A question on sustainability of drinking water supply: a district level analysis of India using analytic hierarchy process

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Abstract

The subject of drinking water supply falls under the legislative jurisdiction of the State governments in India. States have their own mechanism of drinking water supply through urban and rural local bodies. Drinking water supply itself is a multidimensional phenomenon of sources, quality, accessibility, sufficiency, etc. This study combines various aspects of drinking water supply at the district level, by assigning weights through analytic hierarchy process, to result in a drinking water supply index. The spatial pattern of drinking water supply index is not in favor of the areas having abundant natural water endowment. Areas which are low in the natural endowment of water are better in drinking water supply, while areas which have abundant natural water are not able to manage the available water and are low on the drinking water supply index. Among various socio-economic-political factors, water governance is most important in the wake of water supply being the function of urban and rural local bodies.

Keywords: Analytic hierarchy process (AHP); Drinking water supply; Sustainable; Water governance

Introduction

State governments are vested with the constitutional right to plan, implement, operate and maintain water supply projects in India. The 73rd and 74th Constitutional Amendment Acts have further devolved this power to urban and rural local bodies. The Eleventh Five Year Plan appraisal report by the Planning Commission clearly states the sustainability of drinking water supply as a major concern, as habitations that are covered in the earlier years slip back to not being covered or partially covered status due to reasons such as sources going dry or lowering of groundwater, sources which are quality affected, systems working below their capacity due to poor operation and maintenance, and normal depreciation. Increasing population leading to the emergence of new habitations also increases the number of unserved habitations. Groundwater is a dominant source of irrigation as well as drinking water in semi-arid parts of India. Evidence suggests that north-western India is


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consuming a higher quantity of groundwater, which is more than the natural replenishment rate (Central Ground Water Board, 2004). Mapping of estimated terrestrial water storage changes by GRACE (Gravity Recovery and Climate Experiment) averaging function (Rodell et al., 2009), shows the highest change (decline of groundwater) in Rajasthan in general and the semi-arid northern part in particular. Another study by Tiwari et al. (2009) revealed a steady, large-scale mass loss in northern India, from GRACE satellite mission, which can be attributed to excessive extraction of groundwater. Apart from this, more recent (June, 2015) evidence of measuring temporal variations in the gravity field to estimate changes in terrestrial water storage also depicted a critically high change in groundwater in the western part of India (Otto & Maddocks, 2015). Low groundwater level along with minimal surface water availability increases vulnerability to acute water scarcity in this semi-arid part of the country.

According to a World Bank report (World Bank, 2011), increasing population, better economic conditions and water scarcity are the global reality, particularly in arid regions. India is the second largest populated country with more than 1.2 billion population (Census of India, 2011). The rainfall in India shows high spatial and temporal variability, and the paradox of the situation is that Mousinram near Cherrapunji, which receives the highest rainfall in the world, also suffers from a shortage of water during the non-rainy season, almost every year (Kumar et al., 2005). Water scarcity is not a natural phenomenon, but it is an amalgamation of various socio-economic-political processes (Kumar & Singh, 2001). Water scarcity and water stress appear to be synonymous, but water scarcity refers more to volumetric aspect while water stress is a more inclusive concept, which takes into account physical, human and environmental availability of water as well as accessibility (Schulte, 2014). This means areas facing physical water scarcity may not experience water supply crises, or the areas having a sufficient water supply may not be the areas of sufficient water availability.

With 18% of the world’s population, India has only 4% of the world’s renewable water resources and 2.4% of the world’s land area. Utilizable quantities of water are further limited, owing to uneven distribution over time and space (National Water Policy, 2012). Sustainable water supply is attributed to adequate water quantity for given needs, without compromising the future ability to provide water. In India, right from the First Five Year Plan, provision of drinking water and sanitation has been made a high priority by the Planning Commission in the budgets of the Union and the State governments for the Demands for Grants of the Ministries and Departments (Sezhiyan, 2004). Per capita water availability in India was 1,816 m³ in 2001 which reduced to 1,588 m³ in 2010 according to Water and Related Statistics (Central Water Commission, 2010). Although some areas, such as Cherrapunji, receive heavy rainfall, these too face scarcity amidst plenty of water during winter time, only because of lack of proper planning to store water (Talukdar, 2013). Thereby, when it comes to sustainable drinking water supply throughout the year and at all places, all regions need equal attention, whether they be humid, semi-arid or arid. Some areas face physical water scarcity, which means there is a natural water scarcity. Some regions face social water scarcity, where inequitable distribution of water causes the scarcity for the majority, for example, luxury apartments have purified water for swimming purposes, while people in nearby slums do not get enough water for basic needs. Some regions too face an institutional water scarcity, where the institutions are not in a position to manage the abundance of water, such as north-eastern parts of India, which faces water scarcity in winter or non-rainy seasons, in spite of being the wettest part of India. All regions face region-specific problems and to solve them they need to be identified separately, thus here we research the problem of complexities of scale.
The World Commission on Environment and Development (WCED) introduced the concept of sustainability, but there are certain limitations in its applicability in today’s scenario. Seghezzo (2009) argued that

‘The limitations of the WCED definition could be mitigated if sustainability is seen as the conceptual framework within which the territorial, temporal, and personal aspects of development can be openly discussed. Sustainability could be better understood in terms of ‘Place’, ‘Permanence’, and ‘Persons’. Place contains the three dimensions of space, Permanence is the fourth dimension of time, and the Persons category represents a fifth, human dimension.’

Steinitz (2011), while dealing with scales in spatial analysis, came to the conclusion that many methods, processes and ideas that work at one scale do not work at another scale. Everything depends on the lens through which we look at the problem. At larger scale the focus is on strategy, while at smaller scale focus shifts towards details. In the question of sustainability, complexities of scale emerge such as at global, regional and local level. Mebratu (1998) explains the conceptual understanding of sustainability but it is a dynamic concept which varies over space, over time and across scales. Thereby, complexities of scale also explain the dynamism in the concept of sustainability. This study follows the global evidence to carry out a national level analysis and moves to a district level analysis to resolve the complexities of scale in dealing with the sustainability aspect. Sustainable drinking water supply itself is dependent on the source, supply, access, availability and sufficiency of drinking water supply to meet the demand of the ever increasing population.

Scope

This study tries to discover the spatial pattern of drinking water supply in India at the district level. Drinking water supply system is an amalgamation of various dimensions; thereby, this study tries to create a best-fit index which explains the drinking water supply system.

Methods

House listing and housing census data (Census of India, 2011) has been used to discover the scenario of drinking water supply among districts. A total of 626 districts of India have been considered for this study. To assess the district level picture of drinking water supply, various indicators of drinking water supply have been compiled. Indicators have been selected on the basis of explanation to research questions. Absolute values provided by the Census of India (number of households) have been converted into percentage of households. Absolute values have no meaning in comparison because we are comparing the districts with the different number of households. For making indicators comparable the following methodology has been used:

\[
\frac{\text{Number of Households in a district having treated tapwater supply within premises}}{\text{Total Number of Households in the District}} \times 100
\]
Minimum and maximum of these percentage values have been taken into account to normalize these indicators so that their range varies between zero and one, and extremes of data do not distort the final results. For that the following method has been followed:

\[ Z_i = \frac{X_i - \text{min}(X)}{\text{max}(X) - \text{min}(X)} \]

where \( Z_i \) is \( i^{th} \), the normalized value of indicator \( X \). \( \text{Min}(X) \) is the minimum value in indicator \( X \) while \( \text{max}(X) \) is the maximum value of indicator \( X \).

The supply component of drinking water consists of six indicators with different importance in the final index of drinking water supply. Thereby, analytic hierarchy process (AHP) has been used to produce justifiable weights for each indicator, so that a decision can be taken, as to which indicator is more explanatory for good drinking water supply.

Analytic hierarchy process is one of the multi-criteria decision-making methods that was originally developed by Prof. Thomas L. Saaty. It is a method to derive ratio scales from paired comparisons. The input can be obtained from actual measurements or from subjective opinions such as satisfaction feelings and preference. The latter input method has been followed in this study. AHP allows some small inconsistency in judgement because humans are not always consistent. The ratio scales are derived from the principal Eigenvectors, and the consistency index is derived from the principal Eigenvalue.

To derive the final weights a comparison matrix has been created by using the fundamental scale of absolute numbers given by Saaty (2008). Saaty (1987) has provided a detailed methodology of the analytic hierarchy process. Each element in an upper level is used to compare the elements in the level immediately below with respect to it.

To make comparisons, the necessary scale of numbers is exhibited in Table 1. This indicates how many times more important or dominant one element is over another element with respect to which they are compared. The following steps have been used to provide weights for each indicator.

- Pair-wise comparison: A pair-wise comparison has to be done for all indicators in terms of their relative comparison with respect to each other, based on subjective judgements. All indicators are compared on a scale of 1 to 9 depending on their importance.
- Making comparison matrix: Pair-wise comparison and its reciprocal matrix led us to a comparison matrix. In this case, a pair-wise comparison of six indicators formed a 6 by 6 matrix.
- Computing Eigenvalue and Eigenvector of comparison matrix.
- Computing weight which is the priority vector (normalized Eigenvector of the matrix).
- Consistency index and consistency ratio (<10% or <0.1): To measure the consistency of the subjective judgement, consistency index and consistency ratio are computed. Prof. Saaty proposed that this index should be used by comparing it with the appropriate one. The appropriate consistency index is called random consistency index. Consistency ratio is a comparison between consistency index and random consistency index. If the value of the consistency ratio is smaller or equal to 10%, the inconsistency is acceptable. If the consistency ratio is greater than 10%, the subjective judgement should be revived.

Indicators used in this analysis are explained in Table 2.
As the indicators have been explained in Table 2, accordingly, judgement has been done in Table 3. Comparison matrix in Table 3 shows a pair-wise comparison of all indicators. Indicator A is percentage of households having treated tap water supply within premises, which means water is supplied after treatment through institutions. This treatment covers chemical purification of water, whereby water is pure, while safe means it might not be dangerous for health but it is not pure. Water supply from uncovered sources, such as an uncovered well or uncovered pond, is considered an unsafe water supply by Census of India (2011). Thereby, a covered water source is not as safe as the treated water source. There are instances of various impurities like arsenic and fluoride in groundwater. One study (Huang et al., 2008) proved that elements such as magnesium, aluminium and iron were rather high in Tibetan rivers. Contamination with lead and nickel were also identified at a few locations. Thus, when it comes to drinking water even natural resources have their shortcomings.

Concerning the comparison between indicators C and D, we can see that availability of water within premises is a more important aspect than mere ‘safe’ water which is not treated and can be contaminated as seen in the above examples of Tibetan rivers. In 2001, only 39% of households had availability of drinking water within the premises. This had increased to 46.6% in 2011, while access to safe drinking water (tap/hand-pump/tubewell) in households in India has progressed from 38% in 1981 to 85.5% in 2011. Distance to the source has been a major hindrance until now, when the majority of women have to fetch water from distant sources, which has its various socio-economic consequences. Indicator F is not

Table 1. The fundamental scale of absolute numbers.

<table>
<thead>
<tr>
<th>Intensity of importance</th>
<th>Definition</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Equal importance</td>
<td>Two activities contribute equally to the objective</td>
</tr>
<tr>
<td>2</td>
<td>Weak or slight</td>
<td>Experience and judgment slightly favour one activity over another</td>
</tr>
<tr>
<td>3</td>
<td>Moderate importance</td>
<td>Experience and judgment strongly favour one activity over another</td>
</tr>
<tr>
<td>4</td>
<td>Moderate plus</td>
<td>Experience and judgment strongly favour one activity over another</td>
</tr>
<tr>
<td>5</td>
<td>Strong importance</td>
<td>Experience and judgment strongly favour one activity over another</td>
</tr>
<tr>
<td>6</td>
<td>Strong plus</td>
<td>Experience and judgment strongly favour one activity over another</td>
</tr>
<tr>
<td>7</td>
<td>Very strong or demonstrated importance</td>
<td>An activity is favored very strongly over another; its dominance demonstrated in practice</td>
</tr>
<tr>
<td>8</td>
<td>Very, very strong</td>
<td>The evidence favoring one activity over another is of the highest possible orders of affirmation</td>
</tr>
<tr>
<td>9</td>
<td>Extreme importance</td>
<td>The evidence favoring one activity over another is of the highest possible orders of affirmation</td>
</tr>
</tbody>
</table>

Reciprocals of above

If activity i has one of the above non-zero numbers assigned to it when compared with activity j, then j has the reciprocal value when compared with i

1.1–1.9 If the activities are very close May be difficult to assign the best value but when compared with other contrasting activities, the size of the small numbers would not be too noticeable, yet they can still indicate the relative importance of the activities

Source: Saaty (2008).
directly related to institutional efforts to provide drinking water supply, therefore has the lowest position in the comparison matrix.

Weights (Table 4) were derived from the comparison matrix with a consistency ratio of 0.052; consistency index is 0.068 with $\lambda$ value of 6.340. It gives the maximum weight (36.5) to treated tap water supply within premises, which is the ideal condition for better drinking water supply, followed by treated tap water supply (23.6) and safe water supply within premises (16.3). Thus, this indicator which is less explanatory has acquired a lower weight.

Table 2. Indicators used and their explanation for drinking water supply index.

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Name</th>
<th>Explanations</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Percentage of households having treated tap water supply within premises</td>
<td>Indicator is the most optimum condition as the household is getting drinking water from a source where water was treated before supplying the households. Here, distance to source too is zero as water is available within the premises</td>
</tr>
<tr>
<td>B</td>
<td>Percentage of households having treated tap water supply</td>
<td>Here, households are getting treated tap water supply, but this tap can be common or in the neighborhood as tap water is not available within the premises. Thus, this scenario is less desirable in comparison to indicator ‘A’</td>
</tr>
<tr>
<td>C</td>
<td>Percentage of households having a safe water supply within premises</td>
<td>These types of households can access the water within premises, but water supply is not treated. Safe drinking water comprises water from a covered well, which may not be as pure as treated tap water</td>
</tr>
<tr>
<td>D</td>
<td>Percentage of households having water supply within premises</td>
<td>These types of households have neither treated tap water nor safe drinking water supply, but water is available within the premises. Thereby, this indicator is less desirable than ‘C’</td>
</tr>
<tr>
<td>E</td>
<td>Percentage of households having safe water supply</td>
<td>Here, the households neither have access to treated tap water nor is the water available within premises. Thereby, this indicator is so low on the scale of good drinking water supply. Uncovered well and uncovered surface water source are considered unsafe drinking water sources, the rest of the sources are safe sources of drinking water supply according to Census of India</td>
</tr>
<tr>
<td>F</td>
<td>Percentage of households that are not dependent on groundwater sources</td>
<td>It is a proxy and indirect indicator for drinking water supply condition thereby remains lowest on Saaty’s index. Non-dependence on groundwater sources does not provide for treated tap water supply, water supply within premises or safe water source, but non-dependence on groundwater source has some environmental values</td>
</tr>
</tbody>
</table>

Table 3. Comparison matrix of drinking water supply indicators.

<table>
<thead>
<tr>
<th>Indicators</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>B</td>
<td>$\frac{1}{2}$</td>
<td>1</td>
<td>$\frac{1}{2}$</td>
<td>2</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>C</td>
<td>$\frac{1}{3}$</td>
<td>$\frac{1}{3}$</td>
<td>$\frac{1}{2}$</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>D</td>
<td>$\frac{1}{4}$</td>
<td>$\frac{1}{4}$</td>
<td>$\frac{1}{4}$</td>
<td>$\frac{1}{4}$</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>E</td>
<td>$\frac{1}{4}$</td>
<td>$\frac{1}{4}$</td>
<td>$\frac{1}{4}$</td>
<td>$\frac{1}{4}$</td>
<td>$\frac{1}{4}$</td>
<td>$\frac{1}{3}$</td>
</tr>
<tr>
<td>F</td>
<td>$\frac{1}{5}$</td>
<td>$\frac{1}{5}$</td>
<td>$\frac{1}{5}$</td>
<td>$\frac{1}{5}$</td>
<td>$\frac{1}{5}$</td>
<td>1</td>
</tr>
</tbody>
</table>
The above weight pattern can be justified on the basis of the relative importance of all indicators. A weight of 100 has been divided among these six indicators, where the highest explanatory variable has a weight of 36.5 followed by less explanatory (23.6) and finally lowest explanatory, having a weight of 4.3. The above weights have been multiplied to normalized indicators to provide a drinking water supply index. We have adopted arithmetic mean, as weights have already been given to various indicators.

**Results and discussion**

**Insight into various indicators of drinking water supply**

Before looking at the composite picture of drinking water supply scenario, it would be more insightful to look at the spatial pattern of these indicators individually. Indicator ‘A’, which is percentage of households having treated tap water supply within the premises, shows that the eastern part of the country is falling short on this indicator. Districts within northern Bihar, Jharkhand, Northern Chhattisgarh and northern Odisha are the worst performers on this indicator. Leh-Ladakh of Jammu and Kashmir along with the Brahmaputra valley region of Assam too, show a low percentage of households having access to treated tap water within premises, mainly because people rely on natural outlets of water in all these areas as they are rich in availability of water, except for Leh-Ladakh. Thus, people in Leh-Ladakh are dependent on rivulets (a small stream of water) which supply melted water from glaciers for drinking water and irrigation. Given the situation of metal contamination in Tibetan rivers, increasing tourism will also play a role in further polluting these vital rivulets.

North and north-western districts along with southern and south-western districts of India are good performers in supplying treated water through taps. The districts associated with Maharashtra, Gujarat, Rajasthan, Himachal Pradesh, Punjab, Haryana, etc., have a higher percentage of households that have treated tap water supply within the premises. Looking at the depth to water level (January 2011) map of India, provided by Central Groundwater Board, we can clearly see that western and southern parts have a higher depth of groundwater in comparison to eastern and northeastern parts of the country. Likewise, surface water availability too depicts good water availability in the eastern part of the country, which has led to a condition where local people in eastern and northeastern parts of India rely on local water sources, such as spring, river, lake, pond, etc.

The majority of the households rely on treated tap water supply, mainly due to two reasons: first, dependence on ground water is low in the southern part of the country because geology deters the use of groundwater, and that is why it also does not show an alarming decrease in groundwater depth; second, surface water availability is either very low or varies over the seasons and between the years in catchment areas of peninsular rivers such as Pennar.
Distance to drinking water source is an important factor when merely 46% of households have a drinking water supply within the premises. District-wise, spatial pattern shows that north-western districts associated with canal distribution network are better in terms of distance to source, because the percentage of households accessing drinking water within premises are higher in these areas. Eastern parts of India are low in terms of tap water supply within premises, and it is also clear that physical distance to the source is also higher in these areas. A higher percentage of households in western districts of Rajasthan (Jaisalmer and Barmer) and district of Leh (Ladakh) have their drinking water source away from premises. Distance to drinking water source is comparatively lower in the districts of Punjab, Haryana, Uttar Pradesh, Kerala, Maharashtra and Assam. The districts of Karnataka and Tamil Nadu also show lower (physical) accessibility to sources of drinking water, which fall in the rain shadow zone of the south-western monsoon. Districts along the Ganga-Brahmaputra river valley, Western Ghats and Gujarat are better performers on this aspect of drinking water supply.

Dependence on groundwater sources for drinking water needs coincides with the water availability map of India. Water-scarce regions neither have the option nor depend on groundwater as much as do the water abundant regions. Eastern parts of India associated with states such as Bihar, Jharkhand, Chhattisgarh, Odisha, Assam, etc., rely more on groundwater sources for drinking water needs. Central Ground Water Board (2011) shows that groundwater depth in western parts of the country has increased to 50 metres in some areas, but is less than 10 metres below ground level in the majority of eastern India. Therefore, central and eastern districts of India are high in terms of dependence on groundwater source, in spite of having comparatively better surface water availability. This indicator does not include institutional groundwater extraction and supply to households for drinking water needs, which is prominent in north-western India. Groundwater has reached a critically low level in north-western India due to over-exploitation by individuals as well as by institutions. Eastern parts of India, which are comparatively better off in terms of groundwater level, and have good replenishment rate, show a high dependence on groundwater sources.

In terms of safe drinking water (tap/hand-pump/tubewell) supply, a belt extending from the middle western part of the country to the eastern part shows a comparatively lower percentage of households having access to safe water supply, because people rely on local uncovered water sources such as rivers, springs, etc. Districts along the Western Ghats are also low in terms of safe drinking water. Projects in the Western Ghats need to go through an appraisal and environmental clearance process, while drinking water supply schemes are exempt from it; however, the majority of the schemes are multipurpose and therefore have to go through the appraisal process. Uncovered well and uncovered surface water source are considered unsafe drinking water source, and is a source of drinking water for the majority of households in the above-mentioned areas. Thus, districts associated with low water availability as well as high water availability experience low access to safe water.

**Drinking water supply index using analytic hierarchy process**

Drinking water supply in this study is an aggregation of all the above-discussed indicators. Drinking water supply mapping can be seen in Figure 1. The picture is not different from individual indicators, which means all the indicators that were compiled in the making of this index are highly correlated and are also appropriately explanatory in nature. Districts associated with Punjab, Haryana, Himachal Pradesh, Delhi and Indira Gandhi canal area are better performers on drinking water supply index values. Gujarat, which is a natural water-scarce region too shows a good level of drinking water supply. A study
Fig. 1. India – district-wise drinking water supply (Census of India, 2011).
by Biswas-Tortajada (2014) reported that in the year of 2002 emergency arrangements to meet water shortages were replaced with a longer-term strategy in the state of Gujarat. Under this strategy, construction and management of the state-wide water supply grid were done. The scheme has also made Gujarat a pioneer in India in terms of moving towards water security and conservation, from a state of water scarcity.

Northern Maharashtra, associated with the catchment area of Godavari River, is better on drinking water supply index along with western Maharashtra which is associated with a higher urban population as well as higher rainfall. Central and north-eastern India, which are said to be rich in terms of availability of water, are poor in terms of supply. The districts of Karnataka, Andhra Pradesh and Telangana too perform comparatively better than the eastern part of the country on this index. The geology of southern India does not favour groundwater exploitation, therefore, people rely more on institutional tap water supply; in turn, this part is better than the eastern part of the country on the index. Districts associated with Madhya Pradesh, Chhattisgarh, Jharkhand, Odisha, Southern Bihar, Leh-Ladakh, Southern Assam, Meghalaya, Nagaland, Manipur, Nagaland, etc., are poor performers on this index. North-eastern India which is rich in the natural endowment of water shows a low value of drinking water supply index, because of multiple issues. The traditional water system has declined in hilly villages which has led to water scarcity in winter months. Unfavourable terrain also poses a limitation on the construction of the water grid as in the state of Gujarat. Natural hazards such as floods and earthquakes also damage or pollute drinking water sources, which further aggravates the water scarcity. This means the issue is not only about the physical availability of water, but is also about institutional weakness, which fails to manage available water to supply drinking water throughout the year. The resource-rich region of India comprising the tribal belt in the states of Jharkhand, Odisha, Chhattisgarh and Madhya Pradesh is low on the drinking water supply index. Low socio-economic development, lack of amenities and low assimilation of tribal people may be the possible reasons for the dismal state of this area in the drinking water supply scenario. The Economic Survey 2016–17 (Department of Economic Affairs, Ministry of Finance, Government of India, 2017) talked about the ‘resource-curse’ pathology of these areas and found that efforts are needed to improve the socio-economic development of these areas to remove the curse. It is considered that western India should face water scarcity being a naturally water deficit area, but except for Jaisalmer and Barmer, all districts perform relatively better in terms of drinking water supply. Districts low in physical availability of water have to depend on institutional arrangements for drinking water supply. Western India is at a disadvantageous stage in terms of water quantity as well as water quality, whereby people are more reliant on tap water supply and particularly on treated tap water supply, which makes these areas better performers on drinking water supply index. Districts which are associated with a high percentage of the urban population are also better performers on this index because urban areas are better served by institutional water supply in comparison to rural areas, according to Census of India (2011).

Groundwater depth follows a rainfall and river distribution pattern. Eastern and south-eastern India have better groundwater levels in comparison to western India. The districts of Rajasthan, Punjab and some western districts of Uttar Pradesh show critically low levels of groundwater. Groundwater depth data, which are measured through groundwater monitoring wells, are absent for hilly areas of the country. Major parts of India fall in the category of having a drinking water depth of less than 10 m below ground level, while the western part shows groundwater depth of 40 m, which is critically low in comparison to the rest of India. Per capita basin-wise surface water depends on river water volume as well as population. The basins of south-eastern rivers and west flowing rivers of Gujarat
have critically low surface water. Surface water availability has gone down drastically in the last two decades, in all areas except the Western Ghats and north-east region of India. East flowing river basins of Brahmani, Baitarani and Mahanadi, along with the Brahmaputra river system show a better level of per capita surface water availability. Maximum water availability can be seen in north-eastern districts of India and along the Western Ghats. Districts situated in Odisha and south-central India also show high water availability. Most of the districts associated with Rajasthan, Tamil Nadu, Karnataka and Maharashtra show low and lowest water availability.

A comparison between the natural availability of water and drinking water supply index shows that water surplus areas may not have a good drinking water supply system, while water-scarce regions might not be facing drinking water supply scarcity. Thus, natural availability of water is not related to a better drinking water supply scenario. We can see that institutions in the western part of the country have made better efforts to convert the natural water scarcity into a good drinking water supply system in comparison to the eastern part of the country. These results also pose questions on sustainability of the current scenario of drinking water supply in the western part of the country, in the wake of an alarming decrease of groundwater.

**Conclusions**

Drinking water supply index prepared by using AHP, at the district level for India, provided some insights into the scenario of water supply. The difference between the eastern and western part of the country can be clearly seen. Districts situated in the western part of the country that have arid and semi-arid climates are better performers on drinking water supply index. On the other hand, districts situated in the eastern part of the country, which are comparatively better on the natural endowment of water, show a dismal value of drinking water supply index. This result is important in the wake of current constitutional arrangements in which drinking water supply is the function of urban and rural local bodies. Results also question the sustainability of better levels of drinking water supply in the western part of the country, as groundwater level has reduced at an alarming rate primarily because of irrigation; there is already a lack of surface water sources in this part of India. Therefore, there is need for participative sustainable management of drinking water sources. Sustainable Development Goal (SDG) 6 also broadens the aspects of drinking water supply and ensures availability and sustainable management of water. SDG Target 6.1 states that by 2030, universal and equitable access to safe and affordable drinking water for all should be ensured. SDG 6 is more relevant in the current scenario when there are questions regarding the sustainability of the current drinking water supply.

Water supply as a state subject has shown variation among, as well as within the states, and after the 73rd and 74th Indian Constitutional Amendment Act, water supply is the function of urban and rural local bodies. This index shows institutional efforts and efficiencies in providing drinking water supply to households, which has also been established through a micro-level study (Poonia, 2015). The study provided an insight into the associates and determinants of drinking water supply along the urban–rural continuum of two semi-arid cities of western India. This study provided evidence of an association between institutional coverage and better scenario of drinking water supply. The effectiveness of urban and rural local bodies has a larger role in the drinking water supply system.

With this study, we cannot conclude that the effectiveness of urban and rural local bodies of areas having good drinking water supply scenario will be followed by areas which are low on drinking
water supply, since the question follows, is this water supply ecologically sustainable? Mapping of estimated terrestrial water storage changes by GRACE (Gravity Recovery and Climate Experiment) averaging function (Rodell et al., 2009), shows highest change (decline of groundwater) in Rajasthan in general and the semi-arid northern part in particular. In light of this evidence, the current pattern of the better drinking water supply facility in the western part of the country is under question. The states of Rajasthan and Gujarat, being a natural water-scarce region, convert the natural water scarcity into institutional water sufficiency. Drinking water supply has always been the priority of National Water Policies, but the western part of the country, where groundwater has declined to an alarming level, is at risk of falling back into drinking water scarcity. Individual tubewells for irrigation purposes have extracted groundwater recklessly. ‘The Easement Act 1882’, the so-called British Common Law, which states that those who own the land can extract all water (Koshy, 2016), has caused an irrational use of groundwater which has resulted in a drastic decline in groundwater level in those areas.

This study has shown results where institutional management can defeat the vagaries of nature (Gujarat and Rajasthan) and, at the same time, institutional neutrality can cause drinking water scarcity in a water-abundant area (north-eastern part of the country). Some areas face physical water scarcity, which means there is a natural water scarcity, for example, the western part of the country. Some regions face social water scarcity, where inequitable distribution of water causes scarcity for the majority, for example, luxury apartments can use purified water for swimming purposes, while people in nearby slums do not get enough water for basic needs. Some regions face an institutional water scarcity, where institutions are not in a position to manage the abundance of water, such as north-eastern parts of India, which face water scarcity in winter or non-rainy seasons, in spite of being the wettest part of India. Urban and rural local bodies can play a regulating and monitoring role in using the groundwater. Thus, against the backdrop of drastically decreasing groundwater level, rapidly increasing water stress in western and southern parts of India and obsolete British Common Law, there is an urgent need to produce a National Water Framework, which addresses all issue of water governance. Water governance at the local level has potential as well as challenges. Gram Sabha, Gram Panchayats, Pani Samiti, Pani Panchayats, Municipal Corporation, etc., need to follow a participatory approach for sustainable water management in the local area. Sustainability has many dimensions as well as many scales, but the democratic management of water by democratic bodies is a step towards the sustainability of water resources.

References


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