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Measuring Farmers' Satisfaction with Irrigation Water Supply Services: An Extended SERVQUAL Approach

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Abstract
Ensuring the quality of irrigation services plays a decisive role in sustaining agricultural productivity, particularly in coastal rural areas facing climate change and saline intrusion. This study aims to measure farmers' satisfaction with irrigation services in Hai Hau district, Nam Dinh province, Vietnam, by applying an adjusted SERVQUAL model. The research combines descriptive statistics, Exploratory Factor Analysis (EFA), and multiple regression, based on survey data from 120 farming households supplemented with in-depth interviews. Results reveal that five key dimensions—Reliability, Responsiveness, Empathy, Infrastructure Assurance, and Service Fees—significantly influence household satisfaction, with "Service Fees" emerging as a novel and context-specific factor. The findings highlight that improving transparency in irrigation fees, strengthening water delivery reliability, and investing in canal modernization are essential to enhance service quality and farmer satisfaction. This study contributes both theoretically, by expanding the SERVQUAL model with a new variable, and practically, by providing evidence-based recommendations for sustainable irrigation management in Vietnam's coastal agricultural regions.

Keywords: Irrigation Services, Satisfaction, SERVQUAL, Service Quality

1. Introduction

Agriculture in developing countries, including Vietnam, is heavily dependent on irrigation systems. Irrigation water is not only an essential input but also a decisive factor influencing productivity, quality, and the stability of farmers' livelihoods. In the context of climate change, increasing drought, saline intrusion, and irregular floods pose significant challenges to maintaining the quality of irrigation services, especially in coastal rural areas such as Hai Hau district, Nam Dinh province.

For decades, on-farm irrigation services in Vietnam were subsidized by the state. However, since the enactment of the 2017 Law on Irrigation, these services have gradually shifted to a fee-based mechanism. When farmers are required to pay, their satisfaction with irrigation water supply services becomes an important indicator reflecting both policy effectiveness and the sustainability of the management system. Measuring farmers' satisfaction not only helps assess service quality from the supply side but also provides scientific evidence for policy formulation and service improvement.

Globally, numerous studies have approached irrigation management effectiveness and community participation. Small & Svendsen (1992) [11] and Vermillion (1997) [12] analyzed irrigation system performance from an institutional perspective; Meinzen-Dick (2007) [13] emphasized the importance of farmer participation; Hussain & Hanjra (2004) [14] highlighted the impact of irrigation services on productivity and household welfare. In terms of methodology, SERVQUAL, developed by Parasuraman, Zeithaml & Berry (1988), has become a widely adopted scale for assessing service quality, applied extensively in public and water services (Choudhury, 2013; Giné-Garriga & Pérez-Foguet, 2010) [9, 10]. However, most of these studies focus on urban domestic water supply, with limited application in agricultural irrigation services.

In Vietnam, several studies have examined the effectiveness of irrigation investment and policies. Nguyen Huu Nghi (2015) [15] demonstrated that canal concretization reduces water losses and enhances yields; Pham Quang Ha (2018) [16] evaluated the impacts of irrigation fee exemptions, identifying challenges in infrastructure maintenance; Tran Thi Thu Ha (2020) [17] stressed the importance of transparency and community participation in irrigation management. Nevertheless, these studies primarily focus on technical and institutional aspects, with no research applying standardized measurement models such as SERVQUAL to quantify farmers' satisfaction with irrigation water services.

From the above context and literature review, it is evident that a research gap exists in systematically analyzing farmers'satisfaction with irrigation services using a normative theoretical framework adapted to local conditions. This study seeks to address this gap by applying an extended SERVQUAL model—incorporating the variable of "on-farm irrigation fee"—to measure farmers' satisfaction in Hai Hau district, Nam Dinh province. The research aims to contribute theoretically by extending the measurement framework of public utility service quality, and practically by providing scientific evidence to support sustainable irrigation management policies in Vietnam's coastal delta regions.

2. Research Methodology

2.1 Research Framework

This study measures farmers' satisfaction with irrigation water supply services in Hai Hau district, Nam Dinh province, based on the SERVQUAL model (Parasuraman, Zeithaml & Berry, 1988), with adjustments to fit the context of on-farm irrigation. Five groups of factors were examined: Reliability, Responsiveness, Empathy, Infrastructure Assurance, and On-farm Irrigation Service Fee—the latter being a newly introduced variable reflecting the specific institutional and economic context of Vietnam. The research hypothesis posits that these factors exert a positive influence on farmers' overall satisfaction.

2.2 Data Collection Methods

Hai Hau district was selected as the study area, with two representative communes: Hai Nam (located at the tail end of the irrigation system) and Hai Long (located at the head end). A stratified random sampling approach was applied to ensure representativeness. In total, 120 farming households were surveyed using a structured questionnaire, complemented by 10 in-depth interviews with irrigation officers and cooperative representatives to provide qualitative insights.

The questionnaire consisted of two parts: (i) household information, and (ii) a five-point Likert scale measuring satisfaction. Observed variables were adapted from the original SERVQUAL framework, refined through expert consultation, and pre-tested with 20 households prior to formal implementation.

2.3 Data Analysis Methods

Quantitative data were processed using SPSS 22 through the following steps:

- Descriptive statistics to profile the sample and identify evaluation trends.
- Reliability testing of measurement scales using Cronbach's Alpha (removing items with coefficients < 0.3). Reliability was ensured through pilot surveys, Cronbach's Alpha testing, and Exploratory Factor Analysis (EFA). Scientific validity was strengthened through expert validation, cross-referencing with prior studies (Choudhury, 2013; Giné-Garriga & Pérez-Foguet, 2010) [9, 10], and the integration of both quantitative and qualitative methods. This ensured not only generalizability but also explanatory depth, forming a robust basis for conclusions and policy recommendations.
- Exploratory Factor Analysis (EFA) to determine factor structures, with the conditions of KMO > 0.5 and statistically significant Bartlett's Test.
- Multiple regression analysis to examine the influence of independent factors on overall satisfaction ($p < 0.05$).

Qualitative data from in-depth interviews were subjected to content analysis to interpret and supplement quantitative findings.

2.4 The Extended SERVQUAL Model

Building upon the SERVQUAL model (Parasuraman, 1988) and insights from studies on service quality and user satisfaction in irrigation services, this research adopts an extended framework to analyze the development of irrigation systems serving agricultural production. SERVQUAL was chosen given its extensive application across diverse economic contexts and its established appropriateness for service quality assessment.

The original SERVQUAL model comprises five components for measuring expected and perceived service quality: Reliability, Assurance, Tangibles, Responsiveness, and Empathy. This study extends the model by introducing a sixth component—On-farm Irrigation Fee—tailored to the Vietnamese policy and socio-economic setting. A five-point Likert scale, ranging from (1) Strongly Disagree to (5) Strongly Agree, was employed for measurement.

Table 1: Variables in the Research Model

S. No	Variable	Description
		Reliability
1	TC1	The company/enterprise commits to providing irrigation services according to the signed contract.
2	TC2	The company/enterprise promptly repairs faults in the operation of the irrigation system.
3	TC3	Water users trust the financial statements and fee levels provided by the company/enterprise.
4	TC4	Information regarding water usage by households is always securely guaranteed.
		Tangibles
5	PT1	The irrigation infrastructure system ensures service for agricultural production.
6	PT2	The on-farm irrigation system ensures service for agricultural production.
7	PT3	The irrigation system is continually invested in, upgraded, and repaired to meet agricultural production needs.
		Responsiveness
8	DU1	Company/enterprise staff always listens attentively and provides enthusiastic guidance and support to water users.
9	DU2	Company/enterprise staff resolves inquiries and issues from water users quickly and promptly.
10	DU3	The quality of irrigation services is in line with what is stated in the signed contract.
11	DU4	Faults in the irrigation system are quickly and promptly addressed by the company/enterprise.
12	DU5	The volume of water supplied meets the agricultural production needs of the water users during each growth stage and for different crops.
13	DU6	Water supply stability is affected by climate change and groundwater extraction.
14	DU7	The irrigation system utilizes modern scientific and technical methods in agricultural production.

		Empathy
15	CT1	Company/enterprise staff always understands the specific needs of each water user.
16	CT2	The timing and schedule for irrigation services are published in a timely manner for agricultural production.
17	CT3	The company/enterprise always conducts activities to listen to and exchange about irrigation needs to ensure agricultural production activities.
18	CT4	The company/enterprise promotes water-saving irrigation techniques and water protection.
		On-Farm Irrigation Fees
19	PDV1	On-farm irrigation fees are clear and transparent.
20	PDV2	The on-farm irrigation fee level is appropriate to the income of water users.
		Evaluation
21	HL	Water users highly evaluate the operation of the irrigation system serving agricultural production.

3. Research Results and Discussion

3.1 Current Status of the Hai Hau Irrigation System

The Hai Hau irrigation system plays a crucial role in ensuring irrigation, supporting agricultural production, aquaculture, and meeting the water needs of local populations. In recent years, the district has focused on investing in the upgrading and concretization of canal systems, pumping stations, and sluice gates in order to enhance the effectiveness of water resource utilization and management.

Table 2: Irrigation Infrastructure in Hai Hau

S. No	Item	Quantity	Remarks
1	Water intake sluices through dikes	15	Main water sources from the Ninh Co and Dao rivers
2	Large pumping stations	12	Serve inter-commune irrigation
3	Small pumping stations for on-farm irrigation	>50	Distributed across cooperatives, used when water levels are low
4	Canals of all levels	>1,500 km	Many sections have been concreted

Source: Hai Hau Irrigation System Company, 2024

The entire district currently has hundreds of various irrigation structures, among which the most notable are the sluice gates for water intake from the Ninh Co and Dao rivers, as well as the large and small pumping stations distributed across the communes and towns. The system of primary, secondary, and tertiary canals is interconnected, ensuring efficient water regulation and management across the agricultural fields. Additionally, many canal lines have been concreted, and in combination with rural transport infrastructure, this has contributed to the mechanization of production and reduced transportation costs.

Table 3: Status of Canal Concreting

Canal Type	Length (km)	Concreting Rate (%)
Primary Canal	125	90
Secondary Canal	452	75
Tertiary Canal	1,069	~50

Source: Hai Hau Irrigation System Company, 2024

3.2 Current Status of Irrigation Water Supply Services

The entire district currently has 15 water intake sluices, 12 large pumping stations, and over 50 small on-farm pumping stations, ensuring water supply for more than 36,000 hectares of agricultural land. The canal system, with a total length of over 1,500 kilometers, has been largely concreted, especially the primary and secondary canals. However, many sections of the tertiary canals remain earthen, making them prone to sedimentation, which obstructs water flow and increases maintenance costs.

Table 4: Area and Irrigation Service Rate in Hai Hau District

Cultivation Season	Area (ha)	Irrigation Rate (%)
Spring Crop	18,500	100
Summer Crop	17,200	98
Winter Crop	4,800	75

Source: Hai Hau Irrigation System Company, 2024

Although the area dedicated to winter crops has increased significantly in recent years, the provision of irrigation water still faces numerous challenges due to the dry season's characteristics and high pumping costs. This highlights the urgent need to upgrade and expand the small pumping stations and branch canals system.

For vegetable crops and aquaculture, local residents are required to contribute service fees as per the district and cooperative's regulations, approximately VND 200,000/ha/season for vegetable crops and VND 350,000/ha/season for aquaculture. This revenue is primarily used to cover electricity costs for water pumping, maintenance expenses, and salaries for the operation and management staff.

Table 5: Irrigation Service Fees in Hai Hau

Crop Type	Fee (VND/ha/season)	Remarks
Vegetables	200,000	Collected by the cooperative
Aquaculture	350,000	Applied based on the area of water surface

Source: Hai Hau Irrigation System Company, 2024

According to the survey, approximately 40% of farming households rated the water supply service as very satisfactory, 44.6% as satisfactory, and 15.3% as dissatisfied. The main reasons for dissatisfaction are localized drought conditions in some coastal areas and flooding in low-lying regions during the rainy and storm seasons. This reflects the need for additional investment in water regulation infrastructure, enhancing the capacity of pumping stations, and modernizing management practices.

Table 6: Farmers' Satisfaction with Irrigation Water Services in Hai Hau

Satisfaction Level	Number of Households (%)	Evaluation
Very Satisfied	40.1	The water supply is sufficient and timely.
Satisfied	44.6	It meets the needs reasonably well, though there are occasional local limitations.
Dissatisfied	15.3	Difficulties due to drought or heavy rain causing flooding.

Source: Author's Survey, 2025

The current state of the irrigation water supply service in Hai Hau district has effectively met agricultural production needs for many years, playing an essential role in maintaining productivity and ensuring food security. However, the system still faces limitations in terms of integration, resilience to climate change, and management efficiency. In the near future, it is necessary to continue the concretization of tertiary canals, invest in additional small pumping stations, apply digital technologies for monitoring and operation, and enhance community participation to improve sustainability.

3.3 Evaluation of Irrigation Water Supply Service Quality for Agricultural Production in Hai Hau District, Nam Dinh Province

The quality of the system is reflected through the level of satisfaction of service users, including factors such as the infrastructure of the on-farm irrigation system, the service capacity of the irrigation system and its management staff, and the extent to which the service meets users' needs. The average scores for the survey questions ranged widely from 3.10 to 3.74, indicating that while some households are only slightly satisfied with the irrigation service, others are highly satisfied. Among these, the statement "The irrigation system for agricultural production applies modern scientific and technical methods" (DU6) received the lowest average score (3.10).

The satisfaction of households using irrigation water regarding the operation of the irrigation system (HL) was rated at 3.63, which is only a moderate level of satisfaction. Therefore, Hai Hau district needs to implement specific solutions and policies to enhance the irrigation operations of the system, thereby increasing the satisfaction of households using irrigation water.

Table 7: Descriptive Statistics of Variables in the Model

Variable	Observations	Mean Value	Standard Deviation
TC1	106	3.45	1.010
TC2	106	3.22	0.754
TC3	106	3.41	1.023
TC4	106	3.35	0.750
PT1	106	3.58	0.673
PT2	106	3.74	0.923
PT3	106	3.25	0.835
DU1	106	3.27	0.770
DU2	106	3.41	0.632
DU3	106	3.48	0.957
DU4	106	3.25	0.728
DU5	106	3.38	0.823
DU6	106	3.10	0.662
DU7	106	3.20	0.660
CT1	106	3.20	0.887
CT2	106	3.35	0.884
CT3	106	3.42	0.599
CT4	106	3.40	0.552
PDV1	106	3.56	0.820
PDV2	106	3.55	0.961
HL	106	3.63	0.894

a, Measuring Reliability of the Scale Using Cronbach's Alpha Coefficient

- TC Factor Group

The observed variable TC3 has a total correlation coefficient of 0.053, which is less than 0.3. Furthermore, the Cronbach's Alpha coefficient would increase to 0.72 if this variable is removed, compared to the current Cronbach's Alpha of 0.462. Therefore, the observed variable TC3 should be excluded to improve the reliability of the scale. After excluding TC3, the Cronbach's Alpha for the factor group increased to 0.68, indicating that the scale is acceptable. However, the observed variable TC2 has a total correlation coefficient of 0.257, which is still less than 0.3. Moreover, the Cronbach's Alpha coefficient would increase to 0.805 if TC2 is removed, which is higher than the current value of 0.60. Therefore, TC2 should also be excluded from the model. After the third run, excluding TC3 and TC2, the Cronbach's Alpha for the TC factor group increased to 0.781, indicating a good scale. The observed variables TC1 and TC4, both having a total correlation coefficient greater than 0.3, were retained in the model.

- PT Factor Group

The observed variable PT2 has a total correlation coefficient of 0.235, which is less than 0.3. Additionally, the Cronbach's Alpha coefficient would increase to 0.751 if PT2 is removed, compared to the current Cronbach's Alpha of 0.52. Therefore, PT2 should be excluded to enhance the scale's reliability. After the second run, no further variables were excluded, as all the remaining observed variables have a total correlation coefficient greater than 0.3, and the Cronbach's Alpha for the factor group is 0.714, which is greater than 0.6, indicating a reliable scale. The observed variables PT1 and PT3, both with total correlation coefficients greater than 0.3, were kept in the analysis model.

- DU Factor Group

The observed variables DU4, DU5, and DU6, which have total correlation coefficients less than 0.3, were excluded. Moreover, the Cronbach's Alpha coefficient would increase to 0.761 if these variables are removed, compared to the current value of 0.503. Therefore, the variables DU4, DU5, and DU6 should be excluded to improve the reliability of the scale. After the second run, no further variables were excluded, as the remaining variables had total correlation coefficients greater than 0.3, and the Cronbach's Alpha for the DU factor group is 0.698, which is above the 0.6 threshold, indicating that the scale is reliable. The observed variables DU1, DU2, DU3, and DU7, with total correlation coefficients greater than 0.3, were retained in the model.

- CT Factor Group

All the observed variables in this group have total correlation coefficients greater than 0.3. Additionally, the Cronbach's Alpha for this factor group is 0.727, indicating a reliable scale. Therefore, all four CT variables were retained in the analysis model.

- PDV Factor Group

All the observed variables in this group have total correlation coefficients greater than 0.3. The Cronbach's Alpha for this factor group is 0.674, indicating a reliable scale. Therefore, both PDV variables were retained in the analysis model.

Thus, after performing the Cronbach's Alpha test, six observed variables—TC2, TC3, PT2, DU4, DU5, and DU6—need to be excluded before proceeding with the Exploratory Factor Analysis (EFA).

Table 8: Reliability Test Results of the Measurement Scales

S. No	Factor Group	Initial Observed Variables	Remaining Observed Variables	Cronbach's Alpha	Variables Removed
1	Reliability	4	2	0.781	TC2, TC3
2	Tangibles	3	2	0.714	PT2
3	Responsiveness	7	4	0.698	DU4, DU5, DU6
4	Empathy	4	4	0.727	
5	On-Farm Irrigation Fees	2	2	0.674	

b, Exploratory Factor Analysis (EFA)

The results of incorporating the 14 independent observed variables into the analysis show that the KMO value is 0.691, which is greater than 0.5, indicating that the factor analysis is suitable. Additionally, the "Sig. Bartlett's Test of Sphericity" is 0.000, which is less than 0.05, suggesting that the observed variables are correlated with each other within the factor.

Table 9: KMO and Bartlett's Test for Factor Analysis Model

KMO and Bartlett's Test		
KMO Coefficient		0.691
Bartlett's Test	Chi-Square (χ^2)	216.517
	Significance Level (Sig.)	0.000

There are 5 factors with Eigenvalues greater than 1, and the cumulative percentage at 1.193 is 71.64%, indicating that the appropriate number of factors is 5, and these factors explain 71.64% of the variance in the data.
From the rotated matrix results, the observed variables DU2 and DU3 are excluded because both DU2 and DU3 load on two factors, namely Component 2 and Component 5, violating the discriminant validity in the rotated matrix. The loading coefficients for DU2 are 0.517 and 0.622, with a loading difference of less than 0.3, and the loading coefficients for DU3 are 0.569 and 0.583, with a loading difference also smaller than 0.3.
An EFA was conducted again after removing the observed variables DU2 and DU3. The KMO value was 0.718, which is greater than 0.5. The "Sig. Bartlett's Test of Sphericity" value was 0.000, which is less than 0.05, indicating that the factor analysis is appropriate, and the variables are correlated. There are 5 factors with Eigenvalues greater than 1, and the cumulative percentage at 1.136 is 75.84%, indicating that the appropriate number of factors is 5, and these factors explain 75.84% of the variance in the data.

Table 10: Exploratory Factor Analysis Results

S. No	New Factor Group	Observed Variables	Type
1	N1	DU1, DU7, PT3	Independent
2	N2	TC1, TC4	Independent
3	N3	CT1, CT2	Independent
4	N4	PT1, PDV1, PDV2	Independent
5	N5	CT3, CT4	Independent
6	HL	HL	Dependent

The regression results show that the adjusted R-squared (Adjusted R Square) is 0.639, or 63.9%. This indicates that the independent variables included in the regression model explain 63.9% of the variation in the dependent variable, while the remaining 36.1% of the variation is due to factors outside the model and random error.

Table 11: Regression Model Explanation Table

Model	R-Value	R-Squared	Adjusted R-Squared	Standard Error of Estimate	F-Test	Standard Error of F-Test
1	0.653	0.612	0.639	0.402	47.85	0.001

The F-test significance (Sig = 0.001) is less than 0.05, indicating that the multiple linear regression model is appropriate for the dataset and can be used. The variance inflation factors (VIF) for all independent variables are less than 10, suggesting that there is no multicollinearity present in the model. Furthermore, all regression coefficients are greater than 0, indicating that all independent variables have a positive effect on the dependent variable. Based on the magnitude of the standardized regression coefficients (Beta), the order of influence from strongest to weakest of the independent variables on the dependent variable HL is as follows: N4 (0.247) > N3 (0.211) > N5 (0.208) > N2 (0.177) > N1 (0.149).
The regression equation is as follows:

$$HL = -1.105 + 0.247 \times N4 + 0.211 \times N3 + 0.208 \times N5 + 0.177 \times N2 + 0.149 \times N1$$

Table 12: Regression Results

Model	Unstandardized Coefficients		Standardized Coefficients	T - test	Significance Level	Multicollinearity Statistics	
	$\widehat{\beta}$	Standard Error	β			Tolerance	Variance Inflation Factor (VIF)
(Constant)	-1.105	0.180		-3.665	0.000		
N4	0.188	0.010	0.247	7.951	0.001	0.552	1.416
N2	0.192	0.021	0.177	7.328	0.001	0.613	1.537
N1	0.203	0.037	0.149	6.270	0.000	0.792	1.225
N5	0.227	0.035	0.208	5.341	0.000	0.776	1.249
N3	0.186	0.026	0.211	6.847	0.001	0.712	1.247

4. Conclusion

The results of the multiple linear regression analysis show that the satisfaction of farming households is significantly influenced by five groups of factors. Among these, the group N4 (PT1, PDV1, PDV2) with a regression coefficient of 0.247 has the strongest impact, affirming the key role of the irrigation infrastructure system and reasonable service fees. The other groups also demonstrate positive effects: N3 (CT1, CT2) with a coefficient of 0.211, which relates to the reliability and timeliness of information; N5 (CT3, CT4) with a coefficient of 0.208, reflecting the importance of communication, listening, and advocacy; N2 (TC1, TC4) with a coefficient of 0.177, which highlights the value of adhering to service commitments and ensuring information security; and N1 (DU1, DU7, PT3), which helps strengthen trust through service capacity, thorough support, and upgraded infrastructure.

Based on these findings, the proposed solution framework focuses on five aspects: (i) upgrading infrastructure and adjusting service fees accordingly; (ii) enhancing empathy in service provision; (iii) promoting communication and community participation; (iv) increasing reliability and transparency in operations; and (v) improving responsiveness and tangible resources. The coordinated implementation of these solutions will contribute to improving the quality of irrigation services, meeting agricultural production needs, and advancing sustainable irrigation management in the context of climate change.

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