

Spatio-Temporal Variation of Scarcity of Water for Domestic Consumption: A Case Study of Jorhat Town, Assam

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Abstract: Water Scarcity in cities and town all over the world is a most critical and serious issue in recent times. Scarcity means insufficiency of amount or supply, shortage of water, especially domestic water. Water scarcity is an imbalance between supply and demand under prevailing institutional arrangements and/or prices; an excess of demand over available supply; a high rate of utilization compared to available supply, especially if the remaining supply potentials difficult or costly to tap. 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 spatio-temporal variation of scarcity of water for domestic consumption in Jorhat town, Assam. Both primary and secondary data has been used to identify the water scarce areas in Jorhat town and methodology has been adopted here a new strategic approach of neo-Malthusian 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 scarcity 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.

Key Words: Water Scarcity, Spatio-temporal Variation, Water Demand, Water Supply.

1. Introduction:

Water Scarcity in cities and town all over the world is a most critical and serious issue in recent times. No city or town, or even any human settlement, can exist without water. Scarcity means insufficiency of amount or supply, shortage of water, especially domestic water. Water scarcity is an imbalance between supply and demand under prevailing institutional arrangements and/or prices; an excess of demand over available supply; a high rate of utilization compared to available supply, especially if the remaining supply potentials difficult or costly to tap [1]. 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 spatio-temporal variation of scarcity of

water for domestic consumption in Jorhat town, Assam. For temporal variation, both pre-monsoon (March-May) and post-monsoon (October-December) seasons has been considered. Both primary and secondary data has been used to identify the water scarce areas in Jorhat town and methodology has been adopted here a new strategic approach of neo-Malthusian 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 scarcity 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.

2. Study Area:

Jorhat town is situated between 94°11'0''-94°14'0'' East Longitudes and 26°44'30''-26°46'30'' North Latitudes. The town is bounded by Sarbaibandha in the north, Barpool, A.T. Road in the

east, *Kansaikia Jan* in the west and *Bongal Pukhuri* in the south. Administratively, Jorhat town is divided into 19 (nineteen) municipal wards altogether covering an area of 9.20 sq km. *Bhogdoi* is the main river that passes through the town along with other streams like *Tocklai*, *Tarajan*, *Jahkharijan* etc. as the town stretches from the piedmont zone of the Karbi Anglong Hills to the banks of the Brahmaputra river. Besides, the town is dotted with number of ponds (locally known as *pukhuri*). The average annual rainfall is 2045 mm.

3. Database and Methodology:

The present study is based on both primary and secondary data. The primary data has been generated by carrying out household survey in 2010 in both pre-monsoon and post-monsoon season with the help of a structured schedule, which has canvassed in 5% households of the town, nearing about 600 households. The selection of households has been taken by purposive random sampling method. Handheld GPS Garmin 72 has been used to acquire the geographical location of different domestic water sources. The secondary data has been collected from Jorhat Municipal Board, Assam Urban Water Supply and Sewerage Board, Public Health Engineering Department, Swajaldhara Scheme, Marwari Thakurbari Committee, Town and Country Planning Department, Jorhat. Besides, data has also been collected from various published and unpublished literature including journals, books, reports etc.

Both primary and secondary data has been compiled, tabulated and analyzed in EXCEL and depicted through diagrams and maps. Maps are prepared in Arc GIS 9.3 Software to identify the water scarce areas in Jorhat Town. Water demand has been calculated with the help of total population (Household survey) and 135 lpcd of water which is needed for urban residents as per Government of India norms. In case of water supply, only quantity of water collected at household level from four piped water supply schemes in both pre-monsoon and post-monsoon season has been considered. Water Scarcity has been calculated by the gap between water demand and water supply in each of the 19 municipal wards. The classification of water scarcity level is authors own construction depending on the data calculated from water demand and water supply.

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 scarce 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 calculation of neo-Malthusian water scarcity index, which can be used later as a methodology or reference in determining the policy and planning of drinking water provision in the town.

4. Results and Discussion:

Discussion on different water sources, water demand, water supply, water scarcity and calculation of water scarcity index for different wards of Jorhat Town and its analysis helped to demarcate water scarce areas in the Town. Detailed analysis is given in following lines.

4.1 Spatial Variation of Water Sources:

Water is not only vital to all forms of life but it also has a great role to play in socio-economic development of human population. There are three main sources of water in Jorhat Town:

1. Rainfall
2. Surface Water
 - (i) River *Bhogdoi*
 - (ii) Pond
3. Ground Water
 - (i) Shallow Well
 - (ii) Deep Well
 - (iii) Dug Well
 - (iv) Hand Pump, Mark Series Tube Well

Jorhat experiences the predominant influence of the south-west monsoon which reigns from May to July with occasional winter showers. The approach of the monsoon is marked by strong winds, overcast skies and occasional thunder showers, hailstorm and cyclones during April and May and it starts heavy showers from June [2]. River *Bhogdoi* is the main source of surface water in Jorhat town, which passes through Ward numbers 1, 2, 3 and 19 (Fig.1), while other streams like *Tocklai*, *Tarajan*, and *Jahkharijan* also exist but the quality of water of these smaller streams is not potable. Ponds are large excavations in which surface water is stored. They are an important source of water supply in most of areas [3]. The people use about more than 10 public ponds and 28 private ponds (Fig.1) as another important source of domestic water in Jorhat town. Some of the ponds are of historical importance, for example, Rajmao Pukhuri, Mitha Pukhuri, Tarajan Buhagohain Pukhuri, Padum Pukhuri, Rajamaidam Pukhuri and Sonari Gaon Pukhuri, as these were constructed by rulers of different times. Almost all the wards of the Town are having both public and private ponds and ponds are well distributed. It may be noted that ponds provide bathing and washing

places for the poor people who do not have tap connections in their houses. On the other hand, some of the ponds have disappeared from the landscape due to dumping of solid wastes in them, and some have shrunk in area because of encroachment [4].

The usual ground water sources are wells and springs. Wells have been classified into shallow and deep wells, dug wells and tube wells [3]. Shallow wells tap subsoil water, i.e., the water from above the first impervious layer in the ground. In Jorhat town, most of the shallow wells are found in northern, south-western and southern parts at household level as a private water source (Fig.1). People have constructed shallow wells in the premises on their own and 60.96 m bgl (below ground level) water can easily be withdrawn for domestic purposes. The highest numbers of shallow wells are confined in ward number 15. A deep well is one which taps water from the water-bearing stratum below the first impervious layer in the ground and in entire town deep wells are identified as public piped water supply provided by four organizations such as Jorhat Municipal Board, Assam Urban Water Supply & Sewerage Board, Swajaldhara Scheme and Marwari Thakurbari Scheme (Fig.1). Jorhat Municipal Board provides water to a section of the people residing in almost all the municipal wards except ward number 19. This water supply scheme is divided into four zones. All the water supply projects depend on ground water except the Bhogdoi Water Supply Project whose intake is from the *Bhogdoi* River. The other water supply projects are situated far from the river as they depend on ground water. Under the scheme of Assam Urban Water Supply and Sewerage Board, the whole town has been divided into seven water supply zones, but only five zones have been covered until now. The combined Bhogdoi and Na-Ali zone use water from the *Bhogdoi* River. The Swajaldhara Water Supply Scheme serves above 3000 people living in 250 (4.43%) households spread over the ward numbers 10, 11 and 15. Marwari Thakurbari Scheme is a community based water project maintained by the Marwari people. The main source of this project is ground water and it has two deep tube wells at a depth of 121.921 m and 60.96 m. Besides these water supply projects, there are another 250 number of street hydrants located in different wards (Fig.1). Dug wells are of two types: (a) the unlined kutchha well, and (b) the masonry or pucca well. The kutchha well is a hole dug into the water bearing stratum. The pucca well is an open well, built of bricks or stones [3]. Moreover, mostly people are depending on piped water supply but in water deficiency period they use water from kutchha well and masonry pucca well on private basis in both pre-monsoon and post-monsoon seasons. The water table

of the dug well is mostly found from 0.50-1.5 m in both the seasons and high concentration of this type of well is mostly confined to northern part of the town (Fig.1). Hand pump comes under sanitary well. The well should be equipped with a hand pump for lifting the water in a sanitary manner [3]. The hand pump is probably the most important contribution made by the government to the community in support of the wells program and there are both public and private hand pumps in Jorhat town. The public hand pumps have been constructed in different wards by Jorhat Municipal Board, because all the households of the town are not capable of purchasing water from piped water connection due to various reasons. Besides this, people have constructed themselves hand pumps in their premises and the depth of this water source mainly found in 15.24 m bgl. The public hand pumps are found in only ward number 3 and 15 and high concentration of private hand pumps are confined to northern and south western parts of the town. The highest number of hand pumps is found in Ward number 1 (Fig.1). Mark series tube well is another source of water for domestic consumption in Jorhat town, which is constructed by Public Health Engineering Department in public areas. Public Mark series tube wells are found in Ward number 1, 2, 3, 4, 5, 10 and 16 and private Mark series Tube wells are found only in Ward number 1 (Fig.1).

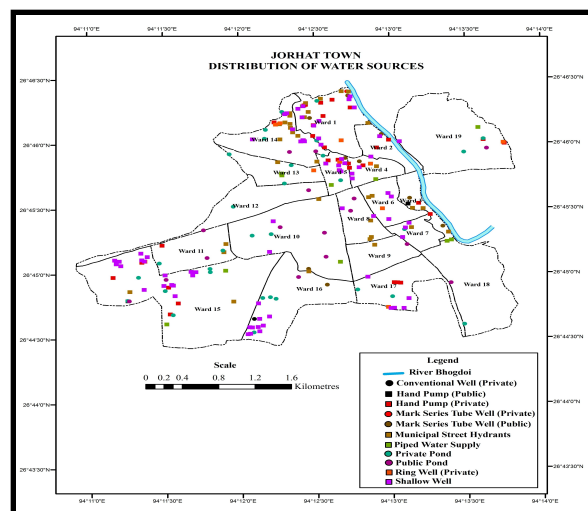


Figure 1

The above discussion shows that the northern and south western parts of the town are very rich in water resource, whether it is public piped water source or private water source (Fig.1). The northern part of the town is very nearer to the main surface water source, i.e., the *Bhogdoi* River and it is nearly 8 km away from the River Brahmaputra. The low coverage and lack of infrastructure of piped

water supply systems also has tremendous negative impact on family relations because fetching of water from other sources involves spending of valuable time and money as the sources are located at long distances. Moreover, these sources are not safe for health as *Escherichia coli* (*E. coli*) are found to be present in considerable proportion. Water from shallow surfaces as well as from the water schemes contains high proportion of *E. coli* as compared to the ground water sources [5].

4.2 Neo-Malthusian indicator of water Scarcity:

Scarcity is a function of demand and availability, with the traditional neo-Malthusian view being that resources are essentially fixed while demand will increase with population [6]. This neo-Malthusian standpoint underlies the most widely used indicator of water scarcity, an indicator which is based upon renewable water resources per capita [7]. Here neo-Malthusian views is used to identify water scarce areas in Jorhat town in both pre-monsoon and post-monsoon seasons and two respective indicator are water demand and water supply has been employed.

4.3 Water Demand:

The demand for water has been increasing due to extensive urbanization, industrialization and the rise in the standard of living [8]. Domestic water use/demand is a complex function of socio-economic

strategies [9]. Presently 135 lpcd (litres per capita per day) of water is needed for an urban resident as per Government of India's norms, accordingly 1,99,32,885 lpcd of water is required in Jorhat Town. Figure 2 provides the water demand at 135 lpcd in Jorhat Town and it reveals that the very high demanding areas comprise of ward number 15 due to the increase of population. The high water demanding areas covers ward number 1, 4, 6, 8, 14 and 19. The remaining wards fall under the category of low water demanding area (Table 1) [10].

4.4 Spatio-Temporal Variation of Water Supply:

The welfare state has the responsibility for the supply of basic resources as water, while the life style, comfort and social welfare depend on the efficient and sufficient supply of this resource [11]. The four water supply systems have failed to provide sufficient water to the consumers; hence water supply is grossly inadequate and very far from civic norms. The sampled survey data (2010) reveals that the total demand of water from all the municipal wards is 3,47,490 lpcd, whereas total supply from the four water supply systems is 1,40,190 lpcd, therefore 2,07,300 lpcd is found to be deficit in Jorhat town. It has led to a serious water scarcity condition in the Town. Figure 3 provides water supply coverage of Jorhat town in pre-monsoon season and it reveals that the very high water supply categories comprise of ward number 13, due to the coverage of both piped water service providers of Jorhat Municipal Board and Assam Urban Water Supply and Sewerage Board. On the other hand, Ward Number 10, 14, 15, 16 and 19 fall under the category of moderate water supply coverage. Ward number 4, 11 and 18 are experiencing very low water supply coverage, because of lack of proper planning, lack of infrastructure in water treatment plants covering these areas (Table 1). Figure 4 shows water supply coverage of Jorhat town in post-monsoon season and it reveals that the high water supply categories comprise of ward number 1, 12 and 13 due to the coverage of both piped water service providers of Jorhat Municipal Board and Assam Urban Water Supply and Sewerage Board. On the other hand, Ward Number 4, 6, 7, 14 and 19 fall under the category of moderate water supply coverage. Ward number 3, 5 and 11 are experiencing very low water supply coverage in post-monsoon season.

Seasonal variation of supply of water to the all consumers in all the wards of Jorhat town exist due to low coverage of water supply, leakage of pipelines and lack of infrastructure. Ward number 11 are common in both seasons where very low supply of water intake by the consumer although

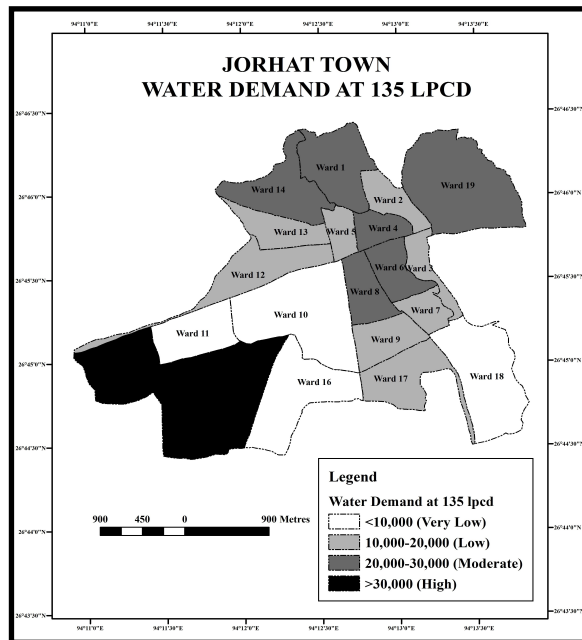


Figure 2

characteristics,
and public water

climatic factors
policies and

respondent’s preferences to both AUWS & SB and Swajaldhara scheme in this ward.

Table 1: Water Demand, Water Supply and Water Scarcity

Ward Number	Total Population	Water Demand at 135 lpcd	Water Supply (l/d)		Water Scarcity (l/d)	
			Pre-monsoon	Post-monsoon	Pre-monsoon	Post-monsoon
1	165	22275	9098	14033	13177	8242
2	122	16470	4522	7679	11948	9229
3	115	15525	4928	4879	10613	10646
4	157	21195	3436	10165	17759	11121
5	147	19845	5488	2955	14675	17208
6	168	22680	11350	12061	10960	11091
7	126	17010	9137	9356	8795	8473
8	166	22410	9092	8173	13918	14885
9	108	14580	4627	7488	10064	7949
10	84	11340	7160	8596	4429	4008
11	47	6345	3634	2580	2873	3765
12	125	16875	11818	14656	7617	4865
13	150	20250	20440	18890	8625	6545
14	157	21195	7190	9550	14005	11240
15	263	35505	7160	6220	28345	5930
16	79	10665	6800	6500	3865	4165
17	143	19305	4530	8290	14775	11015
18	61	8235	3000	5000	5235	3235
19	193	26055	6780	11680	19275	14375
Total	2576	347760	140190	168751	220953	167987

(Source: Household Survey, 2010)

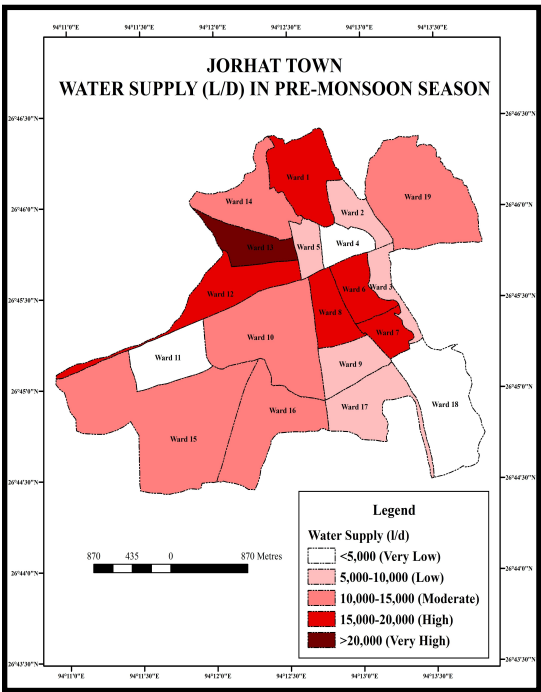


Figure 3

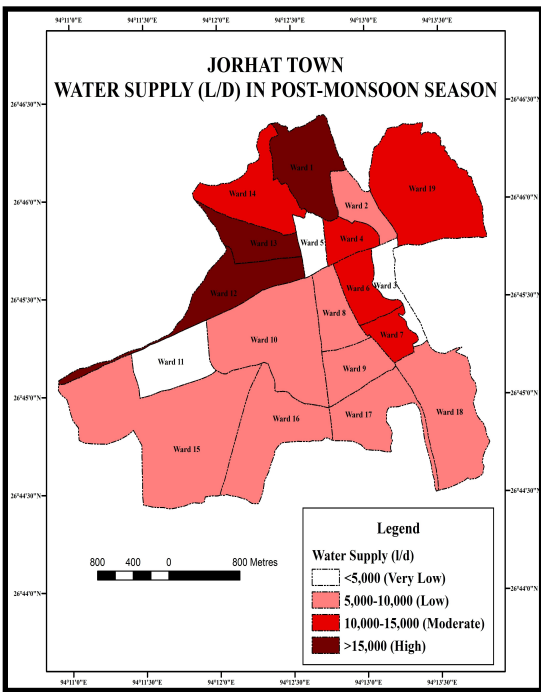


Figure 4

4.5 Spatio-

Temporal

Variation of Water Scarcity:

The population of Jorhat town is increasing at a faster rate. The population is ever increasing many times but the supply has not increased considerably. The supply of water from four present piped water systems is very less than the present demand, so, the rate of water supply is grossly inadequate and far from civic norms. The increasing demand on one hand, and the deteriorating condition of supply, on the other, increases the gap between supply and demand and thus the intensity of water scarcity goes on increasing at a faster rate. Figure 5 and Figure 6 pertains to the categories of water scarcity in both pre-monsoon and post-monsoon season in Jorhat town and the water scarcity is calculated from the gap between water demand (lpcd) and water supply (l/d). The classification of water scarcity is authors own construction depending on data collected from the household survey.

4.5.1 Water Scarcity Index Mapping:

Visual presentation of water scarcity index calculation across Jorhat town has been shown using different colours groupings within the town map. Table 2 shows the colour code classification of water scarcity level used in the present study.

TABLE 2: Colour Code Classification of Water Scarcity in Jorhat Town

Water Scarcity Index	Classification of Level of Water Scarcity	Colour Code
<5,000 (l/d)	Normal Condition	Yellow
5,000-10,000 (l/d)	Abnormal Scarce Area	Orange
10,000-15,000 (l/d)	Moderate Scarce Area	Brown
>15,000 (l/d)	Severe Scarce Area	Dark Brown

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

4.5.2 Calculation of Water Scarcity Index:

Table 1 provides the results of calculation for the two respective indicators of water demand and water supply. Based on the calculation the magnitude

of index is obtained for 19 municipal wards in Jorhat Town. The results reveals that the normal condition in both pre-monsoon and post-monsoon season comprise of ward number 10, 11, 12, 15, 16 and 18 which the lowest water scarcity 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, dug well etc. and ward number 18 is nearer to river Bhogdoi- the main surface water source. Although, the low piped water supply condition is mainly found in ward number 11 in both 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 scarce areas in both seasons comprise of ward number 2, 7, 9 and 13. Although, the river Bhogdoi is nearer to ward number 2 and 7 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 Ward number 4, 14 and 17 fall in moderate water scarce areas in both seasons. 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 etc. In addition, there is no other surface water source available in these areas except the ponds, since there are no rivers crossing these areas and poor quality of its ground water.

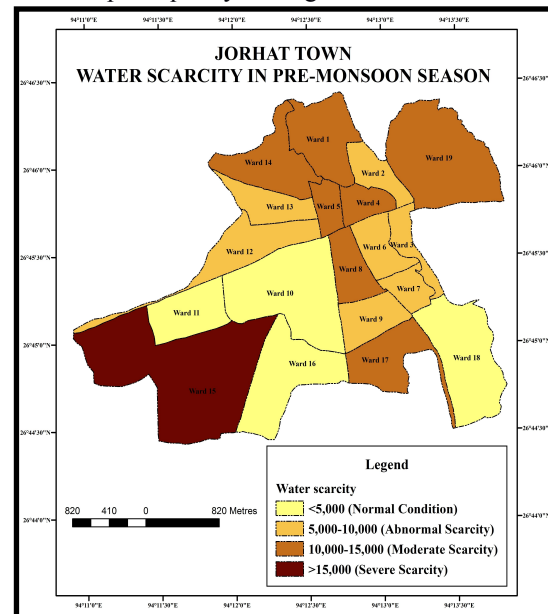


Figure 5

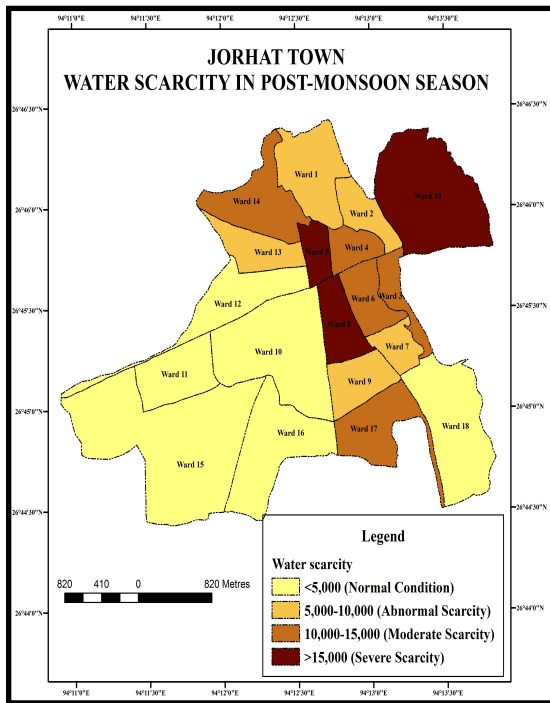


Figure 6

The remaining areas of the Town fall under the severe water scarce areas covering wards 15 in pre monsoon season and 5, 8 and 19 in post monsoon season. This condition is not much better than the previous one, i.e., severe water scarcity, because when this condition is continuously neglected (not properly addressed) it could lead to extreme water scarcity (Figure 5 and Figure 6).

The people who do not have piped water connection depend on other sources of water such as Bhogdoi river, ponds (public as well as private) and dug well etc. which are not safe for health. However, many of them have been using water directly from the Bhogdoi River, which is not suitable for drinking purposes. Almost all the water bodies of Jorhat town have been polluted from different sources [12]. It is interesting to note that for a long time in Jorhat town, there exist a parallel water supply system run by the “Water Vendors” who collect water daily in wheeled barrels mainly from the public ponds and water is often bacterial contaminated [13]. The piped water schemes are depending on Assam State Electricity Board (ASEB) for power. The total Electrical Power Requirement for operating the schemes under JMB is 275 KW and 550 KW for the schemes operated by AUWS & SB. [14]. But due to inadequate rainfall, hydal power projects have not been able to generate enough power. So, piped water supply systems have

failed to provide adequate water to the citizens of Jorhat Town which leads to water scarcity.

5. Conclusion:

From the above discussion, it is clear that the distribution of piped water is not equitable; as a result, some areas are suffering chronically from scanty supply. JMB does not have their distribution lines in ward number 16 & 19 while AUWS & SB does not cover the ward number 4, 10, 14 & 17. The distribution lines connected with each of the schemes are very old, and due to other development activities, viz., development, widening and construction of roads, drains and footpaths etc., there are so many breakage and leakage in the lines. All the schemes of JMB have crossed its intermediate stage since commissioning & condition of all the system components have already outlived their life. All the piped water schemes are highly depends on ASEB for power. But ASEB has been facing the problem of power shortage of itself & depending on other sources. There is a wide gap between demand and supply of domestic water in Jorhat town, thus the intensity of scarcity increasing at a faster rate. The population of Jorhat town is increasing at a faster rate. This faster growth of population sets the urgency for the exploration of the potential resource base which could not be done so far and thus scarcity arises. People who do not have piped water supply, depending on other sources like pond, dug well, hand

pump etc. which are not safe for health and suffering water borne diseases like diarrhoea, jaundice etc. The water consumption (lpcd) of every household of all the wards is very less than the present norms at 135 lpcd, thus water scarcity increasing at a faster rate.

The results of calculation of water scarcity index have been put into a map to demarcate critical areas and that can be used as a basis for policy planning in the development of water supply provision in Jorhat town and also for monitoring and evaluation purpose of water service performance in Jorhat town.

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