A study on Groundwater in West Bengal with Reference to other states in India

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Abstract-Groundwater is prime natural resources in the earth .Not only it supported almost all types of life form to evolve, but also helped in growth of human civilization. The indiscriminate and sometimes excessive use of groundwater has led to questions regarding its sustainability. To what extent can groundwater be exploited without unduly compromising the principle of sustainable development? The sustainability of groundwater utilization must be assessed from an interdisciplinary perspective, where hydrology, ecology, geomorphology, and climatology play an important role. Shallow groundwater flow systems should be distinguished from deep groundwater flow systems; the former interact with surface water, while the latter do not. Generally, groundwater does not recycle as fast as the surface water, with rates of groundwater turnover varying from years to millennia, depending on aquifer location, type, depth, properties, and connectivity.

Excessive pumping can lead to groundwater depletion, where groundwater is extracted at a rate faster that it can be replenished. The effects of excessive groundwater development tend to become apparent gradually, with time often measured in decades. To assure sustainability, studies must show that the hydrological, ecological, and other impacts of groundwater utilization are minimal. In addition to water quantity, sustainability must imply the preservation of water quality.

Index Terms- Groundwater, Sustainability, Geomorphology, Hydrology, Ecology, Aquifer, Utilization etc.

1 INTRODUCTION

At present about two billion people in the world is dependent on groundwater. Fortunately, groundwater is a renewable resource that is recharged every year through rainfall. However, this recharging process is not entirely dependent on rainfall but on various other natural factors that differ from region to region and within space and time. Therefore, recharge of groundwater is never a constant factor .When the average quantity of draft exceeds recharge for repeated years we face the situation of overexploitation. The manner and the scale in which the use of groundwater has accelerated, human being has become so much dependent on the assured source that no sign of the over increasing demand for groundwater stabilizing. Beginning of 20th century witnessed demand for groundwater in industrial sector rising phenomenally at a faster rate than that in agriculture and domestic sector. Groundwater is the largest source of usable, fresh water in the world. In many parts of the world, especially where surface water supplies are not available, domestic, agricultural, and industrial water needs can only be met by using the water beneath the ground. The U.S. Geological Survey compares the water stored in the ground to money. Groundwater is the largest source of usable, fresh water in the world. In many parts of the world, especially where Groundwater is the largest source of usable, fresh water in the world. In many parts of the world, especially where surface water supplies are not available, domestic, agricultural, and industrial water needs can only be met by using the water beneath the ground. The U.S. Geological Survey compares the water stored in the ground to money kept in a bank account. If the money is withdrawn at a faster rate than new money is deposited, there will eventually be account-supply problems. Pumping water out of the ground at a faster rate than it is replenished over the long-term causes similar problems. The Central Ground Water Board (CGWB) has told the ministry of water resources that around 56% of the wells, which are analyzed to keep a tab on ground water level, showed decline in its level in 2013 as compared to the average of preceding 10 years (2003-12) period. Groundwater depletion is primarily caused by sustained groundwater pumping. Some of the negative effects of groundwater depletion:

- **Lowering of the Water Table**

Excessive pumping can lower the groundwater table, and cause wells to no longer be able to reach groundwater.

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- Increased Costs

As the water table lowers, the water must be pumped farther to reach the surface, using more energy. In extreme cases, using such a well can be cost prohibitive.

- Reduced Surface Water Supply

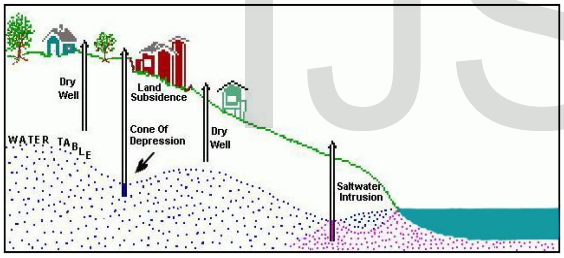
Groundwater and surface water are connected. When groundwater is overused, the lakes, streams, and rivers connected to groundwater can also have their supply diminished.

- Land Subsidence

Land subsidence occurs when there is a loss of support below ground. This is most often caused by human activities, mainly from the overuse of groundwater, when the soil collapses, compacts, and drops.

- Water Quality Concerns

Excessive pumping in coastal areas can cause saltwater to move inland and upward, resulting in saltwater contamination of the water supply.



Groundwater levels in India are plunging at an alarming rate where some states experience water levels dwindling to criticality.

- Use of groundwater spans from irrigation purposes to industries and human consumption. The poor distribution system on part of the government too adds to the existing poor condition of water. Cities like Pune and Delhi lose 40% of water supply due to leakages.

- Water crisis in India is the result of three major causes:

1. The bursting population is a reason for insufficient water per head. While it has been estimated that the amount of usable water should be between 700-1200 billion cubic meter, India has only 1000 cubic meters of water per head.

2. Water in most rivers is polluted making it unfit for drinking or any other use. The poor quality rises from insufficient and delayed investment in urban water-treatment facilities. Industrial effluent rules are not implemented due to inadequate technical and human resource availability with the state pollution control boards.

3. Excess extraction by farmers has led to the dwindling groundwater supplies. This is so because access to groundwater is free and anyone has a right to pump water from their own land.

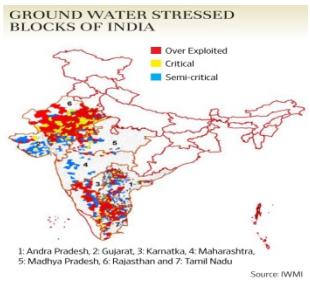
- Poor monsoon due to climate change has further aggravated the groundwater situation since the latter heavily depends on rains. Poor rainfall compels the farmers to dig further down for groundwater to irrigate the field. This results in pushing the tables deeper down.

- Unrestrained urbanization has contributed in a big way and despite India being one of the richest nations in water supply; the government and citizens have exploited the water reserves.
- Quality of groundwater is another issue especially where it is used for human consumption. A number of factors contaminate the groundwater like sewage, run off from landfills, use of pesticides and fertilizers etc.

- Depleting groundwater has posed such a threat that cities are now compelled to look for alternate supplies either because of polluted groundwater or that it will cease to exist very soon.

2 GROUNDWATER STUDIES REPORT OF OTHER STATES IN INDIA

India's north-western region is widely considered to be the country's granary, with states such as Punjab and Haryana accounting for a large share of the country's agricultural output and farm incomes. But farming in both these regions is increasingly becoming unsustainable, owing to depleting groundwater levels. The situation is equally precarious in the south-eastern parts of the country. Both these region account for most of India's groundwater-stressed blocks, as the chart below shows.



The dependence of irrigation on groundwater increased with the onset of the so-called Green Revolution, which depended on intensive use of inputs such as water and fertilizers to boost farm production. Rather than extending surface water irrigation to unirrigated regions, policymakers began providing incentives for groundwater extraction.

Groundwater usage

Use of groundwater for irrigation exploded after Green Revolution

Source	Surface	Groundwater
1950	57.1	28.7
1960	60.6	29.6
1970	54.5	38.2
1980	47.7	45.7
1990	42.5	51.4
2000	33.2	61.6
2009	29.4	61.2
2015	28.5	58.3

Private groundwater irrigation was facilitated by extending credit and subsidies for irrigation equipment. However, the centerpiece of government policy has been the massive subsidy provided on electricity supply. Low power tariffs led to excessive water usage, leading to a sharp fall in water tables. The rush to grow cash crops in recent years has only exacerbated the crisis.

Falling water table (all-India)

Type of structure	Deep tube wells	Shallow tube wells	Dug wells
1986-87	1.3	30.4	68.3
1993-94	2	34.2	63.8
2000-01	2.9	45.2	52.0
2006-07	7.3	46.1	46.6
2014-15	9.1	48.2	47.5

Depth to water table	Below 10m	10-20m	20-40m	40-60m	60m and above
1993-94	61.9	24.8	7	2	4
2000-01	55.8	25.6	8	3	7
2014-15	53.1	26.5	8	2	9

India's groundwater is becoming more difficult to access There's been a 6 percentage point dip in share of groundwater wells within 10 metres below the ground. This depth is the threshold beyond which farmers have to start using deep-water equipment, which adds to their hardship. Data shows percentage share of groundwater wells according to depth below the surface.

Falling water tables prompted the use of expensive deep-water equipment, which added to the debt burden of farmers, and worsened the crisis.

Depth to water table	Below 10 metre	10-20 metre	20-40 metre	40-60 metre	60 metre and above
North	66.1	22.4	6.3	1.3	3.8
South	28.6	20.3	13	8.2	30
East	73	21.3	4	0.7	1
West and Central	38.3	37.6	12.2	4.2	7.6

Regional water-table

South, West and Central India have significantly lower water table than other regions.South has a frightening 30% of its groundwater table lower than 60 metres below the ground. Data shows percentage share of groundwater wells according to depth below ground.

Share of deep-water equipment:

Farmers' response to falling groundwater table

Share of dug wells, which can't extract water from greater depths, has fallen by over 20 percentage points in two decades.

Eastern India faces a different problem. Despite abundant groundwater resources, irrigation continues to suffer due to lack of electricity supply. This is the only region where the proportion of irrigated area has fallen, largely due to lack of electricity to extract water. Jharkhand, Bihar and West Bengal have suffered the most.

Regional inequities in irrigation

Regional disparities in irrigation in India

Data shows percentage share of net irrigation to net area used for sowing crops. North enjoys disproportionate advantage over other regions. East is the only region to have shown decline in share of irrigated area.

Region	North	South	East	Central and Western	All-India
1985-86	71.15	27.24	28.88	14.48	29.44
1995-96	78.03	33.46	37.84	23.83	37.54
2000-01	87.56	34.53	32.31	23.26	38.91
2005-06	90.06	36.1	35.42	34.4	46.84
2014-15	91.2	38.4	36.2	37.2	48.5

Water usage by crops

Water needs of crops

Water-intensive crops like sugarcane and paddy are mostly grown in the naturally water-starved areas of the country (From FAO)

Crop	Water need
Cotton	700-1300
Maize	500-800
Onion	350-550
Potato	500-700
Rice (Paddy)	450-700
Sugarcane	1500-2500
Wheat	450-650

3 GROUNDWATER POTENTIAL IN WEST BENGAL

West Bengal is the only state in India that stretches from Mountain to the Sea and truly a "Asamudra Himachalam" state as the meaning goes. West Bengal has a very good groundwater potential. The reason of such affluence is due to her geographical location, high rainfall and favorable geological setting .The state have land area of about 2.7% but have about 6% of total replenishible groundwater resources of India. Groundwater is the most exploited resource in west Bengal particularly in agriculture sector With the introduction of water intensive high yielding variety , the need for groundwater have skyrocketed. Quinquennial census of minor irrigation structures indicated a 64% growth in number of STWs over last 16years,@4annually.

Table Showing Number of Groundwater Structures from 1986 to 2001:

Name of Structure	1986-87	1994-95	2000-2001
Dug Well	63387	55983	39377
Shallow Tubewell	368316	504638	603667
Deep Tubewell	3122	4039	5139

4 CASE STUDIES

4.1 HYDROGEOLOGICAL CONDITIONS OF WEST BENGAL

Geologically West Bengal can be divided into two broad units (A) Consolidated or semi consolidated formation occurring in the northern most and western part of West Bengal and (B) Unconsolidated formation in the rest of West Bengal.

(A)Consolidated/semi consolidated formations:

These formations cover the western and the northern part of the state. These are comprised of Archaean crystalline rocks and Gondwana group of rocks including Rajmahal traps covering part of Purulia, Bankura, PaschimMedinipur, Birbhum and Burdwan.. Archaean metamorphics, Siwalik and Gondwana covers part of Darjeeling and Jalpaiguri District. In the western part and in some part of Darjeeling district, these hard and semi consolidated rocks are overlain by weathered residuum and laterite capping.

(B)Unconsolidated formations:

These formations belonging to the Tertiary and Quaternary age and covering rest of West Bengal. These formations may be subdivided into (a) Secondary laterite (b) Older alluvium and (c) Recent alluvium.

Secondary laterite occurs at the marginal area between the Consolidated/ semi-consolidated rock and older alluvium mainly in the districts of Bankura, PaschimMedinipur, Burdwan and Birbhum. Older alluvium occurs mainly in the

elevated terraces fringing the lateritic margin of the Chhotonagpur plateau in Bankura, PascimMedinipur, Burdwan, Birbhum, Hoogli and Murshidabad district and in the Barind region of North Bengal. Recent sediments occupy the river courses and flood plains.

4.2 DEPLETION OF GROUNDWATER IN SOME AREAS OF WEST BENGAL

In spite of having high groundwater reserve, exploitation of the resources in West Bengal shot up to such level that 80's decade first witnessed the sign of depletion of groundwater level in some blocks of Murshidabad, Burdwan, Medinipur, and Hoogly where pre-monsoon water level dropped below the centrifugal pumping limit and hand tube wells went dry. Introduction of Submersible motor driven pump though came as a blessing to the cultivators, for it can draw water from far deeper depth – caused further lowering of groundwater level.Depth to water level data analyzed by the State Water Investigation Directorate, Govt. of W. Bengal, indicated significant average annual fall in pre monsoon depth to water level during the period 1995 to 2004 to the tune of 16 to 70 centimeters in some blocks of Murshidabad, Burdwan, PurbaMedinipur and Hooghly districts. In some parts of Hooghly, Burdwan and Murshidabad districts, significant fall was noticed in both pre and post monsoon period.

Case1- No change

Case2- Post monsoon no change but pre monsoon falling trend.

Case3 -both pre & post monsoon show falling trend

Case4- Pre monsoon rising trend, post monsoon falling

5 GROUNDWATER QUALITY IN WEST BENGAL

In addition to the phenomenon of lowering of water level, deterioration in Chemical quality of groundwater was noticed in some parts of the state that took place in the form of Arsenic and Fluoride contamination. On the basis of preliminary survey 81 blocks in the state have been identified where Arsenic was found in groundwater above permissible limit. Similarly, presence of Fluoride beyond permissible limit in groundwater was detected in 49 blocks of the State. It was observed that the entire younger and recent alluvium formation east of Bhagirathi River is arsenic bearing and reason for such occurrence is solely Geogenic. Arsenic held by the solid phases within the sediments, especially iron oxides, organic matter and sulphides might constitute the primary arsenic sources in groundwater under condition conducive to arsenic release from solid phases. Occurrence of Fluoride, in groundwater is generally recorded from hard rock areas. The subsurface water may be contaminated with dissolved substance due to disintegration and dissolution of bed rock that rendered water unfit for drinking due to presence of certain toxic constituents. Fluoride is one such chronic toxic substance, that have affected large number of people causing Skeletal or Dental fluorosis. Fluorite (CaF2), Cryolite (Na Al F6) is the rock forming minerals which contribute Fluoride to the groundwater. Wastewater containing Fluoride originating from various industries viz phosphate fertilizer, ceramic industry brick kiln and pharmaceutical industries may find its way to the groundwater and elevate the Fluoride level. Assessment of Groundwater Resources apprehending phenomenal increase in extraction of Groundwater, Government of India considered that quantitative assessment of these resources is necessary for planning and sustainable development. Accordingly, Ministry of water Resources formed Groundwater Estimation Committee, which came out with a methodology based on reasonably valid scientific principles and reliable data .The first assessment of the resources was carried out in 1984. Meanwhile, Central Groundwater Board and different State Water investigation Organizations carried out further detailed studies and generated additional database which along with the ever-rising Groundwater utilization through the country, indicated need for modifying the methodology for more precise assessment. Another Estimation Committee was set up in 1995 came out with modified methodology in 1997 known as GEC '97 methodology. Assessment of Groundwater resources of all the States were carried out jointly by the Central Groundwater Board and the respective State groundwater Organizations with block as unit and 2004 as base year. The assessment revealed that the national average for stage of groundwater development is 58% whereas the same for the State of West Bengal is 42%.The assessed blocks were categorized, on the basis of stage of development and long term significant decline of groundwater level, as 'Safe', 'Semi-Critical', 'Critical' and 'Over exploited' .In the national scenario, 4078 blocks are Safe out of total 5723 blocks. In West Bengal assessment was carried out in 269 blocks out of total 341 blocks leaving aside 13 hilly blocks in the north and 59 Saline blocks of coastal region. As per the assessment carried out by application of GEC'97 methodology, 231 blocks have been found to be Safe .28 blocks were assessed to be Semi-Critical and 10 blocks as Critical. However State committee on groundwater assessment is reviewing assessment and categorization of this 10block. Based on the assessment carried out the net groundwater availability in West Bengal was calculated to be 27.46 BCM, whereas existing groundwater draft in all sectors –irrigation , domestic and industrial , is 11.65 BCM, leaving 15.81 BCM of dynamic resources reserve for further use. Planned approach for Groundwater development The groundwater scenario at national level and that of West Bengal reveal that exploitation of groundwater in the state has not yet reached alarming critical stage .The national water policy 2002 states that exploitation of groundwater should be

limited to the extent of annual recharge. Although the average stage of groundwater development is 42% in the state , adverse effects like water level depletion and chemical degradation have been noticed in some areas in scattered manner. Government is concerned about incidents of suffering of the local population in such areas due to shortage of water in peak summer and from diseases due to consumption of arsenic and fluoride contaminated water.

It was apprehended that if indiscriminate use of water go on unabated, adverse effects of degrading hydrogeological regime of the state, will amplify and will engulf the whole state in such a manner that the whole agriculture and industrial development process will suffer a setback. The Government had determined view not to allow such situation and decided to promulgate suitable Act to control and regulate the use of groundwater in the State.

6 GROUNDWATER ACT

West Bengal Groundwater Resources (Management , Control & Regulation) Act 2005 was promulgated with effect from 15th September '2005.This act stipulates obtaining mandatory permit for installation of groundwater extraction structures operated by engine or motor driven pump .This act also , stipulate registration of all such structures existed before the act came into force.

Apart from West Bengal, other states viz. Himachal Pradesh, Kerala, Goa and Tamil Nadu have already passed suitable acts for control and regulation of groundwater.Andhra Pradesh had enacted Water , land and tree act in 2002. Maharashtra enacted groundwater (regulation for drinking water sources) Act in 1993 for limited purpose of regulating public drinking water. For the remaining states either the groundwater bill is under drafting or draft bill is under consideration of the respective government.

7 CONCLUDING REMARKS

- Crisis of Water is probably the worst curse any civilization would like to face. It will be tragic for the next generation facing this crisis due to lack of foresight in part of the present generation. The groundwater resources, although renewable, are limited and vulnerable. Crisis of water may not be only quantitative; quality degradation may also add a different dimension to the problem.

  West Bengal, which is considered to have tremendous groundwater potentialities, is no exception. Crunch is already felt in drinking water sector in rural west Bengal during Boro cultivation season precipitating a situation of artificial draught in almost every year. Unpredictable monsoons, destruction of green coverage, siltation of rivers, uncontrolled urbanization have compounded this problem. Area under arsenic and fluoride are increasing day by day. Failures in part of the authority to implement the Groundwater Act and lack of awareness in part of the users have failed to check unrestricted growth of tube wells in the state. Stages of groundwater development with 2004 as base year that show a meager 42% stages of groundwater development in the state as against a national average of 58%, needs to be upgraded. The act for controlling extraction of groundwater is probably not adequate in itself for total management of groundwater resources unless people is made to aware about the adverse situation which may arise from unplanned and indiscriminate use of groundwater.
- The other strategies involve co-ordinate approach to conservation, augmentation and conjunctive use of groundwater, wherever possible. This can be successfully achieved through rain water harvesting and artificial recharge that make it possible to:

1. Restore supply in aquifer, depleted due to overexploitation.
2. Improve chemical quality
3. Prevent salinity ingress.
4. Increase hydrostatic pressure against land subsidence

- To implement rain water harvesting and artificial recharge to be implemented, it is necessary to adopt policy decisions like mandatory installation of roof top rain water harvesting and artificial recharge structures in urban areas and restoration of all derelict tanks in the villages , building check dams etc. in high slope areas.

- Groundwater is not an isolated resource. It is a phenomenon within the hydrological cycle. So depending on the hydrogeological condition, water level condition and stage of development proper measure for augmentation of groundwater should be taken.

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