IRJEMS International Research Journal of Economics and Management Studies
ISSN: 2583 – 5238 / Volume 5 Issue 1 January 2026 / Pg. No: 155-171
Paper Id: IRJEMS-V5I1P119, Doi: 10.56472/25835238/IRJEMS-V5I1P119

*Original Article*

# Performance Evaluation of Jal Jeevan Mission: Evidence of Poverty Reduction, Health-Hygiene Improvement, and Gender Outcomes Among the Tea Garden Workers from Golaghat District of Assam

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Received Date: 25 December 2025 Revised Date: 17 January 2026 Accepted Date: 19 January 2026 Published Date: 22 January 2026

***Abstract:*** *Despite being historically marginalized, the tea garden community plays a vital role in the economy of Assam. These people are exposed to structural poverty, lack of basic sanitation facilities, and poor health-hygiene conditions. The women and children are significantly affected by these outcomes. The Government of India's visionary initiative, Jal Jeevan Mission, appears to be a promising effort to address these issues. This paper attempts to evaluate the performance of the Jal Jeevan Mission in reducing poverty, improving health and hygiene conditions, and gender-related outcomes among the tea garden workers of Khumtai Tea Estate in Golaghat District, Assam. Our analysis is based on primary field survey data. The analysis shows that JJM has emerged as a significant force in improving water access and infrastructure among these people. In terms of health-hygiene, poverty, and gender outcomes, the positive impact of JJM can't be ignored. However, ensuring service reliability, effective maintenance, inclusive access, and active community engagement is critical for tap connections to achieve their intended health, livelihood, and gender equity outcomes in plantation regions.*

***Keywords:*** *Jal Jeevan Mission, Women, Poverty, Development, Marginalization, Gender, Health, Tea Plantation*.

## 1. INTRODUCTION

Access to safe drinking water is a fundamental human right and a cornerstone of sustainable development. This has strong linkages with health, gender equity, and poverty reduction (Mishra and Paunikar, 2023; United Nations, n.d.). Globally, unsafe water, sanitation, and hygiene (WASH) remain major contributors to preventable diseases and mortality, particularly among children under five and populations in low- and middle-income countries (WHO, 2023; Paul, 2023; UNICEF, 2016). Women and children are disproportionately affected due to their primary role in water collection, which exposes them to health risks and constrains education, employment, and empowerment (Pouramin et al., 2020; Naik, 2024). Recognizing these challenges, the UN has emphasized universal access to safe water under Sustainable Development Goal (SDG) 6 and has formally acknowledged water as a human right (Hall et al., 2014).

In this context, the Government of India's Jal Jeevan Mission (JJM) represents a critical public policy intervention that aims to ensure piped water supply to rural households. This initiative has significant consequences for poverty reduction, especially in marginalized regions such as the tea garden areas of Upper Assam, where limited access to safe drinking water has historically constrained health, livelihoods, and overall well-being. These regions face several challenges, including poverty, limited access to basic infrastructure, and high rates of malnutrition and water-borne diseases, along with high mortality rates. Most tea gardens lack adequate infrastructure for safe water access. The people in these areas are mostly dependent on open wells and streams, which are prone to contamination. As a result of the high prevalence of water-borne diseases, it is a very common phenomenon in these areas. Seasonal water scarcity is another major issue. In some of these areas, open defecation persists. Due to a lack of education, these people are not very concerned about their hygiene practices. Water scarcity or lack of safe water access makes this issue more serious. Water illiteracy among the tea tribe is a serious issue that needs to be addressed.

The JJM offers a promising opportunity to address these issues and improve the quality of life for the local population. By improving household-level water access and recognizing water as a basic right, the initiative not only reduces the time and physical burden of water collection but also strengthens water security, enhances the productive use of water, and supports the realization of the human right to water for historically excluded communities. These tea garden areas, characterized by socioeconomic backwardness, have historically faced challenges in accessing clean drinking water. This paper seeks to investigate the impact of the JJM on poverty reduction and on the health of women and children in one of the tea garden areas of Golaghat district, Upper Assam. These areas, with their unique socio-economic, geographical, and political characteristics, present a compelling case study for examining the impact of the JJM. Our paper seeks to investigate the impact of JJM on poverty, health, hygiene, and gender related issues. These 3 are the paper's broad objectives.

## II. LITERATURE REVIEW

The tea gardens of Assam form the economic zone of the state, a region that has historically shaped the state's financial, social, and cultural identity since the colonial period. The tea plantation industry's roots are deeply embedded in British colonial expansionism, but its legacy continues to impact the state's economy and demographic structure in post-independence India as well.

It is important to note that the tea gardens in Assam bring a diverse workforce, including skilled workers, supervisors, managers, and other administrative staff. The tea workers in gardens are burdened by low wages, which continue to hinder their economic advancement. During the colonial era, the tea workers received low wages. Besides, they were frequently trapped in the cycles of debt to their employers. This system of economic exploitation created deep-rooted dissatisfaction that, despite decades of independence, remains highly prevalent in Assam's tea industry. It is worth noting that, despite their critical role in sustaining the industry, the workforce in Assam's tea gardens suffers from some of the poorest health indicators in India. The garden labourers in Assam generally reside in labour lines with inadequate housing, poor sanitation, and unsafe drinking water. In the context of the health economy, a significant section of the tea labourers suffers from malnutrition, with women and children being the most vulnerable. This long-standing health problem on tea plantations not only affects individual well-being but also weakens the productivity and sustainability level of the tea industry in Assam. Nath (2016) has discussed the significance of workers' struggles and the role of the national movement, as well as working conditions in terms of health and education.

As a major revenue source for the state economy, the tea gardens always occupy centre stage in policy implementation. The workers' communities in these tea gardens are marginalized and considered poor. Water scarcity and the burden of water-borne diseases are very common problems in these tea gardens. Drinking water is a basic need, and the Government of Assam has prioritized providing access to clean drinking water under the Jal Jeevan Mission in these tea gardens. The Chief Minister recently announced that 86% of households in tea gardens now have safe drinking water facilities at home (Veda, 2024). However, scientific research on the issue of water insecurity and health, especially among marginalized communities like tea garden workers, is very minimal. There are numerous research works that discuss the health and hygiene issues faced by tea garden workers.

Dey (2018) highlights how the unsanitary living conditions, lack of a proper healthcare system, and challenging environment led to widespread diseases among the tea workers during the colonial period. He also criticizes British colonial rule for neglecting the health concerns of tea plantation workers in Assam. In tea garden areas, infant mortality among the tea plantation population is very high compared to other ethnic groups in Assam. The report by the Regional Resource Centre for North Eastern States. (n.d.) highlights that tea garden communities in Assam continue to face significant health and socio-economic challenges. Key findings indicate a high prevalence of maternal and child health issues, nutritional deficiencies, and communicable diseases, alongside chronic conditions linked to poor sanitation, unsafe drinking water, and occupational hazards. Access to health services remains limited, with many tea estates lacking adequately staffed hospitals or primary health facilities, resulting in low coverage of essential health programs. The report also underscores gender disparities in health outcomes, particularly among women and adolescent girls. It emphasizes that coordinated interventions between tea management and government health systems are essential to improve health outcomes, nutrition, and overall well-being of the tea worker population. Arpana Tiwari's significant work, "The Political Economy of Water" (2020), analyzes the complexities of water distribution and its broader sociological impacts on human society. She clearly pointed out that the stark inequalities in water access, where marginalized communities often suffer from inadequate supply, while elite groups enjoy better access. In her book, she explores how access to, control over, and distribution of water are shaped by social hierarchy, economic power, and institutional arrangements in rural India, especially in canal-irrigated and groundwater-dependent villages. Drawing on empirical research from two villages in Central Uttar Pradesh, the book shows how caste, class, and gender shape who gets water and how, leading to inequalities and conflicts over water use. It also highlights how groundwater irrigation, though less controlled by elites than canal systems, presents its own challenges and opportunities for development through markets and

horticulture. The work underscores the political and social dimensions of water management and argues for more equitable governance to ensure access for all sections of society.

Water security significantly affects health, hygiene, and household income, especially for women and children. Limited access to clean water increases disease risk and the time spent collecting water, reducing opportunities for women's economic activities (Kasongamulilo, 2013). Improving water access enhances health outcomes and empowers women by freeing time for income-generating and other productive tasks. In the master's thesis by Kasongamulilo (2013), the author argues that women support their male counterparts in their market work through various forms of support, and most of these supports depend on the availability of water. Water scarcity affects the household's overall income. The above-mentioned author found that although women and children have the highest participation in water management, their role in decision-making remains low. Despite their active participation in grassroots water management, their opinions are often neglected in policy decisions. Namara et al. (2010) in their paper show that reliable water availability ensures a higher level of agricultural productivity, which in turn stabilizes the income and consumption level of households. Therefore, the overall income level of any household is highly dependent on the water availability at the household. In a report by Soussan et al. (2006), it has been argued that there are mainly a few core dimensions of the link between water security and poverty reduction. These are mainly enhanced livelihood security, reduced health risk, reduced vulnerability, pro-poor economic growth, etc. Paul (2023) reports that unsafe drinking water, sanitation, and hygiene (WASH) caused 395000 deaths among children under 5 years of age, according to a WHO report. The report titled "Burden of disease attributable to unsafe drinking water, sanitation and hygiene" (2019) shows that globally, 771 million people lack access to safe drinking water. UNICEF (2016) has some interesting findings which show that in 2015, more than 30000 children below 5 years died due to some water-borne diseases as a result of lack of safe drinking water and other hygiene practices.

Unsafe drinking water poses a significant threat to public health and societal well-being. A 2019 global burden of disease analysis highlighted the scale of the crisis, attributing 1.4 million deaths and 74 million Disability-Adjusted Life Years (DALYs) to the combined effects of unsafe drinking water, and inadequate sanitation and hygiene (Wolf et al., 2023). This global issue is particularly acute in India. As of 2018, 36% of the nation's population lacked access to an improved drinking-water source directly on their premises. The challenge is even more pronounced in rural areas, where this figure rises to 44% (Govt. of India, 2018). In response to this critical need, the Government of India launched the Jal Jeevan Mission (JJM) in 2019. This ambitious nationwide program aims to provide every household in rural India with a safe, adequate supply of drinking water through an individual tap connection by 2024.

The Jal Jeevan Mission (JJM) is making significant inroads in Assam. However, its implementation and impact within the state's sprawling tea garden communities, home to over a million of the most marginalized workers, present a complex tapestry of progress, persistent challenges, and evolving community dynamics. This analysis delves into the status of JJM in Assam, with a specific focus on the unique ground-level realities, community engagement, regional disparities, and inherent challenges within the tea garden areas.

Based on a recent report on Functionality Assessment of Household Tap Connections under JJM (Ministry of Jal Shakti, 2022), the functionality of tap water connections in Assam shows a layered reality. While 81% of households across the state received water on the day of the assessment, a more detailed look reveals that only 58% have fully functional connections on their premises. For those households with fully functional taps, the quality of service varies. A majority (78%) reported receiving an adequate quantity of water, and 73% stated the water supply was regular. A high point in the findings is water quality: 91% of these households receive potable water.

The frequency of water supply also differs across the state. More than three-quarters of households (75%) received water every day of the week. In contrast, 14% received it on 3 to 4 days, and 7% had access only once a week. Across Assam, the average duration of the daily water supply was reported to be one hour. Regarding infrastructure, the primary method of distribution is through storage systems, with 82% of villages reporting that water is supplied via an overhead tank, a sump, or both. The remaining 18% of villages receive water directly supplied to their households (Ministry of Jal Shakti, 2022).

## III. DATA AND METHODOLOGY

When we see the distribution of tea gardens in Assam, we can see that most are located in upper Assam. Khumtai Grant TE from Golaghat was one of the selected Tea Estates (TE) for our study. Khumtai TE is under the Golaghat Central Development Block. For this paper, we present the findings we gathered from the primary data collected from this tea garden. Our sampling unit is a household.

### *A) Overview of survey area*

Our survey area falls under the Golaghat district of Assam. This district of Assam was created as a separate district by bifurcating from the old Jorhat district. It covers an area of 3,502 sq. km. As per an official record, the total number of tea

estates in this district is 74, which positions it in the top 5th position among the districts of Assam in terms of the number of tea estates within the district.

The following section lists the methodologies we have selected for our empirical analysis. The methodology comprises two components. In the first stage, Composite Indices of Gender, Health, Assets, and Poverty were constructed for the district. In the second stage, Ordinary Least Squares (OLS) regression was deployed, followed by the estimation of the Average Treatment Effect on the Treated (ATT) using inverse-probability-weighted regression adjustment (IPWRA) to assess the robustness of the results.

***B) Construction of composite indices***

We constructed all outcome variables at the household level from a common set of yes/no questions asked after the implementation of JJM. In Stata, all items were coded as indicator variables taking the value 1 when the respondent reported an improvement and 0 otherwise; "don't know" and non-responses were treated as missing.

For any given dimension $d \in$ {poverty, health,gender,assets}, let $I_{idk}$denote the $k$-th binary indicator for household $i$, and let $K_{id}$be the number of non-missing items for that household in that dimension. The composite index is then defined as the simple mean of the available indicators:

$$\text{Index}_{id} = \frac{1}{K_{id}} \sum_{k=1}^{K_{id}} I_{ik}.$$

Each index, therefore, lies between 0 and 1 and can be interpreted as the share of dimension-specific indicators for which the household reports an improvement since JJM.

***C) Poverty and livelihood index***

To fulfil the objective of poverty reduction and livelihood effects, six questions were used:

1. Household income has increased,
2. Direct income from farm activities has increased,
3. Indirect income from other sources has increased,
4. The household has gained an additional livelihood source,
5. Dependence on low-wage labour has reduced,

The change in women's time allocation for managing water has positively affected the household economic situation (coded 1 for "positive change" and 0 for "no change").

All six items were coded so that 1 indicates a favourable poverty/livelihood outcome. The poverty index that we calculated is the unweighted average of these six indicators. A value of 0.7, for example, implies that the household reports gains along roughly four out of the six livelihood channels.

Importantly, the construction of the poverty and livelihood index explicitly incorporates gender-sensitive dimensions, particularly the role of women's time allocation in water management and its economic implications. By including women's time-use changes as one of the six components, the index allows for a direct assessment of how improved water access under JJM translates into livelihood gains for households through reduced drudgery for women and enhanced household economic functioning. This design ensures that poverty reduction effects are not viewed narrowly in income terms but also through pathways that disproportionately affect women.

***D) Health index***

The next objective targets the health and hygiene benefits of improved water access. Eight post-JJM questions were used:

1. Access to safe drinking water has improved
2. Hygiene practices have improved
3. Water-borne diseases have reduced
4. Women and children are now less prone to diseases
5. Child mortality has reduced
6. Complications during pregnancy have reduced
7. Children are now better nourished
8. Post-pregnancy mortality has reduced.

Each item is a 0/1 indicator of perceived improvement. The health index is calculated as the mean of these eight variables. Higher values indicate a broader set of perceived health gains associated with JJM.

The health index is deliberately designed to capture health outcomes that disproportionately affect women and children, such as water-borne diseases, child mortality, maternal health complications, and child nutrition. By focusing on post-JJM perceptions of women's and children's health, the index enables a direct evaluation of whether improved household-level water access contributes to better health and hygiene outcomes for these particularly vulnerable groups.

***E) Gender index***

The final objective focuses on gender-specific impacts, particularly changes in women's time use and decision-making power. Seven questions were used:

1. Since JJM, the availability of clean water for menstrual hygiene for women/girls has improved
2. Time spent on accessing and managing water has reduced
3. Women are now able to work outside the home as wage labourers
4. Women can pursue education or skills development
5. Women can devote more time to childcare and caring responsibilities
6. Women have more time for personal hygiene practices
7. Improved access to water has increased women's decision-making power within households.

The decision-making question originally had three ordered categories ("no change", "yes, to a small extent", "yes, significantly"). For index construction, the ordered categories were coded 1 for any positive change ("small extent" or "significantly") and 0 for "no change". The other items were coded as yes/no, using the same 0/1 scheme as for the health and poverty indices.

The gender index is defined as the average of these seven indicators. Higher values reflect a broader set of perceived improvements in women's time allocation, opportunities, and intra-household bargaining position.

The gender index emphasizes women's well-being, time use, and intra-household agency, thereby enabling the analysis to isolate gender-specific pathways through which JJM may influence broader development outcomes. By focusing on menstrual hygiene, time savings, education, employment, childcare, and decision-making power, the index directly captures dimensions of women's empowerment that are closely linked to improved water access and reduced domestic burdens.

***F) Household asset index***

As a control for pre-existing economic status, an asset index was constructed from household ownership of consumer durables and productive assets. The following 0/1 variables were used:

1. black-and-white television
2. colour/smart television
3. bicycle
4. livestock
5. LPG stove
6. motorcycle
7. refrigerator
8. water pump
9. pesticide/manure spray pump
10. mixer-grinder
11. air-conditioner
12. sewing machine
13. four-wheeler.

Each takes the value 1 if the household owns the asset and 0 otherwise. The asset index is the unweighted mean of these indicators and is interpreted as the proportion of the household's listed assets. This index serves as a proxy for long-run economic status in the regression analysis.

***G) Econometric specification***

Since all three outcome indices are explicitly designed to assess women's and children's welfare, the econometric analysis directly assesses whether JJM coverage is associated with improvements in poverty, health, and gender-related outcomes for these groups. This approach allows the estimated treatment effects to be interpreted not merely as average household-level impacts, but as changes that operate through pathways particularly relevant to women and children.

The main empirical questions were whether households covered under JJM report better outcomes on the three constructed indices, controlling for basic socio-economic characteristics. Because the indices are continuous variables bounded between 0 and 1, ordinary least squares (OLS) regressions with robust standard errors are used.

Let treat_jjm$_i$ be a binary variable equal to 1 if household $i$ has a functional JJM connection and 0 otherwise. Let $X_i$ denote the vector of household covariates: the household head's gender, the respondent's gender, the respondent's age in years, an indicator for having a bank account, and the asset index. Separate regressions are estimated for the three outcome indices.

***H) Poverty regression***

$$\text{poverty\_index}_i = \alpha^P + \beta^P \text{ treat\_jjm}_i + \gamma^P X_i + \varepsilon_i^P.$$

Here $\beta^P$ measures the mean difference in the poverty/livelihood index between JJM and non-JJM households after adjusting for demographic and asset-related covariates.

***I) Health regression***

$$\text{health\_index}_i = \alpha^H + \beta^H \text{ treat\_jjm}_i + \gamma^H X_i + \varepsilon_i^H.$$

The coefficient $\beta^H$ captures the association between JJM coverage and the composite health index, conditional on the same set of controls.

***J) Gender regression***

$$\text{gender\_index}_i = \alpha^G + \beta^G \text{ treat\_jjm}_i + \gamma^G X_i + \varepsilon_i^G.$$

In this specification, $\beta^G$ summarises whether households with JJM connections report systematically higher values of the gender index, and it can be interpreted as improved time allocation and bargaining power for women in comparison with similar households without JJM.

All three models are estimated separately for each district sample to allow for local heterogeneity in programme implementation and socio-economic context.

***K) Robustness: Average Treatment Effect on the Treated (ATT)***

The OLS estimates capture conditional associations. There is a chance these may remain biased due to residual differences between treated and untreated households. To address this concern and assess the robustness of the results, the analysis also estimates the Average Treatment Effect on the Treated (ATT) using an inverse-probability-weighted regression adjustment (IPWRA) estimator. In this framework, two models are specified:

The IPWRA framework involves specifying two models. First, a treatment model for Jal Jeevan Mission (JJM) coverage is estimated using a logit specification, where treatment status is regressed on the same set of covariates. Second, separate outcome models are estimated for each composite index: poverty, health, and gender.

A treatment model for JJM coverage,

$$\Pr(\text{treat\_jjm}_i = 1 \mid X_i) = \Lambda(\delta' X_i),$$

estimated as a logit of treatment on the same covariates $X_i$; and
An outcome model for each index,

$$\mathbb{E}(\text{Index}_{id} \mid \text{treat\_jjm}_i, X_i) = \theta_0^d + \theta_1^d \text{treat\_jjm}_i + \theta^d X_i,$$

Where $d \in \{P, H, G\}$ corresponds to the poverty, health, and gender indices.

IPWRA combines inverse-probability weights derived from the treatment model with regression adjustment in the outcome model, yielding a doubly robust estimator of the ATT. Consistency requires that either the treatment or the outcome model is correctly specified. It reports the ATT for each index as an additional robustness check on the OLS estimate.

Estimating the ATT further strengthens the analysis by examining whether these women- and child-focused outcome measures show consistent improvements among households that actually received JJM connections, thereby reinforcing the credibility of the estimated impacts.

## IV. RESULTS AND DISCUSSION

***A) Preliminary Findings: Descriptive Statistics***

This section presents the primary household-level data collected from tea garden workers of Golaghat district. These focus on the socio-economic characteristics, employment structure, perceptions of water availability, and household-level changes after the implementation of the JJM scheme. These statistics aim to reach a foundational understanding of the sample and to identify emerging patterns relevant for policy reflection and subsequent analysis.

***B) Household Composition and Employment Patterns***

In Golaghat district, households are mostly male-headed. Of the 250 surveyed households in Golaghat, 178 (71.2 per cent) report a male household head, while 72 (28.8 per cent) report a female household head. The district shows a marginally

higher presence of female-headed households, although the overall distribution is essentially comparable across the two districts. This close alignment suggests that the basic household leadership structure in the sampled tea garden communities is consistent across sites. In contrast, the near one-third share of female-headed households in Golaghat remains important to consider when interpreting service access and household-level responses to JJM-related improvements.

**Table 1: Household-head composition by gender**

| | |
|---|---|
| Female | 72 |
| Male | 178 |
| Grand Total | 250 |

***Source:*** *Authors' calculations from primary survey data*

In Golaghat, the employment profile of the working-age population (15–65 years) appears constrained. As reported in Table 2, out of 781 working-age individuals, 383 (49.0 per cent) are employed while 398 (51.0 per cent) are unemployed. This implies that Golaghat shows a slight predominance of unemployment, which is consistent with a relatively tighter local labour market and fewer stable income opportunities within the sampled tea garden settlements.

The gender-disaggregated figures hint towards a persistent, but comparatively less pronounced, inconsistency. Among women in the working-age group **(**N = 366**),** 157 (42.9 per cent) are employed, and 209 (57.1 per cent) are unemployed. Among men **(**N = 415**),** 226 (54.5 per cent) are employed, and 189 (45.5 per cent) are unemployed. The male employment advantage remains clear in Golaghat. In this sense, the district reflects a dual constraint, with women facing weaker employment outcomes and men not exhibiting the relatively high employment rates. This baseline matters for later interpretation, since improvements in household water access can ease time burdens, but the extent to which that translates into economic gains will depend on whether local employment options are actually available.

**Table 2: Employment Statistics by Gender**

| Gender | Employed | Unemployed |
|---|---|---|
| Female | 157 | 209 |
| Male | 226 | 189 |

***Note:*** *Counts of people among working age (15-65 years)*

***C) Livelihood Structure***

In Golaghat as well, livelihoods remain strongly anchored in informal wage labour. As shown in the figure below, labour work accounts for about 79 per cent of the reported main livelihood category, indicating that most households continue to depend on daily wage employment and closely related informal work opportunities. The next most common category is business (13 per cent)**,** which suggests a modest presence of small-scale trading and petty enterprise within the sampled settlements. All remaining categories together form a thin tail: food packaging and manufacturing (2 per cent) and tertiary services (2 per cent) are reported infrequently. In comparison, agriculture and other activities appear to be only marginally significant (around 1 per cent each).

Golaghat shows slightly greater diversification at the margin, mainly through a higher share of households reporting business as their primary source of income. The sources of livelihood are dominated by labour-dependent activities. As a result, households remain economically vulnerable even when basic working conditions improve.

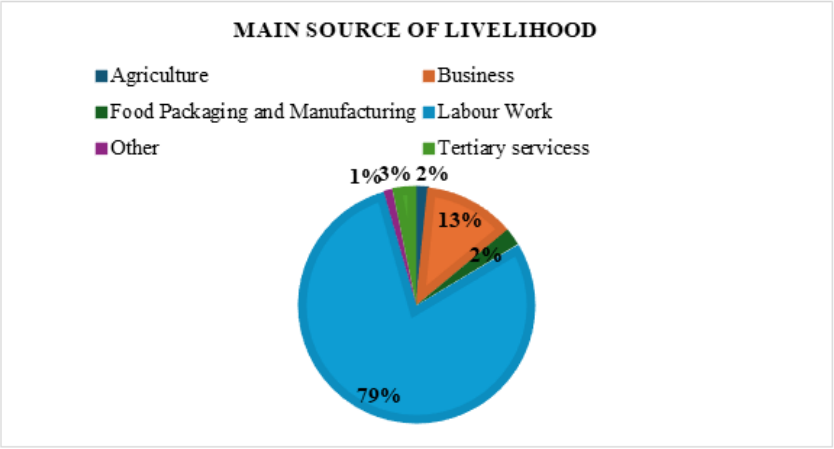


**Figure 1. Details of the Main Source of Livelihood reported by Households**

***D) Income and Expenditure Dynamics: Pre- and Post-JJM***

In Golaghat, the profile of household finances before and after JJM implementation presents a significant pattern. As shown in the table below, the average monthly income of households rose from ₹12,869.75 in the pre-JJM period to ₹ 13,323.53 in thepost-JJM period. On the other hand, average expenditure is virtually unchanged, sticking to ₹13,183 in both periods (Rs. 13,182.97 pre-JJM and Rs. 13,182.98 post-JJM). This suggests that, even when incomes improve slightly, households do not necessarily increase their routine spending in the immediate period, which is plausible in settings where earnings are uncertain. Savings or debt repayment can take priority. The dispersion in expenditure also appears to widen in the post-JJM period. While the maximum pre-JJM expenditure is Rs. 40,000, the maximum post-JJM expenditure rises sharply to Rs. 1,80,000, alongside a lower minimum of Rs. 1,050. Such a jump at the upper end is likely driven by a small number of exceptional observations and should therefore be read cautiously. Golaghat shows a small upward movement in income but a stable expenditure average after the implementation of JJM.

**Table 3: Household Income and Expenditure (INR)**

| | Pre-JJM Income | Post-JJM Income | Pre-JJM Expenditure | Post-JJM Expenditure |
|---|---|---|---|---|
| Minimum | 2000 | 2000 | 2000 | 1050 |
| Maximum | 50000 | 50000 | 40000 | 180000 |
| Average | 12869.75 | 13323.53 | 13182.97 | 13182.98 |

***E) Perceived Changes in Water Access***

Perceptions of water access in Golaghat suggest a clearer tilt towards improvement after JJM than an even split. As shown in the figure below, 143 households reported that the water supply in their locality has improved since the introduction of the scheme, while 107 households reported no improvement. In proportional terms, this corresponds to roughly 57 per cent reporting improvement and about 43 per cent reporting otherwise. The pattern indicates that the scheme is perceived as beneficial by a majority of households in the sampled communities, but it also points to unevenness in the reliability of these improvements across locations.


**Figure 2: Answers by Households on Water-Supply Improvement after JJM Implementation**

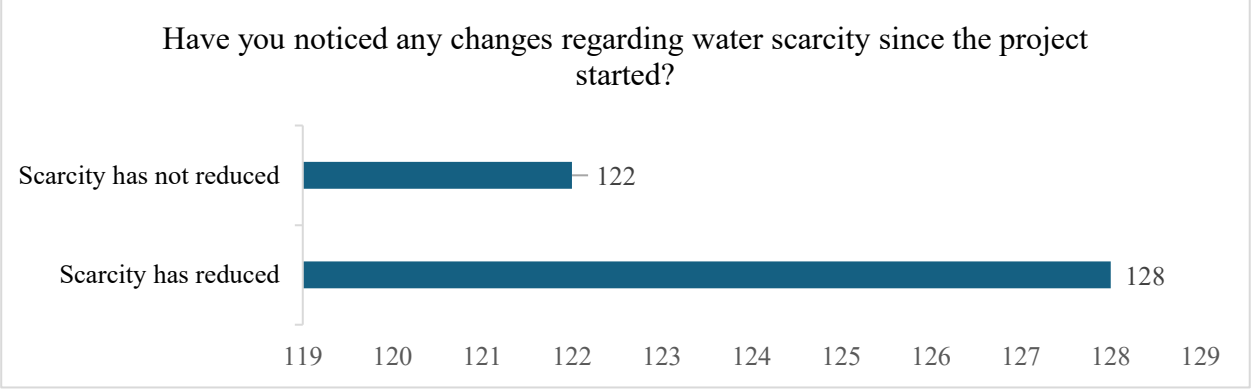


**Figure 3: Answers by Households on Water Scarcity after JJM Implementation**

In Golaghat, perceptions regarding water scarcity after the start of the project are again closely split, but the balance leans slightly towards improvement. As shown in the Figure above, 128 households mentioned that water scarcity has declined. Compared to that, 122 households continue to face water scarcity. It indicates that while some respondents were relieved of water shortage concerns, a significant number of households still face difficulties accessing water. The near-even division indicates that gains in water access are not being felt uniformly across the surveyed localities, and that reliability of supply remains an issue for many households.

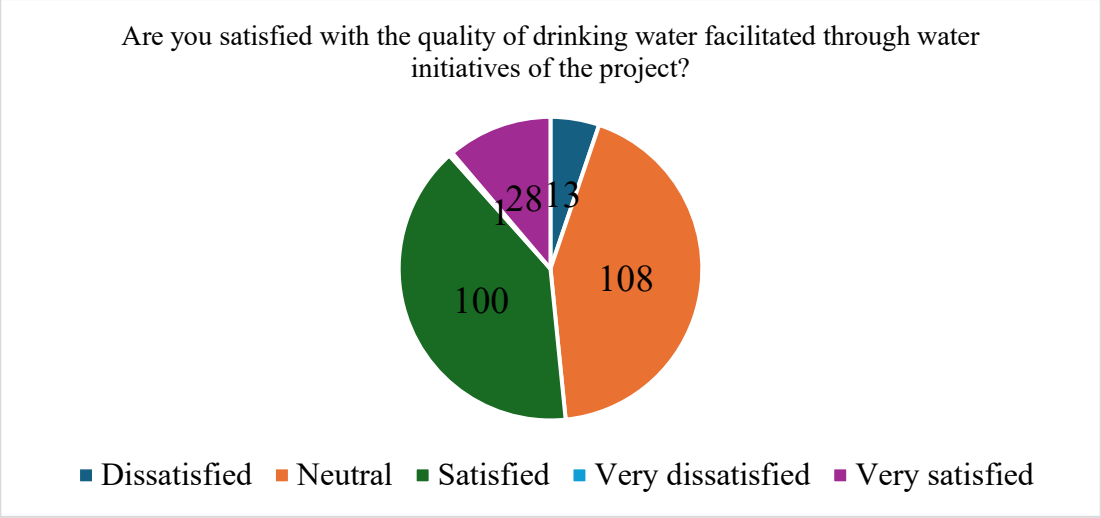


**Figure 4. Answers by Households on drinking water quality**

Responses from Golaghat indicate a broadly mixed but slightly more positive assessment of drinking water quality facilitated through the project. As shown in the figure above, the largest share of households falls in the neutral category (108 responses), followed closely by those who report being satisfied (100 responses). At the positive end, a further 28 households report being very satisfied. Dissatisfaction remains relatively limited, with 13 households reporting dissatisfaction and 1 household reporting being very dissatisfied.

Overall, the distribution suggests that strong discontent about water quality is not widespread, but confidence is also not uniform. The large neutral segment is important because it likely reflects households that have not experienced a consistent enough improvement to form a clear judgment, or those whose experience varies across seasons and days. Therefore, the broader pattern reflects moderate satisfaction, coexisting with a significant share of respondents taking an indecisive stance rather than openly expressing disappointment with the impact of JJM implementation.

***F) Health Outcomes and Hospital Visits***

To examine whether improved water access is associated with changes in self-reported health burdens, respondents in Golaghat were asked about the number of hospital visits in the six months before and after the implementation of JJM. The table below indicates a modest reduction in visits over the post-JJM period. The average number of hospital visits declines from 4.17 before JJM to 3.62 after JJM. The maximum also falls slightly, from 8 to 7, while the minimum remains unchanged at 2 in both periods.

Although these figures cannot be interpreted as causal evidence of a health impact, the direction of change is consistent with the expectation that better access to safer water and improved hygiene practices may reduce common water-related illnesses and associated healthcare seeking. At the same time, the reduction is not large, and the persistence of at least 2 visits suggests that routine illness and other health needs remain even after the scheme's implementation. Overall, the pattern offers a suggestive descriptive signal that can be discussed alongside the broader results in the later analysis section.

**Table 4:** Hospital Visits in Last 6 Months (Before vs After JJM)

| | **Before JJM** | **After JJM** |
|---|---|---|
| Minimum | 2 | 2 |
| Maximum | 8 | 7 |
| Average | 4.17 | 3.62 |

***Source:*** *Authors' calculations from primary survey data*

***G) Regression results***

For the gender index, the estimated association with JJM coverage is positive but borderline**:** the treatment coefficient is 0.047 (robust s.e. = 0.024, p = 0.052). For Golaghat, the evidence is more consistent with modest and statistically weak shifts in the composite gender-related outcomes (time allocation, mobility/work participation, and related dimensions captured in the index).

**Table 5: OLS-Gender**

| | **(1)** |
|---|---|
| VARIABLES | Gender index |
| treat_jjm | 0.047* |
| | (0.024) |
| hh_head_sex_n | 0.067 |
| | (0.030) |
| resp_sex_n | -0.040 |
| | (0.024 |
| resp_age | 0.0075 |
| | (0.0008) |
| bank_acct_n | 0.0696 |
| | (0.049733) |
| asset_index | -0.1593*** |
| | (0.0598) |
| Constant | 0.0625 |
| | (0.0598) |
| Observations | 250 |
| R-squared | 0.0781 |

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The covariates show more structure here than in the poverty regression. Households with a female household head have a higher gender index (0.066, $p$=0.030). In contrast, the asset index **i**s negative and significant **(**−0.159, $p$=0.008), indicating larger reported gains among less asset-rich households, conditional on coverage. Respondent gender is weakly negative ($p$=0.088), while respondent age and bank-account ownership are not significant. Model fit remains limited ($R^2 \approx 0.08$), as expected in this setting.

**Table 6:** ATT-Gender

| | (1) |
|---|---|
| VARIABLES | ATT ,Äì Gender index |
| treat_jjm | 0.057** |
| | (0.024) |
| Z-statistics | 2.36 |
| P value | 0.018 |
| 95% CI lower | 0.010 |
| 95% CI Upper | 0.105 |
| Observations | 250 |

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The IPWRA estimates for Golaghat indicate a positive, statistically significant association between JJM coverage and the gender index among treated households. The estimated ATET is 0.057 (robust s.e. 0.024, $z$ = 2.36, $p$ = 0.018; 95% CI: 0.010 to 0.105), indicating that after reweighting on observables and regression adjustment, covered households score about 5–6 percentage points higher on the 0–1 composite gender outcome than the counterfactual for these same households in the absence of coverage. The estimated treatment effect is markedly smaller, suggesting a more modest shift in reported gender-related gains within the Golaghat sample under the same estimation strategy.

**Table 7:** OLS-Health

| | (1) |
|---|---|
| VARIABLES | Health index |
| treat_jjm | 0.41*** |

| | |
|---|---|
| | (0.041) |
| hh_head_sex_n | 0.111 |
| | (0.057) |
| resp_sex_n | -0.88 |
| | (0.049) |
| resp_age | 0.002 |
| | (0.002) |
| bank_acct_n | -0.0199 |
| | (0.056) |
| asset_index | 0.328* |
| | (0.13) |
| Constant | -0.124 |
| | (0.096) |
| Observations | 250 |
| R-squared | 0.2645 |

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The health index regression shows a strong and precisely estimated association with JJM coverage. The treatment coefficient is 0.410 (robust s.e**.** = 0.041, p < 0.001), indicating a large difference in the 0–1 composite health score between covered and uncovered households after conditioning on covariates. In magnitude, this estimate suggests that the health and hygiene channel is comparatively consistent, even where the poverty and gender indices differ in levels and/or precision.

Among controls, the asset index is positive and significant (0.328, *p*=0.010), and the female household-head indicator is marginal (*p*=0.051). Other covariates, including bank-account ownership, are not statistically significant. The regression explains a non-trivial share of variation ($R^2 \approx = 0.26$).

**Table 8: ATT-Health**

| | (1) |
|---|---|
| VARIABLES | ATT ,Äì Health index |
| | |
| treat_jjm | 0.411** |
| | (0.042) |
| Z-statistics | 2.36 |
| P value | 0.016 |
| 95% CI lower | 0.332 |
| 95% CI Upper | 0.490 |
| Observations | 250 |

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

For the IPWRA health-index results, Golaghat again mirrors the OLS finding. The ATET is 0.411 (s.e. 0.040; *p*<0.01; 95% CI ≈ [0.332, 0.490]), essentially identical to the OLS estimate (0.410). The reported counterfactual mean for untreated (P0mean) is small (≈0.016) and only weakly different from zero, which is not unusual with bounded, composite indices that have substantial mass at zero; it simply reflects that many households report no improvement on the constituent items absent effective coverage. In that setting, the interpretation is straightforward: the IPWRA estimator implies a large shift from near-zero perceived health gains to a markedly higher health–hygiene profile among households receiving JJM water, and the close agreement with OLS strengthens the robustness of the inference.

**Table 9: OLS- Poverty**

| | (1) |
|---|---|
| VARIABLES | Poverty index |
| treat_jjm | 0.095*** |
| | (0.022) |
| hh_head_sex_n | 0.015 |
| | (0.025) |
| resp_sex_n | -0.022 |
| | (0.023) |
| resp_age | 0.001 |
| | (0.001) |

| | |
|---|---|
| bank_acct_n | -0.154 |
| | (0.142) |
| asset_index | 0.103** |
| | (0.052) |
| Constant | 0.106 |
| | (0.136) |
| Observations | 250 |
| R-squared | 0.097 |

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

In the Golaghat sample, JJM coverage is positively and precisely associated with the composite poverty index. The estimated coefficient on the treatment indicator is 0.095 (robust s.e. = 0.022, p < 0.001), implying a sizeable difference in the 0–1 index between covered and uncovered households, conditional on the included covariates. The point estimate is larger in magnitude, though the substantive interpretation remains the same: reported improvements in income and livelihood-related outcomes are higher among covered households.

Among the controls, the asset index enters positively and is marginally significant (0.103, $p$=0.049), while the demographic covariates and bank-account dummy are not statistically distinguishable from zero in this specification. Overall fit is modest ($R^2 \approx 0.10$), consistent with cross-sectional regressions on perception-based indices, but the joint significance of regressors is supported (model $p$=0.0006).

***H) Robustness check: Extensive-margin specification***

**Table 10:** OLS-Poverty-Robustness

| | (1) |
|---|---|
| VARIABLES | Poverty index_Robustness |
| treat_jjm | 0.196*** |
| | (0.038) |
| hh_head_sex_n | 0.110** |
| | (0.054) |
| resp_sex_n | -0.051 |
| | (0.045) |
| resp_age | 0.002 |
| | (0.002) |
| bank_acct_n | -0.106 |
| | (0.130) |
| asset_index | 0.195 |
| | (0.118) |
| Constant | -0.015 |
| | (0.142) |
| Observations | 239 |
| R-squared | 0.119 |

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

As an additional robustness exercise tailored to the bounded, heavily zero-mass distribution of the poverty–livelihood index in Golaghat, we re-estimate programme associations using an extensive-margin outcome. Specifically, we define an indicator. $P_i^+ = 1\{\text{poverty\_index}_i > 0\}$, which equals one if the household reports any positive change on the poverty index and zero otherwise. We then estimate the effect of JJM coverage on $P_i^+$using (i) a linear probability model with heteroskedasticity-robust standard errors and the same covariate set as in the main specifications, and (ii) an IPWRA estimator targeting the ATET.

We implement this check for the poverty index only because its distribution in Golaghat is markedly concentrated at zero, making an "any improvement" formulation empirically informative and directly aligned with the data-generating pattern.

**Table 11: ATT-Poverty**

| | (1) |
|---|---|
| VARIABLES | ATT ,Äì Poverty index |
| treat_jjm | 0.087*** |
| | (0.018) |

| | |
|---|---|
| Z-statistics | 4.47** |
| P value | 0.007 |
| 95% CI lower | 0.123 |
| 95% CI Upper | 0.490 |
| Observations | 250 |

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The IPWRA estimates for Golaghat indicate a positive and precisely estimated average treatment effect on the treated (ATET) of 0.087 on the poverty index (robust s.e. 0.018, $z = 4.74$, $p < 0.01$; 95% CI [0.051, 0.123]**).** Given the 0–1 scaling, this corresponds to an increase of roughly 8.7 percentage points in the composite poverty–livelihood score for JJM-connected households, relative to their estimated counterfactual outcome under non-coverage. The estimated counterfactual mean for the treated group under no treatment (P0mean) is 0.006. It is not statistically different from zero, which is consistent with the heavy mass at zero observed in the Golaghat poverty index distribution.

Relative to the Golaghat OLS coefficient **(**0.095**),** the IPWRA estimate is slightly smaller but of the same order, suggesting that the main association is not being driven by differences in observed covariates between covered and uncovered households.

**Table 12: ATT-Poverty-Robustness**

| | (1) |
|---|---|
| VARIABLES | ATT ,Äì Poverty index |
| treat_jjm | 0.197*** |
| | (0.037) |
| Z-statistics | 5.33 |
| P value | 0.00 |
| 95% CI lower | 0.1242 |
| 95% CI Upper | 0.2689 |
| Observations | 250 |

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

These specifications recode the poverty index composite as a binary outcome, equal to one if the household reports any improvement on the underlying index. Using a linear probability model with robust standard errors, JJM coverage is associated with a 0.196 increase in the probability of reporting any poverty–livelihood gain (s.e. 0.038), implying about a 20 percentage-point higher likelihood among covered households, conditional on the same covariates. Among the controls, female-headed households show a slightly higher probability of reporting improvement (coefficient 0.110), while respondent characteristics and bank account ownership are not statistically significant.

The IPWRA ATET estimates closely mirror the LPM results. After reweighting households by their probability of coverage and applying regression adjustment to the treated group, the estimated ATET of JJM coverage is 0.197 (robust s.e. 0.037; 95% CI …). The similarity of estimates across the two methods suggests that the positive association between JJM coverage and poverty–livelihood improvement is robust and not driven by observable differences between treated and untreated households.

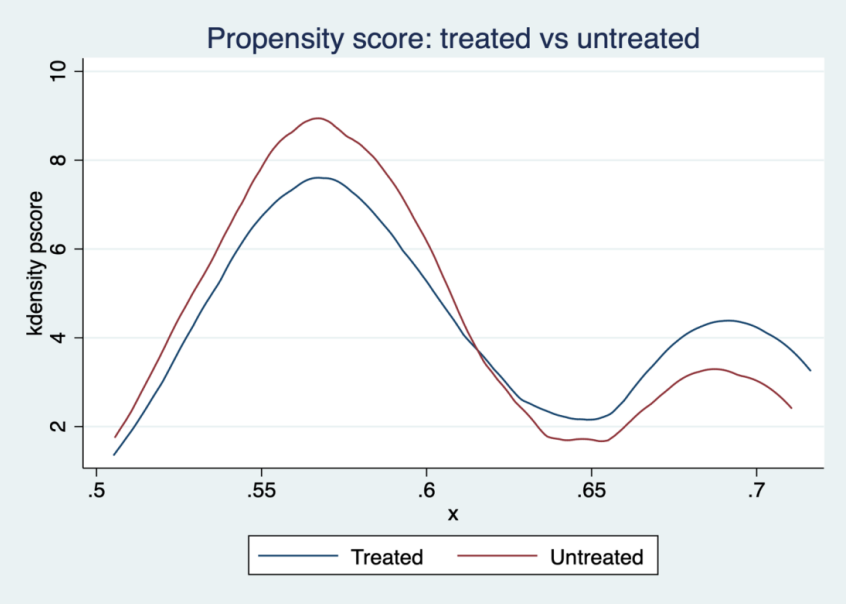


**Figure 5. Propensity Score Graph (kernel Density): Golaghat district**

For the Golaghat propensity-score plot, the kernel densities indicate substantial common support between treated and untreated households over roughly 0.51–0.71. The distribution is bimodal for both groups, with a dominant mass around 0.56–0.59 and a secondary hump near 0.68–0.71. Compared with the untreated group, treated households appear slightly more concentrated in the upper-propensity region (the right-hand mode is higher for treated households). In contrast, untreated households show a sharper peak around the main mode. Importantly, there is no portion of the support in which one group effectively disappears, so the overlap appears adequate for IPWRA inference in Golaghat. The relevant support lies in a lower, wider propensity-score range and exhibits clearer bimodality, suggesting more pronounced stratification in treatment assignment along observed covariates.

Households with and without the programme look quite similar in terms of their likelihood of being covered. Most households in both groups fall within the same range, indicating good comparability between them. There are two clusters of households, but both treated and untreated households appear in each cluster. Households that received the programme are slightly more common in the higher-likelihood group, while those without the programme are more concentrated in the main group. Overall, neither group is missing from any part of the range, so the comparison is reliable. Golaghat shows a wider spread and clearer grouping of households, suggesting that programme coverage varies more clearly with household characteristics.

## V. PERCEIVED DETERMINANTS OF JJM EFFECTIVENESS- EVIDENCE FROM FIELD SURVEYS

This chapter examines how households in tea garden communities themselves define “effective” implementation of the Jal Jeevan Mission (JJM). While the earlier chapters assessed outcomes and impacts using quantitative methods and econometric comparisons, the present discussion shifts attention to respondent perceptions gathered during fieldwork. The survey instrument included open-ended prompts that invited households to identify what, in their view, enables a scheme like JJM to function reliably in everyday life, and what should be improved when the service falls short of expectations. These responses are valuable because they capture practical constraints and local priorities that are not always visible in administrative indicators or standard outcome measures. The objective is not to make causal claims, but to document recurring themes that can inform interpretation of the quantitative results and guide policy reflection on service delivery, maintenance, and community engagement in tea garden settings.

**Table 13: Factors Perceived as Important for Effective Implementation of JJM (Multiple Response)**

| Factor | Yes (n) | Yes (%) | Total (N) |
|---|---|---|---|
| Community participation | 245 | 98.0 | 250 |
| Behavioural change | 245 | 98.0 | 250 |
| Gender and social inclusion | 212 | 84.8 | 250 |
| Local cultural norms | 0 | 0.0 | 250 |
| Others | 0 | 0.0 | 250 |

***Note:*** *Denominator is the full sample (N = 250). Totals exceed 100 percent because households could select more than one factor.*

In Golaghat, responses again emphasise participation and behavioural dimensions, with both community participation and behavioural change selected by 98.0% of households. A notable distinction is the salience of gender and social inclusion, which was selected by 84.8% of households, indicating that respondents in this district more frequently link "effective implementation" with whether delivery and access are inclusive within the settlement. Local cultural norms and "other" categories were not selected, reinforcing that households tend to frame effectiveness through service delivery, governance, and community-level arrangements rather than through culturally specific barriers.

**Table 14: Themes from Open-Ended Suggestions for Improving JJM Implementation**

| Theme | Mentioned (n) | Households (%) |
|---|---|---|
| Regularity and duration of supply | 40 | 16.0 |
| Governance and accountability | 29 | 11.6 |
| Increase quantity/pressure | 28 | 11.2 |
| Improve water quality and filtration | 27 | 10.8 |
| Coverage/connection and infrastructure expansion | 11 | 4.4 |
| Maintenance, repair, and functionality | 10 | 4.0 |

***Note:*** *Themes are coded from households' open-ended suggestions using a simple keyword-based scheme. "Mentioned (n)" reports the number of households whose response maps to a given theme at least once. "Households (%)" is computed using the full sample as the denominator (N = 250). Percentages need not sum to 100 because a single response may be assigned to more than one theme.*

The open-ended suggestions reinforce these priorities while highlighting operational bottlenecks. The most frequently coded themes relate to regularity and duration of supply, governance and accountability, and improvements in quantity or pressure, alongside repeated references to water quality and filtration. The keyword-frequency plot mirrors this pattern: words such as "increase," "government," "quantity," and terms related to cleaning, filtration, and maintenance appear prominently, suggesting that reliability depends on responsive local administration and routine upkeep, not merely on the initial installation of connections. These responses should be read as descriptive evidence of local priorities and constraints; they indicate where households feel implementation is failing or fragile, rather than establishing causal drivers of outcomes.

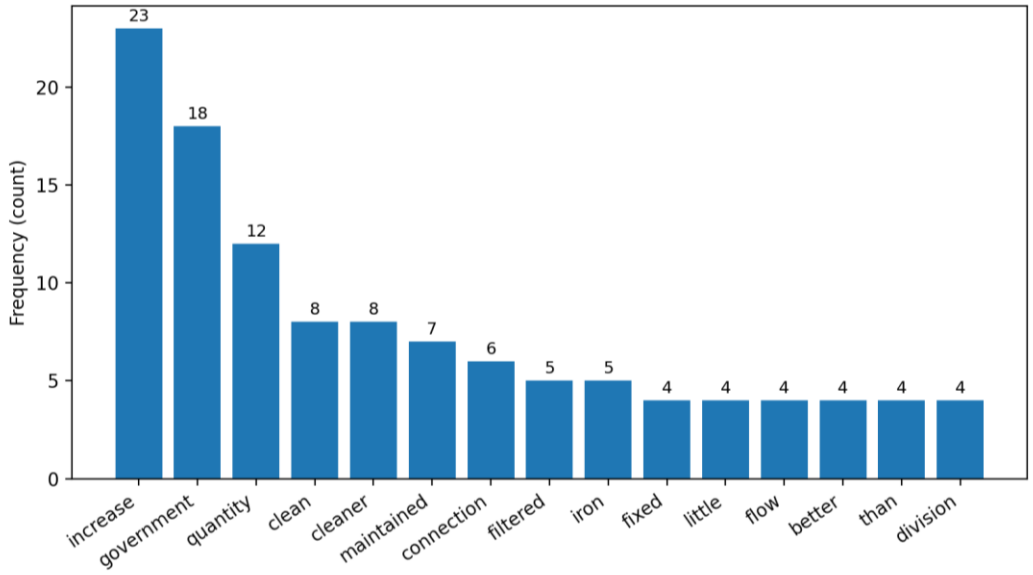


**Figure 6: Most Frequent Keywords in Open-Ended Suggestions (Cleaned Text)**

***Note:*** *Keywords are computed from open-ended responses after basic text cleaning (for example, converting to lower case and removing common stop-words and punctuation). Bars report raw keyword frequencies in the cleaned text and are intended to summarise recurring concerns expressed in the suggestions.*

## VI. CONCLUSION

This study assessed how the Jal Jeevan Mission (JJM) is shaping everyday life in tea garden settlements of Upper Assam, with specific attention to poverty and livelihoods, health and hygiene, and gendered outcomes for women and children.

Tea garden communities occupy a distinctive institutional and socio-economic setting. They carry long-standing deficits in public provisioning and face persistent exposure to unsafe and unreliable water sources. In such contexts, the developmental meaning of a tap connection lies not in the physical presence of infrastructure alone, but in whether it delivers regular, adequate, and safe water that households can use reliably. This study, therefore, approached JJM not only as an engineering intervention but also as a welfare programme whose effectiveness is realised through service quality, functionality, and local governance arrangements.

The empirical analysis was grounded in field survey evidence collected from Golaghat. The district sample consisted of 250 households from tea estates where both covered and uncovered households coexist. This study combined descriptive profiling with econometric analysis using covariate-adjusted regressions and inverse-probability-weighted regression adjustment (IPWRA). This dual strategy strengthened the credibility of inference by addressing observable differences between covered and uncovered households. While the study does not claim experimental identification, the alignment between regression estimates and doubly robust IPWRA estimates provides a consistent basis for interpreting early programme associations in these settlements.

To organise outcomes across multiple dimensions, the study constructed three composite indices, each scaled from 0 to 1. The poverty–livelihood index reflected perceived improvements in income, livelihood stability, and diversification, as well as whether time saved from water collection was redirected toward productive activity. The health index summarised self-reported improvements in safe water practices, hygiene routines, maternal and child health conditions, and experiences with waterborne disease. The gender index captured women's time use, privacy, and menstrual hygiene, childcare and hygiene practices, and women's participation in selected household decisions. This index-based approach was appropriate for plantation settings, where improvements are often incremental and multidimensional, and not easily captured by a single indicator.

Several implications follow from the combined quantitative and qualitative evidence. First, monitoring frameworks should move beyond connection counts toward measures of functionality that capture household experience. Indicators such as daily hours of supply, adequacy of pressure, repair response time, and frequency of breakdowns align closely with the dimensions households themselves use to evaluate effectiveness. Second, operation and maintenance systems require sustained institutional attention in tea garden settlements, where responsibility may be fragmented and where the long-run performance of infrastructure depends on routine upkeep. Third, this study's perception evidence indicates that households view programme success as dependent on social mobilisation and everyday practice. Behaviour change communication, water literacy, and transparent community engagement, therefore, remain essential complements to infrastructure expansion. Fourth, district variation in outcomes implies that the implementation strategy should be locally tailored. Where concerns centre on governance and accountability, as in Golaghat, responsiveness and grievance redress mechanisms merit emphasis.

In conclusion, this study presents a district-level account of JJM's early welfare implications in tea garden communities. Where connections translate into reliable service, as the evidence indicates in Golaghat, households report great improvements in health and hygiene. The central message is therefore not only that JJM matters in tea garden settlements, but that its ability to improve well-being depends on shifting from coverage to consistent functionality. Sustained attention to service reliability, maintenance systems, inclusive access, and community engagement is necessary if tap connections are to deliver their full potential for health, livelihoods, and gender equity in plantation regions.

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## Appendix 1

**Funding**
The author(s) gratefully acknowledge the financial support provided by the Indian Council of Social Science Research(ICSSR), New Delhi, for funding the study on which this paper is based. The funding was sanctioned vide section order no. [45/2024-25/JJM/GEN/RP/ICSSR]. The views expressed in this paper are those of the author(s)and do not necessarily reflect those of ICSSR.

**Acknowledgement**
The authors acknowledge all the participants for their participation and valuable responses to the questionnaire. They also acknowledge the support and cooperation of the local stakeholders during the field survey. The cooperation extended by the tea garden authorities is gratefully acknowledged. The authors further express their gratitude to the administration and the Department of Economics at Dibrugarh University for their continuous support throughout the study. The authors also acknowledge the Indian Council of Social Science Research (ICSSR) for providing financial support for this study.

**Conflict of Interest**
The author(s) declare that there is no conflict of interest.

**Ethical considerations**
We clearly informed the participants about the objectives and purposes of the study prior to the survey. The participation was completely voluntary. We assured the participants that the information gathered through the survey will be used solely for academic and research purposes. Confidentiality of the responses was maintained strictly.