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How Safe are Drinking Water Services in Rural India?

Case for Strengthening the Existing Data and Information System

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Issue Brief | October 2022

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Executive summary

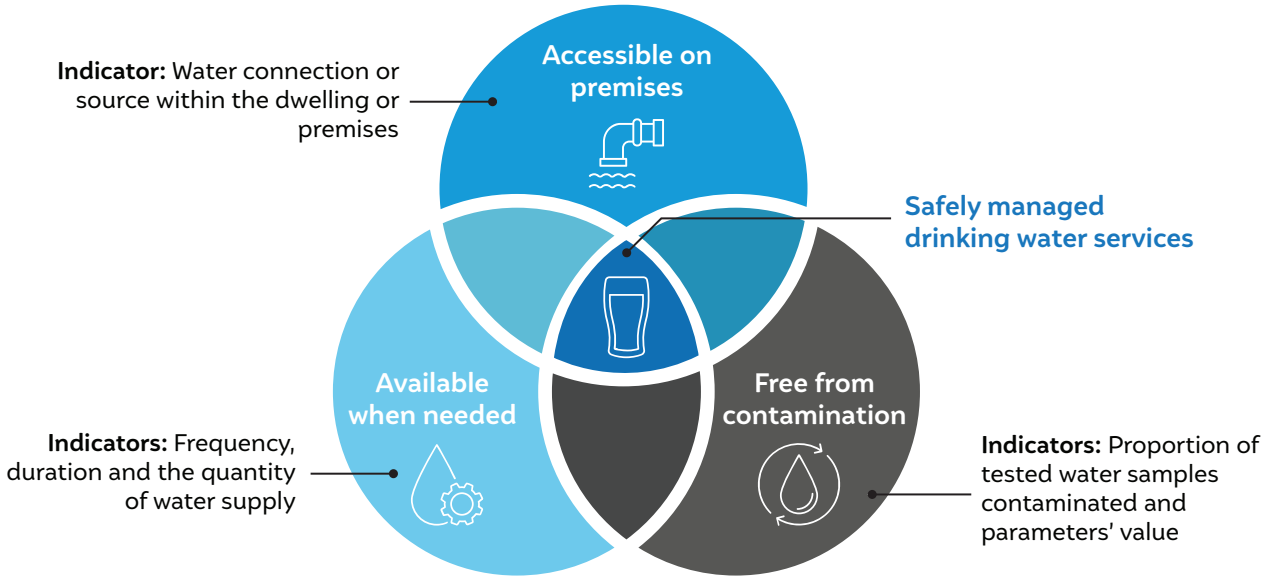
India has made tremendous progress in increasing the coverage of the drinking water supply infrastructure in rural areas. As per the joint monitoring programme of the United Nations Children's Fund and World Health Organization, by 2020, 89 per cent of the rural population in India was covered with at least basic drinking water services, i.e., they had access to an improved water source within a round trip of 30 minutes. Further, as per the latest information reported by the Department of Drinking Water and Sanitation, Ministry of Jal Shakti, Government of India, **as of 31 May 2022, 50 per cent of rural households had a tap connection within the dwelling or premises.** However, there is a dearth of information on whether the progress in creating the physical infrastructure has translated into an improvement in the reliability and safety of drinking water services in rural households.

With this background, our issue brief focuses on ascertaining the extent to which data on safely managed drinking water services are reported in India and makes recommendations to strengthen the existing data and information system. These services are characterised by access to the improved source of drinking water that is located on the premises, available when needed, and free from faecal and priority chemical contamination (refer to Figure ES 1). For this purpose, the four main national government sources that report data and information on rural drinking water services in India were reviewed. These include the *Census of India*, *National Sample Survey* (NSS), *National Family Health Survey* (NFHS), and the Integrated Management Information System (IMIS) dashboard maintained by the Department of Drinking Water and Sanitation (DDWS), Ministry of Jal Shakti, Government of India. These sources were reviewed concerning the data and information they report on rural drinking water services, various terminologies used, and the possibility of using them to make reliable inferences on the progress made in providing safely managed drinking water services.

A. Key findings

- The existing reporting on rural drinking water services by various national agencies is not comparable.
  - They are undertaken with different mandates and frequencies. While the IMIS dashboard of DDWS provides information in real-time, the *Census of India* reports data after every 10 years.
  - They use different indicators. While the IMIS dashboard of DDWS covers most of the indicators of the safely managed drinking water services (some only partially though), the NFHS covers only one indicator, i.e., the water source accessibility.
  - The unit of analysis is different. For the *Census of India*, NSS, and the IMIS dashboard it is households, whereas, for NFHS it is population.
- The indicators considered by various agencies to report progress in rural drinking water services are aligned only partially with those necessary to determine whether such services are safely managed (refer to Table ES 1). Only one indicator related to physical access to a water source can be compared for different years (refer to Figure ES 2).

Figure ES 1 Safely managed drinking water services refer to an improved water source that is within the premises, is reliable, and is safe



Source: Authors' proposed framework based on United Nations Children's Fund and World Health Organization, 2019

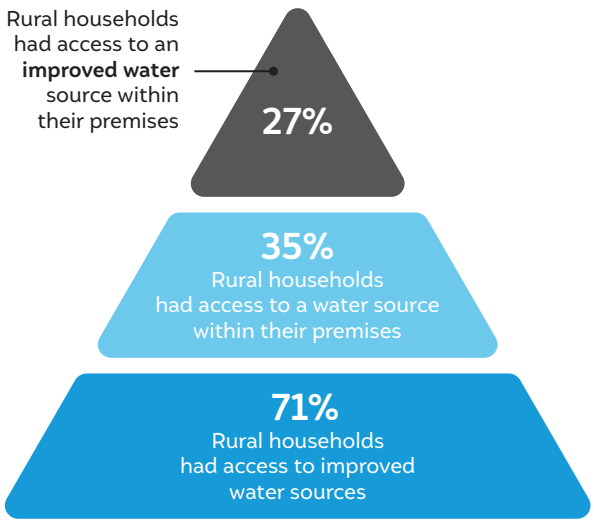
Table ES 1 Data and information provided by various national government sources only partially cover all components of safely managed drinking water services

Sources	Latest data (collection frequency)	Scale (unit of analysis)	Data/Information availability on					
			Accessibility		Reliability		Safety	
			Improved source	Physical access	Supply quantity	Supply frequency and duration	Source/ Supply water quality	Parameters' values
Census of India	2001 (10 years)	Complete enumeration (all HHs*)	Yes	Yes	No	No	Partial	No
NSS	2018 (Intermittent)	Representative sample (HHs)	Yes	Yes	Partial	No	No	No
NFHS	2019-21 (5-6 years)	Representative sample (all individuals within the sampled household)	Yes	No	No	No	No	No
JJM IMIS dashboard	2022 (Real time)	Data reported by respective States & UTs (HHs)	Partial	Yes	Only for pilot 69 villages	No	Partial	No

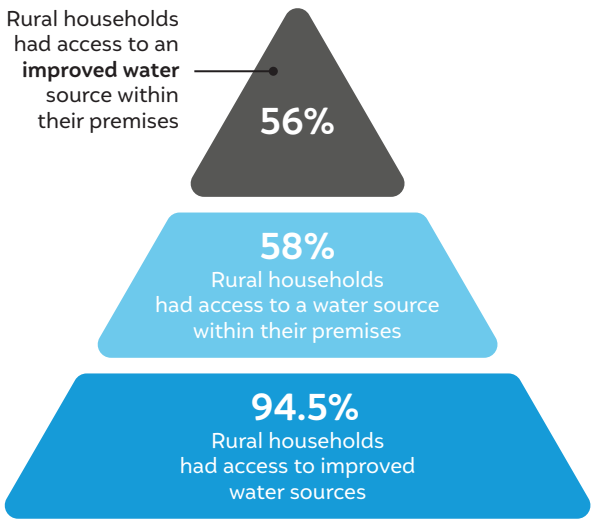
Source: Authors' analysis
*Note: *HHs refers to households*

Figure ES 2 In 2018, 50% more rural Indian households had improved drinking water source at their premises compared to 2011

a) Census of India, 2011



b) NSS 76th Round, 2018



Source: Authors' analysis using Census of India, 2011 and NSS 76th Round, 2018 data

- The existing data sources and information system present a challenge in deriving comprehensive inferences for the policymakers and water managers to decide on actions for improving the provision of safely managed drinking water services in rural India.
- There is a need to strengthen the existing data and information system for them to sufficiently cover all aspects of safely managed drinking water services which include its accessibility, reliability and safety (referring to water quality).

B. Recommendations

We make five recommendations to strengthen the existing data and information systems and validate the progress with the provision of safely managed drinking water services in rural areas. They include:

- **Standardise terminologies and indicators used across existing surveys:** They should be in line with those used for determining the safely managed drinking water services to allow better inferences on the progress made. For this, the agencies engaged in conducting the *Census of India*, NSS, and NFHS and the one managing the *Jal Jeevan Mission (JJM)* dashboard need to initiate discussions for arriving at a consensus.
- **Expand the scope of future surveys to cover all the indicators of safely managed drinking water services:** This will help in validating the progress reported by the recent JJM IMIS dashboard, especially in the context of physical access to the source and the reliability of the water supply. JJM does have a provision to undertake an annual functionality assessment survey of tap water connection for each district by a third-party agency. This provides an opportunity for various national agencies in charge of surveys to collaborate for such assessments and thereby make efficient use of available resources.
- **Scale up the Internet of Things (IoT)-based smart water supply monitoring system piloted under JJM to cover all the villages:** This will need proper planning and substantial investments, therefore, it can only be undertaken in a phased manner with priority to areas that experience water stress so that decisions can be made on the need to augment water supplies in such areas. In addition to the quantity of daily water supply, such a monitoring system should also report 'frequency and duration of water supply' and 'values of water quality parameter'. JJM does have a provision where every state needs to prepare a five-year action plan projecting annual financial requirements for achieving JJM targets. Investments required for the water supply monitoring system can be made part of such a plan.
- **Meter individual water connections to account for water delivery at the household level:** Individual water meters should be installed for generating data on the indicator 'quantity of water supplied at the household level'. Presently, the pilot IoT-based smart water supply monitoring system provides information based on the bulk water supply to the village. However, information about the actual water supply at the household level is unavailable. Household level metering will fill this gap. To ensure regular reporting of such data (at least every month), village water and sanitation committees (VWSC), a local institution for operation and maintenance of village water supply schemes, can be engaged.
- **Compute water quality index (WQI) to monitor source water quality and identify sources that need further investigation:** The WQI provides a single score by summarising the values of several water quality parameters and helps classify source water quality as excellent, good, medium, bad, or very bad. The WQI scores can be used to monitor changes in source water quality over time and identify sources that should be investigated further, especially those that are in the WQI benchmark values for the bad or very bad category. This can help decide on prospective corrective measures for improving the source water quality. Such an approach will augment the existing practice where the VWSC (using field kits) or the laboratories test the water samples for various parameters but only report their values.

1. The context

Target 6.1 of sustainable development goals (SDG) intends to achieve universal and equitable access to safe and affordable drinking water for all by 2030. A report on the progress of household drinking water, sanitation, and hygiene for 2000-2020 observed that 90 per cent of the population in India was covered with at least the basic drinking water services by 2020, i.e., they had access to an improved water source within a round trip of 30 minutes (United Nations Children's Fund and World Health Organization 2021). The coverage was 89 per cent in rural areas and 94 per cent in urban areas. However, this is different from access to the safely managed drinking water services that SDG target 6.1 intends to achieve. It

> Improvement in access to water supply infrastructure does not translate into a reliable water supply at the household level

is defined as the use of an improved water source that is accessible on household premises, is reliable (water is available when needed), and is safe (United Nations Children's Fund and World Health Organization 2019).

The understanding concerning access to water supply, i.e., whether basic or safely managed (as intended under target 6.1 of SDGs), continues to be mystifying for rural India. The improvement in access to water supply infrastructure does not translate into a reliable water supply at the household level. Every summer, many rural areas in different parts of India run short of drinking water (Reddy et al. 2010; Chakraborti et al. 2019; Kumar et al. 2022). Further, the current water supply norms which are usually 40 litres per capita per day (lpcd) for the groundwater-based schemes and 55 lpcd for the surface water-based schemes are considered inadequate due to the multiple-use water demand of rural communities (Bassi et al. 2021). Moreover, our rural water supply schemes are seldom designed to provide water for multiple uses (Kabir et al. 2016). In such a situation, where the current water supply norms that are based on the principle of meeting the basic minimum need of drinking water for the rural population (Gleick 1996) are not met, providing water security to the rural community would be a challenge. Nevertheless, it is important to understand whether the data and information are available on the different components of safely managed drinking water services which can be used to monitor the progress and take policy action for domestic water security in rural areas. The United Nations and the Council on Energy, Environment and Water (CEEW) analysis in the recent past has highlighted the importance of quality real-time data in improving water management at different scales (Kim et al. 2018). This issue brief attempts to clarify the situation concerning the reporting of drinking water access and supply situation in rural India and suggest ways to bridge the reporting gaps and make it more comprehensive.

2. Safely managed drinking water services: Proposed framework

While basic drinking water services consider only the use of an improved water source within a round trip of 30 minutes, the safely managed drinking water services consider the use of an improved water source that is accessible on the household premises (preferably within the dwelling), is reliable (water is available when needed), and is safe or free from bacteriological and chemical contamination, especially *Escherichia coli*, arsenic and fluoride. The improved water sources include piped water, boreholes or tube wells, protected dug wells, and protected springs (United Nations Children's Fund and World Health Organization 2019).

The three components that comprise safely managed drinking water services along with their indicators are presented in Figure ES 1. The indicator to capture 'accessibility on premises' is whether the piped water connection or water source (individual hand pump or well) is within the dwelling or household's premises. The 'reliability' can be ascertained through the frequency, duration, and quantity of water supply during different seasons (winter, summer, and monsoon). And for 'water quality', it is important to know whether the water samples are collected for laboratory testing and the proportion of tested water samples that are found to be bacteriologically or chemically contaminated along with the values of tested parameters.

3. Approach

Four main national government sources report data and information on rural drinking water services in India. These include:

- *Census of India* conducted every ten years by the Office of the Registrar General and Census Commissioner, Ministry of Home Affairs;
- *National Sample Survey (NSS)* periodically undertaken by the National Statistical Office, Ministry of Statistics and Programme Implementation, though intermittently for drinking water;
- *National Family Health Survey (NFHS)* by the Ministry of Health and Family Welfare, undertaken at a gap of 5-6 years; and,
- Integrated Management Information System (IMIS) dashboard maintained by the Department of Drinking Water and Sanitation (DDWS), Ministry of Jal Shakti. The dashboard is operational since 2009-10 with the launch of the *National Rural Drinking Water Programme (NRDWP)*. From 2019 onwards, the NRDWP was restructured and subsumed in the *Jal Jeevan Mission (JJM)*.

The *Census of India* covers all the rural households in India, the NSS and NFHS are based on a representative sample of the rural households, and the IMIS dashboard covers the beneficiary households under the central government-sponsored water supply programmes. The *Census of India* was last undertaken in 2011 (GoI 2011); the latest NSS specific to drinking water was during its 76th round survey for July-December 2018 (GoI 2019) wherein 63,736 representative rural households

were surveyed using schedule 1.2 on drinking water, sanitation, hygiene, and housing condition; and the latest NFHS was during 2019-21 which was spread over two phases due to restrictions imposed by the COVID pandemic (GoI 2020 and GoI 2021). The first phase of NFHS covered representative rural households from 22 states, and the second phase from 14 states and union territories (UTs). The IMIS dashboard of the DDWS provides data on a near real-time basis.

We analyse these four sources for: a) the data and information they report pertaining to rural drinking water services; b) various terminologies used; and, c) the possibility of using them to make reliable inferences on the progress made in providing safely managed drinking water services. The components and indicators of safely managed drinking water services are presented in Figure ES 1.

4. Results and discussions

In this section, we present the results from the review of the four national sources that report data and information on rural drinking water services in India and discuss them.

4.1 Census of India, 2011

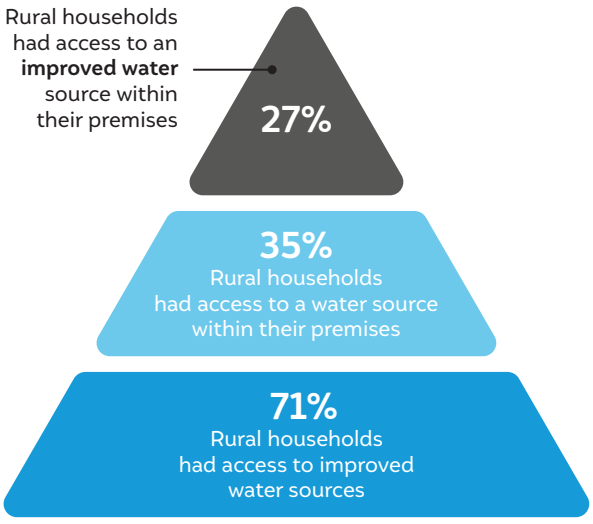
The *Census of India*, 2011 provides information about:

- **The household's physical access to the water souce,** i.e., whether within, near (within a range of 500 metres), or away (beyond 500 metres) from the premises; and,
- **The type of sources,** i.e., whether improved or unimproved. The improved water sources considered were treated tap water, covered wells, hand pumps, tube wells, and bore wells. The unimproved water sources were untreated tap water, uncovered wells, springs, canals, rivers, tanks, ponds, lakes, and other sources (such as tanker water).

In 2011, 71 per cent of rural households received water through improved sources of water but only about half of them had access to a water source within their premises. It should be noted that not all the rural households who have access to a water source within the premises receive water from an improved source as many receive it from an untreated source. The proportion of rural households who had access to an improved water source within the premises was even lower (Figure 1).

The state and union territory (UT) level spatial variation in access to rural water services is presented in Figures 3a and 3b, respectively. In terms of receiving water from the improved water source, the top five states/UTs were Bihar, Puducherry, Chandigarh, Daman and Diu, and Himachal Pradesh, and the bottom ones were Manipur, Mizoram, Nagaland, Sikkim, and Lakshadweep (Figure 2a). On the access to improved water source within the household's premises, the top five states/UTs were Chandigarh, Punjab, Daman and Diu, Goa, and Delhi, and the bottom ones were Chhattisgarh, Nagaland, Manipur, Mizoram, and Lakshadweep (Figure 2b). The north-eastern hill states of Nagaland, Manipur, and Mizoram appear in the bottom list for both the indicators considered by the *Census of India*, 2011. Kerala was a unique case where a high proportion of households who have access to a water source within the premises depend on an unimproved source (about 56 per cent depend on uncovered open well).

Figure 1 In 2011, only 27% of the rural Indian households had improved drinking water source at their premises



Source: Authors' analysis using Census of India, 2011 data.

Figure 2a In 2011, only 14 out of the 37 states had more than 70% of rural households with access to an improved drinking water source

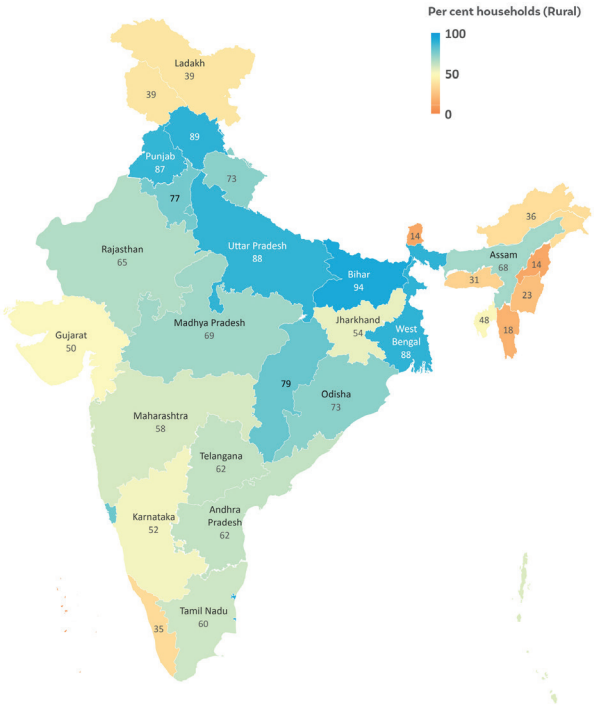
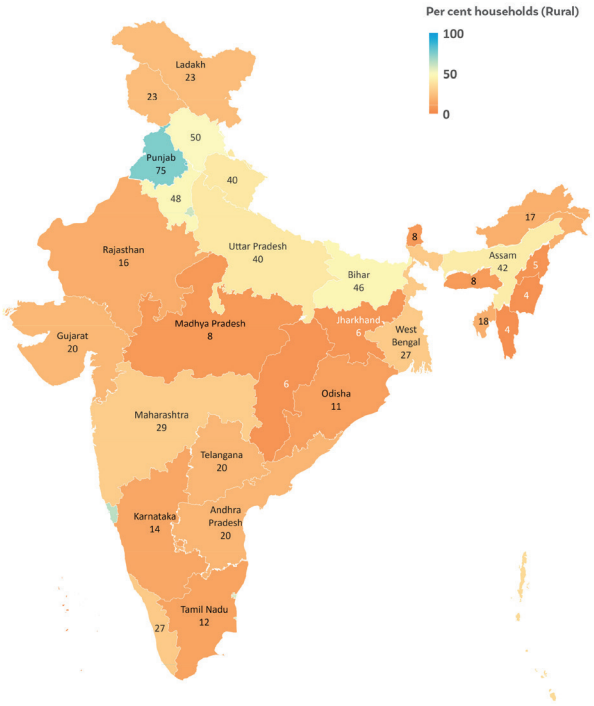


Figure 2b In 2011, only 2 out of the 37 states and UTs had more than 70% of rural households with access to an improved drinking water source within the premises



Source for Figure 2a and b: Authors' analysis using Census of India 2011 data

The Census of India, 2011 for the first time provided the distinction between improved and unimproved sources. However, there are three concerns with the reporting. First, the physical access data does not provide the distinction between the number of households having access to a water source within the dwelling unit and those within the household's premises or compound. Second, information pertaining to the frequency, duration, and quantity (reliability aspect) of the water supply is missing. Third, though the distinction is provided between treated and untreated tap water, the water quality information for other improved sources is missing. Thus, the details provided by the *Census of India* are insufficient to make inferences concerning the different components of safely managed drinking water services as the data for the indicators on the reliability of the service are missing and for those on the quality of water supplied is only provided partially (i.e., only for tap water).

4.2 National Sample Survey (NSS) 76th round, July-December 2018

NSS 76th round collected information on the following indicators:

- **Type of water sources:** 17 source categories were considered. They include piped water into the dwelling, piped water within household premises, piped water from a neighbour, public tap/ standpipe, tube well and hand pump, protected and unprotected well, tanker truck, protected and unprotected spring, rainwater collection, surface water (rivers, dams, lakes, ponds, streams, canals, and irrigation channels), bottled water, and others (cart with small tank or drum, etc.);
- **Sufficiency of drinking water from the principal source:** The principal water source is the one from which the household obtained most of its drinking

water during a year and it was considered sufficient if in each of the calendar months during a year, sufficient water was available for drinking water;

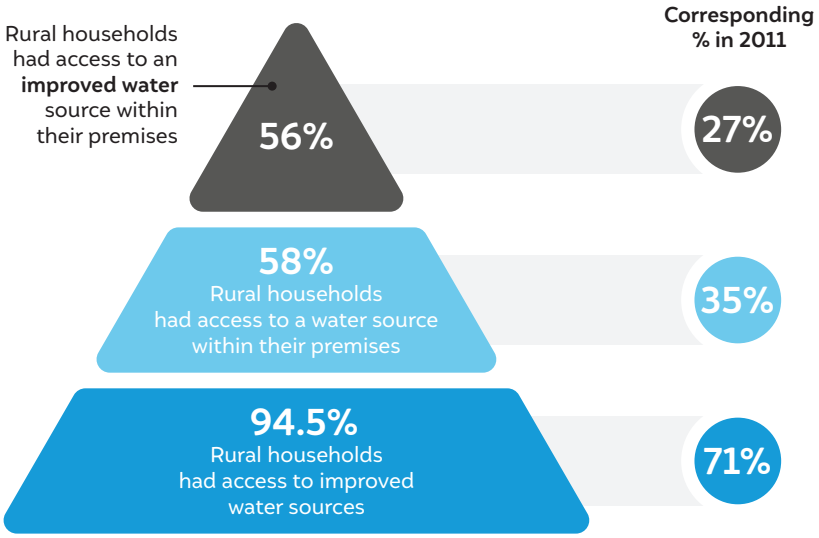
- **Type of household access to the principal source of drinking water:** This was based on existing social norms rather than the legal right to use water. The information was captured in the following eight categories: (i) exclusive use of household, (ii) common use of households in the building, (iii) neighbour's source, (iv) public source restricted to a particular community, (v) public source unrestricted, (vi) private source restricted to a particular community, (vii) private source unrestricted, and (viii) others;
- **Distance to the principal source of drinking water from the household,** i.e., within the dwelling, within the premises, or away from the premises (physical access); and,
- **Treatment and storage of drinking water by the household** (collected for the first time by NSS).

The results from the NSS 76th round, 2018 highlighted substantial progress over the *Census of India*, 2011 in terms of access of households to the improved drinking water source (Figure 3). Overall, 94.5 per cent of rural households receive water from improved sources. The top five states/UTs were Delhi, Sikkim, Chandigarh, Daman and Diu, and Puducherry wherein all households received water from improved sources. Those at the bottom of the list were Kerala, Manipur, Lakshadweep, Nagaland, and Tripura; thus, three out of the five were the north-eastern hill states (Figure 4a).

However, only 56 per cent of the rural households had improved sources of drinking water located within the household premises. The top five states/UTs were Chandigarh, Goa, Punjab, Bihar, and Sikkim. Those at the bottom of the list were Jharkhand, Odisha, Meghalaya, Madhya Pradesh, and Andhra Pradesh (Figure 4b). The figure becomes 51.4 per cent while also considering the sufficiency of the source. In this category, the top five states/UTs were Chandigarh, Bihar, Punjab, Sikkim, and Puducherry, and the bottom ones were Madhya Pradesh, Odisha, Jharkhand, Meghalaya, and Andhra Pradesh (Figure 4c).

Further, it goes down to 42 per cent if the indicator on the exclusive access to the water is considered. In this category, the top five states/UTs were Sikkim, Punjab, Assam, Lakshadweep, and Puducherry. The bottom ones were Odisha, Jharkhand, Andhra Pradesh, Madhya Pradesh, and Dadra and Nagar Haveli (Figure 4d). On all the above-discussed indicators, Sikkim and Punjab appear in the top five, and Jharkhand, Odisha, Madhya Pradesh, and Andhra Pradesh in the bottom five. In terms of the treatment of water at the household level, a high proportion (76 per cent) does not do it.

Figure 3 In 2018, the proportion of rural households with access to an improved drinking water source within the premises doubled in comparison to 2011



Source: Authors' analysis using Census of India, 2011 and NSS 76th Round, 2018 data.

Figure 4a In 2018, almost all the states and UTs had more than 70% of rural households with access to an improved water source

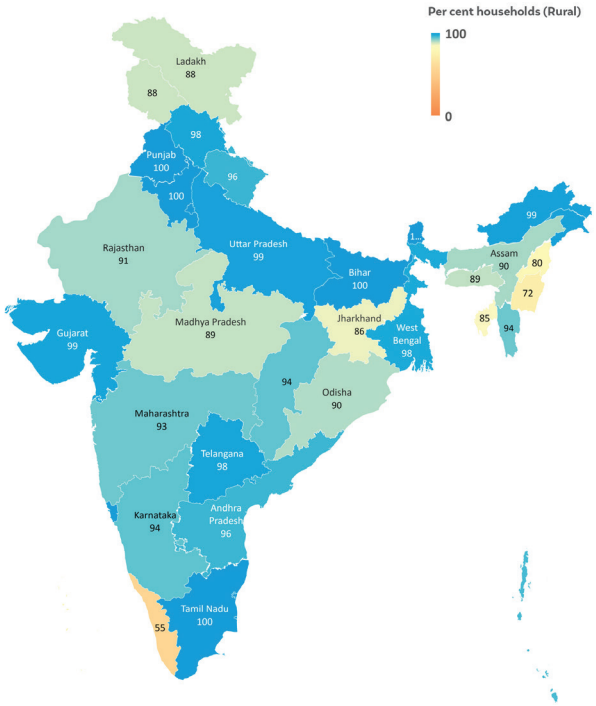


Figure 4b In 2018, only 15 out of the 36 states and UTs had more than 70% of rural households with access to an improved drinking water source within the premises

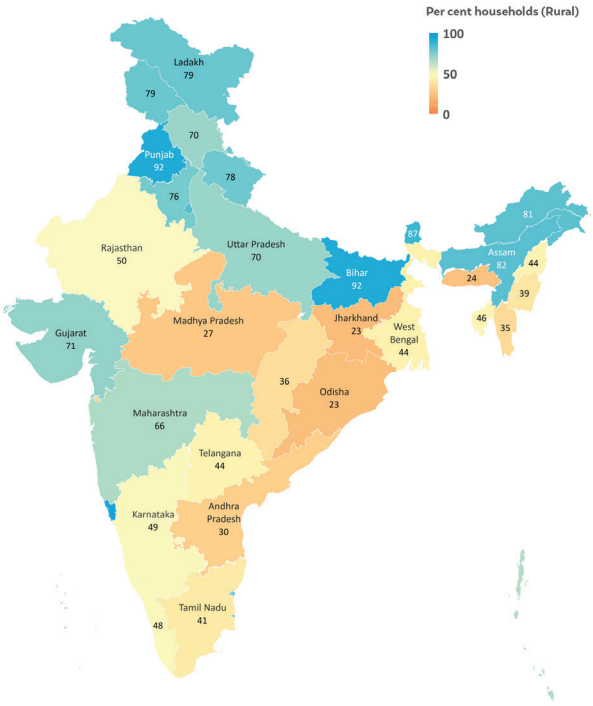


Figure 4c In 2018, only 12 out of the 36 states and UTs had more than 70% of rural households with access to an improved water source within the premises which was sufficiently available throughout the year

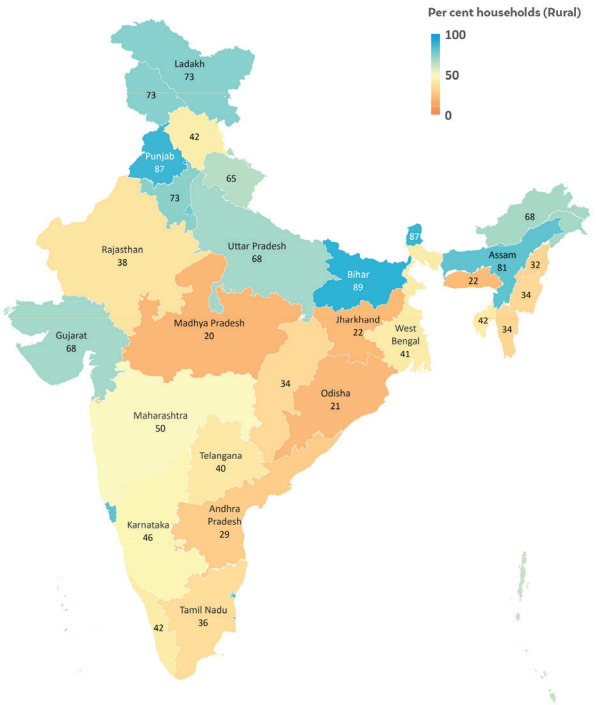
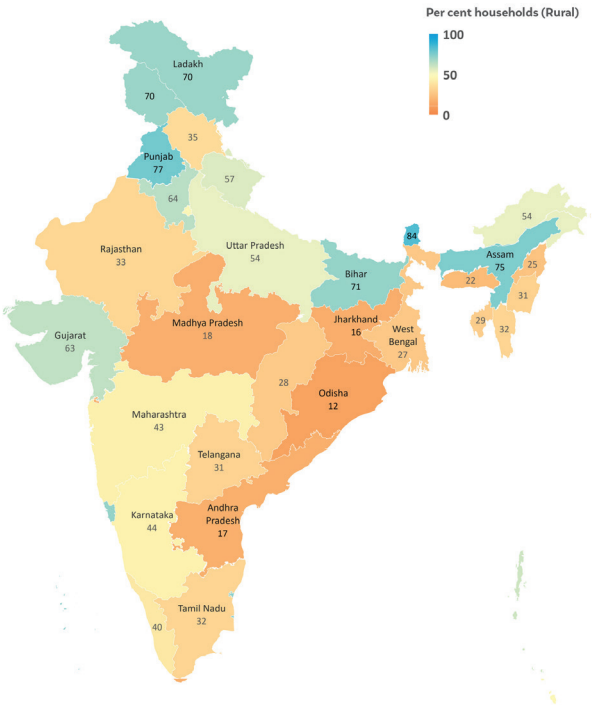


Figure 4d In 2018, only 7 out of the 36 states and UTs had more than 70% of rural households with exclusive access to an improved drinking water source within the premises which is sufficiently available throughout the year



Source for Figure 4a,b,c,d: Authors' analysis using NSS 76th Round, 2018 data.

The NSS makes some interesting additions to the data collected by the *Census of India*, 2011. These include more detailed data on the type of sources, information on the sufficiency of drinking water sources, type of access, and the treatment and storage facility at the household level. But unlike the *Census of India*, 2011, the information provided is for the representative number of households.

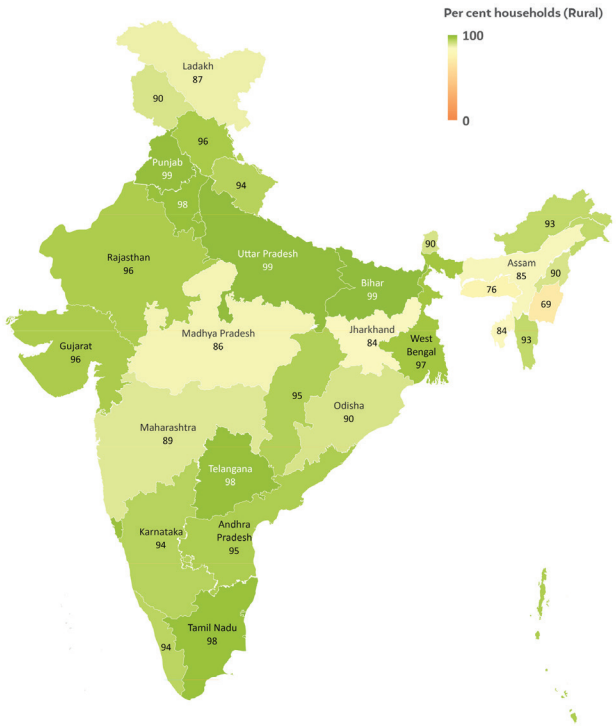
Nevertheless, the information presented in the NSS 76th round provides better insights on the drinking water services but can be made more comprehensive. For instance, though the information pertaining to the percentage of households with the improved principal source of drinking water that is located within the household premises and providing sufficient drinking water is provided, it does not define the improved and unimproved sources, the quantity considered for sufficient water, and the frequency of water supply. Usually, the rural water supply schemes are designed to supply 40 litres (groundwater based) to 55 litres (surface water based) per capita per day of water for domestic use, including for drinking purposes (Government of India 2013). Further, the information on the quality of supplied water (whether treated or untreated) is missing.

4.3 National Family Health Survey (NFHS), 2019-21

The NFHS covers several key indicators of population, health, and nutrition for a representative sample of households. The 5th NFHS (2019-21) only had one key indicator pertaining to the water supply, i.e., people living in households with an improved drinking-water source. The improved water sources considered by NFHS include piped water into dwelling/yard/plot, piped to the neighbour, public tap/standpipe, tube well or borehole, protected dug well, protected spring, rainwater, tanker truck, cart with small tank, bottled water, and community RO plant.

As per the findings of the NFHS 2019-21, about 94.6 per cent of the rural population lives in households connected with an improved source of water. The state and UT level situation is presented in Figure 5. The top five states/UTs in terms of the population getting water from improved sources were Chandigarh, Puducherry, Bihar, Uttar Pradesh, and Punjab. The bottom five, which includes four north-eastern states, were Manipur, Meghalaya, Tripura, Jharkhand, and Assam.

Figure 5 In 2021, out of the 36 states and UTs, 23 had more than 90% of the rural population with an improved drinking water source



Source: Authors' analysis using NFHS, 2019-21 data.

As the case with NSS, the findings are based on a representative number of households and distinction between treated and untreated water supply is not made. Further, it considers population as a unit of analysis whereas both NSS and *Census of India* consider households, and thus it is difficult to compare them. Moreover, it provides no information on the household's physical access to a water source. Thus, apart from getting information on the percentage of the population connected to an improved water source, it is difficult to draw inferences on the access, reliability, and quality of the drinking water services.

4.4 Department of Drinking Water and Sanitation (DDWS) IMIS dashboard

DDWS is maintaining the IMIS dashboard since the launch of the *National Rural Drinking Water Programme* (NRDWP) in 2009. Till 2019, this dashboard provided information mainly pertaining to the sources of water supply, households' physical access to water supply, coverage of water supply (in terms of habitations covered), and water quality affected habitations. In 2019, the NRDWP was restructured and subsumed in the *Jal Jeevan Mission* (JJM). While the former focused on providing safe drinking water to every rural household (source within or outside the premises), the latter intends to provide safe and adequate drinking water through a functional household tap connection to every rural household by 2024 (within the dwelling or premises). It will be achieved by providing the pipeline and taps within the dwelling by extending the existing water distribution system in the villages and providing water supply round the year of sufficient quantity and quality, and from a dependable source.

With the launch of JJM, the DDWS IMIS dashboard witnessed a substantial change. In addition to the information provided previously, it provides real-time information concerning the coverage of households by the functional household tap connection, active laboratories for water quality testing, the number of drinking water samples tested by the laboratories, and those by using the field testing kits, and the number of water samples which were found to be contaminated. However, the information provided previously (during NRDWP) is now available as IMIS reports which are updated periodically.

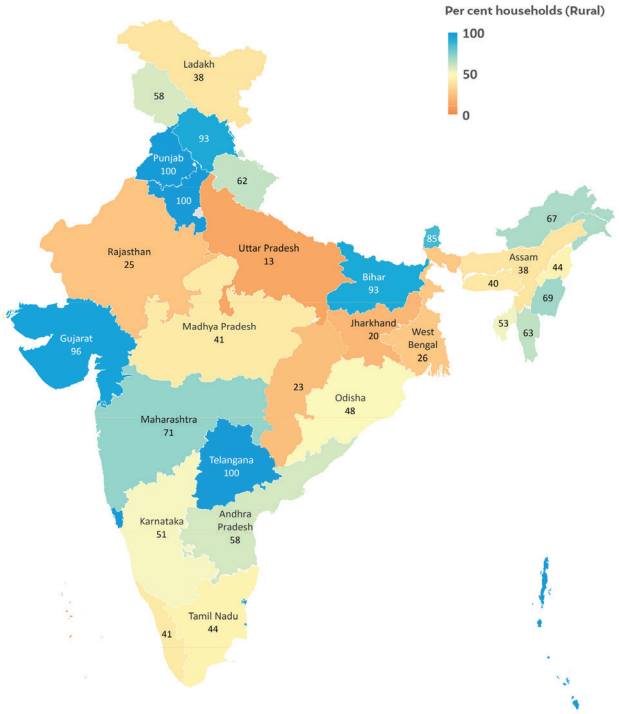
There are about 193 million rural households in India, and as of 31 May 2022, almost 50 per cent of the rural households were provided with a tap connection within the dwelling. In Goa, Telangana, Andaman and Nicobar Islands, Puducherry, Dadra and Nagar Haveli, Daman and Diu, Punjab, and Haryana, 100 per cent of the rural households have a tap connection within the premises. The states/UTs at the bottom of the list are Uttar Pradesh, Jharkhand, Chhattisgarh, Rajasthan, and West Bengal (refer to Figure 6). Further, information on the average daily per capita water supply in 69 pilot villages under the Internet-of-Things (IoT) based smart water supply monitoring system is provided. However, only a small number of the about 600 thousand villages in India are covered and no information is provided on the frequency of water supply, i.e., whether daily, alternate day, etc.

In terms of information on the extent of drinking water quality testing, in 2021-22, water samples from 550 thousand villages were tested, about 77.5 per cent in the laboratories and the rest by the village water and sanitation committee (VWSC), a local institution for operation and maintenance of village water supply scheme, using field testing kits. Out of the total water samples tested, only 11 per cent were found to be contaminated. However, the details on the type and extent of contamination are missing.

Though the DDWS IMIS dashboard on JJM made a technical advancement over the other data sources, there are limitations in terms of the depth of information that it provides on the reliability of water supply and its quality. For the time being, only a small proportion of villages are covered under the IoT for the data on the average daily quantity of water supply. Further, no information is provided on the frequency of water supply, and whether supplied water is treated or untreated. For the tested water samples, the information on the source of water sample collection (whether directly from the water source or the delivery point), and the type and extent of contamination are inadequate.

> **In 8 states and union territories, 100% of the rural households have a tap connection within the premises**

Figure 6 As of 31 May 2022, out of the 37 states and UTs, 8 had 100% of the rural households with individual tap connections within the dwelling or premises



Source: Authors' analysis using data from JJM dashboard

4.5 Overall synthesis of results and discussions

The synthesis from the review of various government sources that report data and information on the progress of drinking water services in rural India is provided in Table ES 1. We infer that existing reporting on rural drinking water services by various national agencies is not comparable.

- First, the data collection is undertaken with different mandates and frequencies. While the IMIS dashboard of the DDWS provides information in real time, the *Census of India* reports data every 10 years.
- Second, they use different indicators. While the IMIS dashboard of DDWS covers most of the indicators of the safely managed drinking water services (some only partially though), the NFHS covers only one indicator, i.e., the water source accessibility.
- Third, the unit of analysis is different. For the *Census of India*, NSS, and the IMIS dashboard it is households, whereas, for NFHS it is population.

Further, the indicators considered by various agencies to report progress in rural drinking water services are aligned only partially with those necessary to determine whether such services are safely managed. Only one indicator related to physical access to a water source can be compared for different years.

Thus, the existing data sources and information system present a challenge in deriving comprehensive inferences for the policymakers and water managers to decide on actions for improving the provision of safely managed drinking water services in rural India. There is a need to strengthen the existing data and information systems for them to sufficiently cover all aspects of safely managed drinking water services which include its accessibility, reliability, and safety (referring to water quality).

5. Conclusions and policy implications

Our analysis suggests that the four main sources of data and information pertaining to the progress of drinking water services in rural India present a challenge when it comes to making an inference concerning the accessibility, reliability, and safety of drinking water services. While the *Census of India* and NSS data mostly determine the accessibility of the water source, the JJM dashboard provides information on all three components but only partially. The NFHS considers only one indicator. Thus, there is a need to strengthen the existing data and information systems so that they can provide complete information related to safely managed drinking water services. Further, additional indicators on the reliability and safety of water supply need to be considered and validated at the household level. These include the quantity of water supplied in different seasons and the information on the values of the tested water quality parameters.

6. Recommendations

We make the following five recommendations to strengthen the existing data and information systems and validate the progress with the provision of safely managed drinking water services in the rural areas of India:

- **Standardise terminologies and indicators used across existing surveys:** They should be in line with those used for determining the safely managed drinking water services to allow better inferences on the progress made. For this, the agencies engaged in conducting the *Census of India*, NSS, and NFHS and the one managing the JJM dashboard need to initiate discussions to arrive at a consensus.
- **Expand the scope of future surveys to cover all the indicators of safely managed drinking water services:** This will help in validating the progress reported by the recent JJM dashboard, especially in the context of physical access to the source (tap connection within the dwelling or premises) and the reliability (frequency, duration, and quantity) of the water supply. JJM does have a provision to undertake an annual functionality assessment survey of tap water connection for each district by a third-party agency. The survey is intended to capture whether clean water is supplied to rural households in adequate quantity, quality, and on a regular basis. However, such surveys are not undertaken regularly in all the states. This provides an opportunity for various national agencies in charge of surveys to collaborate for such assessments and make efficient use of available resources.
- **Scale up the IoT-based smart water supply monitoring system piloted under JJM to cover all the villages:** This will need proper planning and substantial investments, therefore, it can be undertaken in a phased manner with priority to areas that experience water stress so that decisions can be made on the need to augment water supplies in such areas. In addition to the quantity of daily water supply, such a monitoring system should also report 'frequency and duration of water supply' and 'values of water quality parameter'. To start with, water quality monitoring can focus on pH, electrical conductivity (EC) or total dissolved solids (TDS), nitrogen, biological oxygen demand (BOD), residual chlorine, and faecal coliforms (FC), which are considered the most common pressures on water quality at the global level. Such monitoring will help determine the reliability and safety of drinking water supply services. JJM does have a provision where every state needs to prepare a five-year action plan projecting annual financial requirements for achieving JJM targets. Investments required for the water supply monitoring system can be made part of such a plan.
- **Meter individual water connection to account for water delivery at the household level:** Individual water meters should be installed for generating data on the indicator 'quantity of water supplied at the household level'. Presently, the pilot IoT-based smart water supply monitoring system provides information based on the bulk water supply to the village. However, information pertaining to the actual water supply at the household level is unavailable. Household level metering will fill this gap. To ensure regular reporting of such data (at least every month), village water and sanitation committees (VWSC) can be engaged.

> Water supply monitoring system should also report frequency and duration of water supply and values of water quality parameter

- **Compute water quality index (WQI) to monitor source water quality and identify sources that need further investigation:** A water quality index (WQI), which is a convenient means to analyse large amounts of water quality data, should be computed to determine the safety of water at the source as well as delivery points. Such an index is already used by the Central Pollution Control Board (CPCB) and some State Pollution Control Boards (such as in Maharashtra) to classify selected surface water bodies (mainly rivers) based on the values of the specific water quality parameters. The index provides a single score by summarising the values of several water quality parameters and helps classify source water quality as excellent, good, medium, bad, or very bad. Other advantages are that the WQI scores can be used to monitor changes in source water quality over time (seasons and years) and identify sources that should be investigated further, especially those that are in the WQI benchmark values for the bad or very bad category. This can help decide on prospective corrective measures for improving the source water quality. As discussed previously, pH, EC or TDS, nitrogen, BOD, and FC are important water quality parameters that should be considered for WQI computation. Such an approach will augment the existing practice where the VWSC (using field kits) or the laboratories test the water samples for various parameters but only report their values.

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Suggested citation: Bassi, Nitin, Karthik Ganesan, and Ashish Dangi. 2022. *How Safe are Drinking Water Services in Rural India? Case for Strengthening the Existing Data and Information System.* New Delhi: Council on Energy, Environment and Water.

Disclaimer: The views expressed in this report are those of the authors and do not reflect the views and policies of the Council on Energy, Environment and Water

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