Transboundary Aquifers: Challenges and New Directions
UNESCO-IAH-UNEP Conference, Paris, 6-8 December 2010

Setting Stage of Cooperation Between Bangladesh and India for Transboundary Aquifers

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ABSTRACT

Keywords: Ganges, Brahmaputra, Maghna, Farakka, Bay of Bengal, arsenic, shared aquifer.

Bangladesh, a landmass of 147,500 sq. km is sandwiched inside the neighboring country of India. Three big river systems, all originating outside her boarder, dominate the human life, economy, environment and eco-system of Bangladesh.

(i) The Ganges river system having its origin in the foot of the Himalyas has a length of 2510 km, (2185 km in India and 325 km in Bangladesh). (ii) The Brahmaputra river system is 2840 km long with only 410 km in Bangladesh. (iii) The Meghna river system with a total length of 946 km, travels 669 km within Indian territory. These river-systems have altogether 1.72 million sq. km catchment area of which only about 8% is within Bangladesh. Apart from these 3 river-systems, another 51 rivers enter into Bangladesh from India. In the monsoon, all the rivers having origin in India force about 1250 billion cubic meter water annually over the territory of Bangladesh to drain into the Bay of Bengal. This amount of fresh water is mainly generated by monsoon precipitation (about 80% of the total amount) in four months from June to September of the year. On the other hand, Bangladesh faces acute shortage of surface water in the dry season from November to April period when rabi and staple food boro paddy (HYV) are produced with irrigation water. Previously, prior to 1975, Bangladesh had enough water in the rivers in the dry season too that was generated on melting of glacier in the Himalayas, and partly from groundwater at shallow depth released mostly in the Indian territory. But gone are those days! India commissioned a barrage on the Ganges at Farakka in 1975 and started diverting surface water towards Kolkata port in the dry season which otherwise would reach the lower riparian Bangladesh. In fact, such withdrawal of river water by India forced Bangladesh to engage in irrigation practice with groundwater sinking shallow tube wells. At the same time, about 95% population of the country could have access to groundwater as potable water through shallow tube wells. This has become a practice within India bordering Bangladesh. But a serious setback struck in the 1990s when scientists detected large scale contamination of groundwater with arsenic element.

This situation led to severe health problems in Bangladesh and also in regions of India bordering Bangladesh; and of late scientists reported that crops caught up arsenic contamination. Now Bangladesh and India are going for abstraction of groundwater from deep aquifer for irrigation and drinking. In the past for about last three decades, there was insignificant cooperation between India and Bangladesh on sharing of common rivers' water. For this reason sufferings of the Bangladesh citizens were more compared with Indians. Similar situation will develop for people of both the countries in the future in areas of shared aquifers.

This paper will highlight some aspects of conflict of interest, the possible impact of the conflicts, and possible means of cooperation between Bangladesh and India for negotiation and resolution of the shared aquifer.

1.0 INTRODUCTION

While debates about the management of trans-boundary river basins have been taking place for many years between upper and lower riparian countries, there are also internationally shared, or trans-boundary groundwater resources hidden below ground surface, in all parts of the world. Some trans-boundary aquifers contain huge fresh water resources, enough to provide safe and good quality drinking water for the needs of all humanity for many years. But these trans-boundary aquifer systems cannot be stated in the same way as that of the internationally shared river basins, The environmental issues that affect trans-boundary aquifers are wide ranging and can be viewed both from local and global perspectives. If the conventional definition of sustainable development, i.e. "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" can be applied to aquifers within a nation, then there is no reason why the same cannot be applied to trans-boundary aquifers.

Groundwater, though not visible as surface water, is ubiquitous in the global landmass and is contained in the pore spaces of rock formations (aquifers). Aquifer systems, due to their partial isolation from the surface impacts, on the whole, contain excellent quality water. In many countries these systems have been fully evaluated and extensively used to meet municipal and other demands. Such resources represent a substantial hidden global capital that still needs prudent management.

2.0 TRANSBOUNDARY AQUIFERS

However, the hidden nature of trans-boundary groundwater and lack of legal frameworks indulges to misunderstandings by many policy makers. Not surprisingly, therefore, trans-boundary aquifer management is still in its infancy, since its evaluation is difficult; suffering from a lack of institutional will and finance to collect the necessary information. Although there are fairly reliable estimates of the resources of rivers shared by two or more countries, no such estimates exist for trans-boundary aquifers.

The key features of trans-boundary aquifers include a natural subsurface path of groundwater flow, intersected by an international boundary, such that water transfers from one side of the boundary to the other. In many cases the aquifer might receive the majority of its recharge on one side, and the majority of its discharge would occur on the other side. The subsurface flow system at the international boundary itself can be defined to include regional, as well as the local movement of water.

Very few international geographical boundaries follow natural physical features, and water resources can cross them unhindered. For good management and fair share of these resources by riparian countries, scientists estimate the resources that cross these boundaries should warrant urgent attention. In hydro-geological terms, these crossing resources can only be estimated through good observations and

measurements of selected hydraulic parameters, analogous to the estimation process of other trans-boundary resources; such as fisheries and wildlife, each requiring statistically sound observations.

Even where international boundaries may follow such features as rivers, the aquifers underlying them may not reflect the true transfer of groundwater flows from one side to the other. In any legal agreements to be drawn up for the equitable share of trans-boundary underground water resources, the initial stage must be the correct identification of flow and movement of water followed by its quantification. In reality, socio-economic pressures may have either already initiated withdrawal of water, or have such a priority that legal agreements cannot keep pace. Institutional weaknesses and political pressures may fail to address all the relevant issues potentially leading to severe environmental impacts and unsustainable development.

3.0 FACTORS AFFECTING AQUIFER BEHAVIOUR

Many factors may affect the behavior and the development potential of aquifers, which may include:

- hydraulic parameters;
- rainfall and recharge zones;
- confined and unconfined areas;
- natural discharge zones;
- present and planned groundwater development zones;
- water quality, potential risks of its deterioration; and
- vulnerability to polluting agents.

In trans-boundary aquifers, one or more of these factors may receive a different weighting on either side of a boundary. There are several examples of trans-boundary aquifers where recharge is received on one side while the natural discharges (and sometime better yields) take place across the border. Water abstraction from an aquifer transforms and re-organizes the groundwater flow in proportion to the piezometric adjustments induced.

This has a number of practical consequences, which are explained below.

Modification of the groundwater flow pattern

Groundwater flow passing an international boundary cannot be measured directly. It is estimated from parameters and calculated through mathematical models. Abstraction on one side of the border may alter the flow through the border.

- ✓ The underground outflow of the deep aquifer is a source of recharge for the coastal aquifer;
- ✓ Additional development from the deep aquifer may reduce the outflow to the coastal aquifer;
- ✓ Sitting and pattern of production from wells in trans-boundary aquifers can be planned to ensure equitable share of the resources.

Modification of the piezometric surface

Groundwater abstraction from wells results in modifications of piezometric heads in the form of a concentric cone of depression. Cones of depression may spread beyond international borders.

Deterioration of the water quality

Water quality deterioration may take place as a result of development of a well in an aquifer. Poorer quality water from the coastal area or inland saline water-bodies can be mobilized as a result of groundwater abstraction. The impacts could be transmitted from unilateral actions in one of the countries sharing the trans-boundary resources. Vulnerability of aquifer is higher when groundwater moves through formations where large interconnected fractures or cavities are present and encourage rapid flow.

Determining the sustainability of a trans-boundary aquifer with any degree of confidence can only be conducted in a resource planning context having detailed information and understanding. Ultimately, though, resource development policy involves tradeoffs. Most aquifer systems have ecosystems, landscape elements, or pre-existing water users that are dependent on current discharge or recharge patterns. Further development may require trading off these dependencies in favor of new plans or policies. If dependencies are not well understood or considered, management changes may have major unanticipated impacts.

4.0 CONFLICTS OF TRANSBOUNDARY AQUIFERS

Examples of ecosystems that depend partly or totally on groundwater are numerous. There is often no inherent conflict between preservation of these ecosystems and withdrawals from trans-boundary aquifers for socio-economic development. Since an aquifer system is essentially located below the ground, biodiversity issues generally relate to the regions where aquifers discharge through rivers, lakes or swamps. Such water bodies frequently have specific characteristics, related to the physical and hydro-chemical features of the aquifer that create special ecosystems.

The impact of climate change on trans-boundary aquifers of the world is yet to be fully evaluated in the same way as it has been done for agriculture and land use. In some regions, climate change will result in increasing recharge and in other regions reducing resources and increasing groundwater salinity. The consequences of either of these impacts on abstraction, maintenance of wetlands, and discharge to water bodies could be very serious, especially where well developed infrastructure has been established. Global sea level changes may impact marine saline intrusion – the hydraulic reference point change could mean that many aquifers may extend inland intrusions, thus affecting groundwater quality.

The earlier discussion about aquifers with and without contemporary recharge is relevant to climate change. The approaches that have been developed for managing non- recharging aquifers may need to be revised in the context of climate change. Conversely, aquifers currently being recharged, may suffer ‘surcharges’ due to increased recharge. This could have an impact on existing infrastructures, such as, a building with deep foundations. Swamps, wetlands and lakes that are supported by aquifer recharge may extend in area, possibly flooding surrounding infrastructures, such as roads and highways, etc. These impacts could be gradual and problems may not be noticeable until damages are physically detected.

5.0 ETHICAL PRINCIPLE OF TRANSBOUNDARY AQUIFER

An UNESCO Working Group on the ethics of freshwater use reported its activities in June 2000 (Llamas et al., 2000). A major output of the Working Group was a declaration of ethical principles for water management. Although this declaration concerns all waters, it can be made specific to trans-boundary ground waters as well. The key underlying statement is drawn from the universal Declaration of Human Rights and it states that “Every human being has the right to life sustaining resources, including water for drinking, food, industry and well- being.” Access to safe drinking water and sanitation, as well as water for economic development is essential for alleviating poverty and sustaining peace and stability.

In the application of these principles to trans-boundary aquifers, it is clear that water resources that pass through one country are to be utilized and developed ethically – that should not be knowingly abused such that human beings, be they in the country of the development or outside of it, may suffer. Ethical principles should be adopted when trans-boundary ground water resources are devoted to multiple uses, in the situation of natural and humanitarian disasters, such as drought, irrigation, and agriculture, industrial and municipal uses. The links between water and ecology need to be directly maintained.

6.0 BANGLADESH-INDIA TRANSBOUNDARY AQUIFER

Bangladesh is bordered by the Republic of India on three sides: the west, the north and the east (on her south is the Bay of Bengal). There exist some regional aquifer systems in both India and Bangladesh territory. Layers of these aquifer systems have the lateral extension crossing the border from either side and that also have evidence of trans-boundary flow. Such trans-boundary flow is more manifested in North-Western part of Bangladesh.

A brief description of Indo-Bangladesh trans-boundary aquifer systems is presented below.

- In Bangladesh, Major lithological units of the aquifer systems are unconsolidated 'Recent' to 'Sub-Recent' Piedmont Alluvial sediments deposited by rivers draining from the foothills of the Himalayas. Only south-eastern part of this region is occupied by older, somewhat compact, 'Barind' tract of Pleistocene age. Within the depth limits of water well drilling, the lithological change is always found lateral. Tectonic activity in the region may develop in such boundaries. The relict status of the western 'Teesta Fan' in Bangladesh bordering India, reflects tectonic uplift, and a southward tilting of the apical fan segment, which developed southward longitudinal hydrologic divide between Tangon and Karatoya rivers system in the country. In addition, multiple faulting and tilting of the blocks affect the control of movement and distribution of groundwater resources in this region. One of such smaller but prominent lineaments is quite interesting although it lacks any major tectonic significance. The river Punarbhaba in Bangladesh is a small south flowing stream that joins River Dhepa near Dinajpur (a district) town. It is conspicuous even on satellite images because of its straight reach and unusual bend near Kamar Digho, Birgonj that contrast with the pattern of other streams in the area and also with its upstream – downstream alignment as well as river bank sediments of both sides. This unusual river bend occurred due to faulting; and restricts southerly flows of groundwater along the fault-line traversing south (of village Barsha of Birganj Upazilla), where groundwater remains at or near the surface even during the dry season.

7.0 COOPERATION BETWEEN BANGLADESH AND INDIA

In Bangladesh, Groundwater elevation contours ranges from (+) 27 mPWD in the south to (+) 70 mPWD in the north. The general trend of groundwater flow is from north to south of the region. A regional flow is observed from central-southcentral region to west-southwest direction and groundwater flows away from the region towards Indian Territory (through Baliadangi and Haripur Upazila) from Bangladesh. The region's groundwater has also flow direction towards the inland major rivers from their vicinity. The average surface slope of the area is 0.45m/km from north to south; and from the groundwater elevation contour map it was seen that the gradient of groundwater level is steep in northern area, where the average value is 0.65m/km. In the southern part of the region, average gradient is 0.34m/km indicates comparatively slow movement of groundwater in the area. This is small area, where some investigations were carried out by the Institute of Water Modelling, a Trust Body under the Ministry of Water Resources of Bangladesh. From this very small study it is evident that withdrawal of ground water, or contamination or abuse of ground water from the aquifer, which is of course a shared one, will have a repercussion on the

other side of the border. For ethical principle, and also for the mutual benefit of citizens of the both the countries, it is quite desirable that a mutual understanding and cooperation in respect of sharing the trans-boundary aquifer will be very much beneficial to both the countries.

Towards this end, development of a common monitoring and information management systems for facilitate cooperation in protecting regional aquifer and optimum utilization of groundwater resources in long-term integrated water resources management among these two sharing countries is a must. The output from such collaboration will come from the combined efforts of the key and non-key experts and the beneficiaries.

RECOMMENDATION:

The possible outputs of an initiative in respect of trans-boundary aquifer between Bangladesh and India may be achieved in the following manner:

- Review on the baseline situation based on the data available;
- Joint monitoring programmes designed and agreed by both the countries:
- Report on the joint monitoring be carried out in the selected locations;
- Assistance provided to the national water monitoring establishments of both countries where appropriate to help to address the key concerns;
- Common GIS database platform be established to facilitate information management and data exchange between the countries;
- Initially a draft Regional Aquifer Management Plan (RAMP), including tentative programme of measures, may be prepared for the selected pilot areas in each country;
- Proposals can be developed for the future international projects to help address priority IWRM problems in India and Bangladesh.

Acknowledgement:

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