



Feasibility Study of a Community-Based Clean Water Distribution System in Galiukir Indigenous Village, Bali

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Abstract. Access to reliable clean water remains a major challenge in rural hilly areas where distribution performance is strongly affected by elevation difference, long transmission pipelines, limited source discharge, and pump capacity. This study evaluates the feasibility of the existing community-based clean water distribution system in Galiukir Indigenous Village, Bali. Field observation was conducted by identifying the existing pump specification, reservoir dimensions, transmission pipeline length, elevation difference, pipe pressure requirement, and water source discharge. The existing system uses a SHIMGE BLT16-8 vertical multistage centrifugal pump with an estimated head of approximately 80 m based on pump model identification and available manufacturer specifications. Since direct pump performance testing was not conducted, this value is treated as an estimated parameter for feasibility assessment. However, the elevation difference between the lower reservoir and the upper reservoir reaches approximately 136 m, while the total transmission pipeline length is about 910 m. In addition, the available source discharge is limited, ranging from 0.27 L/s to 0.47 L/s when an optional secondary source is included. The findings indicate that the existing system is not feasible under the assessed hydraulic conditions and available source-discharge conditions based on the field-observed parameters and estimated hydraulic requirements. The results provide an initial feasibility basis for future system improvement planning, particularly regarding pump head requirement, source-capacity matching, and pipe pressure safety.

Keywords: Clean Water Distribution, Hydraulic Feasibility Analysis, Pumping System, Rural Water Supply System, Total Dynamic Head

1 Introduction

Clean water availability is a basic requirement for public health, sanitation, domestic activities, and community welfare. In rural and hilly areas, clean water distribution is often constrained by topography, long transmission pipelines, elevation differences, limited source discharge, and inadequate pumping systems (Rahadjeng et al., 2023; Sudirman et al., 2023). These constraints may reduce the reliability of water supply, especially in community-based systems with limited technical and operational capacity (Wayan Diasa et al., 2022).

Galiukir Indigenous Village, located in Kebon Padangan Village, Pupuan District, Tabanan Regency, Bali, is a rural settlement with hilly topography and a strong

dependence on a pump-based clean water distribution system (Santosa et al., 2022). The existing system lifts water from a lower reservoir or source collection point to an upper reservoir before being distributed to the community (Abriani et al., 2021; Lingga et al., 2024). However, field observations indicate that the water distribution system has not operated optimally. Several technical constraints were identified, including insufficient pump head, long transmission distance, limited water source discharge, and potential pipe pressure limitations (Lingga et al., 2024; Pulung & Ponorogo, 2024).

The existing system serves approximately 150 households with an estimated water demand of 36.36 m³/day (0.421 L/s). However, system performance remains unstable due to limited source discharge, elevation difference, insufficient pump head, and long transmission pipeline distance. Previous studies on rural clean water systems have mainly focused on network planning, service coverage evaluation, and infrastructure development. However, integrated hydraulic feasibility assessments considering pump capacity, elevation difference, source discharge limitation, transmission pipeline characteristics, and pressure safety remain limited, particularly in mountainous indigenous areas (Abriani et al., 2021; Pulung & Ponorogo, 2024). Therefore, an integrated field-based hydraulic assessment is required to determine the feasibility of the existing system and provide a technical basis for future improvement planning. Therefore, this study aims to evaluate the technical feasibility of the existing clean water distribution system in Galiukir Indigenous Village.

2 Methodology

This study applied a field-based technical feasibility assessment approach. The assessment was conducted through direct observation of the existing clean water distribution system in Galiukir Indigenous Village. The observed components included pump specification, electrical control condition, reservoir dimensions, transmission pipeline route, pipe material, elevation difference, and water source discharge (Pulung & Ponorogo, 2024). Field data collection included pump identification, reservoir condition, transmission pipeline characteristics, elevation difference, and source discharge evaluation. Elevation analysis was performed by comparing the lower and upper reservoir conditions, while source discharge was evaluated through flow measurement and conversion into operational flow rates. The main uncertainties in this assessment were related to estimated pump performance, variation in source discharge, and limited detailed information regarding existing pipeline characteristics.

Pump data were collected through visual inspection and interpretation of the existing pump model. The installed pump was identified as a SHIMGE BLT16-8 vertical multistage centrifugal pump with a motor power of 7.5 kW or approximately 10 HP. The pump operates at 2900 rpm using a three-phase 380 V electrical supply (Permana & Ariyadi, 2022). The pump head and discharge values were obtained from pump model identification and available technical information. Since direct performance testing was not conducted, these values were treated as estimated parameters for feasibility evaluation. Elevation analysis was carried out by comparing the elevation of the lower reservoir or source collection point with the upper reservoir (Barid et al., 2023).

The transmission pipeline was evaluated based on field distance. The distance from the lower reservoir to the road is approximately 560 m, while the distance from the road to the upper reservoir is approximately 350 m. Therefore, the total transmission pipeline length is approximately 910 m. The existing pipe is PE pipe with a diameter of 2 inch, and the minimum pressure rating requirement is PN16 or 16 bar.

Water source discharge was evaluated by converting the measured flow from L/s into L/min and m³/h. The main source discharge is 0.27 L/s, while the optional secondary source discharge is 0.20 L/s (Ginting et al., 2023; Suarda et al., 2024). The measured values represent the observed field condition, while seasonal variation may influence the long-term availability of the water source. Hydraulic feasibility was evaluated by comparing the available pump head with the estimated total dynamic head (TDH). The required head was estimated considering static head, friction losses, and minor losses as expressed in Equation (1).

$$TDH = H_s + H_f + H_m \tag{1}$$

where H_s is the static head, H_f is the friction loss along the pipeline, and H_m is the minor loss from hydraulic components.

The estimated TDH value was obtained by considering the elevation difference, transmission pipeline length, and hydraulic losses. Due to limitations in detailed pipeline specifications and direct pump testing, the calculated head was considered a preliminary feasibility estimate.

Hydraulic feasibility was analyzed by comparing the existing pump head with the required static head and estimated total dynamic head. Pressure feasibility was evaluated using the following equation:

$$P = 0.0891 \times H \tag{2}$$

where P is pressure in bar and H is head in meters of water column. The key field data used for the feasibility assessment are summarized in Table 1. The measured reservoir dimensions and estimated storage capacities are presented in Table 2.

Table 1. Summary of Key Field Data for Feasibility Assessment

System Component	Field Data	Technical Relevance
Study area	Galiukir Indigenous Village, Bali	Rural hilly clean water system
Existing pump	SHIMGE BLT16-8 vertical multistage pump, 7.5 kW, 380 V, 2900 rpm	Main pumping unit
Existing pump performance	Estimated head ±80 m; discharge ±16 m ³ /h	Used to assess pump adequacy
Elevation condition	Lower reservoir ±544 m asl; upper reservoir ±680 m asl	Static head ±136 m
Transmission pipeline	PE pipe 2 inch; total length ±910 m	Causes friction loss and pressure demand
Pipe pressure class	Minimum PN16 / 16 bar	Used for pressure safety evaluation

Water source discharge	Main source 0.27 L/s; optional source 0.20 L/s; combined 0.47 L/s	Determines feasible pump discharge
Reservoir capacity	Lower reservoir $\pm 9 \text{ m}^3$; upper reservoir $\pm 90 \text{ m}^3$	Indicates storage and buffer capacity

Table 2. Reservoir Characteristics

Reservoir	Dimension (m)	Volume (m^3)	Function
Lower reservoir	$1.5 \times 2 \times 3$	9	Pump buffer tank
Upper reservoir	$5 \times 6 \times 3$	90	Main storage tank

3 Result and Discussion

3.1 Existing Pump and Field Condition

The existing system uses a SHIMGE BLT16-8 vertical multistage centrifugal pump. Based on pump model identification, the estimated discharge capacity and head are approximately $16 \text{ m}^3/\text{h}$ and 80 m, respectively. The existing pump and electrical control panel are shown in Figure 1.

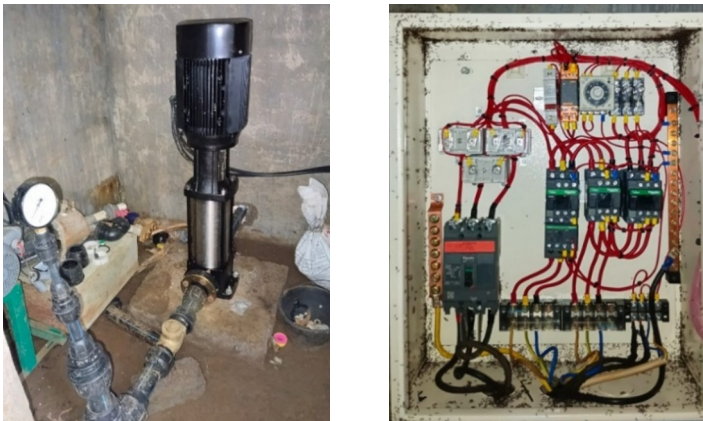


Figure 1. Existing pump and electrical control panel in the Galiukir clean water distribution system.

3.2 Pipeline, Reservoir, and Elevation Condition

The clean water system transmits water from the lower reservoir or source collection point to the upper reservoir. The lower reservoir is located at approximately 544 m above sea level, while the upper reservoir is located at approximately 680 m above sea level. Therefore, the static elevation head is approximately 136 m.

The lower reservoir has an estimated capacity of 9 m^3 , while the upper reservoir has an estimated capacity of 90 m^3 . The field condition of the water source, lower reservoir, pipeline route, and upper reservoir is shown in Figure 2.



Figure 2. Existing water source, lower reservoir, pipeline route, and upper reservoir condition.

3.3 Hydraulic Feasibility of the Existing Pump

The elevation difference between lower and upper reservoirs is approximately 136 m, resulting in a static head requirement exceeding the estimated pump capability (Al-Zaidi et al., 2023). The feasibility comparison is summarized in Table 3.

Table 3. Hydraulic Feasibility of Existing Pump

Parameter	Existing Condition	Required / Design Condition	Technical Assessment
Existing pump head	±80 m	Minimum static head ±136 m	Not sufficient
Static elevation head	±136 m	Must be exceeded by pump head	Existing pump is undersized
Head deficit	±56 m	Additional head still needed before friction losses	Critical limitation
Pipeline length	±910 m	Causes additional friction losses	Total dynamic head must be higher than 136 m
Estimated total dynamic head	—	±170–180 m	Required for reliable operation
Existing pump feasibility	±80 m head	±170–180 m estimated requirement	Not hydraulically feasible

Figure 3 provides a conceptual comparison between the estimated head capability of the existing pump and the hydraulic head required by the system. The figure is intended to illustrate the head mismatch identified in the feasibility assessment and does not represent a field-measured pump performance curve or an experimentally determined operating point.

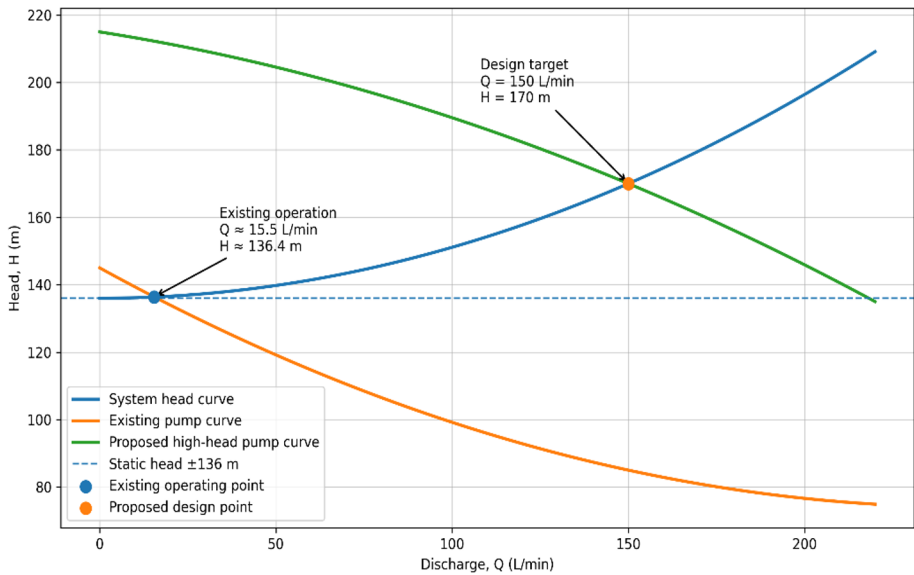


Figure 3. Conceptual comparison between the estimated existing pump head capability and the hydraulic head requirement of the system.

3.4 Water Source Discharge and Pump Capacity Compatibility

The main source provides approximately 0.27 L/s, equivalent to 16.2 L/min or 0.972 m³/h. The optional secondary source provides approximately 0.20 L/s, equivalent to 12.0 L/min or 0.720 m³/h. If both sources are used, the total potential discharge becomes approximately 0.47 L/s, equivalent to 28.2 L/min or 1.692 m³/h.

If the pump operates at high discharge, the lower reservoir may be depleted quickly, causing dry-run risk and unstable system performance. Therefore, the feasibility assessment shows that any future pumping strategy must consider source discharge limitation. The pump should not be operated based only on nominal capacity or desired filling speed. Instead, the discharge should be adjusted to match the source replenishment rate and lower reservoir volume. The conversion of source discharge into operational flow rates is presented in Table 4.

Table 4. Water Source Discharge Conversion

Water Source	Discharge (L/s)	Flow Rate (L/min)	Flow Rate (m ³ /h)	Technical Meaning
Main source	0.27 L/s	16.2 L/min	0.972 m ³ /h	Low source discharge
Optional secondary source	0.20 L/s	12.0 L/min	0.720 m ³ /h	Additional source if available
Combined discharge	0.47 L/s	28.2 L/min	1.692 m ³ /h	More suitable for low-discharge operation

Water Source	Discharge (L/s)	Flow Rate (L/min)	Flow Rate (m ³ /h)	Technical Meaning
Existing pump nominal discharge	—	±266.7 L/min	±16 m ³ /h	Too large compared with available source discharge

3.5 Feasibility of High-Discharge Pumping Scenario

At a pumping rate of 150 L/min for 90 min, the required water volume is 13,500 L. However, the main water source can supply only 3,888 L during the four-hour recovery period. Therefore, the four-hour recovery period was considered as an operational assessment scenario. The water balance was evaluated by considering both the initial storage volume of the lower reservoir and the additional water supplied by the source during the recovery period. Based on a combined supply rate of 0.47 L/s, the total available water volume during the four-hour recovery period is 6,768 L.

The required water volume per cycle is 13.5 m³, while the available water supply during the recovery period is only 3.89–6.77 m³. Therefore, high-discharge pumping would require additional source discharge, larger lower reservoir capacity, or a different operational strategy. The feasibility of the 150 L/min pumping scenario is summarized in Table 5. This scenario is used as an operational feasibility case rather than as a recommended final design condition.

Table 5. Feasibility of 150 L/min Pumping Scenario

Parameter	Calculation	Result	Feasibility Assessment
Pumping discharge scenario	150 L/min	150 L/min	High-discharge scenario
Pumping duration per cycle	1.5 hours = 90 minutes	90 minutes	Proposed operation duration
Water required per cycle	150 L/min × 90 min	13,500 L = 13.5 m ³	High water requirement
Main source supply in 4 hours	0.27 L/s × 14,400 s	3,888 L = 3.89 m ³	Insufficient
Combined source supply in 4 hours	0.47 L/s × 14,400 s	6,768 L = 6.77 m ³	Still insufficient
Feasibility conclusion	Required 13.5 m ³ vs available 3.89–6.77 m ³	Not feasible	Requires source or storage improvement

3.6 Pressure Feasibility and Pipe Safety

Pressure feasibility was evaluated by converting the estimated required head into pressure. For a total head of approximately 170 m, the equivalent pressure is 16.68 bar, while a total head of 180 m corresponds to an equivalent pressure of 17.66 bar.

The estimated pressure associated with the assessed head approaches or may exceed the nominal PN16 pressure rating. Therefore, PN16 should not be considered automatically adequate for the existing system. Pipe pressure suitability requires further verification considering actual operating pressure, pipe condition, transient effects, temperature-related derating, and an appropriate safety margin. Based on this assessment, the existing PE 2 inch pipe pressure rating must be verified before system

upgrading. If the installed pipe is below PN16, it is not feasible for high-head operation. For critical sections, a higher pipe pressure class may be required, but the detailed pipe redesign should be discussed in a separate DED-focused paper. The pressure feasibility and pipe safety implications are summarized in Table 6.

Table 6. Pressure Requirement and Pipe Safety

Parameter	Calculation / Value	Result	Technical Implication
Estimated head	170 m	—	Lower range of required total head
Equivalent pressure at 170 m	0.0981×170	16.68 bar	Slightly above PN16
Estimated head	180 m	—	Upper range of required total head
Equivalent pressure at 180 m	0.0981×180	17.66 bar	Exceeds PN16 nominal pressure
Existing pipe pressure rating	PN16 / 16 bar	Minimum requirement	Must be verified
Feasibility implication	PN16 is marginal	Higher safety margin may be needed	Requires further DED-level verification

3.7 Overall Technical Feasibility Assessment

The main feasibility constraints are insufficient pump head, limited source discharge, and pressure safety concerns. The existing pump head (approximately 80 m) is lower than the static head requirement (approximately 136 m), while the estimated total dynamic head reaches approximately 170–180 m considering friction and minor losses. In addition, the available source discharge (0.27–0.47 L/s) is lower than the nominal pump capacity, making high-discharge operation infeasible without additional source or storage capacity. The estimated operating pressure of 16.68–17.66 bar also approaches or exceeds the PN16 pipe rating, requiring pipe pressure verification before system upgrading.

Since this study focuses on feasibility assessment, future improvements should consider alternatives such as higher-head or staged pumping, pressure-management storage, and lower-flow operation matched with source availability. Detailed engineering design, including pump selection and pipeline modification, requires further investigation summarized in Table 7.

The identified hydraulic limitations suggest that future system improvement may consider higher-head pumping, staged pumping, pressure-management storage, or lower-flow operation matched with source availability. Further engineering evaluation is required to select the most suitable alternative considering hydraulic performance, pressure safety, energy efficiency, and operational feasibility.

Table 7. Summary of Feasibility Findings and Technical Direction

Feasibility Aspect	Existing Condition	Feasibility Status	Technical Direction
Pump head	±80 m	Not feasible	Requires higher-head pumping system
Static head	±136 m	Exceeds existing pump head	Pump head must exceed static head and friction losses
Estimated total dynamic head	±170–180 m	Higher than existing capability	Used as feasibility basis for future design
Source discharge	0.27–0.47 L/s	Limited	Pump discharge must match source availability
High-discharge operation	150 L/min scenario	Not feasible	Requires additional source or larger lower reservoir
Pipe pressure	PN16 minimum	Marginal	Pipe class must be verified before upgrading
Overall system	Existing system	Not technically feasible	Requires system improvement and DED in future work

4 Conclusion

This study evaluated the technical feasibility of the community-based clean water distribution system in Galiukir Indigenous Village, Bali. The existing SHIMGE BLT16-8 pump has an estimated head of approximately 80 m, which is lower than the static head requirement of 136 m. Considering the 910 m transmission pipeline and hydraulic losses, the required total dynamic head is estimated at 170–180 m, indicating that the existing pump is insufficient for the current system condition.

In addition, the available source discharge (0.27–0.47 L/s) is insufficient for high-discharge operation, such as the 150 L/min pumping scenario. The estimated operating pressure of 16.68–17.66 bar also approaches or exceeds the PN16 pipe rating, requiring pressure class verification before system improvement. Therefore, the existing system is not technically feasible and requires further engineering improvement considering pump capacity, source availability, and pipeline safety. Overall, the existing system is not feasible under the assessed hydraulic conditions due to insufficient pump head, limited source availability, and pressure constraints. Further system improvement requires detailed engineering design.

Acknowledgment

The authors would like to thank Politeknik Negeri Bali, the Center for Research and Community Service (P3M), and the community of Galiukir Indigenous Village, Kebon Padangan Village, Pupuan District, Tabanan Regency, Bali, for their support during field observation and technical assessment. Grant number: 07052/DST/PL8/DT.06.05/2026

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