AGGLOMERATION OF ARSENIC LINK TO RAIN WATER HARVESTING IN WEST BENGAL CONSIDERING POPULATION AS FUNCTION

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ABSTRACT:

As many districts in West Bengal face the problem with arsenic in drinking water, so alternative arrangement for drinking water is necessary for those specific districts. For potable water, people mostly depend on the groundwater reserve. However, with the increasing population, groundwater level and its quality are reducing rapidly. Moreover, there is a vulnerability of arsenic content. Some regions are rich in groundwater but its high arsenic concentration makes it non-potable whereas other regions which are free of arsenic, lack sufficient groundwater. Hence, this paper focuses on the study of mass rainwater harvesting in-depth to eke out all these problems and find an effective solution. Here we have described the actual rainfall scenario in the Monsoon season (including pre-monsoon and post-monsoon) of West Bengal in comparison to population and arsenic vulnerability. We have analyzed district-wise rainfall data of West Bengal for a particular period using remote sensing and GIS technique. From that, we make some thematic maps for the individual parameters. We have used QGIS software for preparing and a better understanding of the matter. Efforts are given to observe the thematic maps to decide how much this process is beneficial for society.

KEYWORDS

Arsenic concentration, GIS, Groundwater, Population, Remote sensing.

INTRODUCTION

Arsenic contaminated groundwater has already affected about 6 million people (Mazumder D. G. and Dasgupta U.B., 2011). During the period 80s, due to the usage of ground water contaminated with arsenic some cases of skin diseases prevailed in the districts of North 24 Parganas, South 24 Parganas, Nadia, Murshidabad, and Burdwan (Mazumder D. G. and Dasgupta U.B., 2011; Chakraborti D. and Das B. et al, 2009). The regular use of Arsenic contaminated water led to major health issues like Diabetes mellitus, Skin manifestations, Systematic manifestations, Respiratory Gastrointestinal, Liver, Cardiovascular and Blackfoot diseases i.e. a vascular diseases occurring due to toxicity of arsenic (Mazumder D. G. and Dasgupta U.B.,

2011). Arsenic contamination affected the nervous system of people. Water is the main driving force of our nature. The primary source of water in the dry areas and deserts and even in the semi-dry regions is groundwater because of its ability to get less affected by pollution compared to the surface water in most of the areas of West Bengal (Mondal I. and Bandyopadhyay J. et al, 2013). The climatic conditions of West Bengal range from savannah (a usually warm climatic condition with temperature from twenty-degree to thirty degrees) to mid subtropical climate (i.e. summer and winter) (Fenta A. A. and Kifle A. et al G., 2015). The continuation of the rainy season in West Bengal from July to the end of September. The annual rainfall differs in different parts of the state where the highest rainfall of 200 to 400 cm is received by the North Bengal, almost 200 cm is poured in the coastal area in the Ganga plains and the middle of the central part of the state receives a rainfall of about 150-200 cm and an amount of 100- 125 cm of rainfall is experienced by the western plateau region (Singh J.P. and Singh D. et al, 2009). The importance of rainwater harvesting can be understood from the increasing demand for irrigation and the unsustainable practices of groundwater utilization. It has been found that the farmers of the Bankura and Purulia districts would face a difficult problem in the upcoming years due to the scarcity of water and the only remedy to this major problem is the utilization of rainwater. This phenomenon of utilization and conservation of rainwater is known as Rain Water Harvesting. It is a type of harvesting of water in which the drops of rain are collected and stored for future uses instead of wasting. Water harvesting is very crucial to conserve natural resources like soil and water (Singh J.P. and Singh D. et al, 2009). The ideal places are rivers or roofs from where rainwater can be collected easily and it can be stored in a deep well, any reservoir, shaft, or in an aquifer (Eccles A., 2017; Uddipta G. and Ranajit B.K., 2016). Rooftop rainwater harvesting has already gained much popularity in India and has been inbuilt in many housing complexes or institutes to recharge the aquifers. It is done to maintain the water balance by precipitation and evapotranspiration (Jasrotia A. S. and Majhi A. et al, 2009). We can use this water for gardening purposes, for domestic use after some treatment, the heating purpose for houses, etc. (Eccles A., 2017; Uddipta G. and Ranajit B.K., 2016).

For drinking purposes, the harvested water can also be used (after purification) (Eccles A., 2017). It is a very judicious process of rainwater utilization.

Making available the harvested rainwater in the dry season plays a major role in the agricultural purposes and livelihood of mankind (Agricultural Water Management Learning and Discussion, 2012). It enables the farmers to grow a type of crop called Rabi crop during the winter season (Agricultural Water Management Learning and Discussion, 2012). The funding by MGNREGS focused on the design of hapas to cover 5% of the land to provide irrigation to paddy crops in Kharif season as the SC &ST depended on the rain-fed agriculture (Agricultural Water Management Learning and Discussion, 2012).

Groundwater, a disguised natural resource (Gouri B. S. and Sailesh S. et al, 2012; Bitterman P. and Tate E. et al, 2016). However, to achieve accurate results integrated studies using satellite image data and geographical information system (GIS) tools are used (Gouri B. S. and Sailesh S. et al, 2012).

In urban areas, rainwater is collected in paved areas and at the top of the roof (Sen P., 2012). With the expanding population, the freshwater demand is also increased day by day (Rajasekhar M. and Gadhiraju S. R. et al, 2020). Only groundwater sources can not fulfill public demand regularly (Rajasekhar M. and Gadhiraju S. R. et al, 2020). So the metropolitan cities especially faced some deficit of groundwater supply (Sen P., 2012; Bitterman P. and Tate E. et al, 2016). Seasonal fluctuations, which are the most common, also affect sometimes (Sen P., 2012).

Critical Circumstances In West Bengal Due To Arsenic

During the 1980s some cases of skin disorders in the districts of North 24 Parganas, South 24 Parganas, Nadia, Murshidabad, and Burdwan reported from where it is known that the disease is due to the use of arsenic-contaminated groundwater (Chakraborti D. and Das B. et al, 2009). Out of the twenty districts in West Bengal, 9 districts (Malda, Murshidabad, Nadia, North-24-Parganas, South-24-Parganas, Bardhaman, Howrah, Hooghly, and Kolkata) are very much affected by arsenic-contaminated groundwater [Fig. 4]. Generally, high Arsenic concentration in Groundwater will occur from 20-80M depth (Uddipta G. and Ranajit B.K., 2016). The other six districts in the northern part of West Bengal and 5 districts in the western part of West Bengal are arsenic safe-zone (Chakraborti D. and Das B. et al, 2009; Uddipta G. and Ranajit B.K., 2016).

STUDY METHODS

We are using the GIS (Geographical Information System) technique for this work. This technique is very helpful and has many advantages. It helps in producing and providing information in spatial and temporal domains which is very much important and essential for getting accurate results and analysis (Thapa R. and Gupta S. et al, 2017). It is such a tool that works with different types of data and combines them to work into a single domain to analyze and solve the problems and get perfect correct result and observation (Debabrata Mondal and Swades Pal, 2015). The remote sensing technique helps us to improve the characteristics of the land surface to increase the hydrological studies and the advancement of remote sensing (Fenta A. A. and Kifle A. et al G., 2015).

Study Area

West Bengal lies in between 85˚55′ and 89˚55′ East longitude and 20˚25′ and 27˚13′ North latitude (Jasrotia A. S. and Majhi A. et al, 2009).

Work Flow Of Study

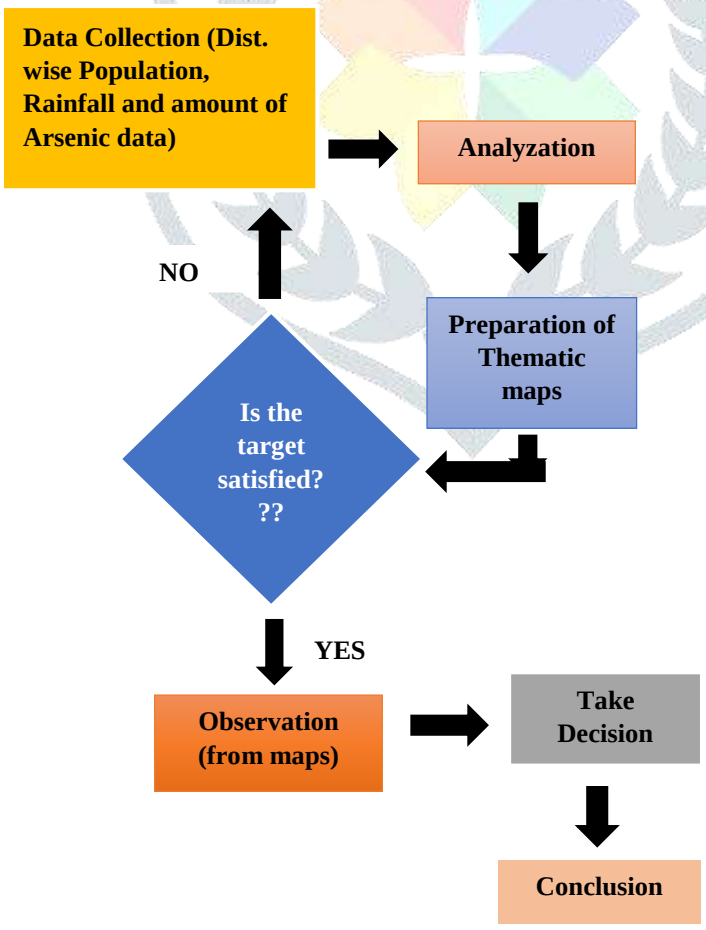

Figure 1 Flow chart of our work

Data Table

Table 1: Tabulated form of Our Collected Data (District wise total population, rainfall and Arsenic Data (https://www.researchgate.net/; http://cgwb.gov.in/GW-data-access.html#; india.gov.in.;data.gov.in.)

SL No.	District.	Population	Total Rain fall (in mm)	Arsenic Concentration (in μg/L)
1.	Bankura	3596292	10273.01	2.5
2.	Bardhaman	7723663	14492.6	2230
3.	Birbhum	3502387	12262.8	2.5
4.	Kolkata	4486679	317.04	800
5.	Darjeeling	1842034	1191.77	19
6.	Howrah	4841638	2005.86	1333
7.	Hooghly	5520389	9184.04	600
8.	Jalpaiguri	3869675	3313.83	27
9.	Cooch Behar	2822780	2256.5	54
10.	Malda	3997970	5973.5	1904
11.	East Midnapore	5094238	6504.06	2.5
12.	West Midnapore	5943300	7534.08	2.5
13.	Murshidabad	7102430	10862	3003
14.	Nadia	5168488	6862.37	3200
15.	North 24 Parganas	10082852	6530.59	2830
16.	Purulia	2927965	8475.01	2.5
17.	South 24 Parganas	8153176	5825.08	3700
18.	North Dinajpur	3000849	1476.15	68
19.	South Dinajpur	1670931	1820.46	51

Thematic Maps For Our Study Table

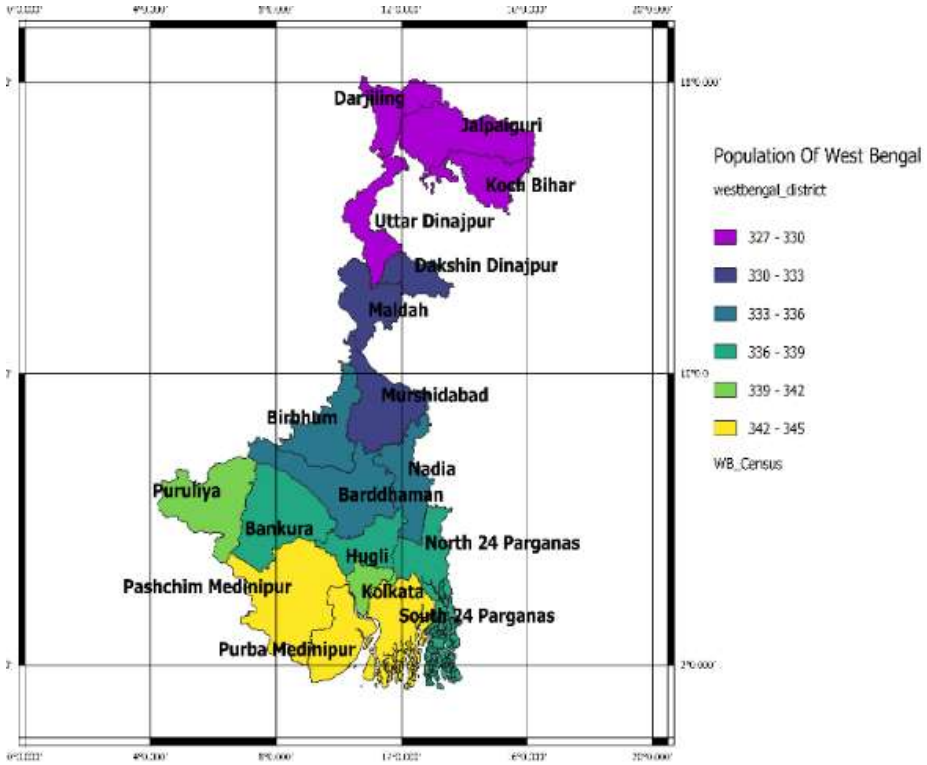

Figure 2 QGIS map (thematic map) for Dist. wise population in West Bengal

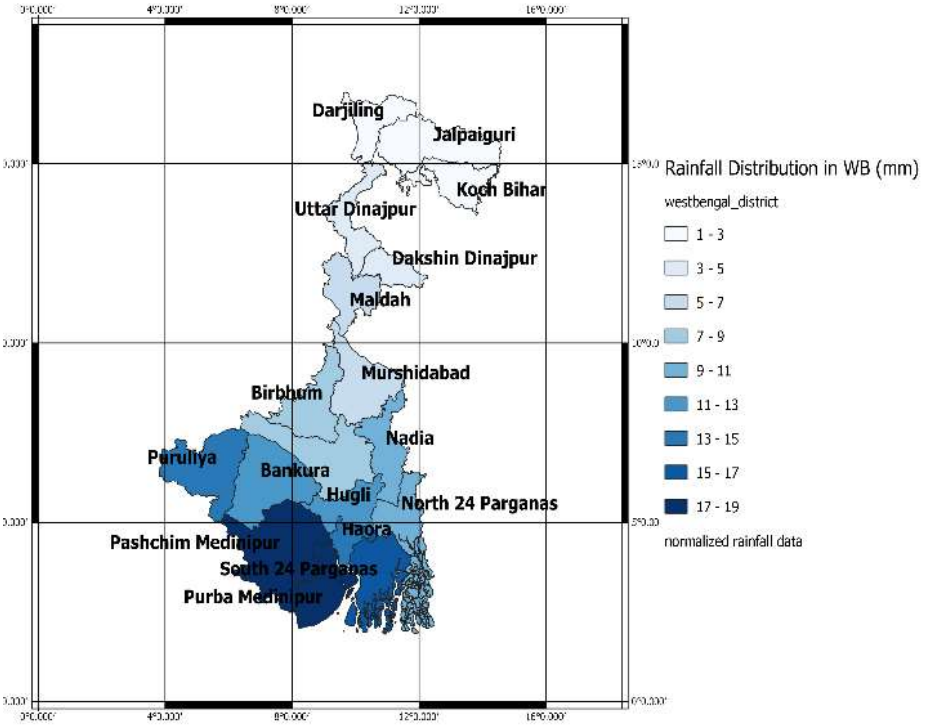

Figure 3 QGIS map (thematic map) for Dist. wise rainfall in west Bengal (in normalized condition)

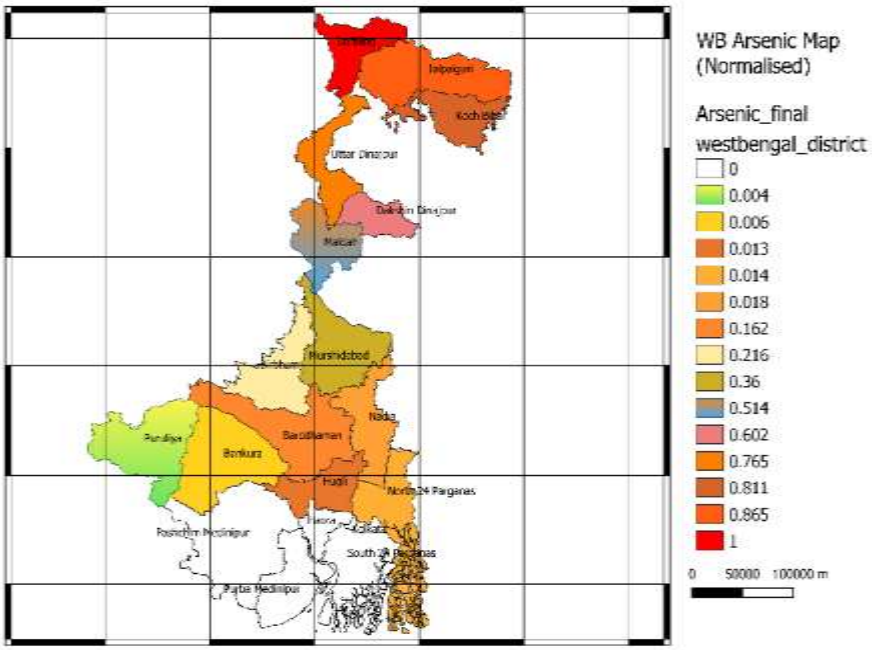

Figure 4 QGIS map (thematic map) for Dist. wise arsenic contamination in West Bengal (in normalized condition)

OBSERVATION

Table 2,3,4 (Normalized data sheet) (Descending order)

District	Total Population
North 24 Parganas	1
South 24 Parganas	0.77
Bardhhaman	0.72
Murshidabad	0.64
West Midnapore	0.51
Hooghly	0.46
Nadia	0.42
East Midnapore	0.41
Howrah	0.38
Kolkata	0.33
Malda	0.28
Jalpaiguri	0.26
Bankura	0.23
Birbhum	0.22
North Dinajpur	0.16
Purulia	0.15
Cooch Behar	0.14
Darjeeling	0.02
South Dinajpur	0

Table 2

District	Total Rainfall
Bardhhaman	1
Birbhum	0.84
Murshidabad	0.74
Bankura	0.7
Hooghly	0.62
Purulia	0.56
West Midnapur	0.51
Nadia	0.46
East Midnapur	0.44
North 24 Parganas	0.44
Malda	0.4
South 24 Parganas	0.39
Jalpaiguri	0.21
Cooch Bihar	0.12
Howrah	0.12
South Dinajpur	0.11
North Dinajpur	0.08
Darjeeling	0.06
Kolkata	0

Table 3

District	Arsenic Contamination
South 24 Parganas	1
Nadia	0.86
Murshidabad	0.81
North 24 Parganas	0.76
Bardhhaman	0.6
Malda	0.51
Howrah	0.36
Kolkata	0.21
Hooghly	0.16
North Dinajpur	0.02
South Dinajpur	0.01
Cooch Bihar	0.01
Jalpaiguri	0.006
Darjeeling	0.004
Bankura	0
Birbhum	0
East Midnapur	0
West Midnapur	0
Purulia	0

Table 4

RESULTS

As we know that population increasing rapidly so the use of water consumption is also increasing.

As per the availability and reliability of the information, we have taken into consideration the years from 2002 up to 2010 and hence analyzed the data. We also analyzed the data about the amount of arsenic is available in groundwater in every district. From the datasheet, we make a comparison with the help of a bar diagram [Fig:5].

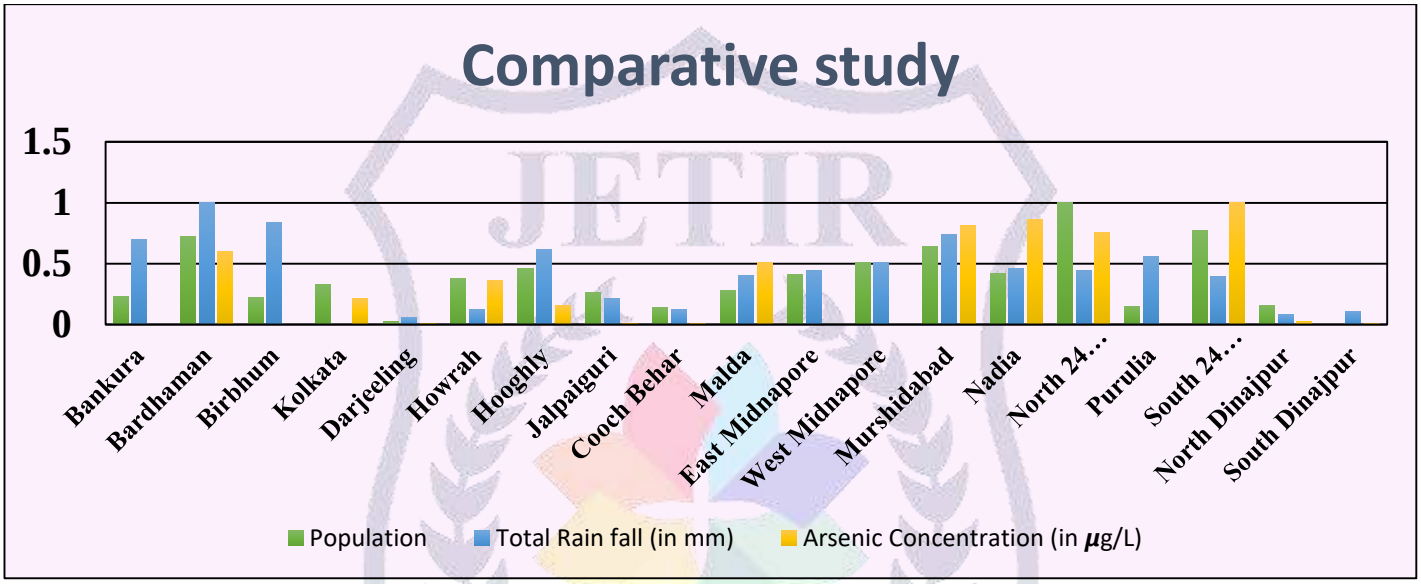

Figure 5 Bar diagram from QGIS maps for our comparative study

DISCUSSION

We have collected information about the arsenic concentration at the groundwater level for all the districts of West Bengal (https://www.researchgate.net/;http://cgwb.gov.in/GW-data-access.html#; india.gov.in; data.gov.in; Mazumder D. G. and Dasgupta U.B., 2011). We have analyzed the data which we have collected, (Fig: 2,3,4) arranged sequentially and take the decision about the actual scenario of the districts [Fig:5].

If we will consider the population [Fig:2] as well as the amount of rainfall [Fig:3] in the highly affected districts then we will see that North 24 Parganas and South 24 Parganas, both districts have a large amount of population and the amount of rainfall is medium. As the groundwater of these two districts is polluted with arsenic, people will face water scarcity during summer. These two districts will have to be the first preference

for rainwater harvesting. Nadia, Murshidabad, Bardhhaman districts will also face some problems due to their large populations. In these districts amount of rainfall is enough. But groundwater is very much polluted with arsenic [Fig:4]. If we harvest this water properly then farmers, as well as people, will be benefitted. This water can be used in the agricultural field as well as daily household work also. Water harvesting is also important for Malda, Howrah, and Kolkata because these districts have faced a lack of rainwater problems. They have to preserve the rainwater during the rainy season for the usage of the non-monsoon season. The amount of Arsenic in Bankura, Birbhum, Purulia, East Midnapore, West Midnapore is less than 3 (Mazumder D. G. and Dasgupta U.B., 2011) [here we consider the value 2.5 for these districts for the benefit of plotting graphs and taking decision]. These districts are not much affected by arsenic [Fig:4].

CALCULATION

We have collected information about the population, rainfall, and arsenic contamination in all the districts of West Bengal. We have calculated these parameters for each district. Then we have normalized the data in a range of 1 to 10 (refer to Fig 5) and arranged it sequentially. The Normalization is done and applied in the data using

A = Smallest value in data set (for the particular parameter)

B = Largest value in data set (for the particular parameter)

a = Normalized scale minimum (here a=1)

b = Normalized scale maximum (here b=10)

x = Any number from the data set whose value needs to be normalized

N_x = Normalized value

Based on the data in Table 1, we have enlisted the population, total amount of rainfall, and total arsenic contamination in the districts.

CONCLUSION

From our observation, it can be said that the higher the population density greater is the water demand. Again, a high-water demand and less rainfall may lead to water scarcity. Similarly, high rainfall and less population

imply an area with surplus water availability. The excess water that is harvested can be collected and transported to those areas suffering from water scarcity. Hence it can provide an independent water supply during regional. The arsenic polluted groundwater is not useful for drinking purposes also. So, rainwater harvesting is required.

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india.gov.in.

data.gov.in.

http://cgwb.gov.in/GW-data-access.html#

https://www.researchgate.net/

FUTURE SCOPE

As a prospect, we have thought of supplying excess water to the neighboring region during urgent need such as drought, flood, etc.

There are many districts in West Bengal such as Dakshin Dinajpur which suffer from lacking freshwater sometimes, mainly during floods, when the seawater percolates the soil and mixes with the groundwater and thus making it unsuitable for human consumption. Then the harvested rainwater will provide some relief.

Again, districts are having large agricultural fields like Bankura, Purulia, Nadia, Birbhum, West Bardhhaman, etc., but the farmers living there may also suffer from water deficiency during summer. Here also harvested rainwater will give them some relief.

Now in the further advancements, we will consider the freshwater bodies present in the districts- be it river or lake, and the groundwater level and modify our distribution system of the harvested rainwater accordingly.

As we know the population across the world is increasing at a great rate and it affects the whole availability

of rainwater and groundwater on the earth's surface (Agricultural Water Management Learning and Discussion, 2012). It affects the farmers in the regions like the arid and semi-arid regions where the yearly rainfall amount is very low. In this region, the soil moisture also is not good for the growth of crops and plants (Agricultural Water Management Learning and Discussion, 2012). In this region, we can also use the method of rainwater harvesting, based on groundwater recharge, for the storage of water (Agricultural Water Management Learning and Discussion, 2012).

Further, this system of harvesting and inter-district distribution of harvested rainwater will prove highly useful to states like Tamil Nadu. As we all know Tamil Nadu receives rainfall only twice a year (Anuj Baran Sarkar & Bidyut Sarkar et al., 2020), so to augment groundwater resources it has been made mandatory to provide rainwater harvesting structures in its buildings. In Tamil Nadu, out of 23,92,475 buildings in Town Panchayat, 22,94,342 buildings have been provided with Rainwater harvesting facilities (Anuj Baran Sarkar & Bidyut Sarkar et al., 2020). In addition to it if the proper authority incorporates our technique of rainwater harvesting and distribution from one water surplus district to another water-deficient district, then they will be able to combat the problem of water scarcity more efficiently.

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