Understanding Water Resources to Enhance Water Security and Ecological Sustainability: An effort under Jal Sakhi Initiative in Deogarh, Odisha, India

Context:

Water security has emerged as one of India's foremost development challenges due to rapid population growth, urbanization, climate change, groundwater depletion, and increasing competition among domestic, agricultural, and industrial users.

According to the Government of India, India possesses nearly 18% of the world's population but only about 4% of global freshwater resources, making efficient water management a national priority. Agriculture accounts for nearly 80–85% of freshwater withdrawals, while groundwater supplies approximately 62% of irrigation and nearly 85% of rural drinking water. Excessive dependence on groundwater has resulted in declining water tables across many regions[1].

Major national challenges include, increasing frequency of droughts and floods, climate-induced variability in monsoon rainfall, groundwater depletion, water quality deterioration (fluoride, arsenic, iron, nitrate), inequitable access among rural and tribal communities, and weak watershed management in rainfed regions.

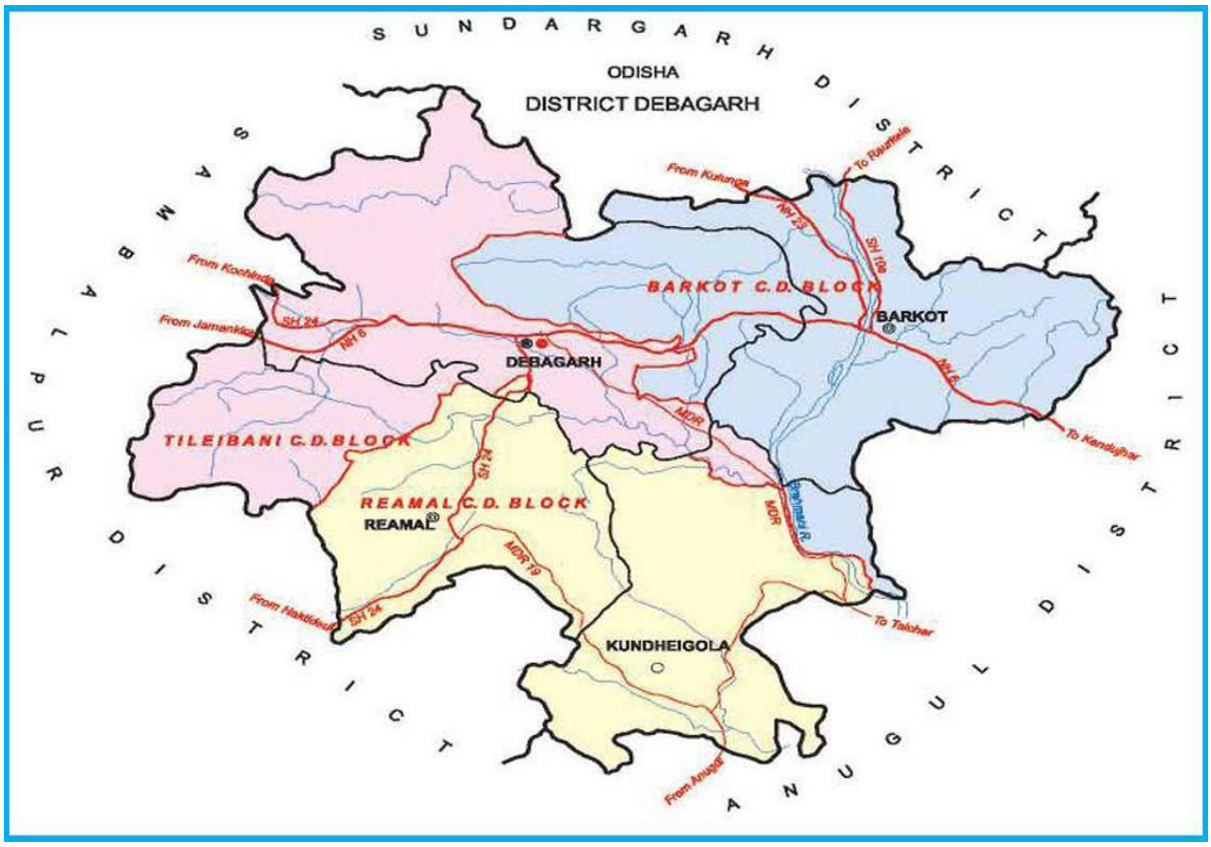
Odisha receives approximately 1,450–1,600 mm annual rainfall, largely concentrated during the southwest monsoon. Although rainfall is relatively high, both spatial and temporal variability create significant water insecurity. The state experiences prolonged dry spells, delayed monsoon onset, erratic rainfall distribution, frequent floods, recurring droughts in western districts, and cyclones causing severe disruption of drinking water systems.

Recent studies analysing 30 years of groundwater data show that hard-rock regions of western and northern Odisha are particularly vulnerable to groundwater decline, while coastal alluvial districts generally exhibit relatively stable groundwater conditions. Rainfall variability, land-use change, lithology and population pressure are major drivers.

Deogarh is one of Odisha's smallest and predominantly tribal districts, characterized by undulating terrain, forested hills and hard-rock geology. Key features include, high dependence on rainfall, limited irrigation, seasonal streams, dispersed tribal settlements, and reliance on groundwater and springs.

[1] https://www.tandfonline.com/doi/full/10.1080/07900627.2023.2279962

Water security in Deogarh is influenced by rainfall variability, groundwater availability, irrigation infrastructure, and access to safe drinking water. Agriculture in the district remains largely rain-fed, making communities vulnerable to droughts and climate variability. Seasonal water scarcity affects irrigation, drinking water supply, and livestock management, especially during summer months. Groundwater plays an important role in rural drinking water schemes and irrigation; however, increasing dependence on tube wells and erratic rainfall patterns may create stress on groundwater resources over time. Environmental sustainability in Deogarh is strongly connected to its forests, biodiversity, land use, and water ecosystems. The district has substantial forest cover that supports groundwater recharge, regulates local climate, reduces soil erosion, and sustains biodiversity. Thus, efforts to protect and augment the water resources in Deogarh stand crucial, both in terms of ensuring water security as well as environmental sustainability. For this, understanding water resources is a first step. This document narrates the efforts taken to understand the water resources in three intensive intervention villages of Deogarh district under “Jal Sakhi” initiative.



Objective:

The objective of the study was to understand the water security aspects through mapping water resources, assessing functionality, water quality, factors affecting water security etc. in three intensive intervention villages of Deogarh district under “Jal Sakhi” initiative.

Methodology:

The sources covered under the study:

A. Surface Water Sources/ Bodies: This covers surface water-based pipe water supply, ponds, lakes, streams, nallas, kata, munda etc.
B. Ground Water Sources: Pipe Water Supply linked with bore, bore wells, hand pumps, open wells, springs.

Criteria for Selection of Village:

A. Selected villages are those which are facing severe water crisis, where lack of community awareness about local Governance and available resources.
B. Community has low understanding about the role of women in addressing village water issue.
C. People have low awareness on government schemes available across various departments regarding water.
D. Unawareness about the water quality and its impact on people's heath and unaware about necessary process to secure a safe and secured water for their village through local governance
E. Due to lack of water the community depend upon *balichua* (path-hole) and people, animal and birds all drank from same place. This was unsafe and caused different diseases.

Information collected:

A. Timeline (Historical trend of the source since inception/ understand of community) – what was the status and how it has been evolved over the period of time. Must cover:
    a. When was the source created and with what purpose?
    b. Seasonality (Availability of water throughout the seasons/ months)
    c. Functionality/ Use (What purposes and need of the community is being met by the source and when)
B. Current status (functioning well/ defunct) Please note: In case of surface water bodies, please take note of encroachment, capacity, investment for renovation and protection.
C. Water quality (for drinking water sources, all parameters as per field testing kits and for other water sources, bacteriological contamination, nitrate contamination etc.)
D. Sanitary risk assessment – what are the natural and human activities posing or may pose threat to the existing water sources from bacteriological contamination point of view.
E. Current governance mechanism – which committee is managing the source, what are the systems and customs associated with the source

F. Threats to the sources – what are the natural and human activities posing or may pose threat to the existing water sources from biodiversity and ecosystem point of view (developmental projects, deforestation, encroachment, climatic impact etc.)

Details of the sample size and participants:

There are three programme villages, Nuamunda, Sindurmunda and Taldihi. The sample size in each village was 10 where respondents were women self-help groups (SHG[2]) and in community level the sample size was 25 to 40 and respondents were men, women, elderly persons youth volunteers. There are 12 FGD conducted comprising Scheduled Tribe (ST) community (men and women), SHGs, Gram Panchayat representatives, youth volunteers, Accredited Social Health Activist (ASHA[3]), Anganwadi Workers (AWW[4]s).

Data Collection Tools:

Participatory Rural Appraisal (PRA) method used for data collection. Community identified different water sources available in village like types of surface water source and ground water source, their location status, water availability in seasons, by whom is it constructed, in which year, the purpose of construction, and its management.

Small FGDs also organised for collecting data on management of water source, which year it has constructed, water availability, purpose of construction, year of construction and their status, ownership and water quality.

Water maps were also collected from Paudi Bhuyan Development Agency (PBDA[5]), Forest Departments, panchayat for identification of water source. Village history was also collected from the elderly persons to know the year of water source, their previous and current status. Spot verifications were also organised to verify the data collected. An official verification was also organised at Gram Panchayat level, Paudi Bhuyan Development Agency (PBDA), soil conservation to verify the year of construction, purpose and the agency responsible for construction.

[2] A women's **Self-Help Group (SHG)** in Odisha is a small, voluntary association of 10 to 20 local women from similar economic backgrounds. They unite to save small amounts of money regularly. They use this pooled money to provide small, low-interest loans to each other.

[3] An **Accredited Social Health Activist (ASHA)** is a trained female community health volunteer in India, acts as the vital first bridge between local villagers and the public healthcare system.

[4] An Anganwadi Centre is a grassroots community hub in India that provides basic healthcare, supplementary nutrition, and pre-school education. The term literally translates to "courtyard shelter". These centres are the primary delivery units of the government's Integrated Child Development Services (ICDS) program.

[5] The agency deals with the developmental activities for “Particularly Vulnerable Tribal Groups” (PVTGs). “Bhuyan” community is listed under PVTG and the agency has been named accordingly. This is a government agency responsible for overall development of PVTGs.

Special Consideration:

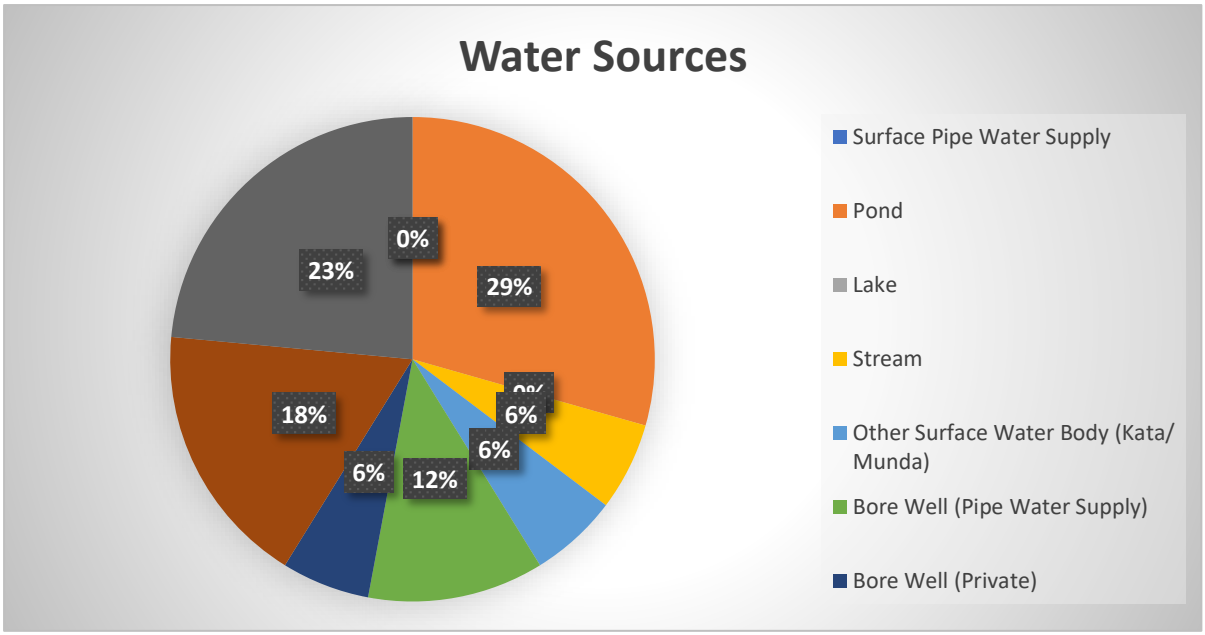
A. Focus Group Discussion (FGD) involving women (including elderly) in all three targeted villages. One in each village along with participatory rural appraisal (PRA).
B. Water quality testing involving women (for drinking water sources, all parameters as per field testing kits and for other water sources, bacteriological contamination, nitrate contamination etc.).
C. Collection of maps from PBDA/ Forest Department/ Block Administration
D. Collection of lists of water source with as much details available (year of inception, ownership, purpose of creation, size/ dimension/ depth etc) from Block Administration
E. Creation of individual map through PRA for each village

Water Sources:

The study covered both surface water sources as well as ground water sources. The surface water sources/ bodies cover surface water-based pipe water supply, ponds, lakes, streams, nallas, kata, munda, whereas the ground water sources cover Pipe Water Supply linked with bore, bore wells, hand pumps, open wells, and path holes. The following table gives the overall picture of water sources available in the study villages.

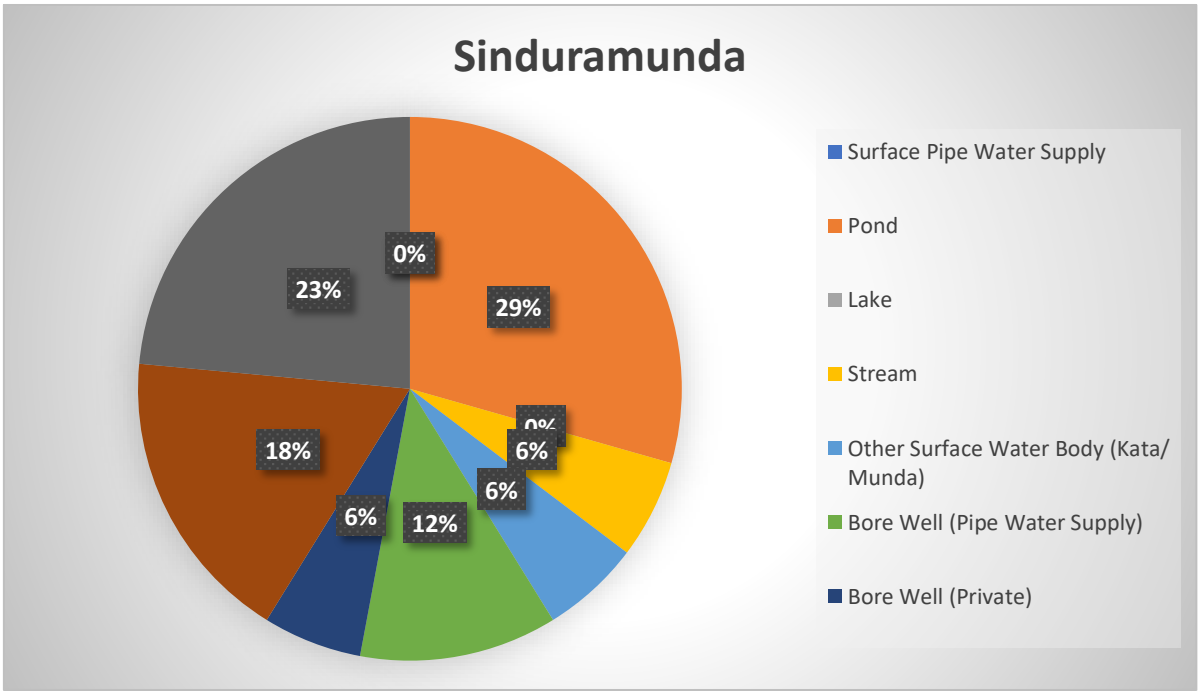
Village	Pond	Stream	Other Surface Water Body (Kata/ Munda)	Bore Well (Pipe Water Supply)	Bore Well (Private)	Bore Well with Hand Pump	Open Well	Path Hole
Sinduramunda	5	1	1	2	1	3	4	0
Taladihi	8	1	1	1	0	3	4	2
Nuamunda	7	0	1	0	10	5	12	0
Total	**20**	**2**	**3**	**3**	**11**	**11**	**20**	**2**

While the surface water bodies are primarily meant for bathing and arboricultural purposes, the ground water sources are for both drinking and domestic purposes as well as irrigation purposes. All private bore wells are primarily for agricultural practices. Though the number looks pretty well as gives a picture of ample water availability in the villages, but the reality is far away from what appears as numbers. A deep dive into the situation of each village will help in understanding the real picture of water security as well as environmental sustainability.



Sinduramunda:

Sinduramunda is a habitation in Gurusang Gram Panchayat of Barkote Block in Deogarh district. Sinduramunda comprises of two hamlets i.e. Sinduramunda and Bandha Sahi with 15 households in each hamlet. Total 30 households and those are Scheduled Tribes (STs). Agriculture and collection of minor forest produces are the primary livelihood of the village. If we look at the status of water sources in the village, it has multiple issues pertaining to availability of water. The following are the details of the water sources:



Surface Water:

Ponds: There are five ponds near the village. One is more than 80 years now and the other four were created between 2012 and 2023. Other than the one created in 2023, the other four are seasonal, and in very poor condition. The one created in 2023 was made by the forest department, and its purpose was to make water available for animals in the forest. The four other wells were created by various other government bodies, and the purpose was to make water available for bathing and irrigation.

Stream: There is one stream nearby the village named “Mati Bandha/ Ganjia Khola Stream”, which is located on the outskirts of the village – inside the forest. Earlier, the stream was perennial. But, over a decade now, the stream has been converted to seasonal. Now, water is available during rainy and winter seasons only. Once, the stream was the lifeline of the village, meeting the drinking and domestic water requirements. But now, people are struggling to get water for drinking and domestic purposes during the lean period.

Ground Water:

Pipe Water Supply: Under the national flagship programme “Jal Jeevan Mission”, a pipe water supply scheme has been started since 2022. However, other than the overhead tank at the header of the village, not much progress has been made so far. Prior to this, one motorized (solar) bore well with one stand post was created 2018 at the lower end of “Bandha Sahi”, whereas another motorized (solar) bore well with five stand posts was created in 2020 at the upper habitation of the village. The purpose of both schemes was to provide safe drinking water to the community.

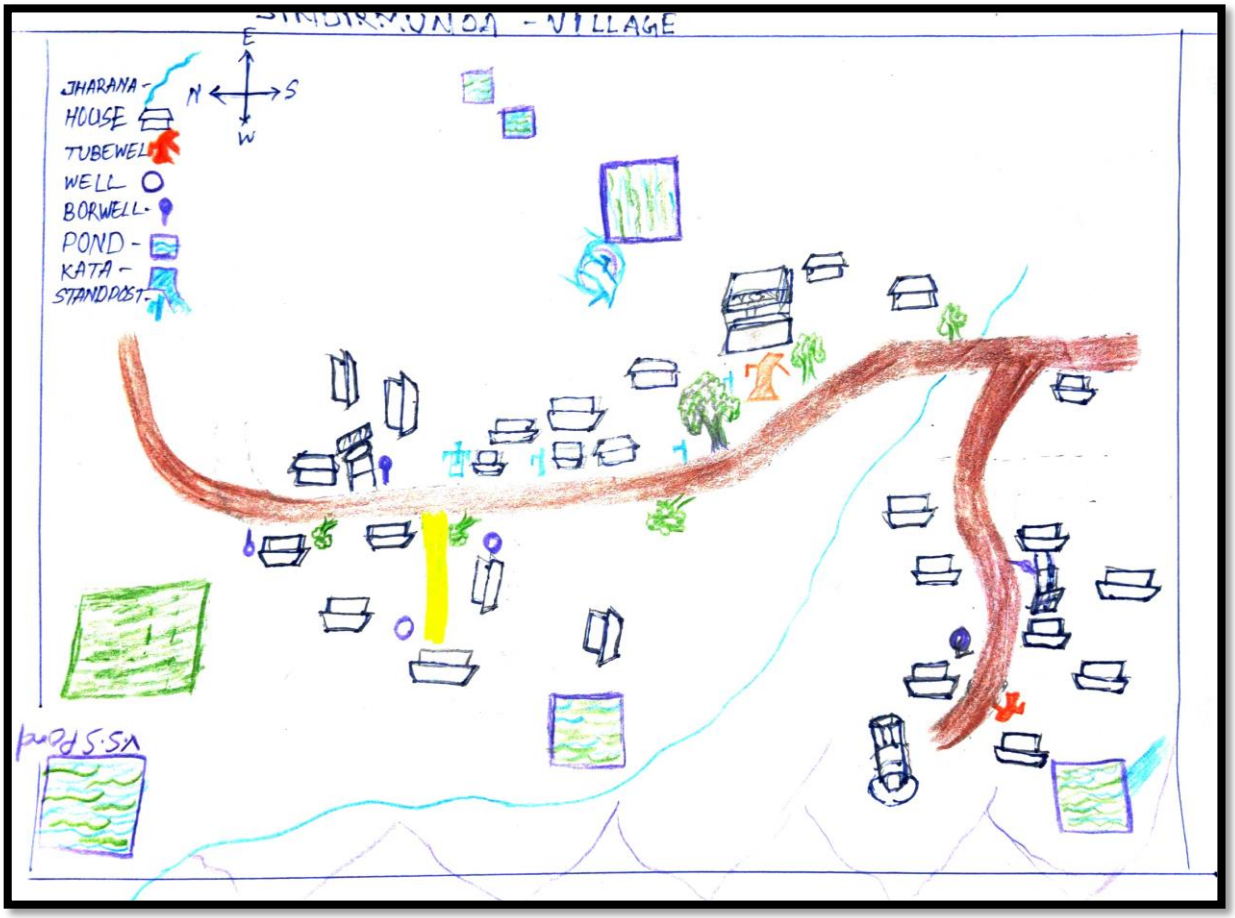
Hand Pumps: There are three Bore Wells fitted with Hand Pumps in the village, installed in 2005, 2010 and 2017 respectively. But since the installation, none of the hand pumps provide safe water. All three sources are highly iron contaminated, and the level of contamination is increasing every year. Since iron contamination has both visible and smell-related impacts, this is forcing people not to use water sources.

Bore Wells: There are two more bore wells fitted with solarized pumping devices that have been installed in 2018 and 2020 by “Paudi Bhuyan Development Agency” (PBDA). Out of two, one motorized (solar) bore well with one stand post was created in 2018 at the lower end of “Bandha Sahi”, whereas another motorized (solar) bore well with five stand posts was created in 2020 at the upper habitation of the village. The purpose of both schemes was to provide safe drinking water to the community. Though the quality of water is good in both the sources, but water is not sufficient for all households to meet their drinking and domestic water needs.

Open Wells: There are four open wells in the village installed from 2010 to 2019 to provide water for drinking and domestic as well as agriculture. But none of the wells

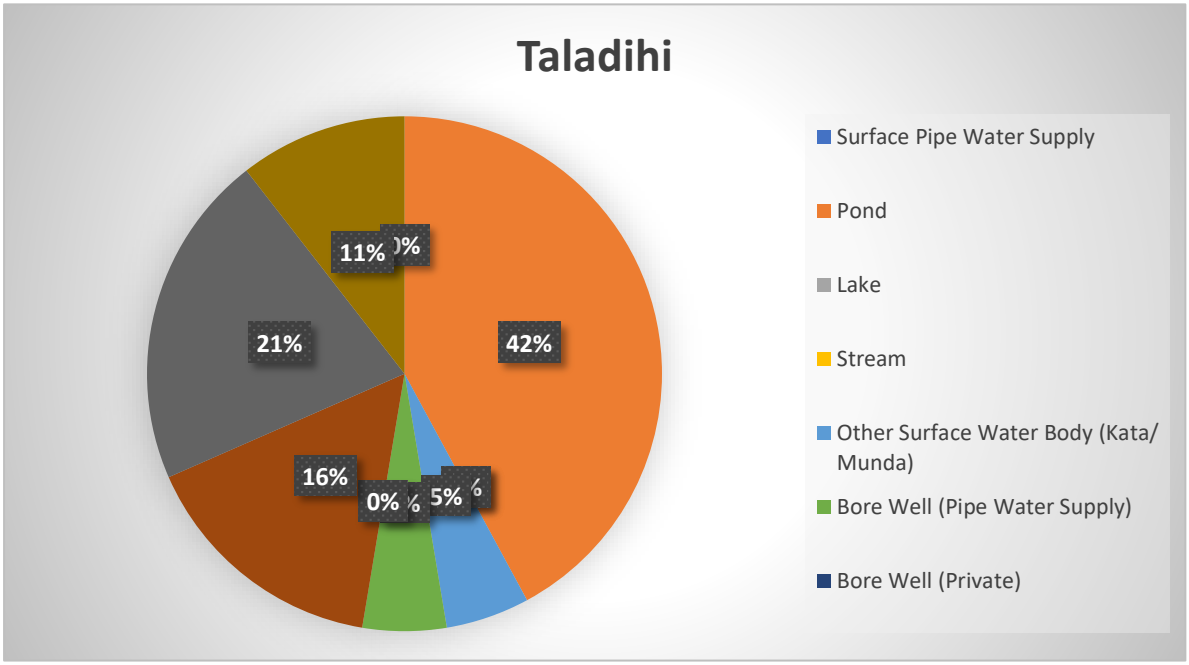
are in condition to be used for drinking and domestic water purposes. Since those are open wells, there is heavy siltation in the wells and the water is muddy. A couple of wells are also seasonal – with no water available during summer. Thus, all wells are being used for agricultural purposes only.

Summing up: Conversion of perennial sources to seasonal, reducing water availability in the surface water bodies and getting dried up, especially during summer and draw down in ground water sources along with iron contamination are multiple problems people are facing in the village. According to their perception, availability of water is reducing every passing year – though the number of sources is increasing, and degradation in the forest cover in the locality is a major reason behind this. To summarise the drinking water situation in the village, the two bore wells installed by PBDA are the only available drinking water sources in the village. Since both the bore wells are yielding inadequate drinking water, a water crisis is still prevailing in the village. To be noted that there is no system of water quality monitoring and surveillance in the village, which puts questions on how safe the little water available to the community for drinking and cooking purposes.



Taladihi

Taladihi is a small hamlet under Saruali revenue village in Barkote Block of Deogarh district. Around 32 tribal (Munda) families reside in this hamlet. Approximately 150 years ago, their ancestors migrated from the Singhbhum region of present-day Bihar due to scarcity of land and forest resources. They initially settled in the Bileipada area of Odisha. After living there for about 20–25 years, they again faced shortages of land, forest resources, and water. As a result, around 1910 (before India's independence), they migrated to Saruali village in Deogarh district. Agriculture and collection of minor forest produces are the primary livelihood of the village. If we look at the status of water sources in the village, it has multiple issues pertaining to the availability of water. The following are the details of the water sources:



Surface Water:

Ponds: There are ten ponds nearby the village, and all are created by the Soil Conservation Department of Government in 2008 for individual households. The purpose was to make water available for agriculture and vegetation, so that soil conservation can be ensured. Out of ten, only three ponds are currently carrying water throughout the year. The other seven are abandoned, as those are seasonal and water is available in those ponds for Even, two ponds are completely dried up due to heavy siltation and those have hardly any water carrying capacity. Though there are three active ponds, but being private in nature, those have limited value for the entire population of the village.

Stream: There is one stream nearby the village named "Bilei Munda Stream", which is located on the outskirts of the village – inside the forest. The stream has been there

for more than 60 years now. Earlier, the stream was perennial. But, over a decade now, the stream has been converted to seasonal. Now water is available during rainy and winter seasons only. Once, the stream was happening to be the lifeline of the village, meeting the drinking and domestic water requirements. But now, people are struggling to get water for drinking and domestic purposes during the lean period.

Ground Water:

Pipe Water Supply: Under the national flagship programme “Jal Jeevan Mission”, a pipe water supply scheme was started in 2022. However, other than the overhead tank at four kilometer away from the header of the village, not much progress has been done so far. Prior to this, in 2018, one motorized (solar) bore well with household connections was created by “Paudi Bhuyan Development Agency” (PBDA) at the upper habitation of Taladihi. But considering the lesser yielding capacity of the bore well against the demand, limited houses have access to water and in lesser quantity than they require.

Hand Pumps: There are three Bore Wells fitted with Hand Pumps in the village, installed in 2005, 2010 and 2017 respectively. But since the installation, only one hand pump provides safe water, which is located in the middle habitation of the village. Rest two sources are highly iron contaminated, and the level of contamination is increasing every year. Since iron contamination has both visible and smell-related impact, this is forcing people not to use water sources.

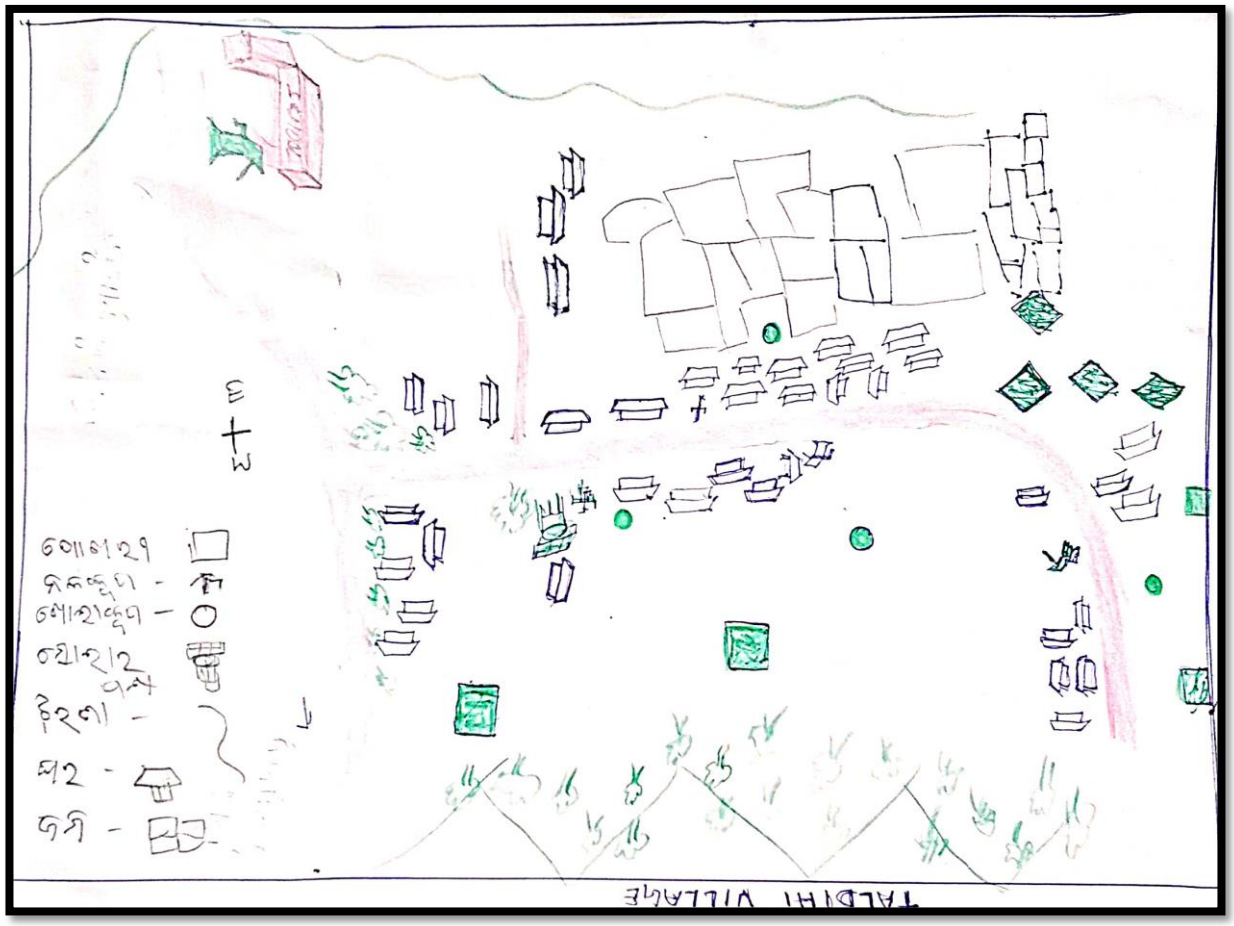
Bore Wells: There is one motorized (solar) bore well with household connection created by “Paudi Bhuyan Development Agency” (PBDA) in 2018, at upper habitation of Taladihi. But considering the lesser yielding capacity of the bore well against the demand, limited houses have access to water and in lesser quantity than they require.

Open Wells: There are four open wells in the village, out of which three were installed in 1994 by Gram Panchayat and one installed in 2000 by an individual house. The purpose of all open wells was to provide water for drinking and domestic as well as agriculture. Though out of four, two (including the private one) are carrying water throughout the year, one being private has nothing to do with community water needs. Since those are open wells, there is heavy siltation in the wells and the water is muddy. Two wells are seasonal – with no water available during summer.

Summing up: Conversion of perennial sources to seasonal, reducing water availability in the surface water bodies and getting dried up, especially during summer and draw down in ground water sources along with iron contamination are multiple problems people are facing in the village. According to their perception, availability of water is reducing every passing year – though the number of sources is increasing and degradation in the forest cover in the locality is a major reason behind this. To sum-up the drinking water situation in the village, the only bore wells installed by PBDA is

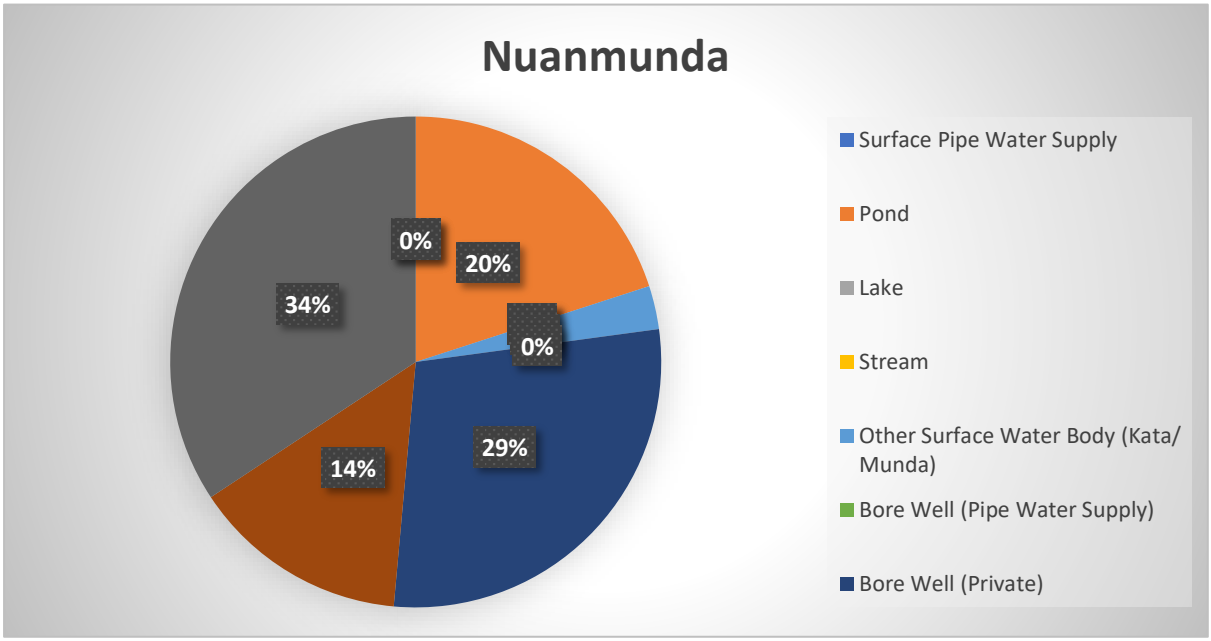
available drinking water sources in the village. Since the bore wells are yielding inadequate drinking water, a water crisis is still prevailing in the village. To be noted that there is no system of water quality monitoring and surveillance in the village, which puts questions on how safe is the little water available to the community for drinking and cooking purposes.

The story of Taladihi Hamlet reflects the broader environmental and livelihood crisis faced by the Munda community. Deforestation, water scarcity, and climate change have deeply impacted their way of life. This highlights the urgent need for forest conservation, water resource management, and the protection of the traditional rights and livelihoods of indigenous communities.



Nuamunda

Nuamunda is a habitation in Saruali Gram Panchayat of Barkote Block in Deogarh district. There are 129 households in the village, out of which 125 households are Scheduled Tribes (STs). Agriculture and collection of minor forest produces are the primary livelihood of the village. If we look at the status of water sources in the village, it has multiple issues pertaining to the availability of water. The following are the details of the water sources:



Surface Water:

Ponds: There are seven ponds nearby the village, out of which six are created by Gram Panchayat and one is private. The purpose of the ponds was to make water available for bathing and agriculture. Out of seven, only three ponds are currently carrying water throughout the year. Rest four are abandoned, as those are seasonal, and water is available in those ponds for four to five months – during and after monsoon. Though there are three active ponds, but being private in nature, those have limited value for the entire population of the village.

Ground Water:

Pipe Water Supply: Under the national flagship programme “Jal Jeevan Mission”, a pipe water supply scheme has been started since 2022. However, other than the overhead tank at the header of the village, not much progress has been made so far.

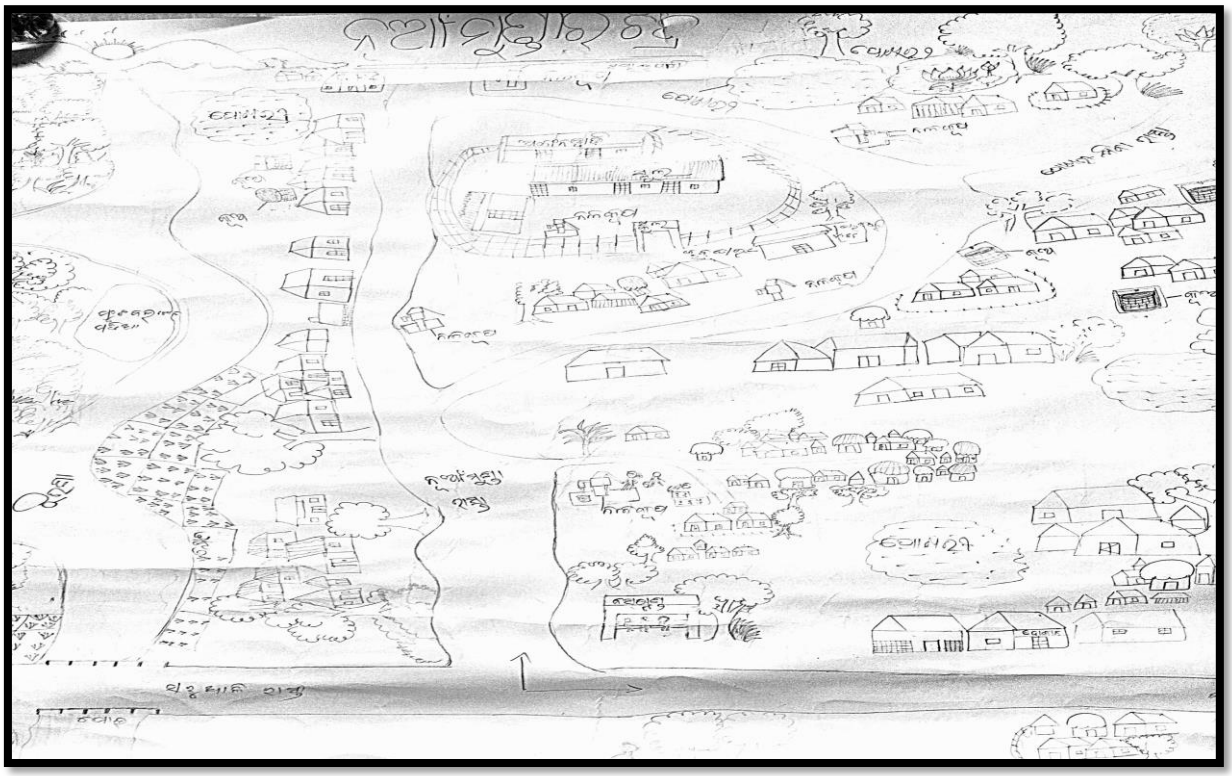
Hand Pumps: There are five Bore Wells fitted with Hand Pumps in the village - the first one installed in 1950 and the rest four between 2000 to 2007. Since installation, the first one was yielding safe water for around 40 years. Then the same got iron contaminated. Rest four installed afterwards are yielding iron contaminated water. All

the five sources are highly iron contaminated and the level of contamination is increasing by every passing year. Since iron contamination has both visible and smell related impact, this is forcing people not to use the water sources.

Bore Wells: There are ten more bore wells installed by individual households primarily for irrigation and drinking/ domestic water purposes. Out of ten, nine were installed in 2011 and one installed in 2024. Currently seven bore wells are functional and three are defunct. Though the seven out of ten are yielding water, but being private owned, those have hardly any contribution towards the community water need.

Open Wells: There are 12 open wells in the village installed between 1982 to 2002 to provide water for drinking and domestic as well as agriculture. But other than one, none of the wells are in condition to be used for drinking and domestic water purposes. Since those are open wells, there are heavy siltation in the wells and the water is muddy. Couple of wells are also seasonal – with no water available during summer and rest are defunct. To be noted that, all wells are private owned and thus, even one is functional, has no contribution towards community water requirement.

Summing up: Reducing water availability in the surface water bodies and getting dried up, especially during summer and draw down in ground water sources are multiple problems people are facing in the village. According to their perception, availability of water is reducing every passing year – though the number of sources is increasing and degradation in the forest cover in the locality is major reason behind this.



Water Quality Testing:

Village meeting organised in three villages and discussed community water issue. During the community water mapping exercise in three villages, community shared that most of the Tubewells yield red water, that turn tongue and teeth black, in some villages the water levels an oily lair on the surface when it stores, and carries iron smell. In one village hamlet community depend on one tubewell but its water is unusable. To address this issue village volunteers contacted district laboratory and water sample collected by an ASHA worker in presence of a local doctor, women leaders and volunteers. The volunteer submitted the water samples in the Community Health Centre (CHC) and along with the responsible representative of CHC submitted the sample at District Head Quarter Laboratory for testing and took an official testing report.

Number of water quality tested:

Sources	Taldihi	Nuamunda	Sindurmunda
Tube well	2	10	0
Borewell	2	0	2
Dug well	1	0	2

Parameters tested are: Bacteriological/ Microbial

Findings: In Nuamunda village 3 tubewells and in village Taldihi 1 Tube wells yields unsafe water.

Comparative Analysis of Three Villages:

The three study villages, i.e. Sinduramunda, Taladihi, and Nuamunda, demonstrate a common pattern of increasing water insecurity despite the creation of multiple water infrastructure assets. However, the severity and nature of the challenges vary across villages depending on the availability of surface water, groundwater potential, ecological conditions, and access to safe drinking water.

Dimension	Sinduramunda	Taladihi	Nuamunda	Comparative Observation
Water availability	Acute seasonal scarcity; both surface and groundwater sources are inadequate	Acute seasonal scarcity with limited perennial sources	Moderate but declining; more private water sources exist	Water availability is declining in all villages, but Sinduramunda and Taladihi face more severe shortages.

Drinking water security	Highly insecure; only two PBDA bore wells provide safe drinking water, but yield is insufficient	Highly insecure; one PBDA bore well provides relatively safe water but serves limited households	Insecure; private bore wells provide some relief, but community access remains poor	Drinking water insecurity is common across all villages due to inadequate safe public sources and delayed piped water supply.
Surface water dependence	Historically dependent on perennial stream and ponds	Historically dependent on perennial stream and ponds	Primarily dependent on ponds; no stream reported	Sinduramunda and Taladihi have experienced loss of perennial streams, while Nuamunda mainly depends on seasonal ponds.
Groundwater dependence	Very high dependence on bore wells due to failure of surface sources	Very high dependence on bore wells	Increasing dependence, with numerous private bore wells	Groundwater has become the principal source in all villages as surface water availability declines.
Groundwater status	Declining yield and inadequate discharge	Declining yield and inadequate discharge	Declining groundwater level despite larger number of bore wells	Groundwater depletion is evident across all villages.
Water quality	All hand pumps are severely iron contaminated	Two of three hand pumps are iron contaminated	All public hand pumps are iron contaminated	Iron contamination is a widespread challenge across the study area, most severe in Sinduramunda

				and Nuamunda.
Status of traditional water bodies	Ponds and open wells heavily silted; several seasonals	Seven of ten ponds seasonal or abandoned; wells silted	Majority of ponds seasonal; most open wells defunct	Traditional water bodies have deteriorated in all villages due to siltation and poor maintenance.
Piped water supply	JJM scheme incomplete	JJM scheme incomplete	JJM scheme incomplete	Delayed implementation of piped water supply is a common issue.
Forest condition and ecology	Community reports forest degradation causing declining water availability	Strong evidence of forest degradation affecting water and livelihoods	Forest degradation perceived to reduce groundwater recharge	Forest degradation is consistently identified as a major driver of water insecurity.
Livelihood vulnerability	Agriculture and forest produce increasingly affected	Agriculture, forest-based livelihoods and historical migration linked to resource scarcity	Agriculture affected by declining water availability	Livelihoods are highly vulnerable in all villages due to dependence on natural resources.
Water quality monitoring	No monitoring system	No monitoring system	No monitoring system	Absence of village-level water quality surveillance is universal.

Common Challenges Across the Three Villages:

Several issues emerge consistently across all three villages:

- Declining water availability despite an increase in the number of water infrastructure assets.

- Transformation of reliable water sources into seasonal sources, particularly streams and ponds.
- Falling groundwater levels, resulting in low-yielding bore wells and increasing dependence on a few functional sources.
- Widespread iron contamination in groundwater, reducing access to safe drinking water.
- Heavy siltation and poor maintenance of ponds and open wells, limiting both storage and groundwater recharge.
- Delayed completion of Jal Jeevan Mission schemes, forcing continued reliance on unreliable groundwater sources.
- Absence of water quality monitoring and surveillance, leaving communities without assurance of drinking water safety.
- Perceived forest degradation and climate variability contributing to declining recharge and increasing water stress.
- High livelihood vulnerability, particularly among tribal households dependent on agriculture and minor forest produce.

Village-Specific Characteristics:

Sinduramunda:

- Faces the most acute drinking water crisis, with only two low-yielding safe bore wells serving the entire community.
- All public hand pumps are iron contaminated, effectively eliminating them as drinking water sources.
- The conversion of the Mati Bandha/Ganjia Khola stream from perennial to seasonal has significantly reduced water security.
- Open wells are largely unusable because of heavy siltation and seasonal drying.

Taladihi:

- Shares many challenges with Sinduramunda but also illustrates the long-term socio-ecological consequences of resource degradation.
- Historical migration of the Munda community reflects repeated displacement driven by shortages of land, forests, and water.
- The village retains a few perennial ponds, but these are privately owned and provide limited community benefit.
- Forest degradation is directly linked to declining livelihoods, making Taladihi the clearest example of the interconnected nature of ecological degradation and water insecurity.

Nuamunda:

- Has a comparatively larger number of private bore wells and open wells, indicating greater household investment in water access.
- However, community drinking water remains insecure because most productive groundwater sources are privately owned.
- Unlike the other two villages, no stream serves as a major water source, making the village more dependent on ponds and groundwater.
- The long history of hand pump installations (dating back to 1950) demonstrates progressive deterioration in groundwater quality, with even previously safe sources becoming iron contaminated over time.

Summary of Findings:

The summary of findings suggests that the underlying drivers of water insecurity are remarkably similar across the three villages. Those are, forest degradation, declining groundwater recharge, climate variability, deteriorating traditional water bodies, and inadequate water governance. The manifestation of these challenges differs according to local ecological and infrastructural conditions. Sinduramunda and Taladihi exhibit higher vulnerability because both have lost perennial streams and possess very limited safe groundwater sources. Nuamunda, although relatively better endowed with groundwater infrastructure, faces significant inequity in access, as most reliable sources are privately owned, and public drinking water infrastructure remains inadequate. Collectively, these findings underscore the need for a combination of village-specific interventions (such as stream restoration in Sinduramunda and Taladihi or improved community access to groundwater in Nuamunda) alongside common strategies including watershed restoration, forest conservation, groundwater recharge, iron removal, rehabilitation of traditional water bodies, completion of Jal Jeevan Mission schemes, and strengthening of community-based water quality monitoring.

Based on the findings from the three case study villages (Sinduramunda, Taladihi, and Nuamunda), the following thematic analysis can be drawn:

Reasons for Groundwater Decline:

The decline in groundwater availability appears to be the result of multiple interacting environmental and management factors:

- Reduced groundwater recharge due to forest degradation: Communities consistently perceived that loss of forest cover has reduced infiltration and groundwater recharge, leading to declining water tables.

- Conversion of perennial water sources into seasonal ones: Streams that once flowed throughout the year have become seasonal over the past decade, indicating a reduction in baseflow supported by groundwater.
- Rainfall variability and prolonged dry periods: Increasingly erratic rainfall patterns, coupled with extended summer dry spells, reduce natural recharge of aquifers.
- Heavy siltation of ponds and open wells: Silt accumulation has reduced the storage capacity of traditional water bodies, limiting infiltration and groundwater recharge.
- Increasing dependence on groundwater sources: As surface water sources become unreliable, communities increasingly depend on bore wells, placing additional pressure on already declining aquifers.
- Limited groundwater yielding capacity: Even newly installed bore wells and solar-powered drinking water systems provide insufficient discharge to meet community demand, suggesting declining aquifer productivity.
- Incomplete piped water supply infrastructure: Delays in operationalizing Jal Jeevan Mission schemes have forced continued dependence on limited groundwater sources.

Causes and Implications of Iron Contamination:

Causes:

- Naturally occurring iron-bearing geological formations: The widespread occurrence of iron contamination across old and newly installed bore wells suggests that groundwater is being abstracted from iron-rich aquifers.
- Declining groundwater levels: Falling water tables may increase the concentration of dissolved iron in groundwater by altering groundwater chemistry and exposing deeper iron-rich strata.
- Lack of water quality management: There is no village-level water quality monitoring, surveillance, or treatment system to detect and address iron contamination.

Implications:

- Reduced usability of drinking water: Visible reddish colour, unpleasant taste and odour discourage households from using contaminated hand pumps.
- Increased dependence on a few safe sources: Communities rely heavily on one or two relatively safe bore wells, leading to overcrowding and inadequate water availability.
- Heightened drinking water insecurity: Even where groundwater is physically available, poor water quality makes it unsuitable for drinking, effectively reducing access to safe water.

- Potential health concerns: Although iron is generally less toxic than many other contaminants, prolonged consumption of high-iron water may cause gastrointestinal discomfort and contributes to poor acceptability of drinking water.
- Risk of undetected contamination: In the absence of routine monitoring, communities remain unaware of other potential contaminants beyond visible iron.

Linkages between Forest Degradation, Rainfall Variability, and Water Insecurity:

The findings reveal a strong perceived relationship between ecosystem degradation and declining water security.

- Forest degradation reduces watershed functions: Loss of vegetation decreases rainfall infiltration, soil moisture retention, and groundwater recharge while increasing surface runoff.
- Declining stream flows: Perennial streams have become seasonal, reducing reliable surface water for drinking, domestic use, and agriculture.
- Reduced water storage: Combined effects of deforestation and siltation have diminished the storage capacity of ponds and open wells.
- Rainfall variability exacerbates seasonal scarcity: Irregular monsoon rainfall and prolonged dry periods reduce recharge opportunities and shorten the duration for which surface water bodies retain water.
- Groundwater depletion follows reduced recharge: Lower recharge leads to declining groundwater levels and reduced bore well yields.
- Climate and ecosystem changes reinforce each other: Forest degradation increases vulnerability to climate variability, while changing rainfall patterns further weaken ecosystem resilience, creating a cycle of increasing water insecurity.
- Community perception supports this linkage: Across all villages, residents consistently identified degradation of nearby forests as a major driver of declining water availability despite an increase in the number of water infrastructure assets.

Social and Livelihood Impacts of Water Scarcity:

Water scarcity is affecting both household well-being and livelihood security.

Social impacts:

- Reduced access to safe drinking water: Communities depend on one or two functioning water sources that cannot adequately meet demand.
- Increased time and effort in water collection: Households must travel farther and wait longer to collect water from limited safe sources.

- Greater burden on women and girls: Responsibility for collecting water largely falls on women and girls, reducing time available for education, income generation, and household activities.
- Persistent seasonal water stress: Water shortages become particularly acute during summer when ponds, wells, and streams dry up.
- Growing uncertainty about water safety: Absence of water quality monitoring creates concerns about the safety of available drinking water.

Livelihood impacts:

- Reduced agricultural productivity: Seasonal drying of ponds and declining groundwater availability limit irrigation opportunities, affecting crop production.
- Threats to forest-based livelihoods: Tribal households dependent on minor forest produce experience reduced livelihood security as forests degrade.
- Increased livelihood vulnerability: Agriculture and forest-based livelihoods become increasingly susceptible to climate variability and water shortages.
- Limited resilience to drought: Inadequate and unreliable water sources reduce households' ability to cope with prolonged dry periods.
- Historical displacement linked to resource scarcity: The experience of the Munda community in Taladihi illustrates how long-term shortages of land, forests, and water have historically driven migration and settlement changes, highlighting the deep connection between natural resources and community resilience.

Overall, the findings indicate that water insecurity in these tribal villages is not solely an infrastructure issue but the outcome of interacting ecological degradation, declining groundwater resources, water quality challenges, climate variability, and inadequate water governance. Addressing these challenges will require integrated watershed restoration, forest conservation, groundwater recharge, water quality management, and timely completion of piped water supply systems alongside community-based monitoring and management.

Conclusion:

Based on the findings from the water resource assessment in Sinduramunda, Taladihi, and Nuamunda villages under the Jal Sakhi Initiative, it can be concluded that despite the presence of multiple water sources, the communities continue to face significant water insecurity due to declining water availability, seasonal drying of traditional water bodies, groundwater depletion, iron contamination, and inadequate functioning of drinking water infrastructure. The conversion of once-perennial streams into seasonal sources, heavy siltation of ponds and open wells, limited yield from bore wells, and delays in completion of Jal Jeevan Mission schemes have reduced access to safe and reliable water for drinking, domestic use, and livelihoods. Community perceptions strongly link these challenges to degradation of forest cover and changing rainfall

patterns, highlighting the interconnectedness of water security and ecological sustainability in the region.

Major Insights from the Study:

The assessment of Sinduramunda, Taladihi, and Nuamunda reveals that water insecurity in the study area is driven by a combination of declining water availability, deteriorating water quality, ecological degradation, and inadequate water governance, rather than the mere absence of water infrastructure. Despite the construction of multiple drinking water schemes, bore wells, ponds, and hand pumps over the years, communities continue to face severe shortages of safe and reliable drinking water.

Across all three villages, perennial streams have become seasonal, ponds and open wells have experienced heavy siltation and reduced storage capacity, and groundwater levels have declined, resulting in low-yielding bore wells. Iron contamination of groundwater has further reduced the number of safe drinking water sources, while the absence of systematic water quality monitoring leaves communities vulnerable to potential health risks.

The comparative analysis also shows that although the three villages share common challenges, their vulnerabilities differ. Sinduramunda and Taladihi face the most severe drinking water insecurity because of the loss of perennial streams and dependence on a few low-yielding bore wells. Nuamunda has comparatively more groundwater infrastructure but experiences inequitable access, as most productive water sources are privately owned and contribute little to community water security.

Implications for Water Security:

The findings indicate that water security cannot be achieved solely through the creation of additional infrastructure. Safe and sustainable drinking water depends equally on the functionality, reliability, quality, and long-term sustainability of water sources.

Several implications emerge:

- Increasing numbers of water supply assets do not necessarily improve water security when groundwater yields are declining and water quality is deteriorating.
- Delayed operationalisation of Jal Jeevan Mission schemes prolongs dependence on inadequate and contaminated groundwater sources.
- Iron contamination substantially reduces the availability of safe drinking water, even where physical water sources exist.
- Heavy reliance on groundwater, combined with declining recharge, threatens the long-term sustainability of village water supply systems.

- Lack of routine water quality surveillance weakens public confidence in drinking water systems and increases health risks.
- Water scarcity extends beyond domestic use, affecting agriculture, livestock, and forest-based livelihoods, thereby increasing socio-economic vulnerability.

Overall, the study highlights that water security is determined by the combined dimensions of availability, accessibility, quality, reliability, and sustainability, all of which are currently under stress.

Relationship Between Ecological Sustainability and Water Availability"

One of the most significant findings of the study is the strong interdependence between ecological sustainability and water security.

Communities across all three villages consistently attributed declining water availability to degradation of surrounding forests. Their observations are supported by the visible transformation of perennial streams into seasonal watercourses, declining groundwater levels, and increasing seasonal drying of ponds and wells.
The findings suggest the following causal pathway:

Forest degradation → Reduced infiltration and groundwater recharge → Declining stream flows and groundwater levels → Reduced water availability → Increased dependence on groundwater → Greater water insecurity

Climate variability further amplifies this process. Erratic rainfall and prolonged dry periods reduce opportunities for groundwater recharge while accelerating the drying of surface water bodies. Consequently, degraded ecosystems become less capable of regulating the hydrological cycle, increasing the vulnerability of both water resources and local livelihoods.

The study therefore demonstrates that healthy forests, functioning watersheds, and restored traditional water bodies are not merely environmental assets but essential natural infrastructure that underpins sustainable drinking water security. Water resource management and ecosystem conservation should therefore be treated as complementary rather than separate development priorities.

Relevance for Policy and Local Planning:

The findings have important implications for rural water governance and decentralized planning in tribal areas.

First, planning should move beyond an infrastructure-centric approach towards Integrated Water Resource Management (IWRM) that combines drinking water

service delivery with watershed management, groundwater recharge, ecosystem restoration, and climate resilience.

Second, village-level planning under the Jal Jeevan Mission (JJM) and Gram Panchayat Development Plans (GPDPs) should incorporate:

- restoration of ponds, streams, and open wells;
- groundwater recharge and aquifer protection measures;
- catchment treatment and afforestation;
- village-based water quality monitoring and surveillance;
- climate-resilient water budgeting; and
- sustainable operation and maintenance of drinking water systems.

Third, the findings highlight the need for stronger convergence among the Rural Water Supply and Sanitation Department, Forest Department, Watershed Mission, MGNREGS/ VB-G RAM G, Panchayati Raj Institutions, and Tribal Development programmes to address the interconnected drivers of water insecurity.

Finally, local planning should recognise community knowledge and participation as critical to sustainable water governance. The consistent perceptions of villagers regarding forest degradation, declining groundwater, and changing rainfall patterns provide valuable evidence for designing locally appropriate interventions and strengthening community ownership of water resources.

Overall Conclusion:

The study demonstrates that water security in the tribal villages of Deogarh is fundamentally linked to ecological sustainability. Declining groundwater availability, degradation of traditional water bodies, widespread iron contamination, incomplete drinking water infrastructure, and forest degradation have collectively created a cycle of increasing water insecurity despite substantial investments in water supply infrastructure. Achieving sustainable water security will therefore require a paradigm shift from isolated infrastructure development to integrated landscape-based water management that simultaneously conserves ecosystems, strengthens water governance, restores natural recharge systems, and ensures equitable access to safe drinking water. Such an approach will not only enhance drinking water security but also improve livelihood resilience and climate adaptation for vulnerable tribal communities.

Recommendation:

A. Drinking water infrastructure: Considering the ground reality, priority should be given to completing and operationalizing pending Jal Jeevan Mission water supply schemes. Alternative drinking water sources should also be made

functional and protected for catering water demand, until main supply system is made functional as well as when there is a major breakdown in the main supply system.

B. Water quality management: Strengthening village-level water quality monitoring and surveillance systems is absolutely essential and that should be in line with "National Water Quality Monitoring and Surveillance Guideline" under "Jal Jeevan Mission".

C. Surface water restoration: Restoration and rejuvenation of ponds, streams, and open wells through de-siltation, catchment treatment, and recharge interventions should be undertaken to improve water availability.

D. Addressing iron contamination: Measures to address iron contamination, including installation of appropriate treatment systems and regular water quality testing, are essential.

E. Groundwater recharge: Community-led groundwater management, promotion of water-efficient agricultural practices, and creation of water harvesting and recharging structures should be ensured for augmenting the ground water level as well as improving ground water quality.

F. Forest and catchment restoration: Protection and restoration of forest ecosystems should be integrated into village development plans to enhance long-term water security and environmental sustainability.

G. Community-based water governance: Capacity building of women-led groups such as Jal Sakhis can further strengthen community participation in water resource management, monitoring, and conservation efforts.

Recommendation Area	Short-term Actions (0–2 Years)	Medium-term Actions (2–5 Years)	Long-term Actions (5+ Years)
A. Drinking Water Infrastructure	Complete and operationalize pending Jal Jeevan Mission (JJM) schemes in priority villages. Repair existing drinking water sources and ensure temporary alternative water supply	Strengthen operation and maintenance (O&M) systems, establish preventive maintenance protocols, and improve service reliability.	Achieve universal, reliable, climate-resilient piped water supply with sustainable source management and uninterrupted service delivery.

	arrangements during system breakdowns.		
B. Water Quality Management	Establish village-level water quality monitoring committees, train community volunteers, and undertake regular testing as per JJM Water Quality Monitoring and Surveillance Guidelines.	Strengthen laboratory networks, digital reporting systems, and periodic surveillance covering all drinking water sources.	Institutionalize community-led water quality surveillance with continuous monitoring, early warning systems, and integration into district water management systems.
C. Surface Water Restoration	Undertake de-siltation and minor repair works for identified degraded ponds, streams, and open wells.	Implement catchment treatment, recharge interventions, and community-led maintenance of restored water bodies.	Develop integrated watershed management systems that sustainably restore local hydrology and enhance ecosystem resilience.
D. Addressing Iron Contamination	Install appropriate iron removal systems, and conduct regular water quality testing in the identified affected habitations/ sources.	Strengthen maintenance of treatment systems, periodic monitoring, and community awareness on safe water use.	Ensure sustainable access to safe drinking water through source protection, improved treatment technologies, and continuous quality surveillance.
E. Groundwater Recharge	Prepare village water security plans, identify recharge sites, and promote rainwater harvesting and water-efficient	Construct recharge structures, scale up community-led groundwater management, and encourage	Achieve sustainable groundwater management through aquifer-based planning, regulated

	agricultural practices.	climate-smart agriculture.	abstraction, and long-term recharge and conservation measures.
F. Forest and Catchment Restoration	Map degraded catchments, protect existing forests, and initiate plantation and soil conservation activities.	Integrate catchment restoration into village development plans and strengthen community-based forest management.	Restore healthy forest ecosystems that improve watershed functions, biodiversity, and long-term water security.
G. Community-based Water Governance	Build capacities of Village Water and Sanitation Committees (VWSCs), Jal Sakhis, and women's self-help groups on water governance, monitoring, and conservation.	Institutionalize community participation through regular monitoring, social audits, and local water security planning.	Establish self-sustaining, inclusive community institutions that lead local water governance, resource conservation, and climate-resilient water management.