THE PERFORMANCE AND THE INFLUENCE OF PHYSICAL INFRASTRUCTURES ON THE PLANT PRODUCTIVITY: A CASE STUDY APPROACH

***Muhamad Hendrie Soesanto[1], S. Imam Wahyudi[2], M. Faiqun Ni'am[3]**
[1,2,3] Fakultas Teknik, Universitas Islam Sultan Agung, Semarang
*) Email : muhendries@gmail.com

ABSTRACT

Irrigation System Performance Index (ISPI) is often used as a parameter in making decisions about the use of irrigation canals. The increase in rice production is dependent on a good condition of physical infrastructures, including the main building, the carrier canal and the buildings on the carrier canal. Performance assessment of Physical Infrastructure and Plant Productivity in Sungapan irrigation area of Pemalang Regency indicated that the physical infrastructure performance in 2012 - 2022 was 38.42%, increasing 3.22%. While the performance assessment of Plant Productivity was 14.96%, increasing 2.99%. Based on the multiple regression analysis using simultaneous test (F), the Physical Infrastructure component was indicated to influence the plant productivity. Meanwhile, based on the partial test (t), the physical infrastructure component partially did not have a significant influence on the plant productivity.

Keyword: *ISPI, Physical Infrastructure, Plant Productivity, F test, t test*

ABSTRAK

Indeks Kinerja Sistem Irigasi (ISPI) sering digunakan sebagai parameter dalam pengambilan keputusan penggunaan saluran irigasi. Peningkatan produksi beras tergantung pada kondisi infrastruktur fisik yang baik, antara lain bangunan utama, saluran pembawa dan bangunan di atas saluran pembawa. Penilaian kinerja Prasarana Fisik dan Produktivitas Tanaman di daerah irigasi Sungaipan Kabupaten Pemalang menunjukkan bahwa kinerja prasarana fisik tahun 2012 – 2022 sebesar 38,42%, meningkat 3,22%. Sedangkan penilaian kinerja Plant Productivity sebesar 14,96% meningkat 2,99%. Berdasarkan analisis regresi berganda dengan uji simultan (F), komponen Infrastruktur Fisik diindikasikan berpengaruh terhadap produktivitas tanaman. Sedangkan berdasarkan uji parsial (t), komponen infrastruktur fisik secara parsial tidak memberikan pengaruh yang signifikan terhadap produktivitas tanaman

Kata kunci: ISPI, Prasarana Fisik, Produktivitas Tanaman, Uji F, Uji t

1. INTRODUCTION

Baground

Irrigation is an effort to provide, regulate and dispose of irrigation water to support agriculture. Irrigation is divided into various types, such as surface irrigation, swamp irrigation, underground water irrigation, pump irrigation, and pond irrigation [1]. Operations in accordance with their designation such as regulating the irrigation water and its disposal in addition to maintaining the irrigation channels in order that they continuously function optimally are needed. Evaluation results of irrigation system performance describe condition and characteristics of an irrigation system. The results of this evaluation can also be a parameter in making decisions about the use of irrigation canals. There are several aspects to consider in evaluating performance of irrigation systems, for example, level of adequacy and accuracy of water supply, irrigation efficiency, condition and function of drainage system, etc.[2]. Main indicators in performance evaluation of irrigation systems include physical infrastructure, plant productivity, supporting facilities, personnel organization, documentation, and condition of Association of Farmers Using Water. Success of irrigated areas in increasing the productivity of rice is basically supported by the condition of physical infrastructures which includes main buildings, canal and buildings on the canal. Sungapan Irrigation Area, Pemalang Regency with a total irrigation area of 7,086 ha became the location of the present study. The performance assessment and the analysis of the relationship between the Physical Infrastructure and the Plant Productivity on the effectiveness of the irrigation maintenance would be the focus of the study.[3]

Research question is how the performance of the Physical Infrastructure and the Plant Productivity in 2012 – 2022. Does the physical infrastructure have an influence on the plant productivity in Sungapan irrigation area. Objectives and significance of the study is to find out the performance, and the performance trends, in addition to the influence/ relationship between the physical infrastructure and the plant productivity in Sungapan irrigation area from 2012 to 2022. From the study, the data collected would not only provide benefits in the form of the actual information related to the condition of the irrigation system, but also provide an input to the management regarding the operational plans and maintenance efforts of the Irrigation Area. Limitation of the study is was conducted in Sungapan irrigation area, Pemalang Regency. The performance appraisal analysis in the present study was carried out based on the Physical Infrastructure and the Plant Productivity indicators from the secondary data from 2012 to 2021 and the primary data for 2022.

Literature Review

General Description

Irrigation area is a place to receive water from irrigation networks. The irrigation networks consist of canals, buildings, and auxiliary buildings. These infrastructures are a unit needed to provide, distribute, share, use, and dispose irrigation water [1], [4]. The irrigation system includes irrigation infrastructure, irrigation water, irrigation management, human resource, and irrigation management institutions [5]. Sungapan irrigation area has an area of irrigation service of 7,086 Ha with the water sources coming from Waluh River through Sungapan dam. Shown in figure 1.

Figure 1. GIS map of Sungapan irrigation area

Sungapan dam divides the water flow for irrigation into; (1) to the right with 2 (two) intake gates in which these are Simangu primary canals with a service area of 1,689.292 Ha; and (2) to the left to Grogek primary canals with 4 (four) intake gates to irrigate an irrigation area of 5,396.708 Ha [6]

Irrigation System Performance Index (ISPI)

Irrigation System Performance Index (hereinafter called ISPI) is a value which indicates the performance of the irrigation system. It is also the evaluation results of the performance indicators of the irrigation system which include physical infrastructure, plant productivity, supporting facilities, personnel organization, documentation, and condition of Association of farmers using water. See table 1. below for details.

Table 1. Table of the Maximum Index of Irrigation Network Performance Assessment [7]

No.	Work indicators	Index of maximum condition (%)
1.	Physical Infrastructure	45
2.	Plant Productivity	15
3.	Supporting facilities	10
4.	Personnel Organization	15
5.	Documentation	5
6.	Condition of Association of farmers using water	10

Evaluation of the Physical Infrastructure Performance and Plant Productivity

a. Physical infrastructure

The physical infrastructure of the irrigation network consists of buildings and irrigation canals with indicators including the main building, carrier canals, buildings on the carrier canals, drainage canals, inspection roads, offices, official residence, and the warehouse infrastructure.

b. Plant Productivitypile.

Plant productivity is the ability of plant to grow and produce in one plant cycle. It is influenced by the fulfillment of water needs for irrigation, plant area, and rice productivity with indicators ranging from the fulfillment of the irrigation water (Factor K), the realization of the plant area, to the rice plant productivity.

Determination of Assessment Weight

Determination of performance evaluation criteria on the aspects of physical infrastructure and plant productivity was carried out by referring to the maximum weight of the assessment for each aspect. See Table 2. for the indicators.

Table 2. Maximum Weight of the Indicators on the Physical Infrastructure and Plant Productivity[8]

No.	Aspects	Maximum Weight Value	
1	Physical Infrastructure	45	
	- Main building		13
	- Carrier canals		10
	- Buildings on the carrier canals		9
	- Communication tools		4
	- Inspection roads		4
	- Offices, oficial residence and warehouse		5
2	Planting Productivity	15	
	- Fulfilment to the need for irrigation water (factor k)		9
	- Actual condition of planting area		4
	- Productivity of rice planting		2

Data Analysis Method with Multiple Linear Regression

Multiple linear regression analysis was conducted not only to find out the relationship between the independent variable (Physical Infrastructure) and the dependent variable (Plant Productivity), but also to find out whether the independent variable had a positive or negative relationship to the dependent variable. In addition, this analysis was also intended to predict the value of the dependent variable, if the value of the independent variable increased or decreased. The following is the formula for multiple linear regression analysis:

$$\boldsymbol{Y = a + b1X1 + b2X2 + b3X3} \quad (1)$$

with:

Y = dependent variable
a = constant
b1, b2, b3 = regression coefficient value
x1, x2, x3 = independent variable

Hypothesis test

This study used the Partial Test (t-test) and Simultaneous Test (F-Test) to test the hypotheses.

a. Partial test (t test) was conducted to test the effect of each independent variable used in this study on the dependent variable partially by formulating hypotheses H0 and H1, determining a significant level of 5% (0.05), comparing the significant level ($\alpha = 0.05$) with a significant level of t which was identified directly, and comparing t-count with t-table.
b. Simultaneous test (F test) was conducted to see the effect of all independent variables at the same time on the dependent variable by formulating hypotheses H0 and H1 for each group, determining the significant level of 5% (0.05), and comparing the significant level ($\alpha = 0.05$) with the significant level of F which was directly recognized, in addition to comparing F count with F table.

2. RESEACH METHOD

This reseach have several step stars from literature review, data collection (primary and secondary data), physical infrastructure and plat productivity performance assessment, make variable determination, definition of multiple linier regression, make hypothesis testing, doing simulation test dan partial test, make conclusion and suggestion.

Types of data

Data of the study consist of primary and secondary data. Primary data refers to data from a survey on the preparation stage for the irrigation asset management (IAM), ISPI (E-Management of Irrigation System Assets and Performance), and the real need for the operation and maintenance of Sungapan irrigation area collected from BBWS Pemali Juana in

2022. Secondary data in the present study include the Maps of Sungapan Irrigation Areas, the schema data on building and Sungapan Irrigation Networks obtained from the Compilation Report of irrigation asset management (IAM), ISPI (E-Management of Irrigation System Assets and Performance), and the real need for the operation and maintenance of Sungapan irrigation area in 2022, in addition to the Calculation data for the Irrigation System Performance Index from Balai PSDA Pemali Comal (Center for Member Resource Development of Pamali Comal) in the years of 2012 to 2021.

Procedure of the study

The following are the stages in this research:

a. Field survey to determine the condition of Sungapan irrigation network in 2022.
b. Secondary data collection for ISPI assessment of Sungapan irrigation area in 2012 to 2021 from Dinas PSDA Pemali Comal (the Office for Member Resource Development of Pamali Comal), and the compilation report of Irrigation Asset Management (IAM), ISPI (E-Management of Irrigation System Assets and Performance).
c. Analysis of the Physical Infrastructure and Plant Productivity in Sungapan irrigation area from the years of 2012 to 2022 was carried out in the following way:
   - Assessing the aspects of the physical infrastructure, including the main building, carrier canal, buildings on the carrier canal, exhaust canal and its building, inspection road, office, and the official residence, as well as the warehouse.
   - Assessing the aspect of plant productivity which consists of fulfillment to the need for irrigation water (factor k), actual condition of plant area, and the productivity of rice plant.
   - Analyzing the effect of the component performance of the Physical Infrastructure which ranges from the influence of the main building, the canal, the buildings on the canal to the plant productivity. The analysis was carried out using the multiple linear regression methods.
   - Conducting a Hypothesis Test to determine the effect of the Independent Variable (Physical Infrastructure) on the Dependent variable (Plant Productivity) in Sungapan irrigation area.

3. RESULT AND DISCUSSION

Physical Infrastructure Performance Assessment

The assessment was carried out by tracing the irrigation network from Sungapan dam to the last building in the secondary canal. The assessment was carried out on the components of the physical infrastructure with a reference to the assessment indicators such as the main building, carrier canal, buildings on the carrier canal, exhaust canal and its buildings, inspection roads, official offices, official residence, and warehouse infrastructure with the results as presented in Table 3. The assessment refers to the Technical Guidelines for the Asset Management and Irrigation System Performance, the module for the Irrigation System Performance Index, and the Main Building in 2019.

Tabel 3. Performance Assessment of the Physical Infrastructure of Sungapan Irrigation Area in 2022

Description	Final Value [%]	Part of Value [%]	Condition Index Existing (%)	Condition Index Maximum (%)
(1)	(2)	(3)	(4)	(5)
Physical Infrastructure	38,42	100	85,38	45
1. Main building	11,52	100	88,62	13
2. Carrier canals	8,50	100	85,00	10
3. Buildings on the carrier canals	7,67	100	85,19	9
4. Communication tools	3,40	100	85,00	4
5. Inspection roads	3,21	100	80,25	4

The following are the table 4 and the figure 2 of the recapitulation results between the assessment data in 2022 and the secondary data of performance appraisal from the year of 2012 to 2022.

Table 4. The Physical Infrastructure Performance of Sungapan irrigation area in 2012 to 2022

Years	Physical Infrastructure (%)
2012	35,20
2013	35,38
2014	36,03
2015	36,45
2016	36,60
2017	36,59
2018	36,69
2019	38,27
2020	37,10
2021	36,91
2022	38,42

Figure 2 explains that the performance of the Physical Infrastructure of Sungapan irrigation area from 2012 - 2019 had increased by 3.07%. In 2020 – 2021 there was a decrease in value of 1.36% due to the damage in the water cushion, drain gate, and the sedimentation in the main canal. Improvements had also been made in 2022 to the physical infrastructure components including the water cushion to right drain, the dam gatehouse, and the mud bag. In addition, some other improvements were also carried out through bridge repairs, installation of signs, normalization of Simangu Main Canal, and Grogek Main Canal, as well as repairs to the dam guardhouse. Therefore, the performance of Physical Infrastructure increased by 1.51% to 38.42%.

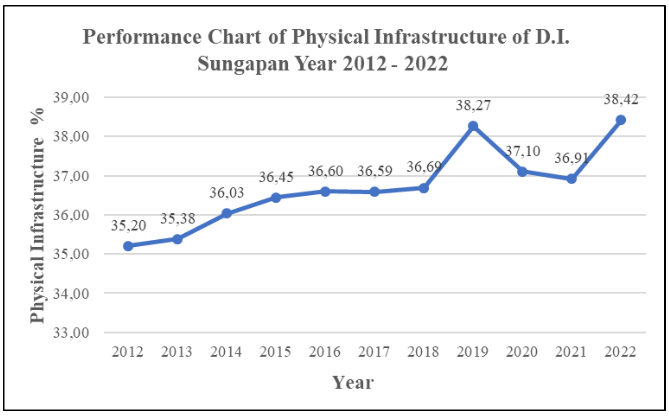

Figure 2. Graph of the Physical Infrastructure performance of Sungapan Irrigation Area in 2012 to 2022

Plant Productivity Performance Assessment

Plant productivity consists of the fulfillment of the irrigation water components (Factor K), the realization of plant area and productivity of the rice plant. The assessment was carried out by adding up the performance of these components as presented in Table 5 below.

Table 4. The Performance Assessment of Plant Productivity in Sungapan Irrigation Area in 2022

Description	Final Value [%]	Part of Value [%]	Condition Index Existing (%)	Condition Index Maximum (%)
(1)	(2)	(3)	(4)	(5)
Plan productivity	14,96	100	88,93	15
1. Fulfilment to the need for irrigation water (factor k)	9	100	100	9
2. Realization of planting area				
3. Rice planting productivity	8,50	100	85,00	10

The following are the table 4 and fig. 3 of the performance evaluation results of the Plant Productivity in Sungapan Irrigation Area in 2012 – 2022.

Table 4. The Performance Assessment of Plant Productivity in Sungapan Irrigation Area in 2022

Years	Physical Infrastructure (%)
2012	11,97
2013	11,97
2014	11,97
2015	11,97
2016	11,97
2017	11,97
2018	12,01
2019	12,59
2020	13,49
2021	13,36
2022	14,96

Figure 3 explains that the Plant Productivity of Sungapan Irrigation Area in 2012 - 2017 did not experience a significant change. In 2018 – 2020, there was an increase of 1.52%. In 2021, there was a decrease of 0.13% due to damage to several components of the Physical Infrastructure. However, the performance has increased by 1.60% after the improvement in 2022.

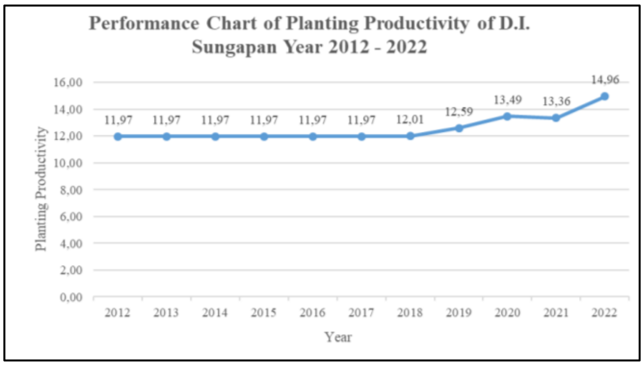

Figure 3. Graph of the Plant Productivity Performance in Sungapan Irrigation Area in 2012 – 2022

Influence/ Relationship between Physical Infrastructure and Plant Productivity in Sungapan Irrigation Area

Based on the performance assessment between the Physical Infrastructure and the Plant Productivity, an analysis was conducted to determine the significant level of the influence among these components. Analysis was conducted using the multiple linear regression analysis.[9]

Correlation Analysis

Correlation analysis was carried out to determine the pattern of the relationship between independent variable (the Main Building, Carrier Canal, and Carrier Building) and the dependent variable (Plant Productivity). See Figure 4 for details.

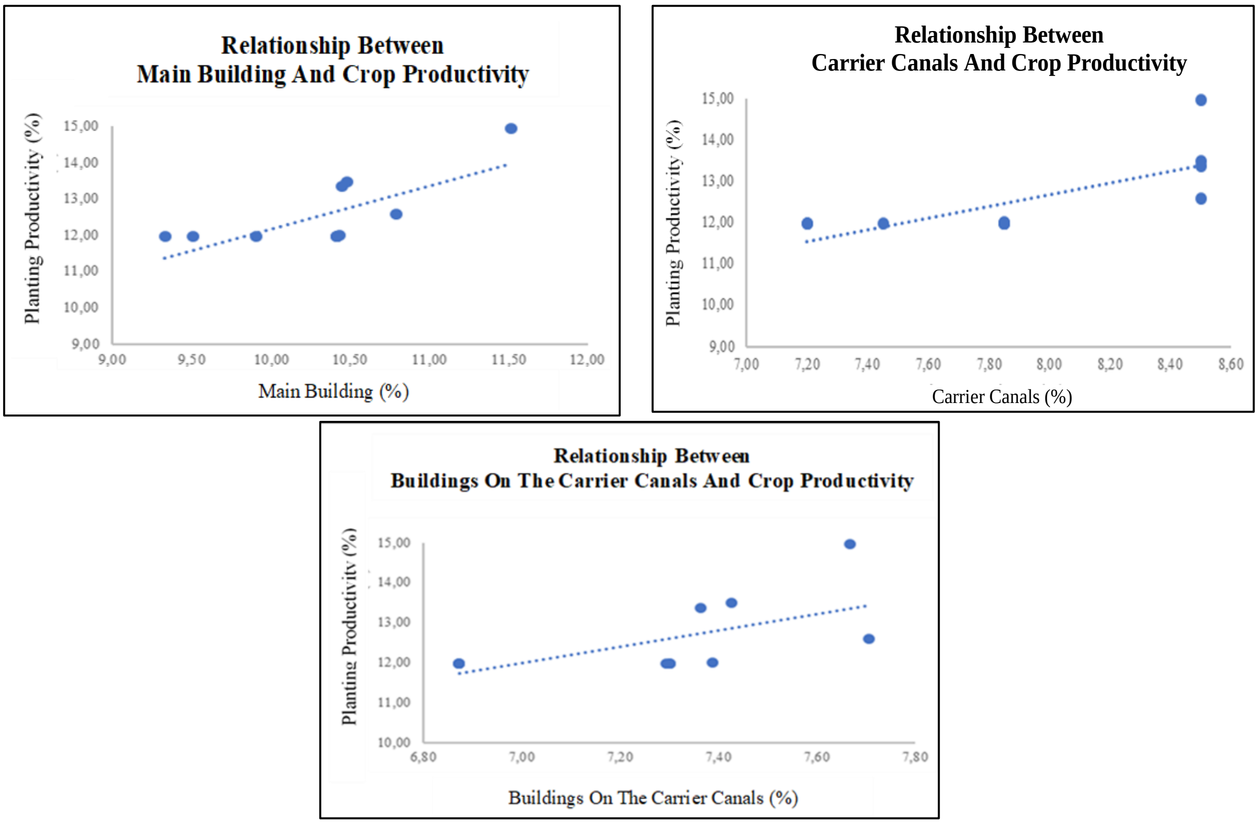

Figure 4. Scatter Plot Graph of the Physical Infrastructure and the Plant Productivity

Correlation Analysis in Figure 4. explained, there has a positive and significant relationship between the Main Building and the Plant Productivity. This positive and significant relationship is indicated by a sharp increase in graphs. The relationship between Buildings on the Carrier Canal and Carrier Canal with Plant Productivity shows a positive but not significant relationship. This appears from the absence of a sharp increase in the graph.

Multiple Linear Regression Analysis

Multiple Linear Regression Analysis was carried out (1) to determine the relationship between the independent variables such as the main building (X1), the canal (X2), and the building on the canal (X3), and the dependent variable (Plant Productivity) (Y); (2) to find out whether the independent variable was positively or negatively related, and (3) to predict the value of the dependent variable if the value of the independent variable increased or decreased. The analysis was carried out using the SPSS 26 application. See Table 5. for detail result of the analysis.

Table 5. Results of the Multiple Linear Regression Analysis

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients
		B	Std. Error	Beta
1	(Constant)	8.707	6.551	
	X1 (Main building)	1.515	.893	.918
	X2 (Carrier canals)	1.800	.972	.938
	X3 (Buildings on the carrier canals)	3.582	2.240	1.083

a. Dependent Variable: Y (Plant Productivity)

The following is the obtained linear regression model.
Y = 8,707 + 1,515 X¬¬1 + 1,8 X2 + 3,582 X3
Which means the variable of Plant Productivity would be worth 8.707, assuming there was no influence from the independent variable. An increase in one unit of the Main Building variable would increase the Plant Productivity variable by 1.515; An increase in one unit of Carrier Channel variable would increase the Plant Productivity variable by 1,800; and an increase in one unit of Carrier Canal Building variable would increase the Plant Productivity variable by 3.582.

Hypothesis Test

Hypothesis testing is used not only to determine the influence of the independent variables on the dependent variable either partially or simultaneously, but also to determine how much influence these independent variables had in the regression model. The hypothesis of this study states that the condition of the physical infrastructure of the Irrigation Area (main building, conveyance and buildings on the conveyance) has a good effect on the increasing plant productivity around the Irrigation Area. Analysis of this study was carried out using the multiple linear regression analysis tests based on the results of the simultaneous test, the hypothesis test (F test), and the partial test (t test).[10]

- **Simultaneous Test (Uji F)**

  Simultaneous tests were conducted to determine the influence of several independent variables simultaneously on one dependent variable.

Table 6. Results of the Simultaneous test

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	6.637	3	2.212	5.128	.035[b]
	Residual	3.020	7	.431		
	Total	9.656	10			

a. Dependent Variable: Y (Plant Productivity)
b. Predictors: (Constant), X3 (Buildings on the carrier canals), X2 (Carrier canals), X1 (Main Building)

From the calculation results of the simultaneous test (See Table 4.6.), a significant F value of 0.035, smaller than α (0.05) was obtained. F count (5.128) in this case is known to be greater than F table (4.066). Therefore, H0 is rejected and H1 is accepted. It means there is a simultaneously significant influence of the Main Building, Carrier Canal, and the Carrier Building on the Plant Productivity.

- **Partial Test (t-test)**

  The Partial test was conducted to determine the influence of each independent variable on the dependent variable partially. The Partial test can be carried out through t test by comparing between the value of Significance t and the value of α (alpha) = 0.05, and also t_count and t_table

Table 7. The Partial Test Results

Coefficients[a]

Model		t	Sig.
1	(Constant)	1.329	.226
	X1 (Main Building)	1.697	.134
	X2 (Carrier canals)	1.853	.106
	X3 (Buildings on the carrier canals)	1.599	.154

a. Dependent Variable: Y (Plant Productivity)

From the results of the partial test in Table 7., the following results are obtained:

- The significant value of the influence of the Main Building variable (0.134) is greater than α (0.05), and the t_count (1.697) is smaller than t_count (2.364). Therefore, the hypothesis H0 is accepted with a conclusion, the Main Building variable does not have a significant influence on the Plant Productivity.
- The significant value of the influence of the Carrier Channel variable (0.106) is greater than α (0.05), and the value of t count (1.853) is smaller than t count (2.364). Therefore, the hypothesis H0 is accepted with a conclusion, the carrier channel variable does not have a significant influence on the plant productivity.
- The significant value of the influence of the Main Canal Building variable (0.154) is greater than α (0.05), and the value of t-count (1.599) is smaller than t-count (2.364). Therefore, the hypothesis H0 is accepted with a conclusion, the Main Canal Building variable does not have a significant influence on the Plant Productivity.

4. CONCLUSIONS

In 2022, the performance assessment of the Physical Infrastructure of Sungapan irrigation area is 38.42% and the performance assessment of the Plant Productivity is 14.96% with the Trend of the Physical Infrastructure Performance Assessment in 2012 - 2022 increasing of 3.22%, and the trend of the Plant Productivity Performance in 2012 – 2022 increasing by 2.99%. Based on the Simultaneous Test (F Test), the Physical Infrastructure (the Main Building, the Carrier Canal, and the Building of Carrier Canal) simultaneously influenced the Plant Productivity. Based on the Partial Test (t Test), the Physical Infrastructure Components (the Main Building, the Carrier Canal and Building of Carrier Canal) partially do not have a significant influence on the Plant Productivity in each component.

REFERENCES

[1] Kementerian PUPR, "PERATURAN MENTERI PEKERJAAN UMUM DAN PERUMAHAN RAKYAT REPUBLIK INDONESIA," 2015.

[2] M. Satria Sebayang and A. Putra Munir, "EVALUASI KINERJA OPERASI DAN PEMELIHARAAN SISTEM IRIGASI MEDAN KRIO DI KECAMATAN SUNGGAL KABUPATEN DELI SERDANG (The Operation Work Evaluation and Maintenance of Medan Krio Irrigation System in Sunggal District Deli Serdang Regency)," 2014.

[3] Hariyanto, "ANALISIS PENERAPAN SISTEM IRIGASI UNTUK PENINGKATAN HASIL PERTANIAN DI KECAMATAN CEPU KABUPATEN BLORA," *RICE*, vol. 02, pp. 29–34, 2012.

[4] "PermenPUPR23-2015 - Lamp.3".

[5] "PermenPUPR23-2015 - Lamp.2".

[6] I. Suryanti, P. I. Dianti Putri, and M. W. Jayantari, "Penilaian Kinerja dan Penyusunan AKNOP Embung di Provinsi Bali," *Jurnal Ilmiah Telsinas Elektro, Sipil dan Teknik Informasi*, vol. 5, no. 1, pp. 1–9, Apr. 2022, doi: 10.38043/telsinas.v5i1.3694.

[7] "PermenPUPR23-2015 - Lamp.1".

[8] T. Prayogo, S. Wahyuni, and M. Iqbal, "A Study of Irrigation Performance Index and Real Cost Value of Irrigation Operations and Maintenance in Surak Irrigation Area," *Civil and Environmental Science*, vol. 004, no. 01, pp. 030–042, Apr. 2021, doi: 10.21776/ub.civense.2021.00401.4.

[9] M. Nugroho, "Evaluasi Kinerja Sistem Irigasi Daerah Irigasi Van Der Wijck Dengan Menggunakan Fuzzy Set Theory. Yogyakarta : Universitas Islam Indonesia," *Universitas Islam Indonesia*, 2018.

[10] C. Mubarok and G. D. Asfari, "PENILAIAN KINERJA IRIGASI BERDASARKAN PENDEKATAN PERMEN PUPR NO.12/PRT/M/2015 DAN METODE MASSCOTE DENGAN EVALUASI RAPID APPRAISAL PROCEDURE (RAP) DI DAERAH IRIGASI Studi Kasus : Glapan-Jawa Tengah."