundary issues between countries. Additionally, ground water is influenced by land development patterns. These influences can cause decreasing water levels and contamination of ground water. It is important to protect the recharge area, which primarily captures the precipitation on the surface in order not to disturb water flow into the ground. Hydraulic behaviour of ground water is much more complex compared to that of surface water. Groundwater disperses beneath the surface irrespective of state boundaries. Unfortunately, the question of how much land needs to be protected for recharging groundwater is still not known to the scientists.

The sovereignty of an aquifer can be determined in five ways namely (i) the entire aquifer within the state, (ii) a confined aquifer divided by the state boundaries, (iii) an aquifer that is entirely within a state but hydrologically linked to international river, (iv) an aquifer that is entirely within a state but hydrologically linked with another aquifer in a neighbouring state, (v) an aquifer that is entirely within the territory of a state but its recharge area is in another state. Intra-state rivers or lakes may have influences where there is hydrological relationship or links to an aquifer.

The International Law Association (ILA), established in 1873, is a non-governmental organisation that works for the development of emerging rules of international law. The earliest works of ILA regarding transboundary groundwater regulations is the Helsinki Rules in 1967. In this rule international drainage basin was defined as "a geographical area extending over two or more states determined by the watersheds limits of the system of waters, including surface and underground waters, flowing into a common terminus". Later in 1986, the Seoul Rules defined that 'an aquifer that contributes water to or receives water from surface water of an international basin constitutes part of an international basin' for the purpose of the Helsinki Rules. An aquifer intersected by the boundary between two or more states that does not contribute water to, or receives water from, surface water of an international drainage basin constitutes an international drainage basin for the purpose of the same rules. The Helsinki and Seoul Rules are the fundamental recognition of hydrologic relationship between surface and groundwater.

Experts have begun to realise and question the competence and capability of the Joint River Commission (JRC) in dealing with issues relating to transboundary water conflicts resolution in the region. A cursory evaluation may surface that the commission is more a talker by shivering shoulders than really understanding the issues by depth required in facing its counterparts across the talking table. The role of JRC as such must shift from 'eating and meeting' to substantially 'acquiring and achieving' the national benefits and interests. The question at this point of time is therefore put before the commission to scour out the answer whether groundwater recharging within the country has any link to surface water development in the co-riparian countries.

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