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A Geographical assessment of water resource pattern with emphasis upon surface water balance and flow equation in Purulia District, West Bengal

[1]Dr. Bhaskar Das

[1]Cartographer, Department of Geography,
Visva Bharati (A Central University of Govt. of India), West Bengal

Abstract:

With increasing population, urbanisation, and industrialisation, drinking water naturally receives the highest priority over the country. Water scarcity and drought associated phenomena has been a chronic phenomena in Purulia since several decades. Therefore, identification of water resource pattern regarding different hydrological and hydrogeomorphological situations in this district is needed indeed. Heavy withdrawal of water vis-a-as a low permeability of water bearing horizon, remarkable water fluctuation results the drying up many public drinking water in Purulia District. Ultimately the proposed work will provide guidelines to scenario of present water availability pattern, estimation of water usage, sub-surface and surface water recharge pattern with emphasis upon surface water balance and flow pattern under hydrogeomorphological aspect.

Index Terms: **Hydrogeomorphology, water table, water intervention, Fluoride contamination**

I. INTRODUCTION:

Problems regarding the encroachment of water scarcity, unavailability of potable drinking water and terrain based surface water management have led to great challenge for Purulia District. In the Purulia District (the present study area), instances of fluorosis are on the rise in this district (PHED report, 1995). The rural population is the worst affected, because of the absence of centralized water-treatment system in these areas. The appropriate application of satellite data to ground water mapping would support the general scientific trend toward a surface manifestation of ground water.

II. LOCATION OF THE STUDY AREA:

The study area is the westernmost District of West Bengal and is girdled by the Tropic of Cancer. Its latitudinal and longitudinal extents are from 22º 42′ 35″North to 23º 42′ 00″ North and from 85º 49′ 25″East to 86º 54′ 37″ East respectively (NRIS Project Report ,2005). Only about a 100kms of the District boundary follows the Damodar in the north and the Subarnarekha in the west. A part of the northern boundary runs through the centre of the Panchet reservoir so that its waters are shared by Dhanbad and Purulia. Similarly, the eastern boundary runs partly through the centre of the Kangsabati reservoir. The total area of Purulia District is 6,259 sq. kms (Ground water information booklet,2008).

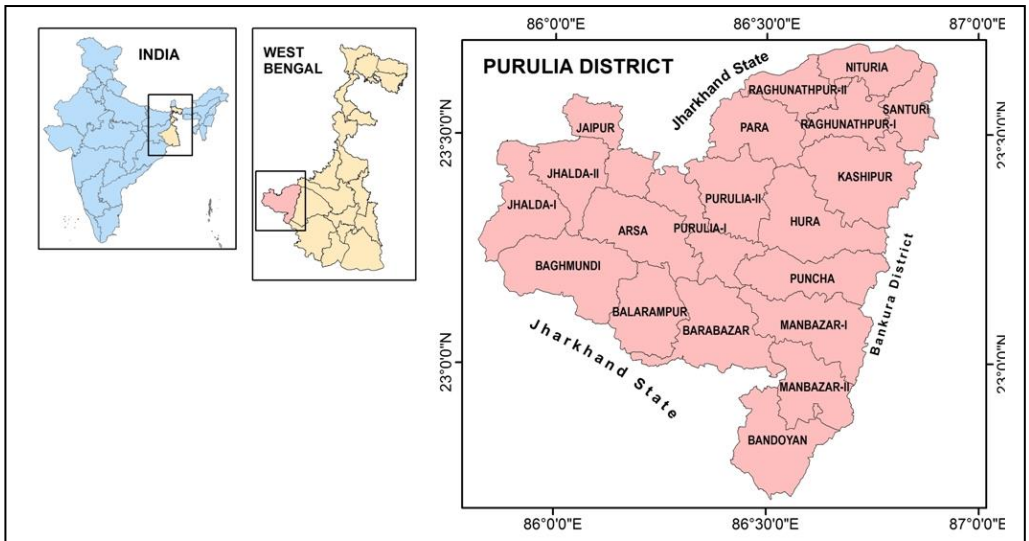

Fig-1: Location map of study area
(Source-Author based on NATMO map)

III. STATEMENT OF THE PROBLEMS IN THE STUDY AREA:

After in-depth study and review of a number of published research articles, different government bodies published reports of West Bengal, project reports associated with this phenomena, the author has found several problems which are as follows:

- The main problem of this area is scarcity of water as well as soil erosion.
- Erratic surface and sub-surface water condition with remarkable fluctuation of water table within short distances.
- Purulia District is heading towards a fresh water crisis as the water resource is in decline water (NRIS report ,2005).
- Fluoride contamination growing rapidly over the district concentrated naturally occurring mineral called 'apatite', which is a fluorinated calcium phosphatic compound (Dasgupta, S. et.al,1992).

IV. OBJECTIVES OF THE STUDY

1. To find out the scenario of present water availability pattern
2. To estimate of water usage
3. To assess the sub-surface and surface water recharge pattern with emphasis upon surface water balance and flow pattern

V. METHODOLOGY

A number of hydrogeomorphological themes have been generated through integration and analysis of thematic layer generated from of IRS P6 LISS-III and LISS -IV rectified satellite image (precision geocoded images). In order to prepare the maps with field verification with attributes as stated in methodology has three phases for carrying out the whole work – i) Pre-field (study of literatures , research articles, reports etc and preparation of base map of Purulia district), ii) Field study (primary data collection in study area), iii) Post data compilation under GIS environment (generation of different thematic layer with limited field check under Arc GIS 10.1 version.

VI. GEO-SCIENTIFIC ASSESSMENT, DISCUSSION AND FINDINGS

1.0. WATER AVAILABILITY PATTERN

1.1 Existing drainage system:

In Purulia district, there are mainly four river basins (watersheds) in this area vis., Damodar, Dwarkeswar, Kangsabati and Subarnarekha. The groundwater in the area occurs mainly in hard crystalline rocks, within weathered mantle and fracture zones of the underlying crystalline rocks. The surface runoff pattern as a whole is diverse due to its terrain characteristics. This is further accelerated under the existing conditions of land use practices (Deb, 1995). The drainage pattern developed in the region is either dendritic or radial. The Kasai is the master-stream of the District, draining more than three-fifth of the District. Other major rivers in this district are Damodar, Dwarkeswar, Gobai, Kumari, Nangasai,Shilabati, Hanumata and the Subarnarekha which are non-perennial rivers and subject to flash floods (Das A., *et.* al.,2012).

1.2 Other sources of water resource availability and utilisation pattern:

The ground water draft for all uses has been calculated to 13.78% out of which 8.55% is for irrigation only and rest for domestic and industrial uses (Bureau of Applied Economics & Statistics report, 2017). Major canal irrigation system has been found both side of Kangsabati reservoir and Panchet reservoir. The quality of water is good for both the irrigation and for potable use. The occurrence and movement of sub surface water depend upon the present lithological strata, ground water storage and seasonal rainfall in the District. The social factors which influence the potential use of water resources for drinking as well as agricultural and irrigation include ownership, control, users, associated uses and rights of use (Chakrabort, P. 1999).

In Purulia District ground water utilisation is yet very little in agriculture and industrial sectors. Drafting of ground water is mainly from dug and bored wells for domestic consumption. The majority of water bodies is seasonal and has the very limited potentiality to be used for irrigation for rabi cultivation.

Table 1: Existing water availability and utilisation scenario in Purulia District

Sl No	Water Resource Type	Seasonality	Ownership	Users	Uses
1	Gully head bund	Post monsoon period	Individual, Group, Govt., Community	Domestic/ Community	Irrigation, Bathing, Washing, Fisheries, Animal use
2	Pond / Tank	Throughout the year	Individual, Group, Govt., Community	Community	Irrigation, Bathing, Washing, Fisheries, Animal use
3	Irrigated seasonal pond	6 to 8 month	Group &Community	Community	Irrigation, Bathing, Washing, Fisheries, Animal use
4	Doba	Water available generally up to 5 to 8 months	Individual, Group,	Domestic/ Community	Domestic use, Irrigation of homestead, Fisheries, Bathing
5	Natural steam /Jor	Water available during monsoon, perennial	Common	Community	Rabi cultivation (Partial)
6	Water harvesting tank	Water available from July to October	Individual and Govt.	Domestic/ Community	Soil water conservation, Irrigation and Fisheries
7	Check dam/ Nalabund	Throughout the year	Community	Community	Crop& vegetables cultivation
8	Irrigation canal	Water available from 8 to 10 months	Group, &Community	Community	Irrigation & Fisheries
9	Khal	May be perennial or seasonal	Govt.	Community	Irrigation, Bathing, Washing, Animal use etc

Source: Database generated on the basis of field observation

1.3 Water Quality Aspect: Chemical Characteristics

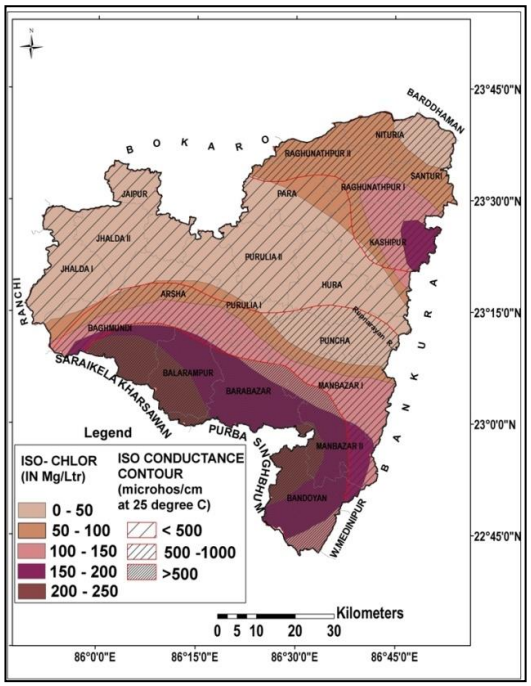

Fig-2: Chemical characteristics in Purulia
Source: Author, based on PHED

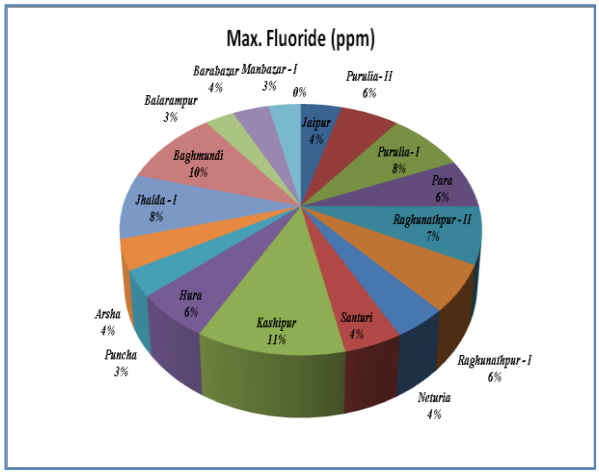

Fig-3: Fluoride concentration at different blocks in Purulia District

1.3.1 Fluoride scenario

Table 2: Fluoride concentration in Purulia District (2017)

Sl No	Block	>=0 to < 1 mg/l	No of wells	>= 1 to <=1.5 mg/l	No of wells	> 1.5 mg/l	No of wells	Max.Fluoride (ppm)	Total TW
1	Jaipur	84.19	426	9.88	50	5.93	30	3.25	506
2	Purulia- II	75.08	446	15.82	94	9.09	54	4.61	594
3	Purulia- I	81.48	519	11.15	71	7.38	47	5.99	637
4	Para	78.87	612	15.72	122	5.41	42	4.67	776
5	Raghunathpur - II	87.57	296	8.58	29	3.85	13	5.43	338
6	Raghunathpur - I	74.61	482	17.18	111	8.2	53	4.41	646
7	Neturia	94.31	431	4.6	21	1.09	5	2.99	457
8	Santuri	94	392	5.52	23	0.48	2	3.24	417
9	Kashipur	90.18	900	7.31	73	2.51	25	8.28	998
10	Hura	87.69	734	8.6	72	3.7	31	4.28	837
11	Puncha	91.52	658	7.09	51	1.39	10	2.42	719
12	Arsha	96.5	634	2.59	17	0.91	6	2.88	657
13	Jhalda - I	94.03	598	4.72	30	1.26	8	6.25	636
14	Baghmundi	97.28	607	1.76	11	0.96	6	7.58	624
15	Balarampur	96.71	412	1.88	8	1.41	6	2.33	426
16	Barabazar	95.67	552	2.95	17	1.39	8	2.88	577
17	Manbazar - I	94.72	826	2.98	26	2.29	20	2.55	872

Source: PHED report,2017

2.0 ESTIMATION OF WATER USAGE

As per Minor Irrigation census 2011 total nos. of Tanks in this District are 27491. Out of which, Tanks used for irrigation purpose are 18726 nos. and Tanks used for non-irrigation purpose are 8265 nos. There is altogether 32 Nos. of medium irrigation Schemes in this District. Out of these 32 Schemes, 23 are completed and 9 are in various stages of execution. There are altogether 135 River Lift Irrigation (RLI) schemes with effective command area. The total irrigation potential created is 15500 acres.5 Nos. of Major RLI and 97 nos (Bureau of Applied Economics & Statistics report, 2017).

Table 3: Surface water development in Purulia District(2017)

Aspect / Attribute	Area
Total water area of Purulia District	27083.43 Hectare
Dams and Reservoir water area	8707.74 Hectare
Ponds/Tanks/Gully head bunds water area	19575.69 Hectare

Source: BAES, 2017,Purulia

The demand for water is increasing due to population growth, economic and technological development, and increasing modernised ways of life in this District. Of the total available surface water consumption rate, agricultural use accounts for approximately 70%, industrial use accounts for 3%,and domestic use accounts for 27%. The expected water consumption should be 60-150litres per day in this District.

Table 4:Block-wise water utilisation in Purulia District

Assessment unit (Block)	Net ground water availability (in ha.m)	Existing gross ground water draft for irrigation (in ha m)	Existing gross ground water draft for domestic and industrial water supply (in ha m)	Existing gross ground water draft for all use (in ha m)	Association for domestic and industrial requirement supply up to next 25 yrs (in ha m)	Net ground water availability for future irrigation development (in ha m)	Stage of ground water development (%)
Arsha	3704	48	204	251	274	3382	6.79
Baghmundi	2172	417	180	597	243	27.47	1513
Balarampur	2988	263	153	416	206	13.93	2518
Barabazar	6275	248	235	483	317	7.7	5711
Banduan	2947	77	133	210	179	7.11	2691
Hura	3417	132	207	338	279	9.9	3007
Jhalda-I	2144	816	180	996	243	46.44	1086
Jhalda-II	2707	369	191	560	257	20.68	2081
Jaipur	2090	799	172	972	232	46.49	1058
Kashipur	6073	764	264	1028	356	16.93	4953
Manbazar-I	5258	157	214	371	288	7.06	4612
Manabazar-II	3992	24	144	166	194	4.2	3775
Naturia	2942	138	139	277	188	9.41	2617
Para	3178	146	256	401	344	12.62	2688
Puncha	4970	257	175	433	236	8.71	4476
Purulia-I	3602	586	199	785	269	21.8	2748
Purulia-II	3781	381	223	604	300	15.97	3100
Raghunathpur-I	2496	168	135	303	182	12.12	2147
Raghunathpur-II	2267	100	146	246	197	10.86	1970
Santuri	3143	112	116	228	156	7.24	2875

(Source: Directorate of Fisheries, 2017,Purulia)

3.0 SUB-SURFACE AND SURFACE WATER RECHARGE PATTERN

It has been observed during the field survey that where surface water is not readily available, the inhabitants resort to extraction of groundwater from riverbed, nala bund, check dam and dug wells. During periods of normal precipitation (about 1,000 mm. to 1,200 mm. in a year) the groundwater which is stored in the zone of weathering pediment shallow and valley-fill portion are adequate for water recharge aspect and availability. However, during summer of each year, heavy withdrawal of water vis-à-vis a low permeability of water bearing horizon results in the drying up of many public drinking-water wells. For ground water, rainfall is the principal source of recharge. The other are the pre-existing or existing drainage system, canal system and return flow of irrigation practices. Due to hilly and undulating terrain river water more than 75% water flow down towards low area.

3.1Hydro-geological aspect:

According to CGWB report (2006) and intensive filed survey that ground water in this District occurs mainly in-

- **Saprolitic zone-**Saprolitic zone is sandwiched between weathered mantle and fresh rock mass in granite terrain. The depth of this zone varies between 10 – 30 mbgl. Having yield up to 2.5 lps is recorded.
- **Fractured zones of hard rock-** Deeper fracture is encountered at 100-110 m depth, yielding around 3 lps to 3.3-5.5 lps.
- **Unconsolidated sediment zone-** Unconsolidated sediments zone along the river valleys are of limited thickness of fall within 5-13 mbgl yield up to 20 cubic mtr.

Hydrogeomorphological investigations include the delineation and mapping of various landforms, drainage characteristics and structural features have a direct control on the occurrence and flow of groundwater (*Baidya, T.K.1992).* Therefore, hydro-geomorphological scenario of this district can be interpreted as follows:

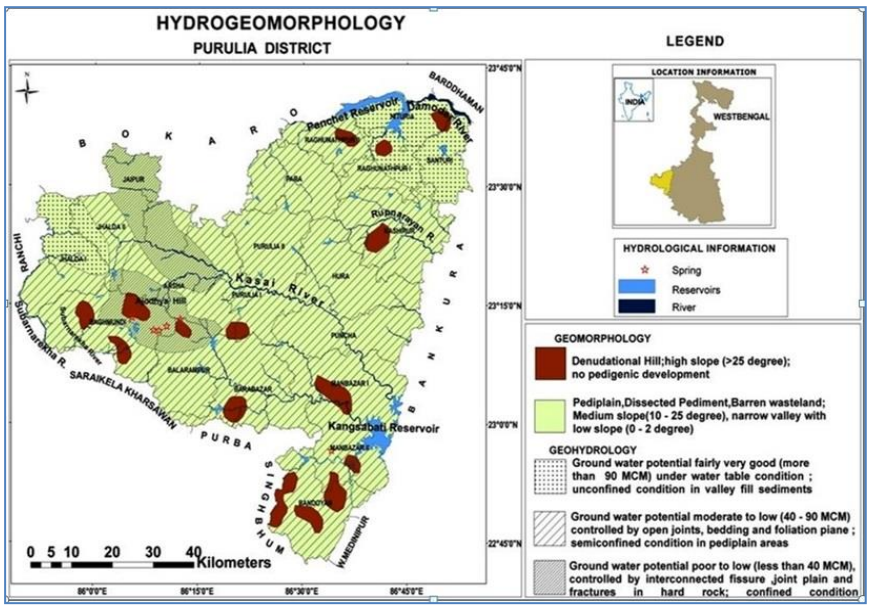

Fig 4: Hydro-geomorphological scenario (Source: Auther,based on CGWB, 1995)

3.2 Water Level Fluctuation

The District is a 'White Zone' in respect of ground water status (i.e. 60% of available ground annual recharge is in use). In general, during the rainy season the water table in the wells raises up to 1.00 to 3.50 mbgl till the end of October and gradually falls down to maximum of 6 to 14 m bgl during April-May. The ground water flow direction is towards south-east i.e. towards Damodar river with hydraulic gradient of 0.01 to 0.008 (NRIS Report,*2005*) while it has been also inferred to be towards Damodar river in the buffer zone which controls the master drainage of the area. Ground water level fluctuation between the pre – monsoon and post monsoon water level measured in the month of May and November (2016-2017) respectively is one of the measure of rainfall recharge and in turn gives the volumetric estimate of replenishable ground water resources of the area.

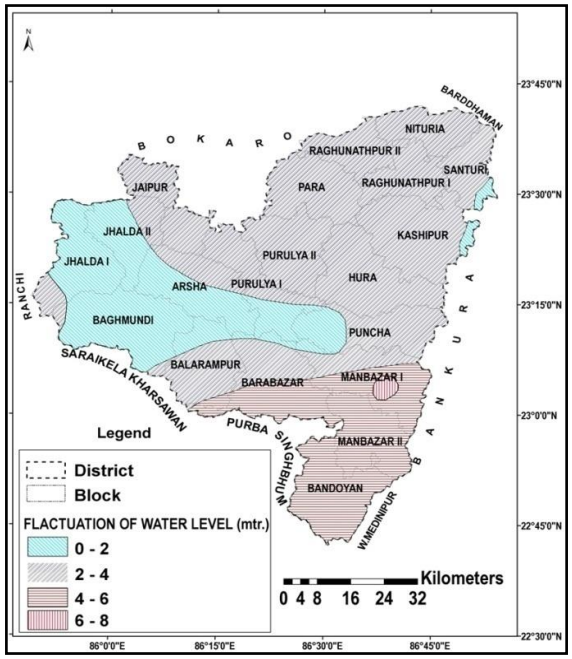

Fig-5:Fluctuation of water level (Pre& Post-monsoon, 2016-17)Purulia District (Source: Auther,based on CGWB, 1995)

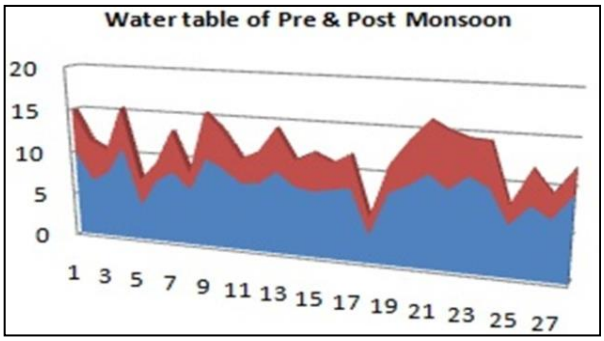

Fig. 6: Average fluctuation of water level (mtr) during Pre& Post-monsoon, 2016-17), Source: Author

The other input to the ground water includes seepage from water bodies, canals etc. The average fluctuation in water levels has been observed between the two extreme seasons around is 6.1 m maximum part of this district(PHED report, 1995). In respect of the confined/semi-confined aquifer in the core zone area, the piezometric head is at deeper level in relation to potentiometric levels of dug wells tapping the unconfined aquifer inferring hydrological discontinuity or low pressure head in deep aquifers. The attributed to overall rise in ground water level resulting in to reduction in thickness of unsaturated zone as it is already filled with water due to seepage from number of water storage tanks and ponds.

3.3 Sub-surface to surface water balance and flow pattern trend

Surface water balance has been maintained through water recharge practices are adopted all over the world to meet the increasing water demand with outburst of population, development of industrial sector and rise in irrigation water requirements (Khan, M.A., & Maharana, P.C. 2002). Surface water balance in this District implies the natural linkage between meteoric water, surface water, and ground water exists to keep up the processes of hydrological cycle. The estimation of the surface water balance of a region requires quantification of all individual inflows to or outflows from a groundwater system and change in groundwater storage over a given time period. The following is the governing trends:

Change in storage of the system = Input to the system - outflow from the system= Change in Storage over a period of time

Table-4**:** Pre- intervention and post- intervention ground water scenario in Purulia District

Pre-intervention groundwater (GW) scenario (in MCM)				Post-intervention groundwater (GW) scenario (in MCM)		
Rainfall year	Total Surface &Sub surface water recharge	Total surface water requirement for irrigation & Drinking Purposes	Net surface water balance	Total Surface &Sub surface water recharge	Total water requirement for irrigation& Drinking Purposes	Net ground water balance
Good	3.02	2.08	0.96	7.13	4.53	2.6
Average	1.63	1.22	0.41	5.29	3.14	1.61
Lean	0.78	1.21	-0.43	2.11	1.32	0.79

(Source: Generated by Author based on SWID data, 2017)

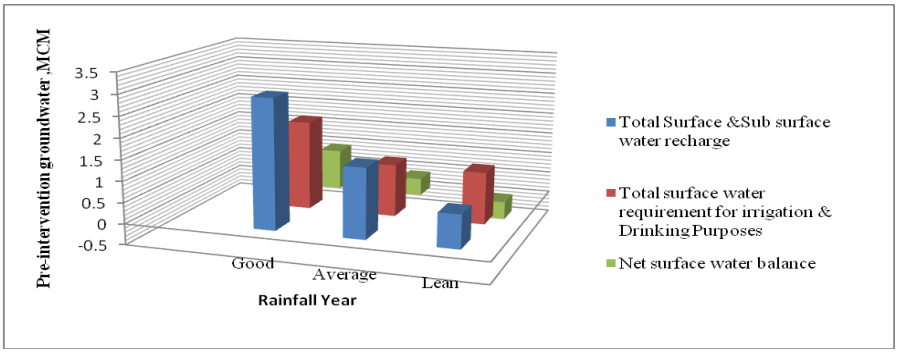

Fig.7: Pre-intervention groundwater (GW) scenario (in MCM,2017)

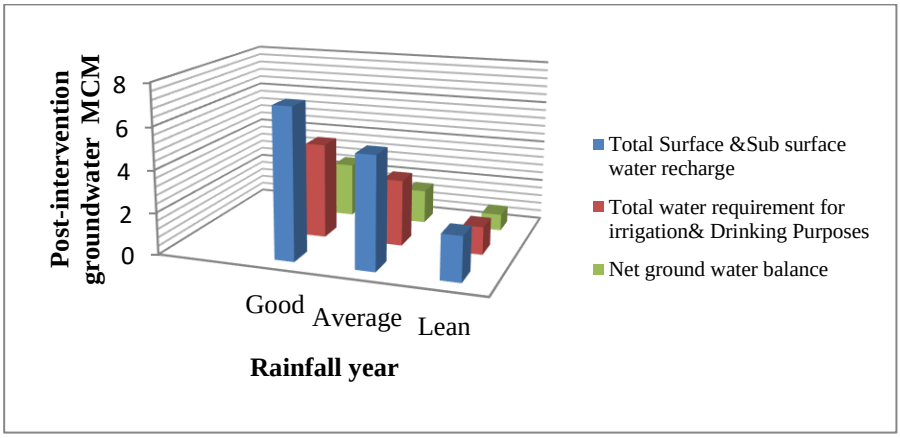

Fig.-8: Post-intervention groundwater (GW) scenario (in MCM,2017)

VII. CONCLUSION:

After in-depth geographical assessment of present scenario of present water availability and utilisation pattern, sub-surface and surface water recharge pattern with surface water balance and flow pattern, the chronic water scarcity of Purulia district has to be given most priority. With respect to the physical alternatives to fulfil sustainable management of freshwater, there are two solutions: finding alternate or additional water resources using conventional centralised approaches; or better utilising the limited amount of water resources available in a more efficient way. Optimizing the water balance for the region is the only way to sustainable water and this should involve the entire community in the effort. To date, much attention has been given to the second option regarding Purulia and intensive attention has been given to optimising water resource conservation and management systems.

VIII. ACKNOWLEDGEMENT

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