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Supply – Demand Dynamics of Community Water Governance of Rural Drinking Water Systems in Kerala, India

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ABSTRACT

Water scarcity is a significant issue for the development sector, especially in developing nations even with high rainfall. Kerala paradoxically faces severe drinking water shortages, particularly during non-monsoon seasons, despite being regarded as a water-rich state with adequate rainfall and water resources. Through an empirical analysis of the water management situation of the Jalanidhi project implemented in Vallathol Nagar Grama Panchayat in Thrissur district of Kerala, this article looked at water management through supply or demand. The Jalanidhi is a community-managed rural water supply initiative funded by the World Bank that aims to replace the centralised water supply approach with demand driven water governance.

Both primary and secondary data were used to examine household water consumption patterns, water sources, supply adequacy, and beneficiary satisfaction. Primary data were collected from 60 beneficiary households across selected wards using structured questionnaires, while secondary data were collected from government reports, academic literature, and policy documents. Statistical tools such as percentage analysis, descriptive statistics, and ANOVA were used to interpret the data.

The results show a persistent gap between water supply and demand, particularly during the summer months, even though the Jalanidhi project has greatly improved access to safe drinking water and decreased reliance on unreliable traditional sources. Indicating socioeconomic disparities in use, water consumption rises with household size and income. The frequency of supply is still restricted, despite recipients' high levels of satisfaction with water quality and service duration. The study comes to the conclusion that although the Jalanidhi project has increased community involvement and water security, long-term sustainability necessitates increased water resource protection, more frequent water supply, and integration with more comprehensive water conservation strategies.

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1. Introduction

Water is a critical natural resource essential for human survival, economic development, and ecological balance. However, achieving sustainable development policies that ensure access to safe drinking water remains a major challenge in rural areas of the Global South, where water insecurity is persistent due to population growth, climate change, and other institutional constraints (Bakker, 2013; UN-Water, 2019).

Globally, per capita water consumption ranges from 50 to 300 liters per day, while in India, per capita water availability has declined from approximately 1,544 cubic meters to 1,486 cubic meters by 2021 (MOSPI, 2021). In India, the average daily domestic water consumption in urban areas is 135 lpcd (litres per capita per day) and in rural areas 55 lpcd. But in Kerala, which is home to 44 rivers, the per capita water availability is estimated at around 1,044 cubic metres which is lower than the national average, placing the state in the category of water-scarce areas (KSPB, 2024). Although governments at the national and state levels implementing several major water infrastructure projects, many rural communities continue to face difficulties not only in terms of availability but also in terms of adequacy, reliability, and long-term sustainability of water supply (Word Bank, 2017).

Water scarcity in Kerala, even with more than 3,000 mm of annual rainfall, is a socially constructed phenomenon through governance, institutional arrangements, and consumption patterns rather than physical phenomenon (Santha & Sasidevan, 2018). Moreover, the unique topography of the state with a steep slopes and small river valleys flows the rain water quickly in to Arabian sea results limitations to ground water recharge. The deforestation, sand mining, wetland loss, and increasing domestic demand are the other leading factors causing the declining groundwater levels and uneven water distribution (Govind, 2022).

These problems have triggered a progressive policy movement away from centralized, distribution-based water delivery schemes to a decentralized, community-controlled governance systems. Such techniques are founded on the idea that local engagement improves efficiency, accountability, and responsiveness to user requirements (Ostrom, 1990). In the water sector, community-based management has been promoted as a solution to the limits of state-led service, particularly in rural and peri-urban areas (Caster, 2011).

The state of Kerala has 44 rivers, vast backwaters and lakes. However, the absence of major rivers and rapid flow patterns based on topography limit the water storage. According to NSSO statistics, Kerala has one of the lowest proportions of households with access to improved

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drinking water sources, particularly in rural areas of the state. Following the 73rd and 74th constitutional amendments, as part of the broader decentralization reforms, the *Jalanidhi* project was implemented by the Kerala Rural Water Supply and Sanitation Agency (KRWSA). This scheme works on the basis of the concept of demand responsiveness, cost sharing, and community ownership. Under this scheme, beneficiaries contribute 10 per cent of the project cost while the state government and local bodies contribute 75 per cent and 15 per cent respectively. Beneficiary communities are involved in the planning, financing, operation and maintenance of this project reflecting the principles of participatory development and decentralised governance.

Water consumption, particularly demand and supply studies, in India show that water demand is growing quickly while supply is shrinked. The water demand is growing due to population growth, rising incomes, and changes in lifestyle. In the meantime, supply is limited by seasonal rainfall and problems with infrastructure (Bhat, 2014; Bhowmick, 2024). Climate change is also exacerbating the water stress. The rise in temperature in India is expected to face significant mismatches between demand and supply of water (Chacko, 2025). Under this scenario, to ensure equitable access to safe drinking water as a policy priority, Government of Kerala, with support from the World Bank, launched the *Jalanidhi project* in 2000 as a decentralized, community-based rural water supply and sanitation initiative. Jalanidhi is a community-led project that emphasizes community ownership, cost-sharing, and local management of water resources. The project shifts responsibility to local communities that have emerged to address gaps in centralized water supply (Govind, 2019). Studies by Sandra and James (2020) show that the Jalanidhi project has significantly improved access to piped water in rural areas facing water scarcity. This has particularly helped BPL and marginalized households. Despite this, concerns remain about water sustainability, quality, and community empowerment (Priya et al., 2016).

This study evaluates the effectiveness of the *Jalanidhi* project in meeting household-level water demand and supply in Vallathol Nagar Grama Panchayat, an area experiencing seasonal water stress.

2. Statement of the Problem

Kerala has a lot of surface and groundwater resources, yet rural communities still have trouble getting clean, sufficient drinking water. Water shortage in summer made worse by a heavy dependence on wells, deteriorating groundwater levels, contaminants, and infrastructural problems. Due to its proximity to forest, Vallathol Nagar Grama Panchayat suffers additional ecological difficulties. Groundwater supply is further diminished by the spread of water-intensive tree species like acacia. During the summer, conventional water sources like borewells and open wells dry up. Households are compelled to rely significantly on piped water systems

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such as Jalanidhi. However, the supply is sometimes restricted to a few days each week, which raises questions regarding sustainability and appropriateness.

Several studies on performance of the *Jalanidhi* project show their improvements in water access, service quality, and customer happiness. However, household-level supply and demand dynamics and the socio-economic variables affecting water use in community-managed systems have received less attention (Babu, 2009; Sandra & James, 2020; Govind, 2022). In particular, little research has been done on how the sustainability of decentralized rural water delivery systems is affected by rising household demand brought on by rising incomes and shifting consumption patterns. This article fills the gap by examining the supply and demand elements of drinking water management, supply features, importance of decentralised water governance, demand driven service delivery and sustainable rural water security of the *Jalanidhi* project in Vallathol Nagar Grama Panchayat, Thrissur district, Kerala.

3. Materials and Methods

Study Area

The study was conducted in Vallathol Nagar Grama Panchayat, Thrissur district, Kerala. The panchayat is located in an area rich in rural settlements, high terrain, and forested areas. The panchayat was selected for the study because it was an early beneficiary of the Jalanidhi project and because it represents the real situation of rural water scarcity in central Kerala despite significant rainfall.

Research Design

The study adopted a descriptive and analytical research design to examine the demand and supply of household-level drinking water under a community-managed water supply system. Both Quantitative and qualitative data were employed to assess the water use patterns, supply characteristics, and beneficiary perceptions of the *Jalanidhi* Project.

Sampling and Data Collection

Primary data were collected from 60 beneficiary households selected through simple random sampling from different wards of Vallathol Nagar Grama Panchayat. Data collection was done using a structured questionnaire conducted through household interviews. The questionnaire included information on socio-economic characteristics, sources of drinking water, household water consumption by activity, frequency and duration of water supply, storage methods, and level of satisfaction with the Jalanidhi scheme.

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Secondary data were obtained from government publications, reports of the Kerala State Planning Board, documents of the Kerala Rural Water Supply and Sanitation Agency, National Sample Survey Office reports, and peer-reviewed academic literature.

Variables and Measures

Domestic water requirement was measured as the estimated daily volume of water used for drinking, cooking, bathing, washing clothes, washing dishes, cleaning the house, and gardening. Water supply variables included supply frequency, duration of supply, storage capacity, and perceived adequacy. Socio-economic variables such as income, education, and occupation were used to examine variations in water consumption.

Analysis Methods

Descriptive statistics were used to summarize household characteristics, water demand, and supply patterns. Analysis of variance (ANOVA) was employed to test the significant differences in total household water consumption based on income. The analysis focused on identifying broad patterns and relationships rather than predictive modelling, consistent with the exploratory objectives of the study.

4. Results and Discussion

The study results focus on socio-economic characteristics, household water demand patterns, supply adequacy, and the effectiveness of the *Jalanidhi* project in addressing water scarcity in the study area. The results are interpreted in light of the existing literature and regional water management challenges.

4.1 Socio-Economic Profile of Respondents

The socio-economic characteristics of respondents play a critical role in shaping household water demand and consumption behaviours. Table 1 presents a consolidated profile of the households surveyed.

Table 1: Socio-Economic Characteristics of Respondents (n = 60)

Variable	Dominant Category	Percentage (%)
Gender	Male	65
Age Group	Above 60 years	31.7
Social Category	OBC	53.3
Family Type	Nuclear	100

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Education	SSLC and below	78.3
Occupation	Self-employed	83.3
Monthly Income	₹30,000–₹50,000	61.7
Ration Card	BPL	76.7

Source: Primary data

The project in the study area disburses their water services mainly to economically and socially vulnerable households, particularly BPL households and OBC communities. The most households were from nuclear families and relied on self-employment for their livelihood (Table 1). The educational attainment was to limited formal education suggest a moderate awareness of water conservation practices. This suggests a high-level dependency of public water supply schemes. Similar socio-economic profiles have been observed in earlier studies on *Jalanidhi* beneficiaries, highlighting the project's pro-poor targeting approach (Sandra & James, 2020; Govind, 2022).

4.2 Sources of Water and Dependence on *Jalanidhi*

All households surveyed had access to piped water through Jalanidhi and Jal Jeevan Mission schemes. However, a significant proportion of households still rely on private wells and tubewells. As shown in Table 2, households in the study area rely on multiple water sources. It is clear that much reliance on multiple water sources is part of the distribution and household strategies for obtaining water during periods of scarce and uncertain drinking water supply.

Table 2: Household Sources of Water

Water Source	Households (%)
Jalanidhi Pipeline	100
Jal Jeevan Mission	100
Own Well	76.7
Borewell	35
Public Tap	0

Source: Primary data

Moreover, the absence of public taps in the study area shown in Table 2 indicates a transition from community shared to household-level water access, which is consistent with Kerala model of decentralized water governance. However, dependence on groundwater sources like borewell

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and own well during the summer months raises concerns regarding sustainability, which are similar to the findings of Mannesh (2015) and Govind (2022).

4.3 Household Water Demand Patterns

Water consumption variations were observed across households in terms of size of house and income levels. The mean daily household water consumption was estimated to be 288 litres. Daily water uses for bathing accounts the largest share followed by cloth washing, and dish washing (Table 3).

Table 3: Mean Household Water Demand by Use (Litres/Day)

Use Category	Mean (L)	Std. Deviation
Drinking	11.67	4.21
Cooking	20.22	7.73
Bathing	148.83	40.09
Cloth Washing	55.33	21.82
Dish Washing	25.33	9.65
House Cleaning	28.17	7.97
Gardening	6.85	4.86
Total Demand	288.12	88.29

Source: Primary survey

Bathing has become the most water-intensive activity, accounting for more than 50% of the total household water requirement. While comparatively less water is used for cooking and drinking. This pattern is consistent with the findings of other studies in Kerala, where lifestyle factors and climatic conditions significantly influence water use (Prajapati e al., 2025). The relatively high level of variations in consumption patterns, suggesting potential for demand-side management and water conservation interventions.

4.4 Income and Water Consumption

Analysis of Variance (ANOVA) and descriptive analysis revealed a significant relationship between household income and total water consumption pattern.

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Table 4: Mean Total Water Consumption by Income Group

Monthly Income (₹)	Mean Water Use (L/day)
10,000–30,000	238
30,001–50,000	304
50,001–80,000	349
Above 80,000	384

Source: Primary survey

Average daily water use increased significantly with income, with higher-income households using significantly more water than lower-income households, especially for bathing, washing vehicles, and gardening.

Table 5: ANOVA Table

			Sum of Squares	df	Mean Square	F	p value
Use of Water and Monthly income	Between Groups	(Combined)	120213.933	3	40071.311	6.605	.001
		Linearity	118842.047	1	118842.047	19.590	.000
		Deviation from Linearity	1371.886	2	685.943	.113	.893
	Within Groups		339720.250	56	6066.433		
	Total		459934.183	59			

Source: computed

The ANOVA results reveal a significant relationship between water usage and monthly income, with an F-statistic of 6.605 (p = 0.001). The linearity test confirms a strong linear trend (F = 19.590, p = 0.000), indicating that water consumption increases with rising income levels (Table 5). The deviation from linearity is not significant (F = 0.113, p = 0.893), suggesting that the relationship is adequately described by a linear model. These findings imply that as income increases, households tend to consume more water, likely due to increased usage in various activities. The results highlight the importance of considering income levels in understanding water consumption patterns and developing targeted water conservation strategies. This finding

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supports earlier studies indicating that economic capacity leads to higher per capita water use (Bhat, 2019; Bhowmick, 2024).

4.5 Water Supply Adequacy under the Jalanidhi Project

The water supply effectiveness under jalanidhi project was characterised by limited supply frequency and predictable duration (Table 6).

Table 6: Water Supply Characteristics of Jalanidhi

Indicator	Dominant Response	Percentage (%)
Supply Frequency	1–2 days/week	81.7
Supply Duration	3–4 hours	100
Tank Capacity	1000 litres	70
Tank Filling	Once per day	98.3

Source: Primary survey

Although the supply period is uniform and unpredictable, most homes receive one to two days per week, with each supply cycle of water lasting three to four hours. The universal reliance on storage tanks, with an average tank capacity of 1000 litres per household, to meet intermittent availability reflects the adaptation strategies of households, but also indicates the limitations of infrastructure of the project. Similar supply constraints have been reported in other Jalanidhi-implemented regions (KSPB 2019).

4.6 Household Satisfaction and Perceived Effectiveness

The high satisfaction level reflects the success of the scheme in providing safe and affordable drinking water. The affordable tariff structure (₹100–200 per month) and community-managed maintenance increase acceptance, especially among BPL households. However, 81.7% of respondents reported that partial sufficiency during the summer months, indicating that satisfaction does not equate to adequate water supply (Table 7). This paradox has been noted in participatory water schemes, where users value reliability and quality despite limited quantities (Babu, 2009).

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Table 7: Satisfaction with *Jalanidhi* Water Supply

Parameter	Positive Response	Percentage
Water Quality	Excellent/Good	86
Quantity on Supply	Days	82
Bill	Affordability	100
Overall Project Rating	Excellent/Good	83

Source: Primary Survey

5. Discussion

The findings show that rural residents in Vallathol Nagar Grama Panchayat have improved access to safe and affordable drinking water in the Jalanidhi project initiative. According to previous evaluations of decentralized water supply initiatives in Kerala, high levels of satisfaction with water quality and service reliability underline the effectiveness of community managed water governance systems in addressing long standing deficiencies associated with centralized water provision (Govind, 2019; Sandra & James, 2020).

The results also revealed a persistent imbalance between supply and demand. The combination of existing water supplies, limited infrastructure, and growing water demand puts significant pressure on the project. In addition, higher-income households often use more water, especially for water-intensive activities, as evidenced by a statistically significant relationship between income and water use. This result is consistent with more extensive data on the income elasticity of household water demand in India, where consumption increases with economic capacity in the absence of strong demand-management measures (Bhat, 2019; Bhowmik, 2024).

From a water governance standpoint, the Jalanidhi scheme is consistent with demand-driven and decentralized development approaches that prioritize user ownership, community manged accountability, and local participation (Ostrom, 1990). However, critical research on water governance caveat that decentralization can switch accountability to local communities without adequately addressing ecological restrictions or limiting demand, which might produce the emergence of new forms of inequality and sustainability stress (Bakker, 2013; Babu, 2009). These constraints are illustrated by recipient household's cyclical deficiency and ongoing reliance on groundwater supplies.

The findings indicate that although community managed water delivery plans enhance access and service quality, they are unable by themselves to guarantee long-term water security.

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Sustainable results demand the incorporation of comprehensive water resource management techniques, comprehensively cover source protection, groundwater recharge, and demand side measures. In the absence of such measures, decentralized systems are likely to face heightened strain when socio-economic conditions and consumption patterns change, especially during climate instability (World Bank, 2017; KSPB, 2024).

6. Conclusion

The research found that *Jalanidhi* project initiative improved the access, water quality and community involvement, and that it demonstrates the successful decentralised approach for rural water provision in Kerala. However, the problem of not having enough water is still persisted. A comprehensive strategy that incorporates demand management, ecological preservation, infrastructure development, and policy integration is needed to address the growing demand–supply gap. In order to maintain community-managed water supply systems in the face of demographic and climate pressures, it is imperative that local governance be strengthened and that ongoing technical and financial support be provided.

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