

Seasonal Variation of Deficiency of Water for Domestic Consumption: A Case Study of Jorhat Town, Assam

Mayurakshi Bhuyan Baruah

Research Scholar, Department of Geography North-Eastern Hill University
Mawlai, Umshing, Mawkynroh, Shillong-793022, Meghalaya

Abstract: Water deficiency in cities and town all over the world is a burning and most critical issue in recent times. No city or town's settlement can exist without water. The problem and concern of city water supply pertain to quantity, quality and equity-across different segments and different sections of population. At the same time cities continue to expand at a rapid rate and its ever increasing number of population which exerts the existing water resources. The existing water supplies are inadequate to meet the growing demands and at the same time use of water bodies as dumping grounds for all sorts of waste have been polluting both surface and ground water. This paper tries to highlight the seasonal variation of deficiency of water for domestic consumption in Jorhat town, Assam. Both primary and secondary data has been used to identify the water deficient areas in Jorhat town in both pre-monsoon and post-monsoon seasons and methodology has been adopted here a strategic approach of water scarcity indicator which is based on two determinants of water demand of the people and water supply from the sources. The classification of different water deficiency level is authors own construction based on the gap between water demand and water supply. The results pertains that all the municipal wards are not covered by piped water supply and people are still struggling to collect water from other sources which is fully contaminated.

Keywords: Water deficiency, Seasonal Variation, Domestic Consumption, Piped Water Supply

Introduction

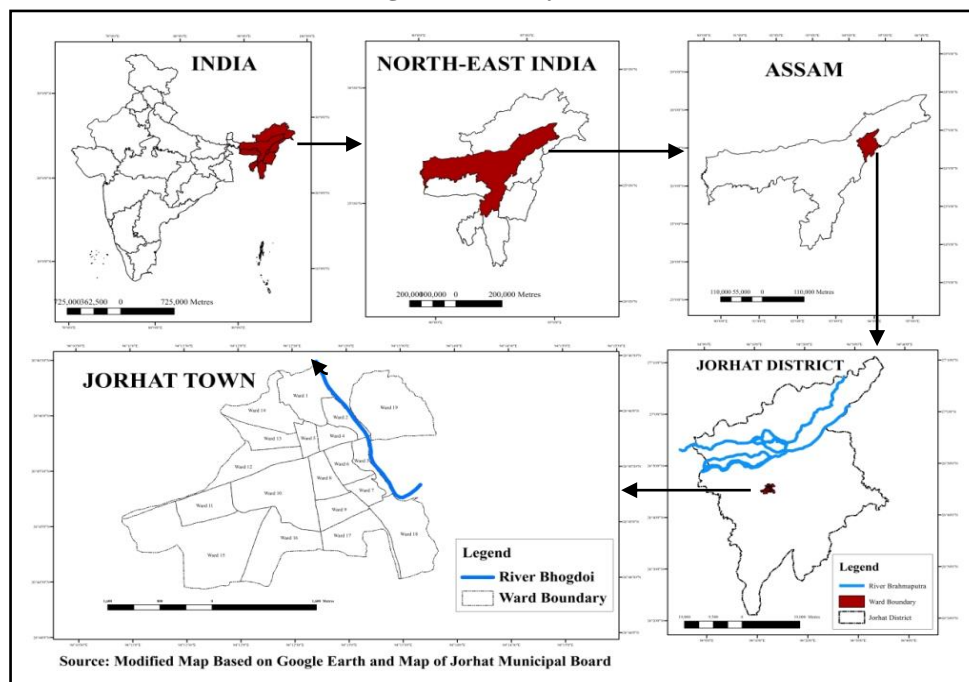
Water deficiency occurs when water demand exceeds supply, leading to water crisis. No city or town's settlement can exist without water. The problem and concern of city water supply pertain to quantity, quality and equity-across different segments and different sections of population. At the same time cities continue to expand at a rapid rate and its ever increasing number of population which exerts the existing water resources. The existing water supplies are inadequate to meet the growing demands and at the same time use of water bodies as dumping grounds for all sorts of waste have been polluting both surface and ground water. Household 'water deficiency' is a result of water consumption requirement higher than the water supply at household level (Lanka Rainwater Harvesting Forum, 1999). The importance of study of water deficiency at household level in geographical perspective, it embraces the areal and seasonal

variations in a regional context in order to highlight water deficiency level within a country or state or city/town etc. It helps to the policy makers or planners to implement any plan in regional context. Therefore, this study tries to highlight the seasonal variation of deficiency of water for domestic consumption in Jorhat town, Assam.

Study Area

Jorhat town (94°12'E longitude and 26°44'N latitude) is situated in the piedmont zone of the Karbi Anglong Hills on the southern bank of Brahmaputra River (Fig.1). The town has an area of 9.20 sq km (Anonymous, 2003). It comprises of 19 municipal wards with a population of 1,47,651 persons and 11,812 households (Census, 2011). The *Bhogdoi* River passes through the town while there are many other streams such as *Tocklai*, *Tarajan*, and *Jahkharijan* etc. which flow in and around Jorhat town. The average annual rainfall is 2044.99 mm (Bhuyan and Husain, 2014).

Fig. 1: The Study Area



Data Base and Methodology

Both primary and secondary data has been used to identify the water deficient areas in Jorhat town in both pre-monsoon and post-monsoon seasons. The primary data has been generated through the household survey with the help of pre-tested structured schedule which was done in 2010 in both the seasons and 600 households from the 19 municipal wards in Jorhat town employed in the present research. The primary data pertaining to amount of water collected from different sources for domestic consumption. The secondary data belongs to the population (2011), physical infrastructure of piped water supply, tapping of piped water supply etc. collected from Jorhat Municipal Board, Assam Urban Water Supply and Sewerage Board, Swajaldhara Committee, Marwari Thakurbari Committee.

Both primary and secondary data were compiled, tabulated and analyzed in Excel and depicted through diagrams and maps. The Town has a very high level of population density and often identified as the area with very low water availability, or in other words it is situated in the “water deficient area”. Other consideration is due to extremity of the water availability in the study area. Hence, it makes the study area a good reference for baseline data to apply the approach and calculating the water deficiency level, which can be used later as a methodology or reference in determining the policy and planning of drinking water provision in the town.

The structured schedule contains questions on amount of domestic water collected during both pre-monsoon (March-May) and post-monsoon (October-December) periods, the later is usually the lean period when the population suffer the most from water shortage. The estimation has been done

for highlighting the deficiency level of domestic water by finding the gap between the national standard and total amount of collection of domestic water both season wise and ward wise, and it is compared with the standard requirements of quantity of domestic water (135 lpcd). Areas of domestic water deficiency have been demarcated by estimating different levels of domestic water shortage.

Results and Discussion

Discussion on deficiency of domestic water in piped water supply, household level, water deficiency index mapping, seasonal and areal variation of deficiency of water detailed analysis is given in the following lines.

Deficiency of Domestic Water

The deficiency of water for domestic consumption in Jorhat town arises due to the gap between water demand from the residents and supply from the sources. First, it is being tried to highlight the water deficiency condition in four water supply systems because more than 80 per cent of households rely on public piped water supply. Secondly, the deficiency of water at household level has been discussed and identified the areal and seasonal variation in terms of quantity of water collected at household level or reliability, adequacy and accessibility.

Deficiency of Water in Piped Water Supply

The population of Jorhat has been growing at alarming rate but growth in the water supply has not kept pace with it. The four water supply systems such as Jorhat Municipal Board, Assam Urban Water Supply and Sewerage Board, Swajaldhara and Marwari Water Supply plant provide water to a section of residents through

piped connections. As per the 135 lpcd standard, Jorhat having a population of 1,47,651 (Census, 2011) currently need a total of 1,99,32,885 litres of water per day to meet the demand (Table 1). Whereas, the water supply from the existing four water supply systems is merely 78,35,000 litres per day, which is highly inadequate to provide sufficient water to Jorhat residents (Fig. 2) and

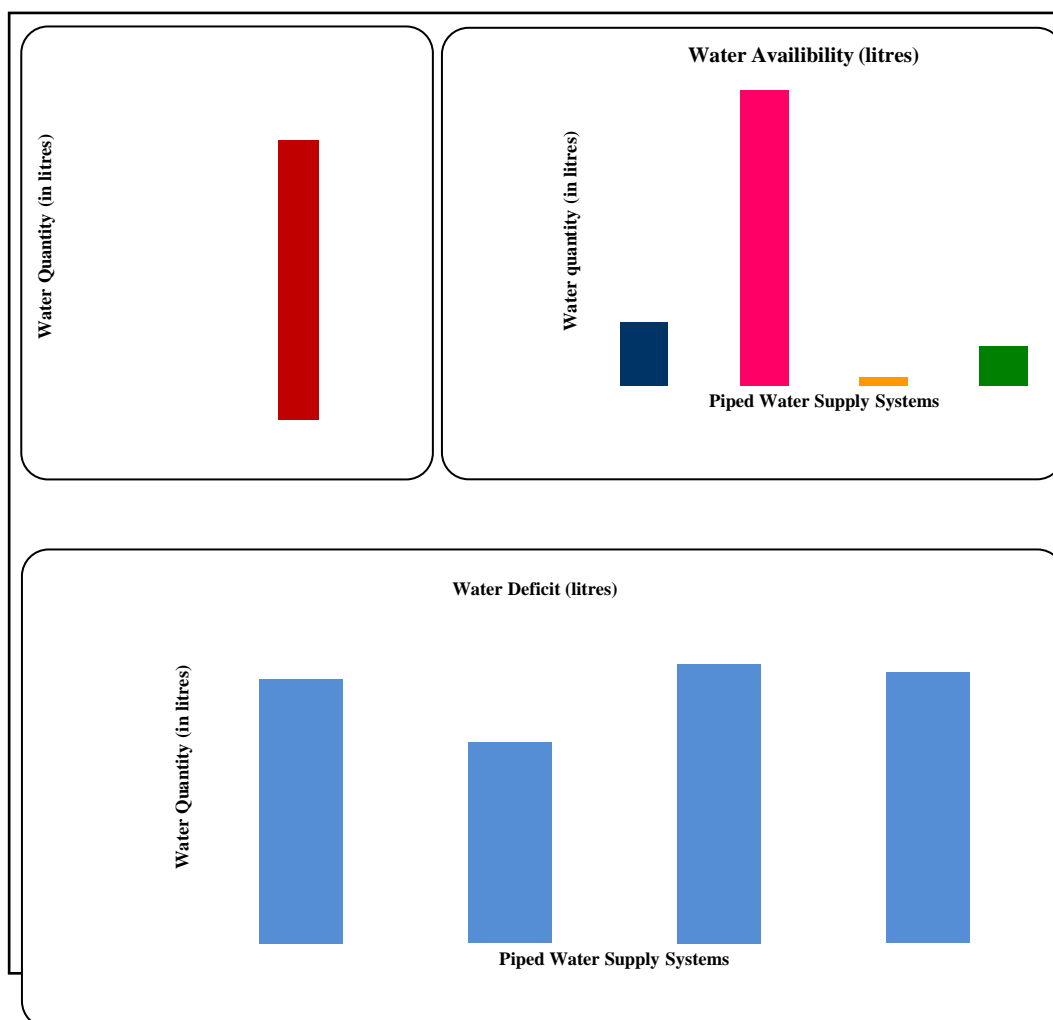
1,20,97,885 lpcd is found to be deficit in four supply systems. Due to the intermittent supply and inadequacy of water from four piped water supply, people often use other sources such as river *Bhogdoi*, ponds, shallow well, hand pump, dug well, water vendor etc. to mitigate the problems of water deficiency in Jorhat town.

Table 1: Water Demand, Availability and Deficit in four Water Supply Systems (2010)

Demand for water from Residential Population (135 lpcd)	Water Availability (litres)				Water Deficit (litres)			
	JMB	AUWS & SB	Swajaldhara	Marwari Thakurbari	JMB	AUWS & SB	Swajaldhara	Marwari Thakurbari
1,99,32,885	12,15,000	57,10,000	1,60,000	7,50,000	1,87,17,885	1,42,22,885	1,97,72,885	1,91,82,885

(Source: Computed data supplied by JMB, AUWS & SB, Swajaldhara Committee and Marwari Thakurbari Water Supply Committee, 2010)

Fig. 2: Water Demand, Availability and Deficit of in four water supply systems in Jorhat Town, 2010



Deficiency of Water at Households Level

The deficiency of water at household level relies on reliability, adequacy and accessibility. More than 80 percent of household’s intake water from public piped water supply but due to intermittent supply of water, people use water from multiple sources to mitigate the deficiency situation in Jorhat town. Taking all the sources together, the availability of water (litres/day) at household level in both pre and post monsoon seasons across the 19 municipal wards is given in Table 2. About 81.17 per cent and 71.33 per cent of households collect water from all the sources below 500 litres per day in pre and post monsoon seasons, respectively. Ward 19 is

the highest collection of water below 500 lpcd, while ward 11 and 18 is the lowest in pre-monsoon season. On the other hand, in post-monsoon season ward 1 is the highest and wards 11 and 18 are the lowest same as pre-monsoon season. The availability of water at household level is comparatively high in pre-monsoon season than post-monsoon season. The water availability at household's level is high in core areas rather than peripheral boundaries. The core areas enjoy more water from different sources, as most of all the zonal tanks of piped water supply schemes are situated in the core parts of the town.

Table 2: Quantity of Water (litres) per day at Household level from all the Sources in both Pre-Monsoon and Post-Monsoon Seasons (%)

Ward No.	<500		501-1000		1001-2000		>2000	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
1	6.00	6.83	1.33	0.83	0.50	0.33	0	0
2	4.00	3.17	0.33	1.00	0	0	0	0
3	2.50	3.17	0.67	0	0	0	0	0
4	3.67	3.00	0.33	0.83	0	0.17	0	0
5	3.33	3.50	0.83	0.67	0	0.17	0	0
6	3.00	2.17	1.17	2.00	0	0	0.17	0.17
7	3.17	2.67	0.67	1.00	0.33	0.50	0	0
8	4.33	3.83	0.67	1.17	0	0.17	0	0
9	3.67	2.17	0.33	1.67	0	0	0	0
10	3.83	3.67	0.83	0.83	0.17	0.17	0	0
11	2.33	2.00	0.33	0.67	0	0	0	0
12	3.83	3.00	0.83	1.67	0.17	0.17	0	0
13	4.83	3.67	1.83	3.00	0.17	0.17	0	0
14	5.83	4.33	1.50	2.83	0	0.17	0	0
15	6.50	5.83	2.00	2.83	0.33	0.17	0	0
16	4.50	4.17	1.00	1.33	0	0	0	0
17	6.50	5.67	1.00	1.67	0	0.17	0	0
18	2.33	2.00	0	0.33	0.33	0.17	0	0
19	7.00	6.50	0.83	1.00	0	0.17	0	0
Total	81.17	71.33	16.50	25.33	2.00	2.67	0.17	0.17

(Source: Household Survey, 2010)

Table 3: Average Per capita Water Availability (lpcd) by Season and Source wise Categorization

Seasons	Piped Water Supply				Bore Well					Dug Well		Pond		River Bhogdoi	Water Vendor
	1	2	3	4	5	6	7	8	9	10	11	12			
Pre-monsoon	16	43	0.15	0	8	1	0.08	1	4	1	1	3	1	7	
Post-monsoon	18	67	0	0	8	0	0	0	2	0	0	1	1	2	

(Source: Household Survey, 2010)

Note: 1=JMB, 2=AUWSSB, 3=Swajaldhara, 4=Marwari Thakurbari, 5=Shallow Well, 6=Public Mark Tube Well, 7=Private Mark Tube Well, 8=Public Hand Pump, 9=Private Hand Pump, 10=Ring Well, 11=Public Pond, 12=Private Pond

The average per capita water availability (lpcd) reflect the light of only the piped water supply of JMB and AUWSSB, Jorhat (Table 3) in pre-monsoon and post-monsoon seasons. The other sources also plays a major role in household consumption but the quantity of water collect from these sources is less as compared to piped water supply. Table 4 shows the per capita availability of water (lpcd) from all the sources in both pre and post monsoon seasons. It indicate that about 44.83 per cent and 39 per cent of households fetch water per day ranges 50 to 100 lpcd in both the seasons, respectively and this is the range, where highest per cent of households receive water daily and it is depicted in the map covers almost all the 19 municipal wards in pre-monsoon season (Fig. 3). While in post-monsoon season, it covers mostly north-eastern and south-western part of the town comprising ward 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 15, 17, 18 and 19 (Fig. 4). The per capita availability of water 50 to 100 lpcd is high in pre-monsoon season as compared to post-monsoon season. On the other hand, about 23.50 per cent and 37.50 per cent of households receive water ranges 100 to 200 lpcd in both pre and post monsoon seasons, respectively and the availability rate is high in post-monsoon season. In pre-monsoon season it covers ward 1, 10, 12, 13, 14, 15, 16 and 18, while in post-monsoon season it covers ward 1, 3, 6, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18 and 19. Only 27 per cent and 16.83 per cent of households receive water below 50 lpcd in both the seasons, respectively and it covers ward 2, 4 and 5 in pre-monsoon season and ward 2 in post-monsoon season. While 4.17 per cent and 6 per cent of households receive water ranges 200 to 400 lpcd in both the seasons, respectively.

Table 4: Per Capita Availability of Water (lpcd) from all the Sources in Pre and Post Monsoon Seasons (% of Households to the Total)

Ward No.	<50		51-100		101-200		201-400		>400	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
1	3.33	2.83	2.00	3.17	1.67	1.33	0.67	0.67	0.17	0
2	2.83	2.50	0.67	0.83	0.67	0.67	0	0.17	0	0
3	1.83	2.33	1.00	0.83	0.33	0	0	0	0	0
4	2.67	1.67	1.17	1.67	0.17	0.67	0	0	0	0
5	2.67	2.33	1.17	1.83	0.33	0	0.17	0.17	0	0
6	1.00	0.33	2.67	2.50	0.67	1.33	0	0.17	0	0
7	2.17	0.67	1.50	2.50	0.33	0.67	0.17	0.33	0	0
8	2.17	0.83	1.00	2.50	1.67	1.50	0.33	0.33	0	0
9	1.83	0.67	1.67	2.00	0.50	0.83	0	0.33	0	0
10	0.33	0.83	2.17	0.83	2.00	2.50	0.33	0.67	0	0
11	1.00	0.50	1.17	1.17	0.50	1.00	0	0	0	0
12	1.17	0.50	1.83	1.17	0.83	2.17	1.00	1.00	0	0
13	1.00	0.33	3.00	1.83	1.83	3.17	1.00	1.50	0	0
14	2.33	0.33	2.83	3.17	2.00	3.50	0.17	0.33	0	0
15	0.17	0.17	4.67	3.67	3.67	5.00	0.33	0.17	0	0
16	0.17	0	3.17	2.33	2.00	2.67	0	0.17	0	0
17	0.33	0	5.67	3.50	1.50	3.83	0	0	0	0
18	0	0	1.67	0.83	0.83	1.67	0	0	0	0
19	0	0	5.83	2.67	2.00	5.00	0	0	0	0
Total	27.00	16.83	44.83	39.00	23.50	37.50	4.17	6.00	0.17	0

(Source: Household Survey, 2010)

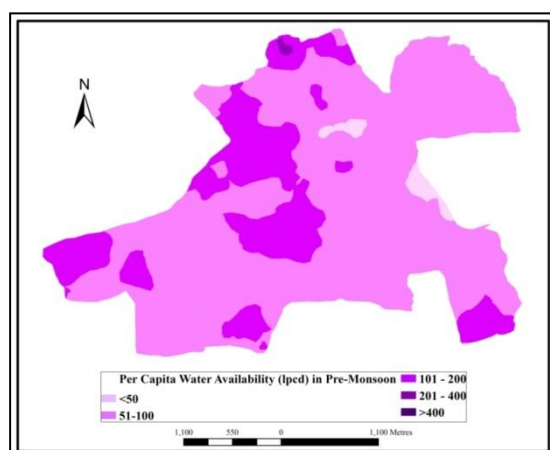


Fig. 3: Per Capita Availability of Water (lpcd) from all the Sources in Pre-Monsoon Season

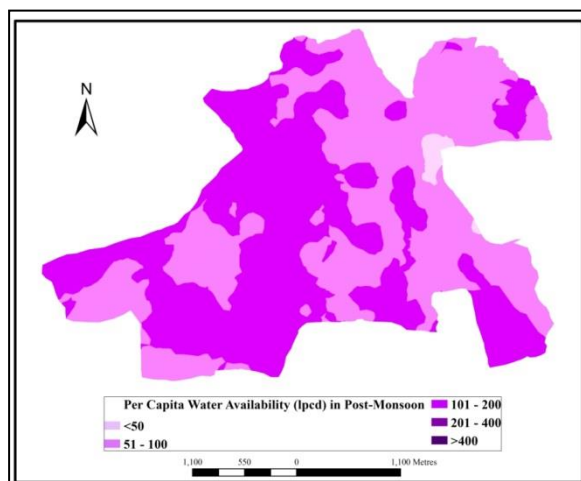


Fig. 4: Per Capita Availability of Water (lpcd) from all the Sources in Post-Monsoon Season

About 71.83 per cent and 55.83 per cent of household's per capita availability of water below 100 lpcd in both pre and post monsoon seasons, respectively and which is very far from the civic norms of 135 lpcd (Table 5). The remaining 27.84 per cent and 43.5 per cent of household's per capita availability of water above 100 lpcd. The post-monsoon season plays an integral role where the per capita availability of water is high and it is found above 100 lpcd as compared to pre-monsoon season. It is due to the reason of high access to water from other sources in post-monsoon season. The households of core areas in Jorhat town receive water more than 100 lpcd, due to the existence of zonal tanks of piped water supply systems and other sources too. The western part of the town enjoys more water due to the existence of piped water supply of JMB, AUWS & SB and Swajaldhara scheme and ponds and wells.

Table 5: Per Capita Availability of Water from all the Sources (% of Households to the Total)

Ward No.	Pre-monsoon		Post-monsoon	
	<135	>135	<135	>135
1	5.67	2.17	6.00	2.00
2	4.17	0	3.83	0.33
3	3.00	0.17	3.17	0
4	4.00	0	3.83	0.17
5	4.00	0.33	4.17	0.17
6	4.33	0	3.50	0.67
7	3.83	0.33	3.17	1.00
8	4.50	0.50	4.33	0.83
9	3.50	0.50	3.17	0.67
10	4.00	0.83	3.17	1.67
11	2.50	0.17	2.33	0.33
12	3.67	1.17	3.00	1.83
13	5.00	1.83	4.00	2.83
14	6.00	1.33	6.00	1.33
15	8.17	0.83	8.33	0.50
16	5.00	0.50	4.67	0.83
17	7.33	0.17	6.67	0.83
18	2.33	0.17	2.17	0.33
19	7.50	0.33	6.50	1.17
Total	88.50	11.33	82.00	17.50

(Source: Household Survey, 2010)

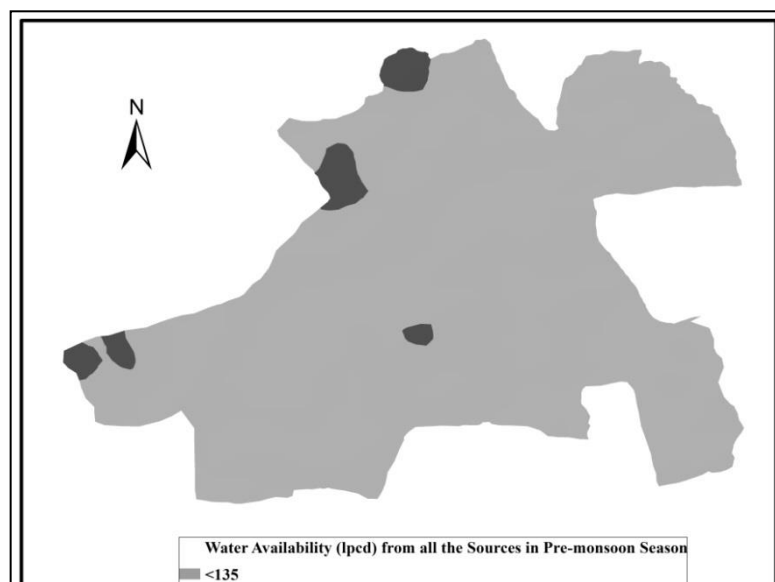


Fig. 5: Per Capita Water Availability (lpcd) from all the Sources in Pre-Monsoon Season

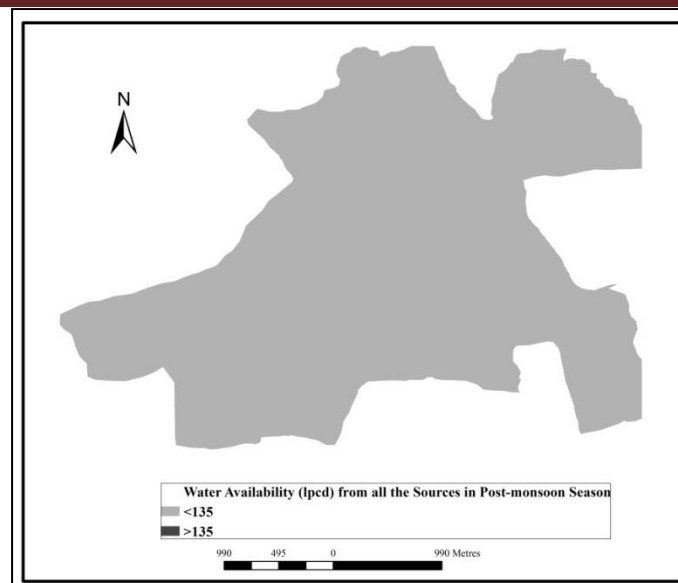


Fig. 6: Per Capita Water Availability (lpcd) from all the Sources in Pre-Monsoon Season

On the other hand, if the standard norm of 135 lpcd is taken, about 88.50 per cent and 82 per cent of households of all the municipal wards receive water less than 135 lpcd, respectively in pre and post monsoon seasons (Table 5). The remaining 11.33 per cent and 17.50 per cent of households receive water more than 135 lpcd in both the season. Figures 5 and 6 highlight the areal and seasonal variations in per capita availability of water from all the sources in Jorhat town. Per capita availability of water above 135 lpcd is only confined to limited pockets of Ward 1, 13, 15 and 16 in pre-monsoon season and remaining parts receive water less than 135 lpcd. Whereas, in post-monsoon season residents of almost all the 19 municipal wards receive water less than 135 lpcd.

Water Deficiency Index Mapping

Visual presentation of water deficiency index calculation across Jorhat town has been shown using different colours groupings within the town map. Table 6 shows the colour code classification of water deficiency level used in the present study.

Table 6: Colour Code Classification of Water Deficiency in Jorhat Town

Water Deficiency Index	Classification of Level of Water Deficiency	Colour Code
<500 (lpcd)	Normal Condition	
500-1,000 (lpcd)	Abnormal Deficient Area	
1,000-2,000 (lpcd)	Moderate Deficient Area	
>2,000 (lpcd)	Severe Deficient Area	

The purpose of using different colours is to see and distinguish various levels of water deficient areas in Jorhat town and find out the most critical areas. The information on water deficient areas can be used by the policy makers in setting up priority for the development of piped water service.

Seasonal and Areal Variations of Water Deficiency

Based on the calculation the magnitude of two respective indicators i.e. water demand and water supply, an index is obtained for 19 municipal wards in Jorhat Town. The results reveals (Fig. 7 and Fig. 8) that the normal condition in pre-monsoon season comprise of some portion of central part of the town and a few areas in southern and western part of the town covering ward 1, 11, 10, 12, 13, 14, 15, 16, 18 and 19 and post-monsoon season comprise of relatively a small portion of central, southern and western part covering ward 10, 12, 13, 14, 15, 16 and 19 but which is comparatively decreases in this season which is the lowest water deficiency category in case of Jorhat Town. This is not only because the area is served by three water supply systems, but also due to its existence of serve by other sources of domestic consumption like ponds, hand pump etc. Although, the low piped water supply condition is mainly found in ward number 11 in pre-monsoon seasons, but this ward represents a normal condition due to low population density and above mentioned all the factors contributing and resulting in relatively significantly good water security in the areas. On the other hand, the abnormal water deficient areas in pre-monsoon season comprise of northern, western and some portion of southern part covering ward 1, 10, 11, 12, 15, 17, 18 and 19 and post-monsoon season comprise of north-

western, central, some portion of southern and a fewer areas in eastern part of the town covering ward 1, 5, 10, 12, 13, 14, 15, 16, 17, 18 and 19.

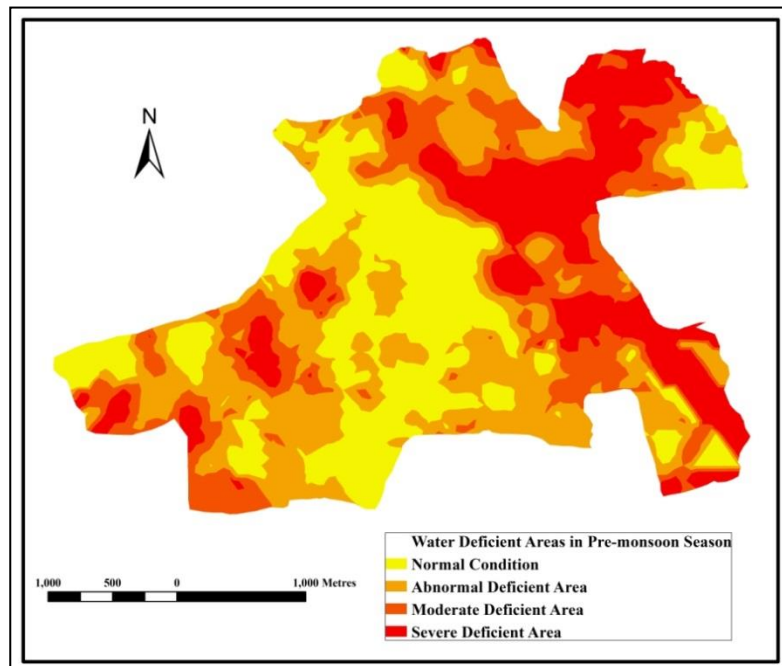


Fig. 7: Water Deficient Areas in Pre-Monsoon Season in Jorhat Town

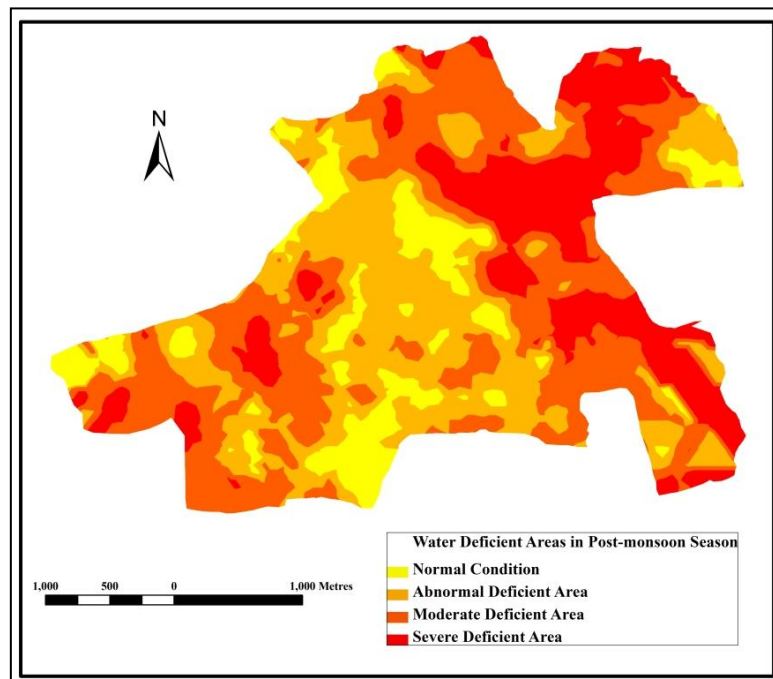


Fig. 8: Water Deficient Areas in Post-Monsoon Season in Jorhat Town

Although, the river *Bhogdoi* is nearer to eastern part of the town and good water supply condition in order to existence of both JMB and AUWS and SB in ward number 13, but these area facing abnormal water scarce condition. It is seen that some areas of western and eastern part of the town fall in moderate water deficient areas in both seasons, respectively and covering ward 1, 2, 3, 6, 10, 11, 15, 16, 17, 18 and 19. This is due to low water coverage and lack of infrastructure facilities in treatment plants. All the communities in these areas depend on bottled water, water vendors, public and private ponds and river *Bhogdoi* etc. The remaining areas of the Town fall under the severe water deficient areas covering the eastern and some portion of western part of the town covering ward 1, 2, 3, 4, 5, 6, 7, 8, 11, 12, 15, 18 and 19 in pre-monsoon season and ward 1, 2,

3, 4, 5, 6, 7, 11, 12, 15 and 19 in post-monsoon season, respectively. This condition is not much better than the previous one, i.e., severe water deficiency, because when this condition is continuously neglected (not properly addressed) it could lead to extreme water deficiency.

Conclusion

From the above discussion it suppresses on water deficiency at household level across the 19 municipal wards in Jorhat town. It tries to highlight the deficiency condition not only in piped water supply but it also throws the light at the household level. The residents still struggling to collect water from multiple sources but water deficiency condition has tremendously affected in this area. The citizens of Jorhat do not get even half of the quantity of water prescribed as standard norms (135 lpcd). But it cannot be concluded that there is deficiency of water resource as such, because the main cause of deficiency is human management. Therefore, the gap between water demand and supply will always remain as a challenge to the water managers.

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