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Optimization of Wawotobi Irrigation Network System Performance

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ABSTRACT

Water availability tends to decrease and water demand increases with the condition of water can change in quality and quantity, causing various problems, water must be managed wisely through an integrated and comprehensive approach. Water use optimization can be used more effectively and efficiently, in response to increasing water demand. Optimization of the Wawotobi irrigation network system needs to be done to determine the effect of the performance of the Wawotobi irrigation network system on farmer satisfaction. The purpose of this study is to find out the optimal performance of the Wawotobi irrigation network in terms of farmers' satisfaction or interests. The research method uses the Importance Performance Analysis (IPA) and Customer Satisfaction Index (CSI) methods, the analysis of the effect of satisfaction on the performance of the irrigation network system using Structural Equation Modeling (SEM) analysis using the AMOS version 18.0 program. of farmers, according to the IPA analysis, the gap between satisfaction and expectations of farmers on the performance indicators of Wawotobi irrigation system services an average value of 87.38, farmers assess the existence of a good irrigation network with a CSI value of 0.51 where farmers feel quite satisfied, except for 3 (three) service areas, namely Unaaha Pondidaha and Tonguna Districts with the performance of the Irrigation network Not Satisfied with CSI values = 0.48, 0.41, and 0.48, based on SEM analysis the estimated value for performance is positive, which is equal to 0.033 implies that the performance of the Wawotobi irrigation network system has a positive effect on farmer satisfaction with the performance model of the optimization of the Wawotobi irrigation network KP = 0.033. KN+e.

Keywords: Optimization, performance, irrigation

INTRODUCTION

Water availability tends to decrease and water demand increases with water conditions can change in quality and quantity, causing problems. Water needs depend on source debit, service area, building, irrigation network, management, and farmers, Prasad.et.al (2011) states that irrigation water needs must be sufficient from all systems in the irrigation network, if it is not sufficient, scheduling is needed . Smout et.al (2005) irrigation water management can be carried out in three processes namely on water allocation in service areas, water distribution operations and evaluation of water management systems. The success of irrigation water management depends on the process carried out according to the objectives and irrigation schemes.

Optimizing water use can be used more effectively and efficiently, in response to increasing water demand. Problems often encountered in irrigation network operations that are used as an indication of the low performance of the network, the low efficiency of water distribution, especially at the tertiary network level. Incorrect implementation of irrigation operational management can lead to conflicts, insufficient operational and maintenance costs so that the network functions quickly decrease.

If you look at Wawotobi irrigation conditions with a potential area of 20,458 ha, functional area of 9,447.80 ha, irrigation channel length of ± 153,156 km. The current condition is in accordance with the area of the planned land that has not been optimal both in the regulation and provision of water, irrigation networks, discharge conditions and buildings in the Wawotobi irrigation network system (BWS Sulawesi IV, 2015). The yield of rice production has only reached 4.4 to 7.2 tons / ha, with a large flow of water supplied by irrigation Wawotobi ± 21,042 m3 / sec, so large to meet the needs and potential land area. Optimization of the Wawotobi irrigation network system needs to be done so that the effect on the performance of the irrigation network system is known, the amount of potential water produced, the amount of discharge requirements, and knowing the condition of the building, researchers are interested in reviewing the optimization of the Wawotobi irrigation network system in support of increasing rice productivity.

LITERATURE REVIEW

The water saving optimization model is carried out on the basis of land parcels and expressed in optimal water allocation on a regional scale divided into two basic components to reduce the effects of hydrology and hydraulic uncertainty, by using linear programming in decision making and applying the optimization model using water allocation for irrigation system (Maeda, 2011). Another opinion, according to Yakubov (2011), states that irrigation performance is an important tool in irrigation service providers at various levels of water management that is used for monitoring, benchmarking and improving service conditions, although irrigation performance can be assessed directly from the farmer's perspective.

Lack of water allocation is a complex process that can be unsuccessful or failed in an irrigation project (Boubker, 1997).

Multicrop Irrigation Optimization System (MIOS), optimal for irrigation water allocation when conflicts arise between needs and availability. MIOS strives to provide irrigation agency decision support tools that can be used. MIOS combines the programming of a dynamic optimal allocation model and a water balance simulation model, to reduce short-term decisions for irrigation areas. Singh et.al (1999) states that the irrigation system optimization model (IOS) is a monitoring module, which controls and directs the flow between various modules. Such as channel hydraulic modules, hydrological modules, irrigation scheduling, plant growth, optimization, water costs. The irrigation scheduling model is based on the water balance technique using the soil moisture approach or the water surface approach.

Determination of the size of the sample in this study must be met including knowing the total population in the Wawotobi irrigation area and taking samples that represent service areas with the desired significant level α, and choosing practical methods in determining sample size (sample zise) used simplifed formula for proportions Yamane, Taro, (1967) as follows:

$$n = \frac{N}{1+N(e)^2} \tag{1}$$

$$n = \frac{126.143}{1+126.143 * (0.05)^2} = 398{,}735 \approx 399$$

Where :

n = number of samples

N = total population

d = percentage of leniency due to inaccuracy due to sampling errors that can still be tolerated

or desired (5%).

The population in the wawotobi irrigation service area in Konawe Regency is 126,143 inhabitants, using equation (1) a population sample of 398,735 people or 399 people farmer sample was rounded.

a. System optimization and irrigation network services

The operational aspects of irrigation networks are based on indicators, and a general assessment of the objective performance of existing conditions for each indicator in the Wawotobi irrigation network, namely: safety, accessibility, capacity, smooth and fast, easily achieved, on time, affordable, orderly, safe, and efficient. Performance Analysis of irrigation network services using the Importance Performance Analysis (IPA) and Customer Satisfaction Index (CSI) methods, this method combines the measurement of the level of importance and the level of satisfaction of irrigation users in a graph, making it easier to explain the data. The interpretation of natural science charts in the four quadrants is based on the measurement results obtained from the results of the questionnaire in the field.

b. Optimization of irrigation network systems with Importance Performance Analysis

Analysis of the optimization of the irrigation network system is done by using the Importance Performance Analysis (IPA) method, to find out the performance of the irrigation network is done by multiplying the importance and satisfaction of each respondent so that the average performance index of each research parameter is obtained, (Putra AA 2016).

$$\text{Tki} = \frac{Xi}{Yi} \times 100\% \tag{2}$$

Where :

Tki: Compliance level of the respondent

Xi: Scoring score on irrigation network performance

Yi: Score of interests or expectations of irrigation users

The horizontal axis (X) is filled by the score of the implementation level, while the vertical axis (Y) will be filled by the score of the expectation level (expectations), in simplifying the formula, then every factor influencing the satisfaction of irrigation users;

$$\bar{X} = \frac{\sum xi}{n} \tag{3}$$

$$\bar{Y} = \frac{\sum Yi}{n}$$

A Cartesian diagram is a structure divided into four sections that are bounded by two lines that intersect perpendicular to the points (X, Y), the symbol X is the average of the average score of the level of implementation or user satisfaction of all factors or attributes, and Y is the average of the average score of the importance of all factors that affect user satisfaction;

$$Q = \frac{\sum_{i=1}^{n} \bar{X}_i}{k} \tag{4}$$

$$P = \frac{\sum_{i=1}^{n} \bar{Y}_i}{k} \tag{5}$$

Where :

K = Number of attributes or facts that can affect user satisfaction

Q = Midpoint of the performance level score

P = Midpoint of expectation level score

c. Analysis of Customer Satification Index (CSI)

Irrigation user satisfaction analysis is done using the customer satisfaction index (customer satisfaction index) is a measurement to determine the overall level of satisfaction with an approach that considers the expected level of the factors measured. The satisfaction index measurement is done by using the average value of the level of expectation and performance of each service item, to get the satisfaction index number done with the following work steps:

1) Determine the Mean Importance Score (MIS)

MIS value of the average level of consumer expectations of each variable:

$$MIS_t = \frac{\left(\sum_{t=1}^{n} Y_t\right)}{n} \tag{6}$$

Where :

n = Number of respondents

Yi = i-th expectation value

2) Determine the Mean Satisfaction Score (MSS)

MSS is the average value of the level of reality felt by each variable or attribute:

$$MSS_t = \frac{\left(\sum_{t=1}^{n} X_t\right)}{n} \tag{7}$$

Where :

n = number of respondents

Xi = i Reality of Xth Attribute Value

3) Make a Weight Factor (WF)

This weight represents the MIS value per attribute to the total MIS of all attributes:

WF value;

$$WF_t = \frac{MIS_t}{\sum_{t=1}^{p} MIS_t} \tag{8}$$

4) Make a Weight Score (WS)

WAS multiplication between WF and the average level of reality perceived by users of the irrigation network as MSS (Mean Satisfaction Score);

$$WS_t = WF_t \, x \, MSS_i \tag{9}$$

5) Determine CSI

The equation used to determine CSI;

$$CSI = \frac{\sum_{t=1}^{p} WS_t}{HS} x100\% \tag{10}$$

Where :

p = attribute of p interests

HS = (Highest Scale) The maximum scale used

CSI values in this study were divided into five criteria from dissatisfied to very satisfied, these criteria are shown in the following table :

Table 1. Criteria for Customer Satisfaction Index Value

CSI Value	CSI Criteria
0.81 – 1.00	Very satisfied
0.66 – 0.80	Satisfied
0.51 – 0.65	Quite satisfied
0.35 – 0.50	Less satisfied
0.00 – 0.34	Not satisfied

d. Analysis of the effect of satisfaction on the performance of the irrigation network system

Analysis of the effect of satisfaction on the performance of irrigation network systems using Structural Equation Modeling (SEM). Structural testing using the AMOS version 18.0 program. Structural equations are formulated to express the relationship between variables;

$$Y = \beta X + e \tag{11}$$

Where :

Y = satisfaction of irrigation network users

X = Irrigation network system performance

e = Error measuring latent variable performance

β = Regression Weight (Unstandardized Beta regression coefficient)

METHODOLOGY

This research is located in the irrigation area of Wawotobi, Konawe Regency, Southeast Sulawesi Province. The weir has 7 intake gates, and the weir is 99.00 m wide with a river width of 82.00 m, potential irrigation area is ± 20,458 ha, functional area is 9,442 ha, with 2 planting times a year. The length of the channel is 153,156 km, the number of buildings for tapping 127 units with 221 complementary buildings, the length of the dump channel 130 km, with a level of rice production of 4.4 -7.2 tons / ha. Konawe, Wawotobi Subdistrict, West Wonggenduku Subdistrict, Wonggenduku Subdistrict, and Pondidaha Subdistrict while for right intake include Uepai Subdistrict and Lambuya Subdistrict.

Model of the effect of satisfaction on performance and importance based on indicators in the IPA in the Wawotobi irrigation network system, indicators of each performance variable, interests and satisfaction are safety, accessibility, cohesiveness, capacity, organized, smooth and precise, young and fast, timely, comfortable , affordable, orderly, safe, irrigation and efficient. Structural Equation Modeling (SEM) analysis which examines the effect of farmer satisfaction on the performance and interests of the Wawotobi irrigation network system and the application of Structural Equation

Modeling (SEM) analysis is carried out several stages such as stages: assumption test, test model measurement through confirmatory factor analysis, structural relationship model analysis and testing hypotheses that were built in the research conducted. Furthermore estimating the loading value of each indicator variable and the influence between variables of this study was carried out with the help of Software Analysis Of Moment Structural (AMOS. 18).

RESULTS AND DISCUSSION

The population in the wawotobi irrigation service area in Konawe Regency is 126,143 people, a population sample of 398,735 people or rounded 399 people representing the Wawotobi irrigation service area. The position of the performance indicators in each quadrant determines the value and treatment to be taken for each performance indicator. The position of each indicator in the IPA quadrant is shown in table 2.

Table 2. Position Indicators in Natural Sciences in the Wawotobi Irrigation Network

No	Indicator	Performance	Interests	Tki	Quadrant			
		X	Y		I	II	III	IV
	A	C	B	D				
1.	Safety	2.68	2.95	90.68			v	
2.	Accessibility	2.61	2.93	89.15			v	
3.	Cohesiveness	2.59	2.90	89.23			v	
4.	Capacity	2.58	2.98	86.54		v		
5.	Regular	2.62	2.86	91.36			v	
6.	Smooth and precise	2.64	2.91	90.64			v	
7.	Easy and fast	2.42	2.95	81.93		v		
8.	On time	2.41	2.90	83.24		v		
9.	Comfortable	2.47	3.04	81.22		v		
10.	Affordable costs	2.61	2.96	88.23			v	
11.	Orderly	2.65	2.96	89.44			v	
12.	Secure	2.56	2.87	89.14			v	
13.	Irrigation function	2.52	2.91	86.55		v		
14.	Efficient	2.52	2.93	86.02		v		
	Amount	35.87	41.06	1223.36				
	Average	2.56	2.93	87.38				

Source: Analysis Results, 2017

Based on table 2. shows the performance of irrigation networks and the value of farmers' interests in the existing irrigation networks in the Wawotobi Irrigation Area. The gap between farmers' satisfaction and expectations of service performance indicators, the large gap is a convenient indicator (81.22), regular (81.93), on time (83.24), with an average value of 87.38. Farmers assess that in general the existence of a good irrigation network. Specifically, the gap between the interests and performance of the Wawotobi irrigation network can be shown in Figure 1.

The farmer satisfaction level will be translated into a Cartesian diagram for the performance of the Wawotobi irrigation network system. The Cartesian diagram illustrates the quadrant intersection line on the average value of observations on the axis of importance and the axis of performance appraisal with the aim to find out specifically which indicators each quadrant lies in which quadrant.

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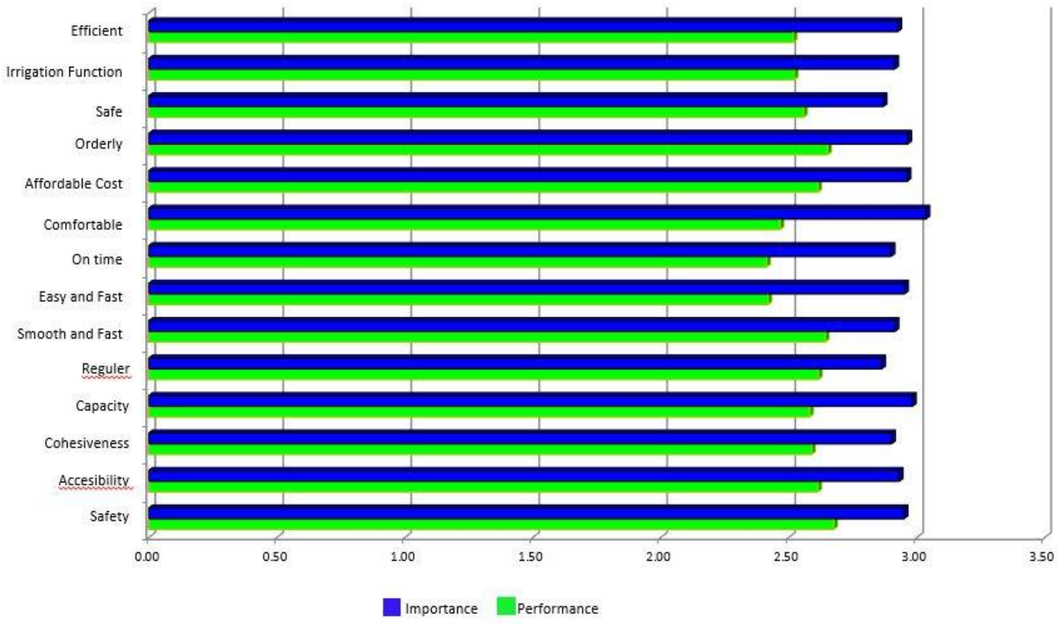

Figure 1. Gap Chart of Interest and Performance of Wawotobi Irrigation Network

The treatment for each indicator is based on its location in each quadrant. Quadrant I First Priority (high expectations and low performance), Quadrant II Maintain Performance (high expectations and high performance), Quadrant III, Excessive (low expectations of high performance) and Quadrant IV Priority low (low expectations and low performance). A complete picture of the position of indicators in the Cartesian quadrant can be shown in Figure 2.

Based on Figure 2 the Cartesian diagram shows that in quadrant I as the first priority there are no indicators that enter into the quadrant, in quadrant II that is expected to be able to maintain performance there are indicators of safety, capacity, easy and fast, convenient, affordable, orderly cost. Whereas in quadrant III as an excessive quadrant there are indicators of accessibility, cohesiveness, regular, smooth and precise, timely, safe, irrigation and efficient functions, while for quadrant IV there are no priority indicators. For an assessment of the farmer satisfaction index for the performance of the Wawotobi irrigation network system, see Table 3.

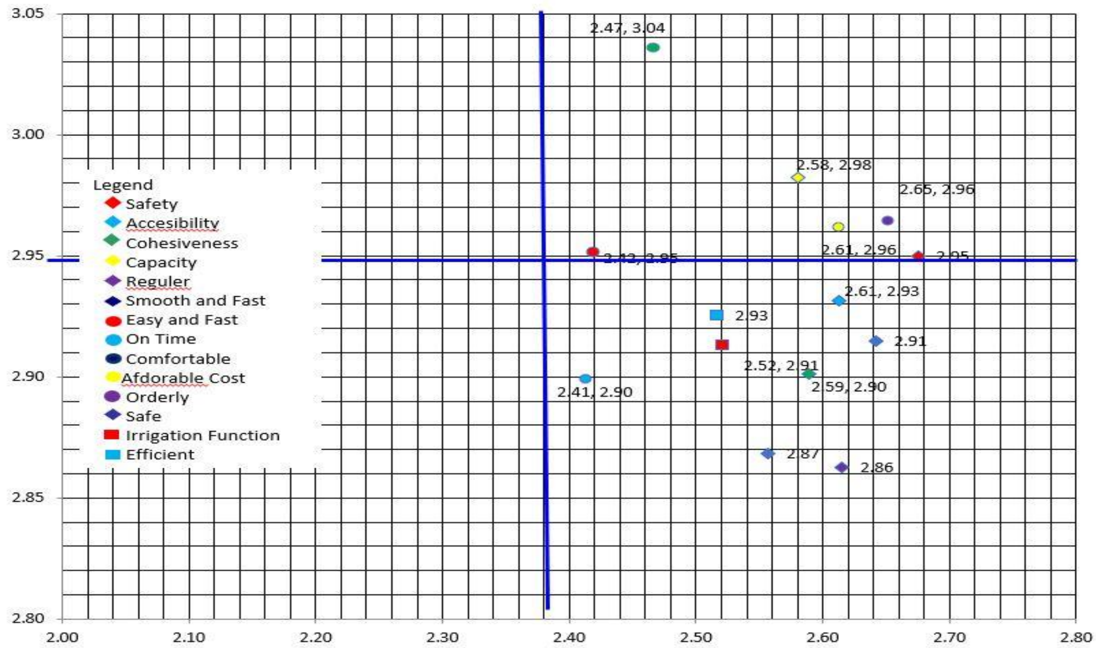

Figure 2. IPA Cartesian Diagram of Wawotobi Irrigation Network System

Tabel 3. Matriks CSI Pelayanan Sistem Jaringan Irigasi Wawotobi

NO.	Indicator	Performance	Interests	Tki	Weight (WF)	Score Weight (WS)	CSI
		X	Y				
	A	C	B	D	E	F	G
1.	Safety	2.68	2.95	90.68	1.01	2.58	0.52
2.	Accessibility	2.61	2.93	89.15	1.00	2.56	0.51
3.	Cohesiveness	2.59	2.90	89.23	0.99	2.53	0.51
4.	Capacity	2.58	2.98	86.54	1.02	2.61	0.52
5.	Regular	2.62	2.86	91.36	0.98	2.50	0.50
6.	Smooth and precise	2.64	2.91	90.64	0.99	2.55	0.51
7.	Easy and fast	2.42	2.95	81.93	1.01	2.58	0.52
8.	On time	2.41	2.90	83.24	0.99	2.53	0.51
9.	Comfortable	2.47	3.04	81.22	1.04	2.65	0.53
10.	Affordable costs	2.61	2.96	88.23	1.01	2.59	0.52
11.	Orderly	2.65	2.96	89.44	1.01	2.59	0.52
12.	Secure	2.56	2.87	89.14	0.98	2.51	0.50
13.	Irrigation function	2.52	2.91	86.55	0.99	2.54	0.51
14.	Efficient	2.52	2.93	86.02	1.00	2.56	0.51
	Amount	**35.87**	**41.06**	**1223,36**	**14.00**	**35.87**	**7.17**
	Average	**2.56**	**2.93**	**87.38**	**CS Index Results**		**0.51**

Source: Analysis Results, 2017

Farmer satisfaction is the level of feeling that arises between expectations and expected services. Based on Table 3. farmers feel quite satisfied with all the indicators with CSI values between 0.51 - 0.65. Overall the CSI value for the Wawotobi irrigation network system is 0.51 where farmers feel quite satisfied with the performance of the existing irrigation network services.

In this study the outliers test was used to determine the criteria for the distance of mahalanobis distence at a probability level smaller than $\propto$ = 0.05 or 95%. This mahalanobis distance is evaluated by using X^2 on free degrees equal to the number of indicator variables (observed variables) used in the study of 14 manifest variables. If the mahalanobis distence value > X^2 value at the probability level $\propto$ = 0.05 or 95%, then there will be univariate and multivariate outliers. Outlier data test is performed to determine the extreme observation data points.

The number of indicator variables (observed variables) in this study were 14 indicator variables with a sample of 42 so that the value of X^2 (0.05; 96) = 119.87 (MS Excel = CHIINV (0.05; 42)). All data that have a magnetic value greater than X^2 = 119.87 means that there are univariate and multivariate outliers. The results of the mahalanobis distance testing using AMOS 18.0 software showed that the value of the mahalanobis distance was greater than X^2 = 119.87 at a 95% confidence level. Mahalanobis minimum distance value is 78.717 on the 29th observation. Model of measurement of variable indicators that form latent variables or latent constructs in this research are satisfaction (KP), interests (KT), and performance (KN).

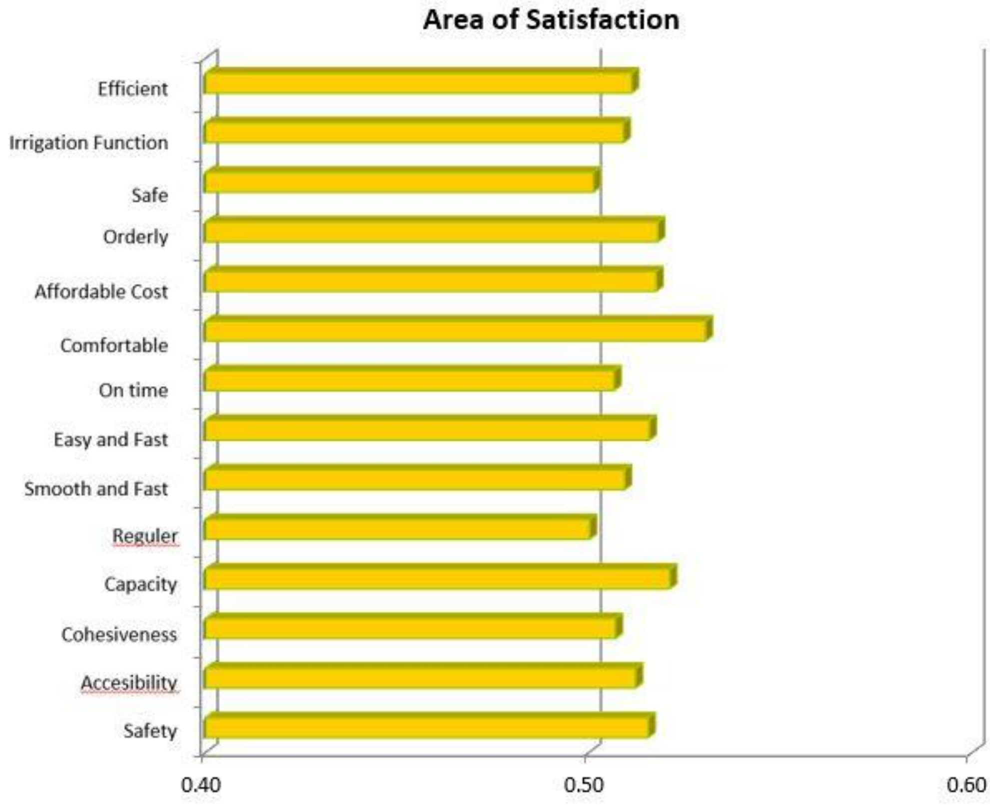

Figure 3. Farmer Satisfaction Level Against Wawotobi Irrigation Network System

The estimation results of the measurement model of latent performance variables consist of one manifest variable (observed variable), namely: efficiency. The measurement model for confirmatory factor analysis for each of the observed performance variables can be seen from the factor loading and probability values that reflect the level of significance and the amount of contribution in the formation of latent variables of satisfaction through standardized regression weights are shown in Figure 4.

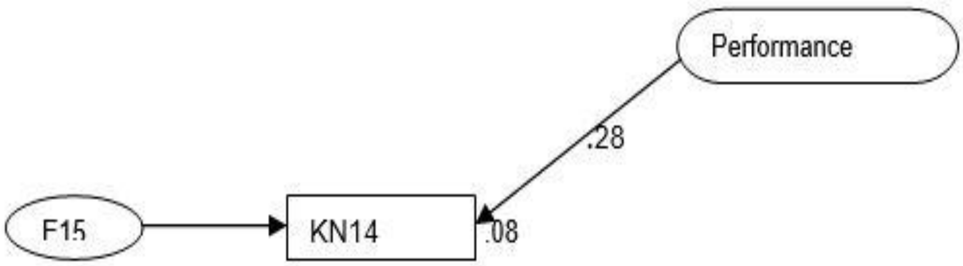

Figure 4. Confirmatory Factor Measurement Model of Latent Variables in Wawotobi Irrigation Network Performance

Based on Figure 4, the structural model can be entered into the equation as follows:

$KN = \lambda\ KN + e$

$KN14 = 0,284\ KN14 + e15$

The estimation results of the measurement model of latent performance variables consist of seven manifest variables (observed variables), namely: cohesiveness, capacity, regular, smooth and precise, young and fast, on time and comfortable. The measurement model for confirmatory factor analysis for each of the observed performance variables can be seen from the factor loading and probability values that reflect the level of significance and the amount of contribution / role in the formation of latent variables of interest through standardized regression weights shown in Figure 5.

Based on Figure 5, the structural model can then be entered into the equation as follows:

KT = λ KT + e

KT3 = 0,338 KT3 + e12

KT4 = 0,432 KT4 + e11

KT5 = 0,320 KT5 + e10

KT6 = 0,358 KT6 + e9

KT7 = 0,349 KT7 + e8

KT8 = 0,318 KT8 + e7

KT9 = 0,247 KT9 + e6

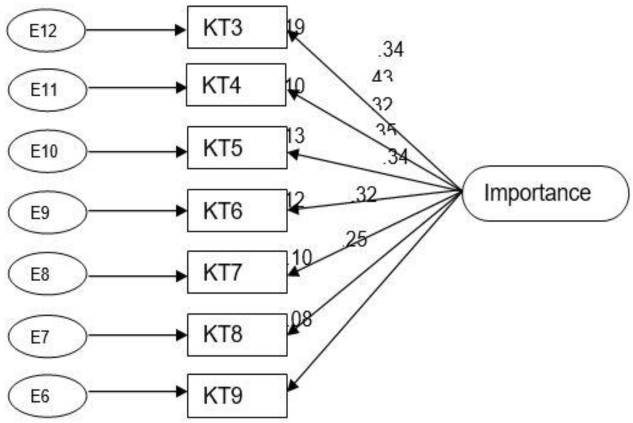

Figure 5. Confirmatory Factor Measurement Model of Latent Variable Interest in Wawotobi Irrigation Network

The first step taken is to evaluate whether the data used can meet SEM assumptions. For this test, several suitability indexes and cut-off values are needed to be used in testing a model. The results of the model suitability test can be shown in Table 4.

Table 4. Model Suitability Test Results

Goodness of Fit Indeks	Cut of Value	Analysis Results	Model Evaluation
Chi Square	Kecil	78,717	Small
Probabability	≥0,050	0,102	Good
CMIN / DF	≤2,000	1,230	Good
GFI	≥0,900	0,971	Good
AGFI	≥0,900	0,959	Good
RMSEA	≤ 0,080	0,024	Good

The test of the model hypothesis shows that this model is in accordance with the data or fit to the available data as seen from the level of significance of the chi-square model of 78.717 must be smaller than the chi-square calculated chiinv (0.05; DF) = 83.675. A probability index value of 0.102 is greater than 0.05 and an RMSEA value of 0.024 must be smaller than 0.08. Because the chi-square and CMIN / DF values are of good value, this model can be accepted using authentic data from the field and the resulting model can be used to predict farmers' satisfaction with optimizing the services of the Wawotobi irrigation system.

Based on the structural model testing framework, in general there are two sub-structural relationships that will be tested in this study, namely the effect of satisfaction on performance. This means that the relationship between latent variables shows the magnitude of the influence of exogenous variables on endogenous variables. The results of the processed data show that the relationship built in this research has a positive and significant relationship. The results of the structural model conformity analysis were built as a basis for analyzing the relationships between latent variables through the value of standardized regression weights with the aim of knowing the relationship between latent variables and the level of significance of the relationship shown in Table 5.

Table 5. Standardized Regression Weights Direct Effect of Latent Variables in Wawotobi Irrigation Network System

condition			Estimate	S.E.	C.R.	P	information
satisfaction	<---	performance	0,033	0,018	1,845	0,065	Signifikan

Estimated results of standardized regression weights, it can be seen the effect coefficient value, c.r (critical ratio) is the same as the t test in the regression analysis and the level of probability of each direct relationship between latent variables. Table 5, and Figure 6, show a direct relationship, namely: the performance of the Wawotobi irrigation network system has a significant effect on farmer satisfaction on optimizing the Wawotobi irrigation network system.

CONCLUSIONS

The results of the Structural Equation Modeling (SEM) analysis whose structural testing uses the AMOS version 18.0 program, shows that the performance of the Wawotobi irrigation network in terms of farmers' satisfaction or interests, in accordance with the IPA analysis, the gap between farmer satisfaction and expectations of the overall service performance indicator 87.38 .

Farmers assess the existence of a good irrigation network. Analysis of the average value of CSI = 0.51 where farmers feel quite satisfied with the performance of the existing irrigation system services. 3 (three) Districts assess the performance of the Less Satisfied irrigation network, namely Unaaha District, CSI value = 0.48, Pondidaha District CSI value = 0.41, and Tonguna District, CSI value = 0.48. SEM analysis for the estimated value of performance is positive, which is equal to 0.033 which means that the performance of the Wawotobi irrigation network system has a positive effect on the satisfaction of farmers in the Wawotobi irrigation network system.

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