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Analysis of Clean Water Availability and Satisfaction Needs in the Duyu Relocation Housing Area, Palu City

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Abstract
Clean water distribution system in the Duyu Relocation Housing area, established for individuals displaced by the earthquake on September 28, 2018, has encountered ongoing issues. Initially relying on deep groundwater wells, the system failed to fulfill the residents' clean water demands. Consequently, surface water from the Lewara River intake was added to supplement supply. This study examines how the availability of clean water influences resident satisfaction in the Duyu Relocation Housing area. The objective is to explore the key factors affecting satisfaction and assess whether the Lewara River water source can meet future demand over the next two decades. The research applies a qualitative descriptive approach, utilizing Proportional Random Sampling. Data collection involved questionnaires distributed to 146 respondents representing households in the relocation area. Statistical analysis, including validity and reliability testing, was conducted using SPSS software, while the relationships among variables were analyzed through multiple linear regression. Findings reveal that both individually and collectively, clean water availability significantly impacts satisfaction levels. Notably, the assurance of water during the dry season and water quality (colorless, odorless, tasteless) emerged as critical components. A projection for the year 2045 estimates that the clean water requirement will reach 1.67 liters per second, which is still well within the current capacity. Recommendations for PDAM Palu City include enhancing service quality and coverage while maintaining a focus on resident satisfaction to boost overall service performance.

Keywords: *Clean Water Satisfaction, Huntap Duyu Palu Services*

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I. AN OVERVIEW

Challenges in providing clean water in residential areas are becoming increasingly complex with population growth and urbanisation. Research by UN-Habitat (2016) shows that cities in developing countries are facing increasing pressure to meet the clean water needs of their residents. Therefore, a deep understanding of the factors influencing user satisfaction with clean water piping networks is crucial for better infrastructure planning and management.

Analysing the factors affecting clean water availability and the satisfaction of permanent residents in Duyu is an important step in improving service quality and ensuring the fulfilment of community needs. According to (Baietti & van Ginneken, 2006), customer satisfaction with clean water services can serve as a key performance indicator for service providers and policymakers. Factors influencing this satisfaction may include technical aspects such as water flow continuity, water pressure, and water quality, as well as non-technical aspects such as customer service and tariffs (Kayaga et al., 2018).

Palu City, the provincial capital of Central Sulawesi, is one of the Indonesian cities currently facing serious challenges in water supply. These challenges stem from both geographical constraints and the aftermath of natural disasters. Situated in a valley flanked by mountains and a bay, Palu's topography complicates the routing of water pipelines from sources to service areas. The municipal water supply system in Palu is managed by the local water utility (PDAM Kota Palu), relying primarily on surface water and groundwater sources. The Palu River, one of the surface water sources, has experienced water quality degradation due to pollution, thus requiring intensive treatment before distribution (Sutapa, 2014).

Following the earthquake and tsunami that struck Palu City in September 2018, the clean water pipeline infrastructure suffered significant damage. This further complicated the availability of clean water to the

community. The government and various aid agencies have undertaken rehabilitation and reconstruction efforts for the clean water pipeline network post-disaster (UNICEF, 2019). To improve clean water services, the Palu City Government has planned several programmes, including expanding the piped water network, repairing damaged infrastructure, and increasing clean water production capacity. However, the implementation of these programmes still faces funding and technical challenges (Palu, 2020).

Related to the above description, it is also inseparable from the conditions in the area to be studied, where the previous water source came from deep groundwater that produced insufficient flow to meet the needs of residents in the Duyu permanent housing area. Therefore, due to this insufficiency, in 2023, a piped distribution network was built with surface water sourced from the Lewara River to the Duyu permanent housing area in Palu City. Therefore, it is necessary to link the provision of continuous clean water supply service, which is an important indicator in assessing the success of this public service. A deep understanding of the application or response using accurate measurement methods can assist managers in providing quality and sustainable clean water services based on the needs of residents in the permanent housing area of Duyu in Palu City.

II. METHODOLOGY

This research employs a descriptive design to observe and analyze existing conditions related to clean water availability for residents living in the permanent housing area of Duyu. The aim is to understand the factors contributing to resident satisfaction with clean water services in the post-disaster context of Central Sulawesi. To capture the perspectives of the affected community, a qualitative method was employed, utilizing interviews and an online questionnaire distributed to selected respondents. Questionnaire responses were examined through SPSS software) software.

Research Location and Scope

This research was conducted in Central Sulawesi Province, specifically in Palu City, at a permanent housing location (huntap) in the Duyu neighbourhood of Palu City. This location was chosen based on the difficulty of obtaining clean water at the beginning of the survivors' occupancy, after which clean water was provided by taking water from the Lewara River.

Data Collection Techniques

This research made use of initial and supporting data; initial data were obtained through an online questionnaire answered by 146 residents of the Duyu permanent housing area. Secondary data were drawn from relevant literature, official reports, and supporting documentation. Additional insights were gathered through direct observations and field documentation.

Descriptive Qualitative Analysis

The analysis focused on identifying relationships between independent variables and a dependent variable. The independent variables included:

- Physical Evidence (X1)
- Clean Water Guarantee (X2)
- Service Response (X3)
- Reliability (X4)

The dependent variable (Y) represents the level of resident satisfaction with clean water availability.

Descriptive analysis was conducted to present the data collected in a structured and interpretable format. Prior to regression analysis, data validity was tested using the Pearson Correlation method with a 95% confidence level ($\alpha = 0.05$). Items with significance values below 0.05 were deemed valid. Internal consistency was measured via Cronbach's Alpha, accepting values above 0.60.

To ensure data suitability for regression, a normality test was performed using both the probability plot and the Kolmogorov-Smirnov method. These classical assumption tests helped determine whether the data followed a normal distribution and were appropriate for further analysis.

III. OUTCOMES AND ANALYSIS

This study was carried out at Duyu's Huntap permanent housing community, Palu City, Central Sulawesi, which is home to survivors of the 28 September 2018 disaster. The research results describe the factors influencing satisfaction with the supply of potable water to residents in the permanent housing area. Among the variables used, there is an influence on clean water satisfaction.

This section presents the research findings related to the factors influencing resident satisfaction with clean water availability in the Duyu permanent housing area. The study surveyed 146 residents, all directly affected by the provision of clean water in their homes.

Test Validity

To ensure the accuracy and legitimacy of the study variables, validity tests were conducted. A variable is considered valid when the p-value (two-sided) falls below 0.05, and the computed correlation exceeds the threshold. The test confirmed that all observed variables met these criteria and could be used in the next stages of analysis.

Tabel. 1. Validy Testing

Variable	Statement	Sig.(2-tailed)	Sig.Required	Calculated r-value	Table r value	Description
X1.1	Water Debit/Volume Outflow from Residential Taps	0.001	< 0.05	0.880	> 0,1625	Valid
X1.2	24-hour Clean Water Availability	0.001	< 0.05	0.872	> 0,1625	Valid
X2.1	Clean water available during the dry season	0.001	< 0.05	0.922	> 0,1625	Valid
X2.2	The Quality of Clean Water (Taste, Colour, Smell)	0.001	< 0.05	0.905	> 0,1625	Valid
X3.1	Response to Clean Water Damage	0.001	< 0.05	0.765	> 0,1625	Valid
X3.2	Easy Access to Information on Clean Water	0.001	< 0.05	0.483	> 0,1625	Valid
X3.3	New Price for Clean Water Connection Installation	0.001	< 0.05	0.894	> 0,1625	Valid
X4.1	Clean Water Tariff	0.001	< 0.05	0.509	> 0,1625	Valid
X4.2	Easy Access to Clean Water Repairs	0.001	< 0.05	0.846	> 0,1625	Valid
Y.1	Strong water pressure from the Duyu Permanent Housing Tap	0.001	< 0.05	0.459	> 0,1625	Valid
Y.2	Continuous supply of clean water to permanent housing in Duyu	0.001	< 0.05	0.866	> 0,1625	Valid

Source: Output of Data Processing, 2025

Further research will continue to use the variables above because, based on the validity test results for each statement in the questionnaire variables above, it is known that all of the statements submitted are valid because they have a calculated r value greater than the table r value and a significance value less than 0.05.

Test With Reliability

A reliability test was performed in addition to the validity test to determine the internal consistency of questionnaire items, measured using Cronbach's Alpha, and in general, $\alpha > 0.60$. Physical Evidence (X1), Clean Water Guarantee (X2), Service Response (X3), and Trustworthiness (X4) are the variables that may be used to analyze the aspects that affect satisfaction with the availability of clean water in the Duyu City of Palu settlement. The table below shows the test results.

Table 2. Reliability Testing

No	Variable	Cronbach's Alpha (α)	Cronbach's Alpha Requirements	Description
1	Physical Evidence (X_1)	0.881	> 0.6	Very Reliable
2	Clean Water Guarantee (X_2)	0.900	> 0.6	Very Reliable
3	Service Response (X_3)	0.847	> 0.6	Very Reliable
4	Reliable (X_4)	0.875	> 0.6	Very Reliable
5	Citizen Satisfaction (Y)	0.868	> 0.6	Very Reliable

Source: Output of Data Processing, 2025

After reviewing the data processing results in the table above, internal consistency results showed Alpha coefficients surpassing the 0.6 benchmark. Therefore hence, it may be inferred that instruments used in this study are highly reliable and capable of consistently measuring the variable of satisfaction with clean water availability. The respondents' answers on the questionnaire form a logical pattern, thereby strengthening confidence in the research results.

Results of Classical Assumption Tests

Test with Multicollinearity

This an analysis was carried out to detect interrelations among predictors. Ideally, there should be no association among predictors in the model is assessed; multicollinearity signs include VIF < 10 and adequate

tolerance should be greater than 0.10, to ensure the model shows no signs of variable interdependence. Outcomes were generated through SPSS statistical software are as follows:

Table 3. Results Test With Multicollinearity

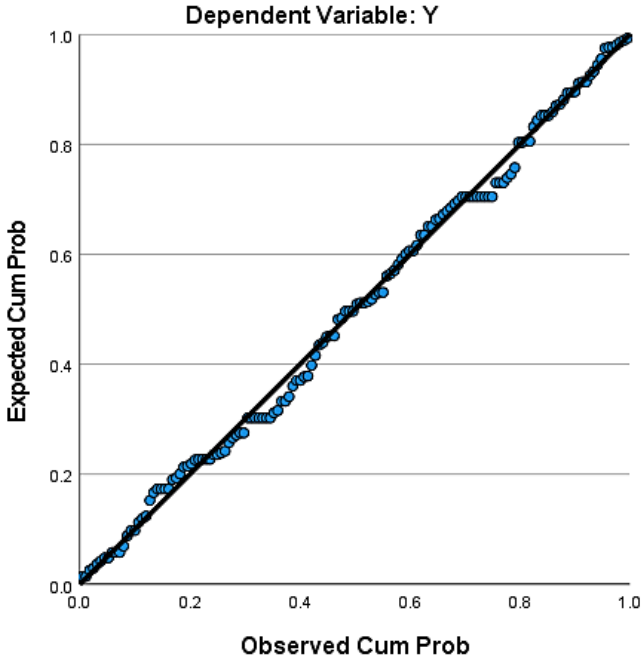
Variabel	*Collinearity Statistics*		**Description**
	Tolerance	*VIF*	
Physical Evidence (X_1)	0,953	1.049	No correlation between independent variables
Clean Water Guarantee (X_2)	0,515	1.941	
Service Response (X_3)	0,324	3.088	
Reliable (X_4)	0.305	3.276	

Source: Output of Data Processing, 2025

Independent variables are uncorrelated as shown by acceptable VIF indicators test results, which showed a value below 10 and a tolerance value above 0.10.

Normality Test

After the two tests, a a test for distribution shape was done to assess normality of variables using a normality probability plot test with the following results :



Source: Output of Data Processing, 2025

Figure 1. Test with Probability Plot

Test of the graph above shows that the points near the line are the tested data; these points are either attached to the line or very close to it, indicating that the data from the questionnaire is normally distributed.

Kolmogorov Smirnov Testing

Using Kolmogorov Smirnov, residual distribution was evaluated for conformity with normal curve prior to doing multiple linear regression modelling of the questionnaire data. The residual values of a suitable regression model are regularly distributed. Decision-making relies on the notion that residual values are normality is assumed when p-value exceeds 0.05vice versa. The Kolmogorov Smirnov test findings are as follows.

Table 4. Test with Kolmogorov Smirnov

		Unstandardized Residual
N		146
Normal Parameters[a,b]	*Mean*	0.0000000
	Std. Deviasi	0.93385609
Most Extreme Differences	Absolute	0.050
	Positif	0.050
	Negatif	-0.033
Tes Statistik		0.050
Asymp. Sig. (2-talled)[c]		0.200

a. Tes distribusi adalah Normal
b. Perhitungan berdasarkan Data
c. *Lilliefors Significance Correction*

Source: Output of Data Processing, 2025

a summary of the test findings, which had a statistical significance level of 0.20 > 0.05, the respondents' data is normally distributed based on the study variables.

Regression in Multiple Linears

The effect between the independent variables (X), namely Physical Evidence (X1), Clean Water Guarantee (X2), Service Response (X3), and Reliability (X4), and the dependent variable (Y), namely Satisfaction with Clean Water Availability, was detected applying multivariate regression to examine the association among variables independent variables. Following processing, the following table presents the degree of satisfaction with the availability of clean water (Y) :

Table 4. Multiple Linear Regression Results Testing

		Unstandardized Coefficients		*Standardized Coefficients*		
Model		B	Std. Error	Beta	t	Sig.
1	*(Constant)*	2.770	0,685		4.046	< 0,001
	X_1	0,086	0,070	0,081	1,236	0,219
	X_2	0,482	0,084	0,507	5.715	< 0,001
	X_3	0,071	0,091	0,088	0.787	0,433
	X_4	0.111	0.135	0.095	0.828	0,409

Source: Output of Data Processing, 2025

Results of the model generated a regression formula as an output:

Y = 2.770 + 0,086.X1 + 0,482. X2 + 0.071.X3 + 0.111.X4 + 0,05

Here's an explanation of the regression equation:

1. Result constant value is 2.770, meaning clean water services which includes the indicator Physical Evidence (X1), Clean Water Guarantee (X2), Service Response (X3), Reliability (X4), has a value of 0 or constant, then the satisfaction value of clean water availability for residents of Permanent Housing Duyu in Palu City is 2.770.
2. The Physical Evidence variable (X1) is yielded a favorable regression sign value of 0.086, that indicates that if the Palu City Water Supply Company (PDAM) makes improvements to the physical evidence factors in the clean water supply service, the influence of clean water availability on the satisfaction of the needs of permanent residents in Duyu, Palu City, will also increase, and the other way around.
3. Clean water guarantee variable's regression coefficient value (X2) is positive (+) at 0.482. This suggests that if PDAM Kota Palu improves the availability of clean water through improved clean water supply services, especially with regard to availability during the dry season and the quality of clean water, then residents' satisfaction with their needs in the Duyu permanent housing area will also increase, and the other way around.
4. Service Response Variable (X3) exhibits a positive regression effect value of 0.071. This indicates that there will be more clean water available to meet the needs of people living in permanent housing in Duyu if the factors affecting prompt and accurate service response are improved. The reverse is also true.

5. As indicated by the positive (+) coefficient estimate of 0.111 associated with Reliability (X4), the availability of clean water and, consequently, the satisfaction of residents' needs in the Duyu permanent housing area will increase if the X4 variable sustains customer trust in service provision. Conversely, it is also true.
6. For the linear regression equation model, the error value of the predictor constructs (X) in connection with the outcome factor (Y) is 0.05, this suggests a reduced margin of error.

Hypothesis Testing

After conducting a test using multiple linear regression, the following significant effects on satisfaction with clean water availability in the Duyu settlement can be observed:

1. Significant value of 0.219 and test statistic of 1.236 were obtained from the data analysis for the physical evidence variable (X1). When examined separately, the physical evidence variable (X1) has a bearing on the dependent variable, but this effect is not statistically significant, based to this its conclusion. This is because once the transmission pipeline network had been finished and the Lewara river intake was built as a water supply, which previously utilized the Dalam well, citizens saw concrete evidence of clean water flowing into their houses for two years.
2. With a significance threshold higher than 0.001, the data analysis produced a test statistic of 5.715 for the clean water assurance variable (X2). It can be said that the variable is significantly impacted by the clean water guarantee variable (X2), which is partially observed. This factor has a significant effect because, in fact, during the four years of residence, during the dry season, water did not flow at all in their residences, so currently, residents are grateful that during the dry season, clean water services are still available for residents to enjoy. The clean water quality factor also makes residents happy because the water they previously experienced, which had an odour due to being sourced from deep wells, has disappeared due to the construction of the Water Supply Management System (SPAM) in Duyu.
3. Information analysis for the service response variable (X3) generated a test statistic value of 0.787 with a significance level of 0.433, which is greater than the 0.05 α value. Therefore, the predictor variable influences the outcome partially but insignificantly. This factor is related to the PDAM service in Palu City, where residents feel that it affects the availability of clean water flowing into their homes, but the impact is not significant because residents perceive the service as a consequence of the rights they should receive after fulfilling their obligation to pay monthly water bills.
4. The fourth variable is called the trustworthy variable (X4). At a p-value of 0.409, the findings indicate that the t-value is 0.828, which is higher than the α value of 0.05. Consequently, it can be said that the the explanatory variable contributes slightly to the dependent but lacks significance relationship with it. This has an effect because this variable is part of the Palu City PDAM service as the manager of clean water in the Duyu Huntap community. Therefore, the effect remains but is not significant.

Analysis of Research Results

Physical proof, service response, and the reliability of the clean water supply in permanent housing in Duyu, Palu City, all have an impact on residents' happiness with the provision of clean water, but these effects are not statistically important, according to the study's hypothesis testing results. The clean water guarantee variable's test results, which included the assurance of the condition of water and access to clean water throughout the dry season, show a significant influence on clean water availability on the satisfaction of the needs of permanent residents of Duyu.

Analysis of Clean Water Availability and Demand

Water availability from the Lewara River's reliable discharge (Rahman, n.d.) shows that the total average reliable discharge from the Lewara River is 0.210 m3/second or 210 litres/second. From this reliable flow, 6.64 litres/second is allocated for domestic and non-domestic water needs of permanent residents in Duyu. The provision of clean water services in Duyu is supported by a Main Distribution Pipeline Network and a Distribution Network. Based on a 20-year projection for population growth, the water requirement for permanent residents in Duyu is 1.67 litres/second. The conclusion for the water balance based on the availability of clean water from the Lewara River at 6.64 litres per second (Rahman, n.d.) compared to the projected demand until 2045 is that it is still more than sufficient, thereby presenting a significant potential for the development of water supply services for the surrounding community. To ensure maximum service, it is important to maintain a continuous flow of clean water during the dry season by allocating raw water for agricultural land and addressing leaks in the transmission and distribution pipeline network. A linear regression method is needed to clarify the comparison between the projected availability and demand for clean water based on the number of permanent residents in Duyu.

Source: Google Earth, 2025

Figure 1 Map of the Huntap Duyu Pipeline Network

III. CONCLUSION

1. The results of the analysis of factors affecting clean water availability on satisfaction in the Duyu permanent residential area revealed variables consisting of Physical Evidence (X1), Clean Water Guarantee (X2), Service Response (X3), and Reliability (X4) that simultaneously and partially influence satisfaction with clean water availability without being correlated with each other in relation to residents' satisfaction with clean water availability in the Duyu permanent residential area. The significantly influential factor is clean water guarantee (X2), which includes the guarantee of water availability during the dry season and the guarantee of water quality in terms of colour, taste, and odour.
2. The level of clean water satisfaction among permanent residents of Duyu in Palu City can be determined using the equation Y = 3.705 + 0.001X1 + 0.431X2 + 0.102X3 + 0.082X4 + 0.05
3. The current clean water availability flow rate serving permanent residents in Duyu is 6.64 litres/second, with a projected population growth over 20 years, i.e. by 2045, the flow rate requirement will be 1.67 litres/second. Therefore, the availability of clean water is still more than sufficient to meet the needs of permanent residents in Duyu, Palu City.

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