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A Study of Household Drinking Water Security in Rural Areas of Haryana

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ABSTRACT

Household drinking-water security is essential to rural well-being, public health, and sustainable development. In Haryana, drinking-water security is particularly important because rural households depend heavily on groundwater and other local water sources, while water availability and quality vary considerably across space. The present study examines household drinking-water security in rural Haryana from a geographical perspective, focusing on the interrelationship between water availability, accessibility, quality, reliability, affordability, and sustainability. The study conceptualises drinking-water security as a multidimensional condition extending beyond the presence of a household tap connection. Haryana's physical environment, groundwater characteristics, rainfall variability, settlement patterns, agricultural pressure, and socio-economic conditions create considerable spatial differences in household water security. Official water-resource assessments indicate that groundwater quality is especially problematic in parts of central, western, and southern Haryana, while groundwater availability also varies significantly among districts. The study also examines the role of groundwater dependence, rural water infrastructure, household characteristics, and gender in shaping water security. It pays particular attention to the Jal Jeevan Mission, which defines rural drinking-water security as adequate quantity, prescribed quality, regular and long-term supply, and affordable service delivery. The study argues that the transition from physical access to functional and sustainable water security is essential for rural Haryana. It concludes that drinking-water planning must integrate groundwater management, water-quality monitoring, source sustainability, community participation, and spatially differentiated strategies.

Keywords: Water Security, Groundwater, Water Quality, Water Accessibility, Rural Water Supply, Jal Jeevan Mission, Water Governance, Spatial Inequality, Sustainability

INTRODUCTION

Safe and reliable drinking water is fundamental to human health, dignity, livelihood security, and quality of life. For rural households, drinking water is required not only for consumption but also for cooking, personal hygiene, sanitation, and other essential domestic activities. Consequently, drinking-water security extends beyond the simple physical availability of a water source. A household is water secure only when it has access to an adequate quantity of safe water on a regular, reliable, affordable, and sustainable basis. This broader understanding is reflected in the vision of the Jal Jeevan Mission (JJM), which seeks to ensure that every rural household receives drinking water in adequate quantity and prescribed quality on a regular and long-term basis at affordable service-delivery charges (Ministry of Jal Shakti, 2026).

The issue has grown increasingly significant in India because rural water systems are affected by groundwater depletion, water-quality deterioration, seasonal variability, inadequate infrastructure, and changing household demand patterns. The Government of India launched the Jal Jeevan Mission in 2019 with an emphasis on Functional Household Tap Connections (FHTCs), but the programme's framework explicitly extends beyond infrastructure provision. It incorporates source sustainability, groundwater recharge, rainwater harvesting, greywater management, water conservation, and community participation as important components of long-term rural drinking-water security (Ministry of Jal Shakti, 2026).

Haryana provides an important geographical setting for examining these issues. The state lies in the northwestern Indo-Gangetic Plain and has a predominantly alluvial landscape, although its hydrogeological conditions vary considerably from north to south and east to west. Rural drinking-water sources include groundwater, tube wells, canals, and other local water-supply systems. The Haryana Water Resources Atlas identifies tube wells and canals as two major drinking-water sources and shows substantial spatial variation in their distribution (Haryana Water Resources [Conservation, Regulation and Management] Authority [HWRA], 2025).

Groundwater is particularly important because it serves both domestic and agricultural purposes; the same resource is subject to intensive agricultural extraction. This creates potential competition between agricultural and domestic water needs, particularly where groundwater levels decline or water quality deteriorates. The geographical distribution of groundwater quality further complicates the situation. The Haryana Water Resources Atlas reports relatively better groundwater quality in parts of northern Haryana, while several areas of central and southern Haryana fall into low or very-low water-quality categories based on the Water Quality Index (HWRA, 2025).

The Central Ground Water Board (CGWB, 2020) similarly reported substantial spatial variation in groundwater quality in Haryana. Its assessment indicated that groundwater in northern and northeastern areas was generally more suitable for drinking, whereas groundwater in parts of southern and western Haryana was affected by salinity, nitrate, and fluoride, making it unsuitable for drinking in several locations.

HOUSEHOLD DRINKING-WATER SECURITY

From Water Access to Water Security: Traditional assessments of rural drinking-water provision have often focused on whether a household has access to a water source or a household tap connection. Although physical access is an important indicator, it is insufficient for assessing complete water security. A household may possess a tap connection but receive water irregularly, receive inadequate quantities, experience poor water pressure, or receive water that is chemically or microbiologically unsafe.

The Jal Jeevan Mission therefore distinguishes the broader objective of drinking-water security from simply creating infrastructure. Its official vision refers to adequate quantity, prescribed quality, regularity, long-term availability, and affordable service delivery. The Mission also emphasises monitoring the functionality of tap connections and maintaining the sustainability of water sources and infrastructure (Ministry of Jal Shakti, 2026).

Availability: Availability refers to whether sufficient water resources exist to meet household requirements. Rainfall, groundwater recharge, surface-water availability, aquifer characteristics, and competing demands from agriculture and other sectors influence it.

The Haryana Water Resources Atlas indicates considerable spatial variation in surface- and groundwater availability. According to the Atlas, districts such as Sirsa, Fatehabad, Jind, and Karnal have comparatively higher water availability, whereas Mahendragarh, Mewat, and parts of Jhajjar and Charkhi Dadri have lower availability (HWRA, 2025).

Accessibility: Accessibility refers to households' ability to physically obtain drinking water. Traditionally, rural households may have depended on hand pumps, wells, tube wells, public standposts, village waterworks, and other community sources. Household tap connections can substantially reduce the physical burden of water collection, but their effectiveness depends upon whether the connection is functional and whether water is actually supplied.
The JJM framework specifically identifies the Functional Household Tap Connection as an important objective and emphasises monitoring functionality rather than merely creating connections (Ministry of Jal Shakti, 2026).

Water Quality: Water quality represents one of the most important dimensions of drinking-water security in Haryana. Groundwater may be physically accessible but unsafe because of naturally occurring or human-induced contaminants. The 2024 groundwater-quality assessment of Haryana by CGWB emphasises salinity, fluoride, nitrate, arsenic, iron, and uranium as key parameters for determining groundwater suitability for drinking (Central Ground Water Board [CGWB], 2024).

Reliability and Continuity: Reliability refers to the regularity and continuity of water supply. Rural households may face interruptions because of seasonal water scarcity, declining groundwater levels, electricity problems, pump failure, pipeline leakage, or inadequate storage capacity. The JJM explicitly recognises the importance of reliability, with a vision of regular, long-term water supply rather than occasional access (Ministry of Jal Shakti, 2026).

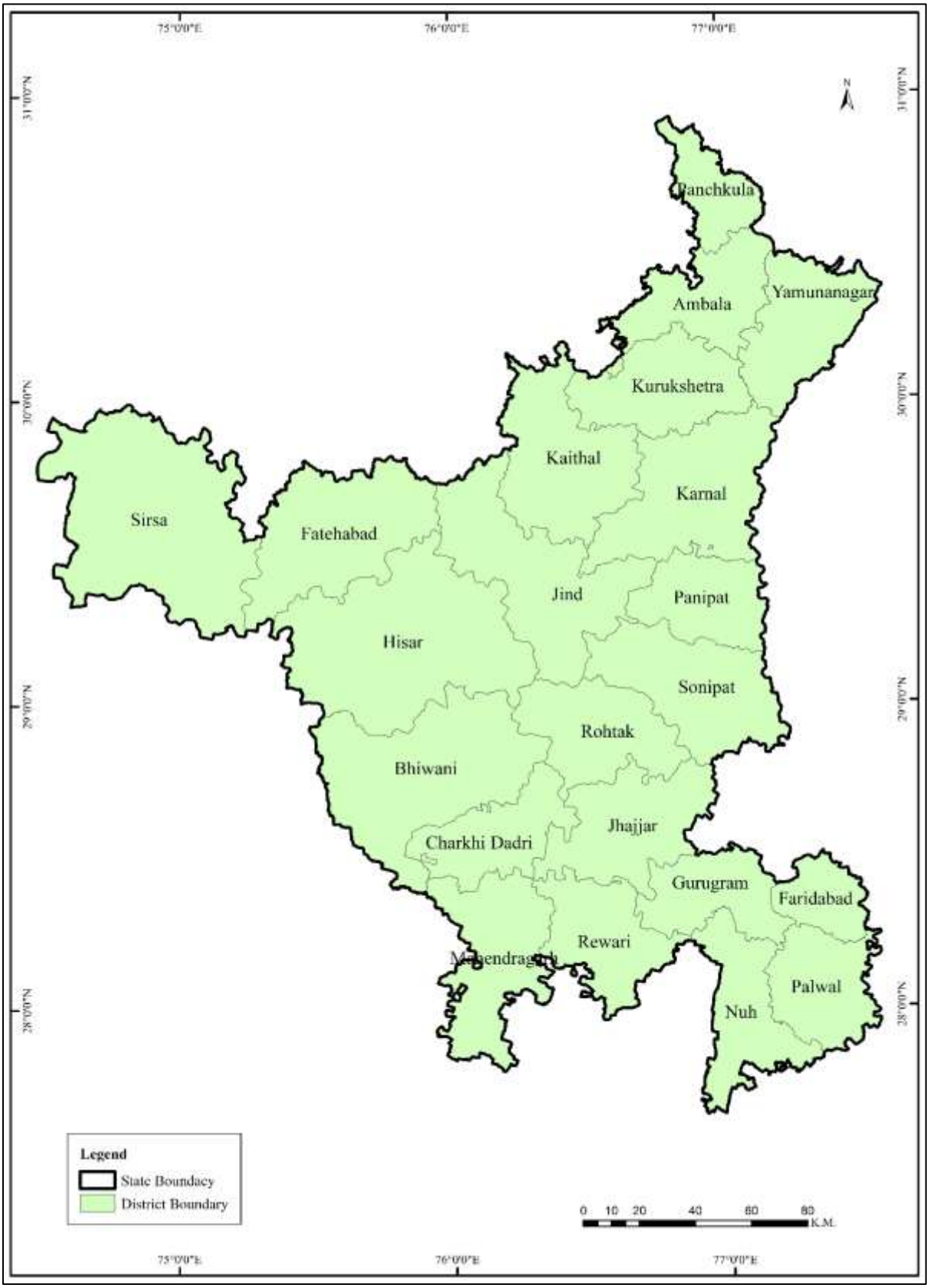
Affordability: Affordability refers to the economic burden associated with obtaining safe drinking water. Although piped supply can reduce the time and physical cost of water collection, households may still incur expenditure on pumping, filtration, storage, bottled water, or alternative private sources. Therefore, a complete assessment of household drinking-water security must consider the relationship between water quality, household income, treatment costs, and alternative-source expenditure.

Sustainability: Sustainability concerns a water source and supply system's ability to continue meeting household requirements in the future. This is particularly important in Haryana because groundwater is a major source of both domestic and agricultural water. The JJM explicitly incorporates source sustainability, recharge, rainwater harvesting, water conservation, and greywater management (Ministry of Jal Shakti, 2026). The sustainability dimension therefore connects household drinking water with broader groundwater and watershed management.

STUDY AREA

Haryana occupies an important position in northwestern India and covers approximately 44,212 square kilometres. The state is predominantly characterised by alluvial formations, although hard-rock formations occur in the south and Shiwalik formations occur in the north. The CGWB's groundwater-quality assessment places Haryana approximately between 27°39′ and 30°55′ N latitudes and 74°27′ and 77°35′ E longitudes (CGWB, 2024).

Map 1: Study Area



The geographical setting produces considerable variations in water availability and quality. The northern and northeastern parts generally have relatively favourable groundwater conditions, whereas the western and southern regions include areas affected by salinity, nitrate, and fluoride. The Haryana Water Resources Atlas similarly identifies differences in groundwater quality between districts. Karnal and Kurukshetra, for example, contain extensive areas categorised as fresh groundwater based on electrical conductivity, while Bhiwani, Hisar, and Sirsa contain substantial marginal or saline groundwater areas (HWRA, 2025).

Groundwater movement also shows a spatial pattern important for water-resource planning. The Atlas reports predominantly southward and southwestward groundwater flows in northern and central Haryana, with other flow directions associated with the Aravalli region and southeastern districts. Groundwater extraction, irrigation, and canal recharge influence these patterns (HWRA, 2025).

The rural population and settlement structure further influence drinking-water demand. Haryana's Water Resources Atlas reports a rural population of approximately 16.5 million according to the 2011 Census, representing a substantial proportion of the state's population (HWRA, 2025). The spatial distribution of rural settlements, household density, agricultural activity, and infrastructure creates different levels of pressure on drinking-water systems.

RURAL DRINKING-WATER RESOURCES IN HARYANA

Rural drinking-water security in Haryana depends on a combination of groundwater and surface-water resources. Historically, tube wells, wells, hand pumps, canals, and village-level water systems have played important roles in supplying rural households. The Haryana Water Resources Atlas identifies tube wells and canals as major drinking-water sources and provides district-level evidence of considerable variation in their distribution (HWRA, 2025).

Groundwater is particularly important because it can be accessed locally and does not always require extensive centralised infrastructure. However, dependence on groundwater also exposes households to fluctuations in water level and quality. Groundwater is also under pressure from agricultural irrigation, making domestic water security closely connected to the broader agricultural-water system.

Groundwater recharge occurs through rainfall, irrigation return flows, canal seepage, and infiltration from surface-water bodies. The Haryana Water Resources Atlas emphasises that groundwater recharge varies according to aquifer characteristics and geographical conditions (HWRA, 2025). Consequently, groundwater management strategies suitable for one district may not necessarily be effective in another.

Surface water can provide an important alternative or supplementary source. Canals are particularly significant in parts of Haryana, although their distribution is uneven. Where surface-water systems are available, conjunctive use of surface and groundwater may help reduce pressure on individual groundwater sources; the suitability of surface water for direct consumption depends on treatment and quality monitoring.

The geographical distribution of water resources therefore underpins household drinking-water security. Infrastructure determines whether these resources can reach households, while water quality determines whether the supplied resource is safe for consumption.

REVIEW OF LITERATURE

Research on groundwater demonstrates that the quantity and movement of groundwater vary considerably across Haryana. The CGWB's state assessment indicates that groundwater quality in northern and northeastern Haryana is comparatively more suitable for drinking, whereas several southern and western areas are affected by salinity, nitrate, or fluoride (CGWB, 2020). This geographical pattern indicates that household drinking-water security cannot be assessed independently of hydrogeological conditions.

Recent official assessments have expanded this geographical perspective. The Haryana Water Resources Atlas uses Water Quality Index and electrical conductivity to map groundwater quality and identifies major areas of concern in central, western, and southern Haryana (HWRA, 2025). These findings reinforce the importance of spatially differentiated water-management strategies.

At the institutional level, the Jal Jeevan Mission represents a significant transformation in India's rural drinking-water policy. The Mission's approach explicitly links infrastructure provision with service delivery, water quality, source sustainability, community ownership, and operation and maintenance (Ministry of Jal Shakti, 2026). The policy framework therefore offers an opportunity to move from a narrow, infrastructure-oriented approach to a more comprehensive understanding of household water security.

The literature on household drinking-water security in rural Haryana indicates that a single indicator, such as household tap connections, cannot capture the issue. Existing research and official assessments increasingly emphasise the combined importance of water availability, quality, accessibility, regularity, and sustainability. The Jal Jeevan Mission

(JJM) defines a Functional Household Tap Connection (FHTC) as a connection that provides water in adequate quantity, prescribed quality, and regularly. The service-level benchmark under JJM is 55 litres per capita per day (lpcd), demonstrating that infrastructure provision and actual service delivery are conceptually different (Ministry of Jal Shakti, 2026).

Rural Drinking-Water Access

Historically, rural drinking-water studies in India have focused substantially on physical access to water sources and the expansion of piped-water infrastructure. In Haryana, rural households have traditionally depended on groundwater sources such as tube wells, bore wells, hand pumps, and wells, supplemented in some areas by canal and surface-water systems. The geographical distribution of these sources is uneven, reflecting differences in hydrogeology, settlement pattern, infrastructure, and local water-resource availability.

The shift toward household tap connections represents an important transformation in rural water supply. However, the literature suggests that a tap connection should not automatically be equated with water security. The JJM's functionality framework recognises a tap as functional only when water is supplied in adequate quantity, prescribed quality, and with regularity (Ministry of Jal Shakti, 2026). This distinction is particularly relevant to Haryana, where differences in source sustainability and water quality can influence whether household connections provide dependable drinking water.

A functionality assessment undertaken for Haryana provides useful empirical evidence. The assessment found that 98% of sampled households received water on the day of the survey, while 55% had fully functional tap connections within the premises. Among households with fully functional connections, 82% received an adequate quantity, 83% reported a fully regular supply, and 76% received potable water. The assessment also reported that more than 67% of households received water on all seven days of the week, while 22% received water three to four days a week; the average reported supply duration was approximately five hours per day (Ministry of Jal Shakti, 2022).

Groundwater Dependence and Rural Water Security

Groundwater represents a major component of Haryana's rural water-resource system. Its accessibility through tube wells, bore wells, and hand pumps makes it particularly important for domestic supply. However, farmers also use groundwater extensively for irrigation. This creates a close relationship between agricultural water demand and household drinking-water security.

As groundwater levels decline, households dependent on shallow wells and hand pumps may face increasing difficulty accessing water. Declining water tables can require deeper bore wells, additional pumping infrastructure, or alternative water sources. Such changes may increase the financial burden on households and local institutions.

Groundwater quality presents another dimension of vulnerability. The Central Ground Water Board's assessment of Haryana demonstrates considerable spatial variation in groundwater quality, with salinity, fluoride, nitrate, iron, and other parameters affecting suitability in different locations (Central Ground Water Board [CGWB], 2024). This means that groundwater-dependent households may face both quantity-related and quality-related insecurity.

Drinking-Water Quality

Water quality is one of the most critical dimensions of household drinking-water security. The JJM framework uses prescribed drinking-water standards and identifies parameters including pH, turbidity, total dissolved solids, chloride, sulphate, iron, nitrate, fluoride, arsenic, residual chlorine, total coliform, and *E. coli* for water-quality assessment (Ministry of Jal Shakti, 2026).

In Haryana, groundwater-quality problems vary geographically. The state contains areas where groundwater is affected by salinity and high electrical conductivity, while fluoride and nitrate contamination are also reported in particular locations. The geographical distribution of these contaminants is associated with geological conditions, groundwater movement, agricultural practices, fertiliser application, wastewater disposal, and other human activities.

Village- and block-level studies highlight the importance of localised assessment. Such studies demonstrate that water quality can vary considerably even between nearby settlements. Therefore, district-level averages may conceal important local variations in household exposure.

From a geographical perspective, water-quality mapping is particularly valuable because it enables identification of hotspots of drinking-water vulnerability. GIS-based integration of groundwater-quality measurements with settlement locations, population characteristics, infrastructure, and health information can identify areas requiring priority intervention.

Fluoride, Nitrate, Salinity and Other Contaminants

Fluoride represents an important groundwater-quality concern in parts of Haryana. Its presence may be linked to natural geological conditions, and long-term exposure to excessive fluoride concentrations can pose serious health risks. The JJM water-quality framework identifies fluoride at 1.0 mg/L as the acceptable limit and 1.5 mg/L as the permissible limit in the absence of an alternative source (Ministry of Jal Shakti, 2026).

Nitrate contamination is particularly relevant to agricultural landscapes because excessive fertiliser use and poor sanitation can contribute to groundwater nitrate. Under the JJM framework, the acceptable and permissible limit for nitrate is 45 mg/L, with no relaxation if no alternative source is available (Ministry of Jal Shakti, 2026).

Salinity and high total dissolved solids are particularly important in parts of western and southern Haryana. Saline groundwater can reduce the availability of safe drinking water and may require treatment or alternative sources. The problem is geographically significant because aquifer characteristics, evaporation, recharge, drainage, and groundwater movement influence groundwater quality.

Iron and hardness may also affect drinking-water acceptability and household treatment requirements. In addition, microbiological contamination may occur where sanitation infrastructure is inadequate, sources are poorly protected, or pipelines and storage systems are not properly maintained.

Thus, the literature shows that rural drinking-water insecurity in Haryana has chemical, biological, and physical dimensions and requires regular, location-specific monitoring.

SPATIAL DIMENSIONS OF HOUSEHOLD DRINKING-WATER SECURITY

Geography provides an important framework for understanding why drinking-water security varies between rural areas. Water availability, groundwater quality, settlement distribution, infrastructure, climate, agricultural pressure, and socio-economic conditions differ spatially across Haryana.

Eastern Haryana: Eastern Haryana generally contains relatively favourable groundwater and surface-water conditions compared with several western and southern areas. Districts associated with intensive agriculture, including Karnal, Kurukshetra, Panipat, Sonipat, and parts of Yamunanagar, have substantial irrigation infrastructure.

Intensive agriculture also creates considerable pressure on groundwater. The rice–wheat system requires substantial irrigation, particularly where paddy cultivation is widespread. Consequently, a region may have relatively good physical water availability while simultaneously experiencing long-term groundwater stress.

For household drinking-water security, the major concern is therefore not simply source availability but long-term sustainability and quality. Agricultural extraction, groundwater-level changes, and contamination from agricultural and domestic activities can influence household water security.

Central Haryana: Central Haryana represents a transition between relatively better-watered northern/eastern areas and drier western and southern regions. Rural households may depend substantially on groundwater, while agricultural irrigation creates competing demands.

In such areas, drinking-water security requires integration between rural water-supply planning and groundwater management. Household drinking-water sources cannot be considered independently from agricultural pumping because both often depend on the same aquifer system.

Western Haryana: Western Haryana contains relatively dry climatic conditions and extensive areas affected by groundwater-quality problems. Districts such as Sirsa, Fatehabad, Hisar, and parts of Bhiwani experience conditions in which salinity, high total dissolved solids, and groundwater-level variability may influence drinking-water security.

In these regions, water quality can be as important as water quantity. Providing a household connection to an unsafe groundwater source would not necessarily improve drinking-water security. Alternative sources, treatment technologies, surface-water transfer, rainwater harvesting, and groundwater-quality monitoring may therefore be necessary.

Southern Haryana: Southern Haryana includes relatively dry areas with more limited rainfall, and groundwater availability can be constrained. Districts such as Mahendragarh, Rewari, Charkhi Dadri, and parts of Bhiwani face particular challenges related to climatic conditions and groundwater quality.

Here, household water security may be vulnerable to seasonal scarcity. Rainwater harvesting, groundwater recharge, source diversification, and climate-resilient infrastructure can therefore play an important role.

MAJOR CHALLENGES TO HOUSEHOLD DRINKING-WATER SECURITY

The literature reviewed above indicates that rural drinking-water security in Haryana faces several interconnected challenges. The first is groundwater dependence, which creates vulnerability to declining water levels and changing

water quality. The second is chemical contamination, including fluoride, nitrate, salinity, and other parameters that may make groundwater unsuitable for direct consumption.

The third challenge is seasonality. Rural water requirements and source availability can vary substantially between summer and monsoon seasons. A system that appears adequate during one period may experience stress during another. The fourth challenge is infrastructure functionality. Pipeline leakage, pump failure, inadequate storage, electricity interruptions, and maintenance problems can reduce water supply reliability.

A fifth challenge is the potential mismatch between infrastructure coverage and actual service delivery. The Haryana functionality assessment clearly shows that having a tap connection does not automatically mean adequate, regular, and potable water (Ministry of Jal Shakti, 2022).

Finally, climate change may increase uncertainty through changes in rainfall, temperature, evapotranspiration, drought, and groundwater recharge. Sustainable rural drinking-water planning therefore needs to consider not only present conditions but also the future resilience of water sources and infrastructure.

SUSTAINABLE STRATEGIES FOR HOUSEHOLD DRINKING-WATER SECURITY

Sustainable household drinking-water security in rural Haryana requires a shift from a narrow focus on water-supply infrastructure toward an integrated approach that combines source sustainability, water conservation, quality management, efficient infrastructure, and community participation. Haryana's geographical diversity means a uniform strategy may not suit all rural areas. Regions experiencing groundwater depletion require stronger recharge and demand-management measures, while areas affected by salinity, fluoride, nitrate, or other contaminants require alternative safe sources and appropriate treatment technologies. The Jal Jeevan Mission (JJM) recognises this integrated approach by including source sustainability, groundwater recharge, rainwater harvesting, water conservation, and greywater management within its framework (Ministry of Jal Shakti, 2026).

Groundwater recharge and rainwater harvesting should constitute important components of long-term rural water management. Rooftop rainwater harvesting, recharge pits, recharge wells, village ponds, check structures, and other locally appropriate measures can enhance groundwater recharge and reduce pressure on existing sources. However, such interventions should be based on local hydrogeological conditions because recharge potential differs considerably across Haryana. In groundwater-stressed areas, recharge should be paired with measures to control excessive extraction, so additional recharge is not immediately offset by increased pumping. Village-level water budgeting can help communities compare available water resources with domestic demand and develop locally appropriate conservation measures.

Source diversification is another important strategy for improving household water security. Excessive dependence on a single groundwater source can increase vulnerability to depletion, contamination, or infrastructure failure. Rural water-supply systems should therefore use groundwater, surface water, rainwater, and treated community supplies appropriately, based on local conditions. In areas where groundwater contains excessive salinity, fluoride, nitrate, or other contaminants, communities should develop alternative sources and suitable treatment systems rather than continuing to depend exclusively on contaminated groundwater. Regular village-level water-quality monitoring is essential to identify contamination hotspots and protect households from potential health risks.

Operating and maintaining rural water infrastructure is equally important. Household tap connections can provide meaningful water security only when pipelines, pumps, storage facilities, treatment systems, and distribution networks remain functional. The Jal Jeevan Mission emphasises functionality, regularity, adequate quantity, prescribed quality, and long-term service delivery rather than infrastructure creation alone (Ministry of Jal Shakti, 2026). Therefore, village water-supply systems should include adequate financial provisions, technical support, timely repair mechanisms, and trained local personnel.

Community participation and local water governance are essential for sustaining these interventions. Gram Panchayats, Village Water and Sanitation Committees, and local residents should participate in water-resource planning, source protection, quality monitoring, operation and maintenance, and water conservation. Women's participation is particularly important because they often have detailed knowledge of household water needs, seasonal shortages, collection practices, and water-quality concerns. Strengthening women's representation in local water institutions can therefore improve both equity and effectiveness.

Finally, sustainable drinking-water security requires spatially differentiated planning supported by GIS and groundwater information. Spatial databases combining groundwater levels, groundwater quality, rainfall, water infrastructure, population, and household characteristics can help identify areas of high drinking-water vulnerability. Such information can support district- and block-specific interventions and enable policymakers to prioritise villages facing severe water scarcity or contamination. Overall, sustainable household drinking-water security in rural Haryana

requires an integrated transition from “providing water connections” to “ensuring safe, adequate, reliable, affordable, equitable, and sustainable water services.”

RECOMMENDATIONS

The present study suggests that Haryana should move from a narrow “tap connection” approach toward a comprehensive “functional household drinking-water security” approach.

First, Haryana should develop district- and block-specific drinking-water security plans because water-resource conditions differ substantially across the state. The groundwater-quality evidence presented in the Haryana Water Resources Atlas demonstrates that different regions require different management strategies.

Second, groundwater management should be integrated with rural drinking-water planning. When evaluating the long-term sustainability of domestic water sources, consider agricultural groundwater extraction. Areas experiencing groundwater stress should receive priority for recharge, demand management, crop diversification, and alternative drinking-water sources.

Third, strengthen water-quality monitoring at the village level. Communities should have appropriate testing facilities, training, and mechanisms for reporting contamination. Priority should be given to villages located in known fluoride-, nitrate-, salinity-, or other contamination-prone areas.

Fourth, evaluate household tap connections using functionality indicators, including quantity, regularity, pressure, quality, and supply duration. JJM's own framework emphasises monitoring functionality rather than simply counting connections.

Fifth, rainwater harvesting and groundwater recharge should become integral components of village water-security plans. Source sustainability is already a core element of JJM, which promotes recharge, water conservation, rainwater harvesting, and greywater management.

Sixth, women should have meaningful representation in Village Water and Sanitation Committees and other local water institutions. Their participation can strengthen monitoring, household-level awareness, and the practical management of water resources.

Finally, GIS and remote sensing should be incorporated into water-resource planning. A spatial drinking-water vulnerability index could help identify villages requiring immediate intervention.

CONCLUSION

Household drinking-water security in rural Haryana is a complex geographical phenomenon shaped by the interaction of physical resources, groundwater conditions, climate, infrastructure, household characteristics, gender relations, and institutional arrangements. The review demonstrates that water security cannot be defined simply by the presence or absence of a household tap. A genuinely water-secure household requires adequate, safe, accessible, reliable, affordable, equitable, and sustainable drinking water.

Haryana presents particularly important geographical variations in this regard. The state's groundwater-quality conditions vary considerably, with relatively favourable conditions in parts of northeastern Haryana and more significant marginal and saline groundwater conditions in several western and central districts. The Haryana Water Resources Atlas specifically identifies Bhiwani as having particularly poor groundwater quality and reports extensive marginal and saline groundwater in Hisar and Sirsa. These variations demonstrate why a uniform state-wide drinking-water strategy may not be sufficient.

The central conclusion of this review is that rural drinking-water policy in Haryana should shift from measuring access to measuring security. Household tap connections remain essential, but they should be treated as the beginning, not the end, of drinking-water security. The ultimate objective should be to ensure households receive sufficient, safe water year-round from sources that remain sustainable under groundwater stress and climate variability.

A geographically differentiated strategy is therefore essential. Areas with groundwater depletion require recharge and demand management; areas with poor groundwater quality require treatment and alternative sources; areas with seasonal scarcity require storage and rainwater harvesting; and relatively secure areas require preventive groundwater and infrastructure management. GIS, remote sensing, groundwater monitoring, household surveys, and community-based information systems can support such spatial planning.

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