Infrastructure performance of irrigation canal to irrigation efficiency of irrigation area of Candi Limo in Mojokerto District

S Kisnanto¹, R R R Hadiani¹ and C Ikhsan¹
¹Master Program of Civil Engineering, Sebelas Maret University, Jl. Ir. Sutami 36A Surakarta

E-mail : kisnanto.satriyo@student.uns.ac.id

Abstract. Performance is a measure of infrastructure success in delivering the benefits corresponding it’s design implementation. Debit efficiency is a comparison between outflow debit and inflow debit. Irrigation canal performance is part of the overall performance aspects of an irrigation area. The greater of the canal performance will be concluded that the canal is increasingly able to meet the planned benefits, need to be seen its comparison between the performance and debit efficiency of the canal. The existing problems in the field that the value of the performance of irrigation canals are not always comparable to the debit efficiency. This study was conducted to describe the relationship between the performance of the canal to the canal debit efficiency. The study was conducted at Candi Limo Irrigation Area in Mojokerto District under the authority of Pemerintahan Provinsi Jawa Timur. The primary canal and secondary canal are surveyed to obtain data. The physical condition of the primary and secondary canals into the material of this study also. Primary and secondary canal performance based on the physical condition in the field. Measurement inflow and outflow debit into the data for the calculation of the debit efficiency. The instrument used in this study such as the current meter for debit measurements in the field as a solution when there is a building measure in the field were damaged, also using the meter and the camera. Permen PU No.32 is used to determine the value of the performance of the canal, while the efficiency analysis to calculate a comparison value between outflow and inflow debit. The process of data running processing by performing the measurement and calculation of the performance of the canal, the canal debit efficiency value calculation, and display a graph of the relationship between the value of the performance with the debit efficiency in each canal. The expected results of this study that the performance value on the primary canal in the range of 0 to 100 % with debit efficiency value in the range of 0 to 100 %, while for the secondary canal 1 has a performance range between 0 to 100% with efficiency ranges between 0 to 100%, the performance of the secondary canals 2 ranges between 0 to 100% with efficiencies ranging from 0 to 100%, the secondary canal 3 performance ranges between 0 to 100% efficiency ranges between 0 to 100%, the secondary canal 4 performance ranges between 0 to 100% efficiency ranges between 0 to 100% and secondary canals 5 performance ranges between 0 to 100% efficiency ranges between 0 to 100%. For the tendency to expect from the performance and efficiency of the debit canal can have a proportional clockwise or counterclockwise, which amount can be random. The tendency to be graphed the relationship between performance and efficiency of the debit of each segment studied canal.
1. Introduction

Irrigation in Indonesia are mostly used for rice crops, and partly also for palawija, fruits and vegetables. Irrigation management continue to be improved both the operation and maintenance of irrigation networks, making it more advanced and more efficient in distributing water availability.

Water is one of the most valuable natural resources that has very diverse functions. Increasing population growth in Indonesia is also increasing the need for water for various purposes, such as agriculture, settlement, urban, industrial, fishery, energy, tourism, environment and others. This results in water becoming scarce at a certain time for some locations prone to water shortages [1].

Irrigated agriculture would seem to be a prime candidate for interventions aimed at reducing water demand and inducing water savings [2]. The conveyance efficiency is the efficiency of canal and conduit networks from the reservoir, river diversion, or pumping station to the offtakes of the distributary system [3].

Considering the importance of irrigation water efficiency in reducing water criterion, it is necessary to conduct research to know efficiency of irrigation water utilization and water availability index with pipe irrigation input so that available water can be utilized properly and efficiently. Water utilization in a good and efficient way can be one step in irrigation water management [4].

Seepage from canal cannot be controlled completely. Significant seepage losses do occur from a canal even if it is lined. This problem more aggravates in percolation soils. Thus, the conversion of canal lining to pipeline may lead to further reduction in seepage losses [5].

Performance assessment of irrigation canals carried out by water worker with the search, observe any damage, leakage and interference of wild plants that exist in the irrigation canals. Construction activities carried out so that the performance assessment of irrigation officers observation can be improved.

Conservation of water resources has become an international issue that always suggests the importance of saving water consumption, because many countries are experiencing a water crisis and drought. Indonesia's water availability are abundant enough, although its advanced management hasn't apply well. Conflicts among farmers occasionally occur during the dry season, because of scarcity of water and poor water management. The more efficient a canal that can reach farther distribution, so it is expected to reach areas with water scarcity problem.

A gradually decrease in the efficiency of irrigation canals were influenced by many factors, which can lead to water scarcity, particularly in the rice field far away from the source or the dam intake. Good maintenance for technical irrigation in addition to improving performance may also improve the efficiency of the irrigation canal as it has been planned accordingly.

This study discusses the relationship of the performance of the canal towards the discharge efficiency of irrigation canals, is expected to provide insights and another point in the maintenance and rehabilitation of irrigation infrastructure. The amount of the performance and efficiency of data derived from observations in the field.

1.1. Efficiency

The efficiency of the distribution (Conveyance efficiency) is the efficiency in the main canal of the primary and secondary of the weir to the tertiary tapping, and can be calculated by the

\[
Ec = \frac{W_f}{W_r} \times 100\%
\]  

(1)

Where:

- \( Ec \) = Efficiency distribution
- \( W_f \) = the amount of water in the canal
- \( W_r \) = the amount of water taken from the river
1.2. Performance of channel
The performance of the irrigation area is considered good, when the realization of the field going according to plan has been created. Components of the performance of irrigation areas such as physical infrastructure, productivity, supporting facilities, personnel organization, documentation, institutional conditions (i.e P3A).

One element of the performance of the physical infrastructure is infrastructure performance of irrigation canal, which is a review of the research.

1.2.1. Search. Under the proposal sent by the interpreter damage on a regular basis, do a search to determine the level of damage to tissue in order to making the proposed maintenance work next year. Maintenance of an inventory of activities indispensable condition of irrigation network is data including data damage and its effect on the service area.

Based on the results of a survey conducted inventory identification of problems and maintenance needs in a participatory manner, and made a series of structured action plan with priorities and a description of the maintenance work. In determining criteria for the maintenance of physical damage was apparent from the irrigation network. In essence the maintenance of irrigation networks were delayed will result in more severe damage and require early rehabilitation.

1.2.2. Indicator. According Permen PU 32 2007 said about some success indicator maintenance activities. The performance assessment of irrigation canals can be written:
   a) good condition, when the canal has a performance value greater than 90%.
   b) slightly damaged condition, when the canal has the value performance of 80-90%.
   c) broken and, when the canal has the value performance of 60-79%.
   d) heavily damaged condition, when the canal has a value of less than 60% performance.

2. Experimental
This study took place in the Candilimo Irrigation Area. Candilimo Irrigation Area has an area of 1938 Ha services are in Mojokerto, East Java, Indonesia. This Irrigation area is the authority of the Government of East Java in the management of the Dinas PU Pengairan in East Java Province.[7]

Mojokerto save a lot of history, especially the buildings of the kingdom of Majapahit famous relic in Southeast Asia. Heritage sites that still exist as an Kolam Segaran, candi tikus and other temples as the cultural heritage. Residents in mojokerto fraction are farmers, but agricultural land in mojokerto holds the first rank in the appeal of other sectors with an area that is approximately 38% of total area 371.01 km² Mojokerto regency.

Candilimo Irrigation Area located around the coordinates 7° 35’ 52.35 ”S and 112° 26’ 02.09” East.

This study concentrated on the performance and efficiency of discharge in each segment of primary and secondary canals in irrigated areas candilimo Mojokerto regency.
3. Result and Discussion
Total length of primary canal in candilimo irrigation area were about 5.59 km length and total length of secondary canal were about 21.64 km length.

There are one intake and six tapper building (in some location tapper building was exist together with divider building in the same point) in the primary canal of candilimo irrigation area. Intake is a building that tapping the water from the river and flow it to the primary canal. Tapper building flow the water from primary canal to the paddy fields or tertiary canal.

*B.CL* is a symbol that written in the building scheme mapping. The letter of *B* represent the word of building, and *CL* represent the words of candilimo primary canal. Every tapper building were represented by *B.CL* symbol letter. There are *B.CL.1, B.CL.2, B.CL.3, B.CL.4, B.CL.5, and B.CL.6* for every six tapper building.

There are six segment in the primary canal. First segment start from intake and end to *B.CL.1*, second segment start from *B.CL.1* and end to *B.CL.2*, and continued to sixth segment start from *B.CL.5* and end to *B.CL.6*. All of six segments in primary canal was detailed in the table 1.
Table 1. Primary canal 1 in the Candilimo irrigation area

| No | Segment       | Boundary | Length (km) |
|----|---------------|----------|-------------|
| 1  | 1 (primary canal) | Intake   | B.CL.1      | 1.126       |
| 2  | 2 (primary canal) | B.CL.1   | B.CL.2      | 0.2         |
| 3  | 3 (primary canal) | B.CL.2   | B.CL.3      | 0.582       |
| 4  | 4 (primary canal) | B.CL.3   | B.CL.4      | 2.175       |
| 5  | 5 (primary canal) | B.CL.4   | B.CL.5      | 1.242       |
| 6  | 6 (primary canal) | B.CL.5   | B.CL.6      | 0.265       |

Figure 2. Relationship of performance and discharge efficiency in the canal segment in primary canal of Candilimo

Performance and efficiency are some of many characteristics that exist in every canal segment. Performance and efficiency have its own value in all six of canal segments. Each of value of performance and efficiency in six of canal segments was illustrated in a chart. The value of performance and efficiency was the expected value from search survey in the field. The chart was illustrated in figure 2.

From chart in figure 2 illustrated the value of performance and efficiency in the six segment of primary canal. The value is in percentage, it range between 0 % to 100 %. Segment 1 have performance value about 60 %, it is the lowest value of performance in all segment on primary canal. Segment 2 have performance value about 80 %, it is the highest value of performance on primary canal.

In this case, segment 1 have lowest performance, so it will have the first priority to maintained, instead segment 2 have the highest performance, it will have the last priority to maintained. In the application of maintenance work package, it take only performance for main indicator. It means that the canal with low performance will get the first priority.

There are thousand kilometers length of canal in east java province only that use performance for main indicator. In some location took 2 milions rupiah for maintain 150 meters length of canal, it is...
depend on the wide of canal and kind of degradation. It increase the performance only.
This chart will compare the performance and efficiency in each of segment, so the maintenance work package not only to increase the performance, but also to increase the efficiency in the canal. It will use efficiency and performance for indicator for succes in maintenance work package.

We can use the budget more efectively by increasing the efficiency in every canal. It will decrease the water conflict, that occur in the downstream of irrigation network. The conflict especially happen in the dry season.

4. Conclusion and Recomendation
Efficiency is the important indicator, beside performance especially in the canal segment maintenance. There are many building in irrigation network. measuring building is one of some building in irrigation network. Measuring buildingused for measure debit of water that flow on the measuring building. Measuring building was ussualy instaled after tapper building.

In the primary canal, measuring building was instaled after intake building that tapping the water from the river. After intake building, there are some tapper building that has current distance from each other, so from intake building. Tapper building flowing water from primary canal to tertiary canal.

In this case, point location is at the tapper building in the primary canal. There are measuring building that exist only after tapper building in the downstream of tapper building. So the measuring building lies in the tertiary canal closed to tapper building.

In this point location, there are no measuring building in the primary canal. It is needed to instal measuring building in the primary canal after tapper building or before tapper building. It is needed to know the debit that flows in the primary canal in this point location. So it is knowing the efficiency in this canal segment before it point location.

Then in every tapper building need to instal measuring building in the primary canal position after tapper building or before tapper building. So we hope that there are some advanced research about evaluation of instaling addition measuring building in the primary canal or secondary canal in the irrigation network.

References
[1] Bancin A A, Jayanti D S, and Ferijal T 2015 Jurnal Rona Teknik Pertanian 8(1) 19 – 28
[2] Bekchanov M 2016 J. Water Res. and Economic 13 30–45
[3] Bos M G, Nugteren J 1990 On irrigation efficiencies (Netherlands : International Institute for Land Reclamation and Improvement)
[4] Fajar A, Purwanto M Y J, and Tarigan S D 2016 Jurnal Irigasi 11(1) 33 – 42
[5] Jadhav P B 2014 Int. J. Eng. Innov. Res. 3(6) 820 – 826
[6] Kementerian PUPR 2013 Standar Perencanaan Irigasi, Kriteria Perencanaan Bagian Saluran KP-03 (Jakarta : Direktorat Irigasi and Rawa, Direktorat Jenderal Sumber Daya Air)
[7] Kementerian PUPR 2015 Kriteria dan Penetapan Status Daerah Irigasi (Jakarta : Menteri Menteri Pekerjaan Umum and Perumahan Rakyat) Rakyat)