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Research Article

Assessment of Dynamic Groundwater Reserve of Kamarup District Lower Assam, India

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Abstract Despite sufficient rainfall, a large portion of the northeast region of India suffers from water scarcity especially during dry seasons when groundwater acts as a significant source of water supply. Consequently, a proper assessment of groundwater condition at a district/block level is very much essential to adopt sustainable water management practices. Additionally, climate change and cross-border water disputes generate new challenges in the water management of Northeast India. In this study, an attempt has been made to present groundwater scenario of Kamarup district in lower Assam as a case study representing North-East India. For this purpose, we used the available temporal groundwater-level data derived from observation wells at five sites namely Agyathuri, Azara, Bamunigaon, Khara and Rangia located in the Kamrup district (lower Assam) of north-east India. The dynamic groundwater reserve (DGWR) has been estimated for the period from 1996 to 2006 using groundwater level data from these five sites along with monthly rainfall data and published pumping test data. This will help to analyze the groundwater dynamics of the study area. In order to cross check the obtained results, we used terrestrial water storage changes (TWS) derived from GRACE (Gravity Recovery and Climate Experiment) satellite data. TWS is a satellite-based monthly mean liquid water equivalent thickness with one degree spatial and monthly temporal resolution available from 2002. Terrestrial water storage includes the soil moisture, surface water equivalent and groundwater anomaly based on satellite observations of earth gravity field from the (GRACE). In the present study, TWS data was analyzed for over a period of 5 years from 2002 to 2006. The results of the study indicate that the maximum groundwater fluctuation was in the range of 0.84 to 3.48 m and minimum between -5.07 to -1.47m. Over the entire study area, we observed a decrease in dynamic groundwater reserves. From the trend analysis, it is obvious that there is an increasing trend of groundwater level at Khara, Rangia and Bumungiaon site and a decreasing trend at Agyathuri and Azara site. Further, the DGWR results showed that two sites (Agyathuri and Azara) were continuously subjected to stress from 1999 onwards. We observed that the DGWR and TWS are showing a comparable negative trend in the dynamic groundwater storage capacity for the study period. In the year 2004 the recorded TWS and estimated average_DGWR are relatively high during the study period. Thus, the results of this study provide a clear picture of spatial and temporal variations of dynamic groundwater resources in the study area, based on which important recommendations can

be made for managing the scarce groundwater resources of the study area in a sustainable manner to address future challenges.
Keywords *Groundwater reserve; Specific yield; Terrestrial water storage*

1. Introduction

The demand for fresh water is on an exponential increase due to the rapid growth of the population augmented by the subsequent increase in urbanization, industrialization as well as irrigation needs from agricultural sector. It was estimated that around 2.5 billion people worldwide depends purely on groundwater resources to satisfy their basic daily water needs (UNESCO, 2012). A global assessment on the groundwater consumption shows that countries such as India, China, Nepal, Bangladesh, and Pakistan are using nearly half the world's total groundwater resources (WWRD, 2015). Over exploitation of groundwater is a dominant concern for India as well as in many other parts of the world (Mutao et al., 2015). Moreover, the recharge process of the aquifer is impacted by the change in climate pattern and land use changes. Consequently, the conservation and management of groundwater resources is getting more attention from the scientific community. Likewise, the concept of conservation and management of groundwater resources have a noticeable role in adapting sustainable development. Therefore, an understanding of groundwater recharge process and assessment of groundwater recharge quantity is very essential. Numerous methods are available to quantify and monitor groundwater recharge that can be categorized as physical, chemical, analytical and numerical methods (Ahmadi et al., 2013 & Park 2012). Recent advancement in satellite based remote sensing techniques has led to the development of GRACE (Gravity Recovery and Climate Experiment) satellite which is widely used to evaluate the temporal changes in global ground water storage (Chinnaswami et al., 2015 & Richey et al., 2015).

In the present study an attempt has been made to understand the groundwater resource scenario of Kamrup district of lower Assam as a representation of the scenario of North East. Dynamic Groundwater Reserve (DGWR) of the study area was calculated with the available groundwater data from CGWB (Central Groundwater Board) using the guidelines provided by GWREC (1997). The method is found to be an effective method in calculating the status of groundwater in a region (Murasingh et al., 2015). Terrestrial water storage from GRACE data is found to be valuable in analyzing the regional trends in the groundwater as well as surface water scenario of North East region. In the present study, DGWR is validated with respect to the trends in precipitation as well as regional trends emerging from the analysis of terrestrial water storage.

The study area falls in the in the Survey of India Toposheet No. 78 W and No. 78 O and bounded by North longitude 25°42'03" and 26° 50' 10" and East latitude 91° 00' 01" and 92° 10' 04". The Kamrup district covers an area around 4,345 square kilometers and can be classified physiographical into three units namely the hilly region in the south, the alluvial plain in the central and western part and the swampy areas along Brahmaputra plains. The climate of the area has been classified as the sub-tropical humid climate with heavy rainfall, hot summer, and high humidity. The mean maximum and minimum temperatures recorded in the area are 12 to 38℃. The average annual rainfall of the area is about 1752 mm as per IMD records. The average number of rainy days in the district is 97 days in years. Based on variation in proportions of sand, silt, clay and organic material the soil group in the district are grouped into three broad categories district are grouped into three broad categories.

2. Methodology

Dynamic Groundwater Reserve (DGWR) of the study area was calculated for Kamrup district using well data available from CGWB (Central Groundwater Board) using the guidelines provided by GWREC (1997). Dynamic groundwater reserve is the optimum amount of water which an aquifer can store or release at the maximum consumption. In this method, the groundwater storage or release is related to the hydraulic property of aquifer media (specific yield) and water level fluctuations. The following equation gives the Dynamic Groundwater Reserves:

$$DGWR = S_y(h_{pre} - h_{post}) - - - - - - - - - - -(1)$$

Where

Sy = Specific yield of aquifer media
h_{pre} = Depth to water level during pre-monsoon season of next year (L)
h_{post} = Depth to water level during the post-monsoon season of the current year (L)

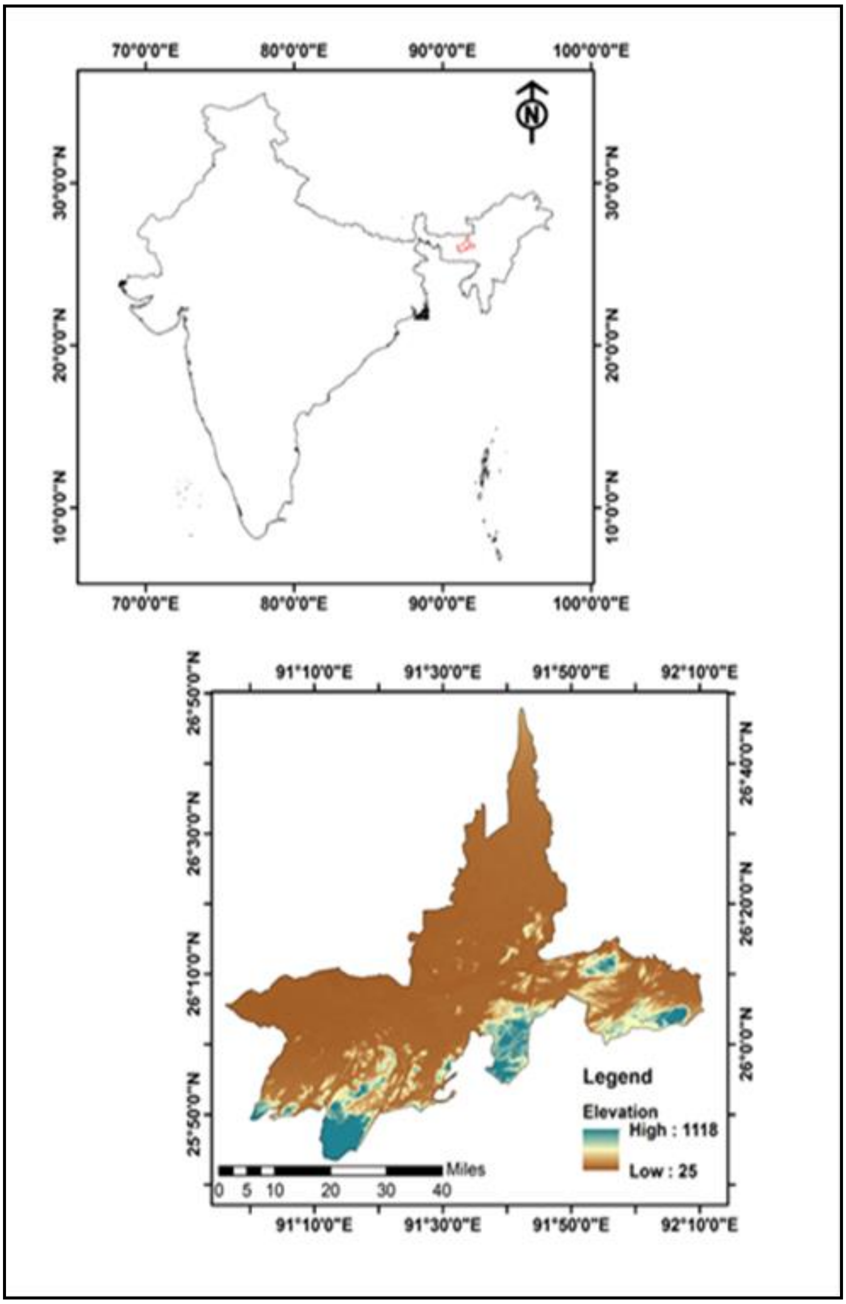

Figure 1: *Study area map*

Where depth to water level data (mbgl) were collected from Central Groundwater Board, India website. The CGWB, observes the groundwater level for entire India using a network of monitoring wells. For this purpose, CGWB measures water level depth four times in a year, in the month of January, April, August and November. This temporal variation in the depth of water level represents the seasonal variations in water level. In the present paper we discuss the analysis carried out for 10 years of water level data recorded by CGWB. The other major parameter used in the DGWR is specific yield, which is one of the major hydraulic property of an aquifer. The specific yield is estimated by CGWB based on in situ aquifer test and textural characteristics of soil sediments in the study area. The specific yield is a fraction of constant value for an area based on the textural characteristic of aquifer material (GWREC, 1997). The specific yield value used in the analysis is given in Table 1. The outline of the methodology adopted in this study is depicted in the flowchart (Figure 2).

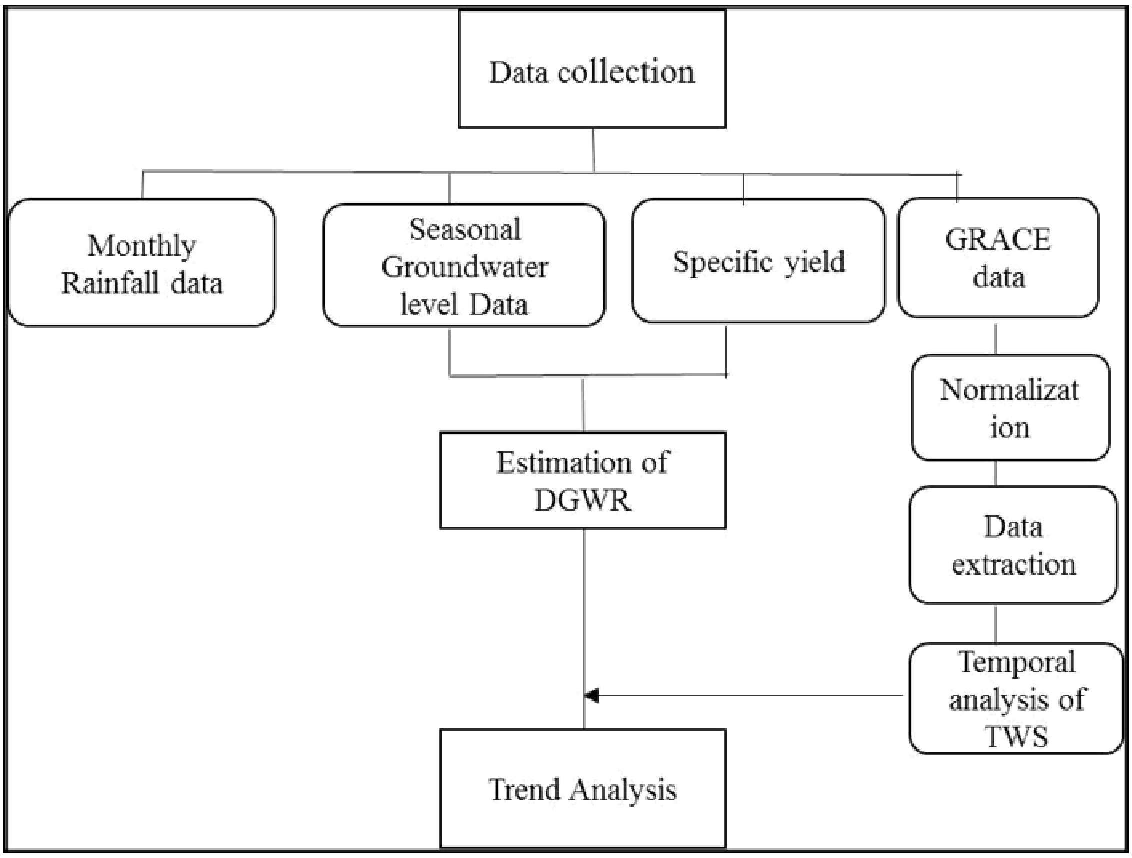

Figure 2: *Flowchart of methodology adopted in the present study*

Table 1: *Specific yield of geological formations based on the well locations (GWREC 1999)*

S. No	Site name	Geological formation	Specific yield
1	Hajo (Agyathuri)	Alluvium	0.2
2	Chandrapur	Alluvium	0.2
3	Chhaygaon (Bamunigaon)	Hard rock	0.04
4	Boko (Khara)	Alluvium	0.2
5	Palasbari (Azara)	Hard rock	0.04
6	Rangia	Alluvium	0.2

Terrestrial water storage (TWS) is one of the end products of satellite-based gravity measurement popularly known as GRACE, which continuously sample the variation in the Earth's Gravity field. GRACE mission was launched by US and German space agencies (NASA and DLR) in 2002. The spatial resolution of GRACE data is 1° by 1°with monthly temporal resolution. The TWS, or liquid water equivalent is a major component of the global hydrological cycle. In the present study, we used GRACE data to extract the TWS data for the entire region of North East, which includes the Kamrup district of lower Assam. For the analysis purpose, we considered only four years of TWS data that overlap the groundwater depth data available from CGWB. TWS change reflects natural variability in climate and is controlled through a series of processes and feedback mechanisms. The seasonal variation of TWS for the study area is illustrated in Figure 3.

The other parameters used in this study are monthly rainfall data. The rainfall data for the study area was obtained from Indian Metrology Department, Pune. For the analysis purpose, 10 years of rainfall data was considered. We considered the entire year in seasonal context as Monsoon I, Monsoon II, Post monsoon, and pre-monsoon in accordance with CGWC (1997). The seasonal variation of rainfall for a period of 10 years over the study area is illustrated in Figure 4.

3. Results and Discussion

In the present study, we identified five well locations for the study area from the network of wells monitored by CGWB. Depth to groundwater levels was analysed for these five sites of Kamrup district in lower Assam namely, Agyathuri, Azara, Bamunigaon, Khara and Rangia for a period of ten years from 1996 to 2006. Rainfall data of the study area for the same period was considered and the total rainfall for the entire year was separated in a seasonal context as Monsoon I, Monsoon II, Post monsoon, and Pre-monsoon. The average trend in the rainfall pattern shown an increasing trend with the highest rainfall contribution in the monsoon I season followed by pre-monsoon. In 2004, though the total rainfall shows an average trend, the area received the lowest rainfall in Monsoon I but highest rainfall in pre-monsoon period. The analysis of TWS from 2002 to 2006 shows that TWS is the highest during the monsoon I of 2004. This could be due to the fact that the groundwater recharge was maximum in 2004 as that year received the highest amount of rainfall during pre-monsoon.

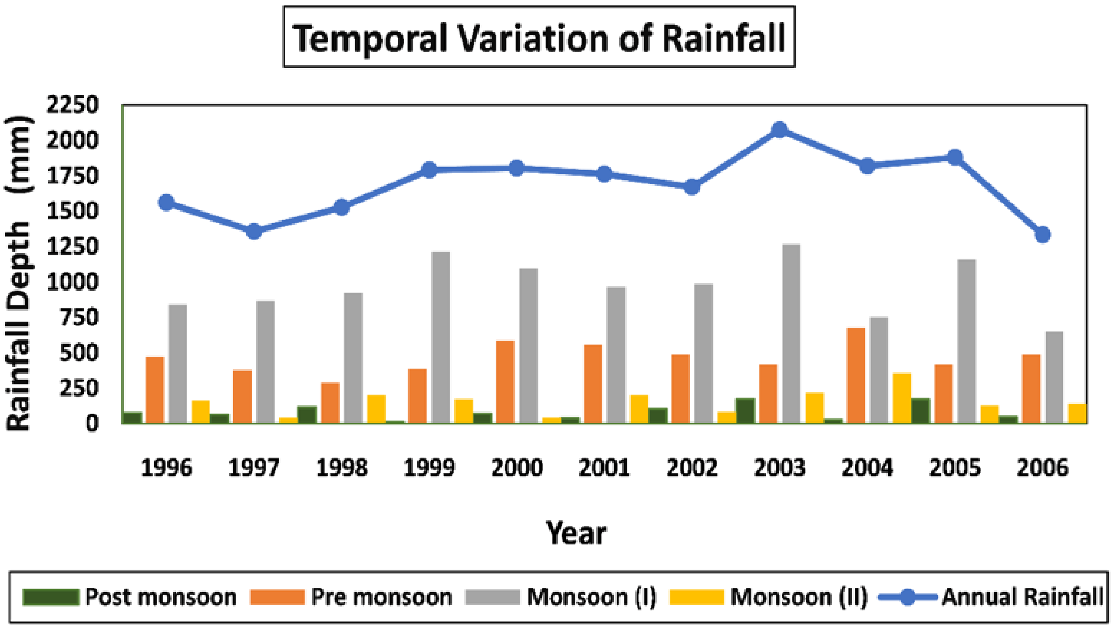

Figure 3: *Temporal variation of rainfall*

For the five well locations namely, Agyathuri, Azara, Bamunigaon, Khara and Rangia, the pre-monsoon depth to groundwater level ranges from 10.97 to 0.19 (mbgl) and the post-monsoon depth to groundwater level ranges from 10.15 to 0.35 m. Season-wise depth to groundwater level and seasonal fluctuations are tabulated in Table 2.

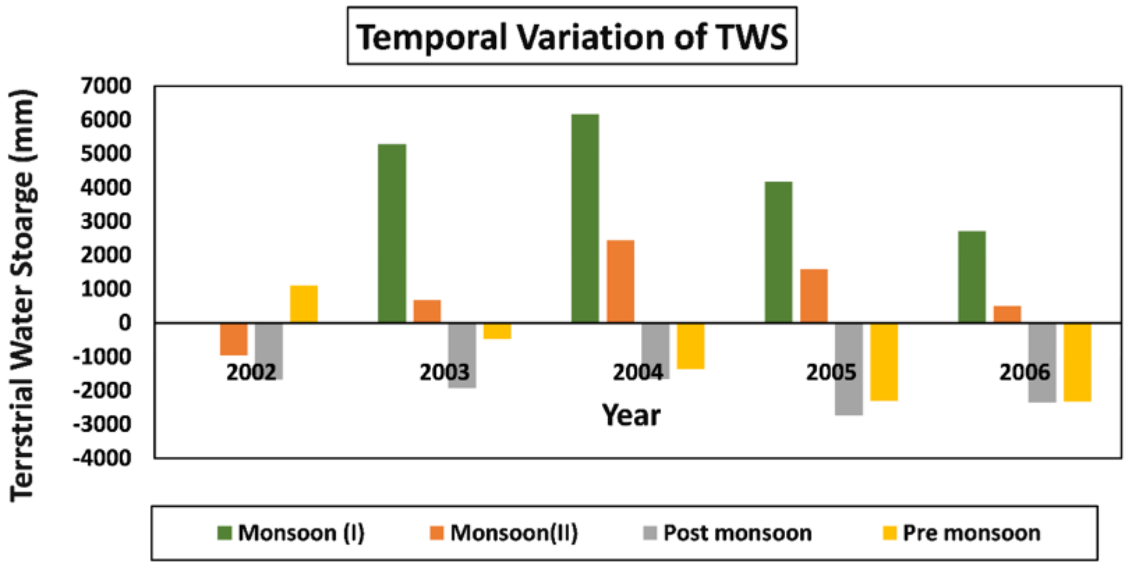

Figure 4: *Temporal variation of TWS*

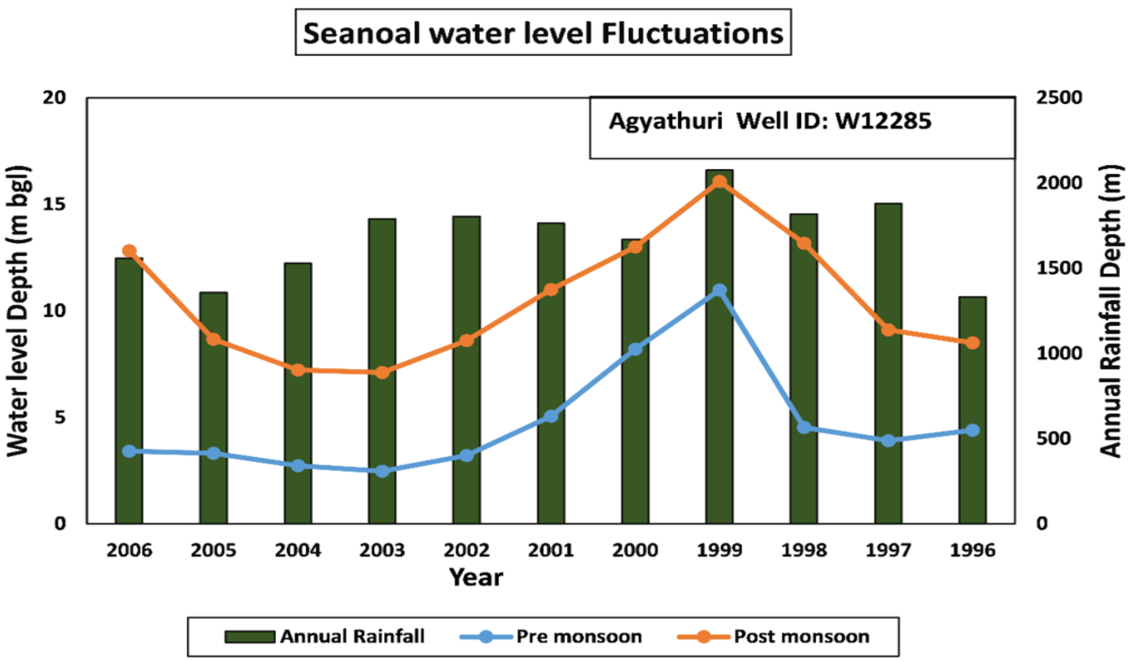

Figure 5: *Seasonal water level variations at Agyathuri*

Table 2: *Range of water level fluctuations at different sites*

Well id	Site name	The range of Level (mbgl)	Groundwater	Seasonal fluctuations	
		Pre-monsoon	Post monsoon	Maximum	Minimum
W12285	Agyathuri	10.97-2.47	10.15-4.1	3.48	-5.07
W12293	Azara	5.77-1.22	5.79-2.31	1.22	-2.97
W12275	Bamunigaon	4.96-1.97	4.4-3.6	0.84	-1.97
W12289	Khara	3.79-0.42	3.55-0.35	1.95	-1.47
W12300	Rangia	10.97-2.47	10.15-4.1	2.85	-2.47

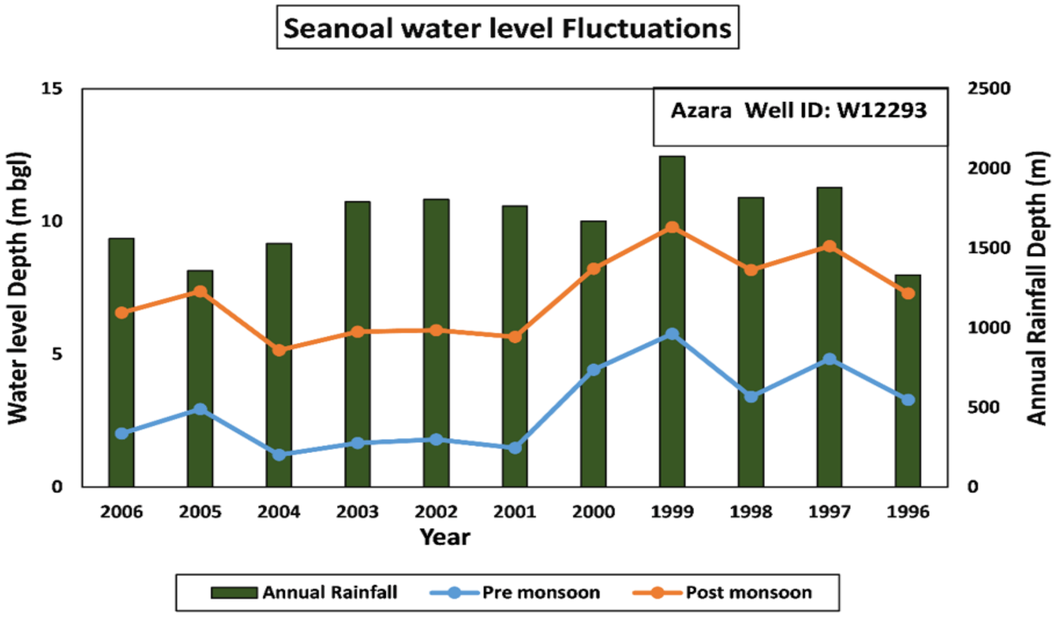

Figure 6: *Seasonal water level variations at Azara*

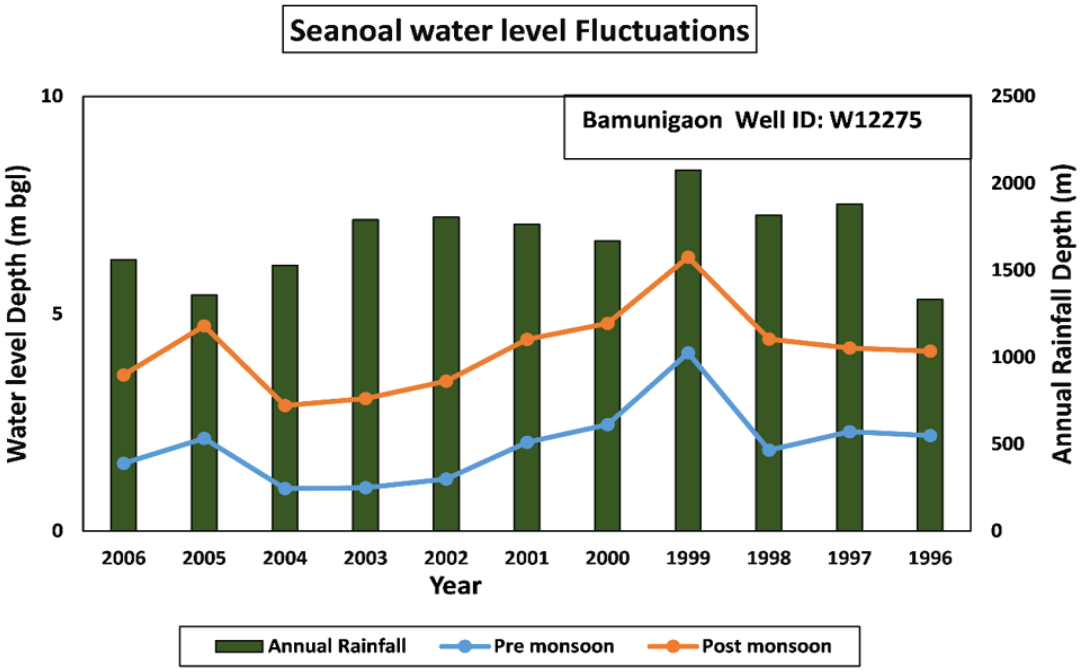

Figure 7: *Seasonal water level variations at Bumunigaon*

Moreover, the trends at all five sites were examined for the period from 1996 to 2006. At Agyathuri the water level was showing a declined trend from 2002 onwards both in the pre-monsoon and the post-monsoon seasons as shown in Figure 4. Azara site exhibit a change in the trend with a decreasing (year 1999-2001) and increasing trend (2004 to 2006) as shown in Figure 5. The groundwater level trend at Bamunigaon (Figure 6) site was more are less similar to the Azara. Figure 7 and Figure 8 shows a declining water level trend at Boko and Rangia. We observed that at all five sites the water level declination commenced from 2002 onwards even though the rainfall was higher than the previous years.

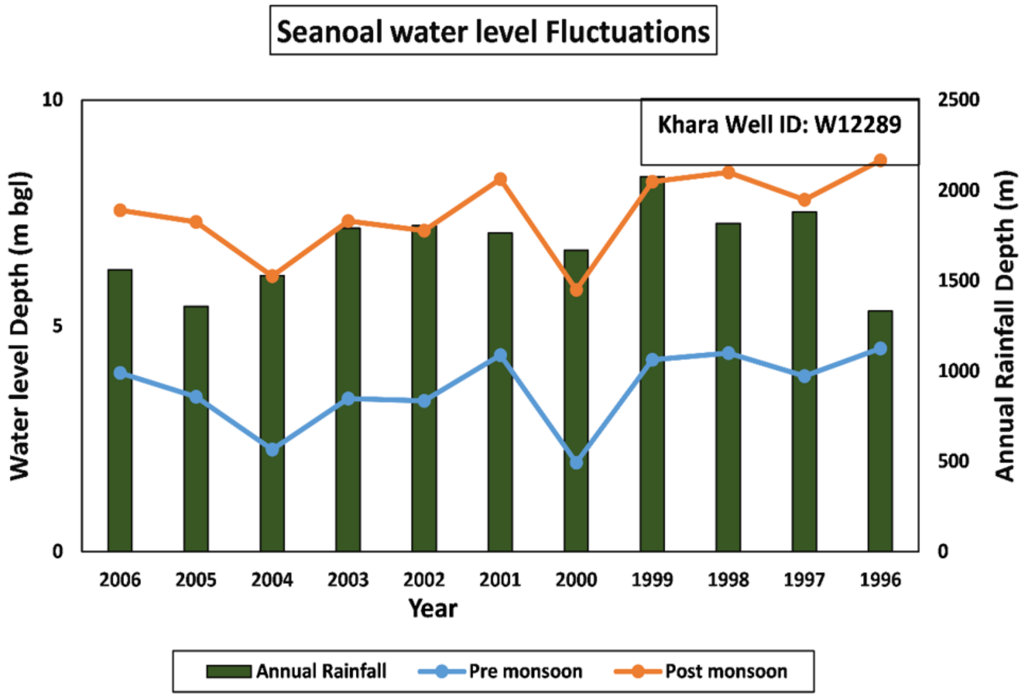

Figure 8: *Seasonal water level variations at Khara*

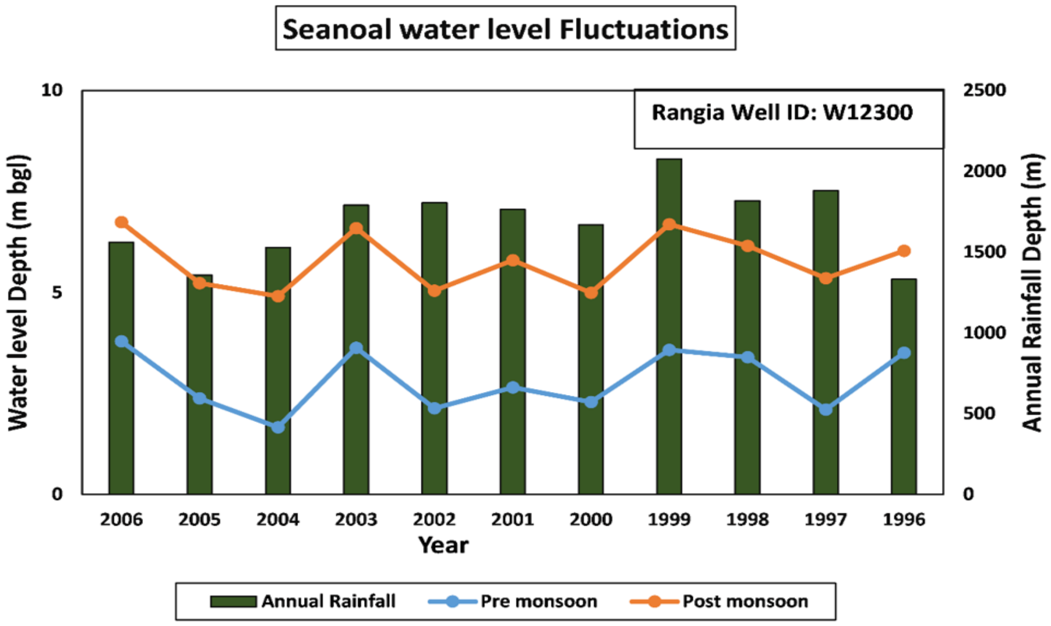

Figure 9: *Seasonal water level variations at Rangia*

Dynamic Groundwater Reserves

Dynamic groundwater reserve (DGWR) is the potential amount of water, which can be released or stored in an aquifer. In the present study we estimated the DGWR for ten years (1996-2006) from each well using the post and pre-monsoon water level data. Figure 9 illustrates the change in DGWR for a period of ten years. From the Figure 9, it is very much obvious that the DGWR is getting lowered with time for all the five locations at an alarming rate.

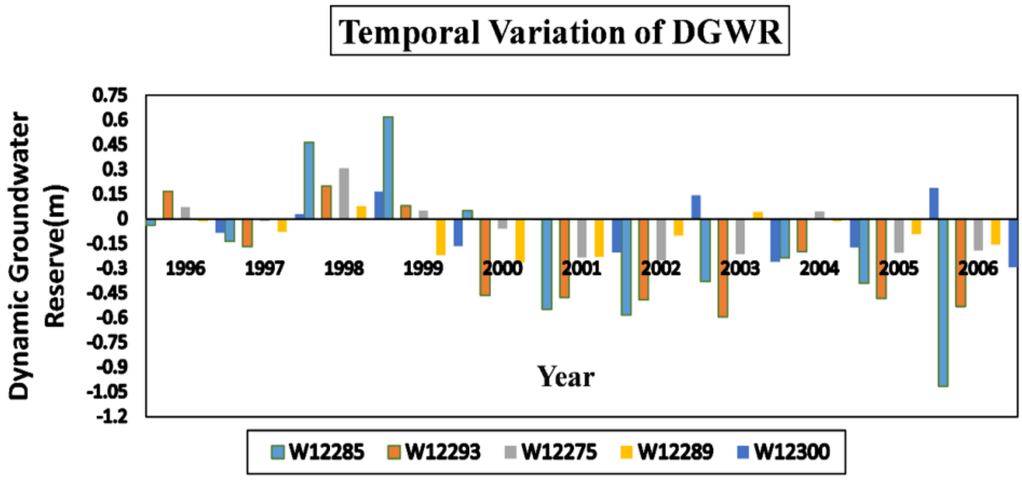

Figure 10: *Dynamic Groundwater Reserve*

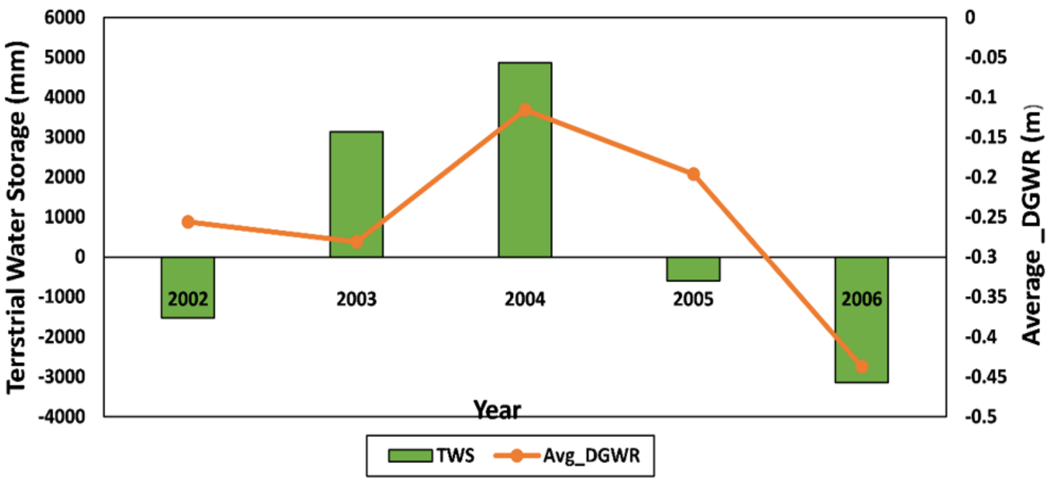

Figure 11: *Comparison of Dynamic Groundwater Reserve with TWS*

For the entire analysis, in 1998 and 1999 at few locations the DGWR was positive but with time the reserves are showing a gradual depletion. From the trend analysis, it is clearly indicating that at Agyathuri (Well ID: W12285) the DGWR are under more critical situation compared to other locations. At Bamunigaon (Well ID: W12275), there is consistency in results that are also under stress. At Rangia (Well ID: 12300) in the years 2002 and 2005 the DGWR was positive and in the remaining years the reserves are showing a negative trend. At Khara (Well ID: W12289) the trend is rising towards positive situation from 2002 onwards. At Azara (Well ID: W12293) location each year the reserves show distinct variations and those are negative in nature. Overall from results, we observed that availability of groundwater is in critical condition and further extraction of groundwater may lead to a severe groundwater crisis in the district. An average value of DGWR was calculated for five years from 2002 to 2006 to do a comparative analysis with respect to TWS since TWS is on a regional scale. In the present study it was observed that the average DGWR computed for the five well sites for each year is showing a consistent trend with respect to TWS. The result is very much indicative of a decreasing trend in the groundwater reserves.

The DGWR and TWS trends are following the same pattern. In the year 2004, the recorded TWS and estimated average DGWR are relatively high. The results indicating that the DGWR and TWS are showing a comparable negative trend in the dynamic groundwater storage capacity for the study area.

4. Conclusion

In the present study, an attempt was made to know the groundwater scenario of Kamrup district of lower Assam district. The basis of this study is dynamic groundwater reserve at five sites of the study area for a period of 1996 -2006. The following things are observed during the study period.

- The maximum groundwater fluctuation was in the range of 0.84 to 3.48 m and minimum between -5.07 to -1.47m.
- From the trend analysis, it is obvious that there is an increasing trend of groundwater level at Khara, Rangia and Bumungiaon site and a decreasing trend at Agyathuri and Azara site.
- The two sites (Agyathuri and Azara) were continuously subjected to stress from 1999 onwards.
- The DGWR and TWS are showing a comparable negative trend in the dynamic groundwater storage capacity.
- Overall, we observe a decrease in dynamic groundwater reserves.

Thus, the results of this study provide a clear picture of spatial and temporal variations of dynamic groundwater resources in the study area based on which important recommendations can be made for managing the scarce groundwater resources of the study area. Such studies can motivate the policymakers and experts to formulate and implement effective, appropriate and sustainable response strategies to minimize the undesirable effects on groundwater.

Acknowledgement

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References

Ahmadi, T., Ziaei, A.N., Davary K. and Izadi, A.A. 2013. Estimation of groundwater recharge using various methods in Neishaboor Plain, Iran. *Journal of Groundwater Modeling and Management under Uncertainty*. International Groundwater Symposium, At Kuwait Institute for Scientific Research, Kuwait.

CGWB. 2013. Ground water information booklet of Kamrup & Kamrup Metro District, Assam.

Chinnasamy, P., Maheshwari, B. and Prathapar, S. 2015. Understanding groundwater storage changes and recharge in Rajasthan, India through remote sensing. *Journal of Water* 7, pp.5547-5565.

GWREC. 1997. Ground Water Estimation Methodology - 1997, Ground Water Estimation Committee (GWREC). Ministry of Water Resources, Government of India, New Delhi. Available from: *https://blogs.egu.eu/network/water-underground/2017/03/20/wtf-of-the-wtf-method*.

Murasingh, S., Wable, P. and Jha, M.K. 2015. *Groundwater scenario in South Tripura District of North-East India*. International Conference on Hydraulics, Water Resources and River Engineering, IIT Roorkee, Uttarakhand, India.

Mutao, H. and Yong, T. 2015. *Prediction of groundwater level for sustainable water management in an arid basin using data-driven models*. International Conference on Sustainable Energy and Environmental Engineering.

Park, E. 2012. Delineation of recharge rate from a hybrid water table fluctuation method. *Journal of Water Resources Research,* 48, pp.1-6

Richey, A.S., Thomas, B.F. and Rodell, M. 2015. Quantifying renewable groundwater stress with GRACE. *Journal of Water Resources Research*, pp.5217-5238.