Jurnal Mekintek,13 (1) (2022) pp. 1-6

Published by: IHSA Institute

Jurnal Mekintek: Jurnal Mekanikal, Energi, Industri, Dan Teknologi

Journal homepage: www.ejournal.isha.or.id/index.php/Mekintek

Evaluation Of Water Delivery Performance In The Paya Sordang Irrigation Area, Padang Sidimpuan Tenggara District, Tapanui Regency

Andri Kurnia Nasution

Department Of Civil Engineering, University Of North Sumatra, Jl. Dr. Mansur No. 9 Padang Bulan, Kec. Medan Baru, Kota Medan 20222

ARTICLE INFO

Article history:

Received Feb 01, 2022
Revised Mar 05, 2022
Accepted Apr 30, 2022

Keywords:

Water Demand Analysis
Mainstay Discharge
Efficiency
Effectiveness

ABSTRACT

Irrigation plays a role in increasing crop production, by regulating, providing water needs for plants. Water demand for plants is affected by water loss due to decreased performance of irrigation networks. For this reason, a good irrigation system is needed so that water needs for plants can be met. Loss of water that occurs in irrigation canals can affect the efficiency of water requirements needed by plants. To increase crop production, it can also be done by optimizing the available land so that land use becomes more effective. The location of the research study is in the Paya Sordang Irrigation Area, Southeast Padangsidimpuan District, South Tapanuli Regency. Analysis of irrigation water needs was carried out using the FJMock method, from the analysis of irrigation water needs it was found that the mainstay discharge of the Batang Angkola watershed was obtained in order to obtain a good planting pattern and period. From the measurement of the discharge can be seen the efficiency of the irrigation canal. Meanwhile, to calculate land effectiveness, it is done by dividing the irrigated area by the design area. Based on this research, the mainstay discharge is 17.75 m3/s and the water demand is 0.7 lt/sec/ha. The efficiency of the secondary network is 91.1962%, this efficiency has met the efficiency specified in the criteria for irrigation planning, namely for the secondary channel, the efficiency is 90%. From the research results, it can be seen that Paya Sordang irrigation is currently less effective. This can be seen from the initial planned irrigation area which is 4,350 ha and which can be irrigated only 1,232 ha during the dry season and 3,118 during the rainy season, so that the effectiveness of Paya Sordang irrigation is only 28.322% during the dry season and 71.678% during the rainy season.

Corresponding Author:

Andri Kurnia Nasution,
Department Civil Engineering,
University Of North Sumatra,
Jl. Dr. Mansur No. 9 Padang Bulan, Kec. Medan Baru, Kota Medan 20222.
Email : andrinasution@gmail.com

1. INTRODUCTION

Efforts to increase the production of food crops, especially rice, as a commodity in Indonesia can basically be done through various approaches, including extensification, intensification and rehabilitation. Increasing food production in the short term can be done intensively by increasing the optimization of the utilization of existing resources, in lowland rice farming the optimization of resource utilization can be done, among others, through the efficient and effective use of irrigation water.

The main obstacle faced to spur the growth of food production, especially rice is the decline in land productivity. This is caused by over-intensification of paddy fields associated with high cropping intensity with fertilizer doses that tend to exceed optimal requirements. In addition, many lands experience water shortages as a result of the declining quality of an irrigation system.

The decline in irrigation quality is a result of the declining performance of an irrigation system. Many factors cause a decrease in irrigation performance, including the conversion of land from paddy fields to other forms of use (settlement). Thus, the condition of many irrigation networks is not utilized or is left damaged.

The decline in the performance of the irrigation network is a real threat to the lack of water demand for rice fields. The impact of decreasing irrigation performance will affect the commitment of farmers to maintain the rice field ecosystem. This is due to poor irrigation performance which makes the land less conducive to farming, especially rice.

The low physical quality of irrigation networks is due to damage to infrastructure related to limited resources to carry out maintenance and repairs or due to environmental changes, especially upstream areas so that irrigation networks are damaged. Assessment of the physical condition of irrigation can be done by assessing the extent to which irrigation buildings can function as expected. The indicator is the effectiveness of the infrastructure which is determined by the ratio between the number of functioning buildings and the total number of irrigation buildings in the irrigation area.

The change in irrigation management policy that is being carried out by the government at this time has a further target, namely only a change in processing authority, but also the achievement of service levels with a fairly high capacity at the level of primary, secondary, tertiary and quarter irrigation networks.

To determine the service level of an irrigation system, it is necessary to conduct an assessment of the performance of the irrigation network. Paya Sordang Irrigation Area, Southeast Padang Sidempuan District, Padang Sidempuan City, South Tapanuli Regency is the main source of irrigation for rice fields in Padang Sidempuan. In this case, many farmers who use Paya Sordang irrigation as a source of water to meet their water needs in agricultural areas experience water shortages, this is presumably due to the declining performance of the existing irrigation network.

2. RESEARCH METHOD

This final project is structured in the following stages:

a. Collect some literature from books, papers, journals and lecture notes related to the study for literature study.
b. Collect primary data in the form of documentation of research locations and water distribution.
c. Collect secondary data in the form of rainfall data, and irrigation network schemes. Secondary data is data from agencies, community institutions, and related parties related to the discussion.
d. Analyzing rainfall and climatological data to calculate mainstay discharge, adjust cropping patterns and calculate water requirements using the method FJ Mock.
e. Analyzing the efficiency and effectiveness of the irrigation network.
f. Make conclusions and suggestions. Broadly speaking, the methods and stages of the research.

3. RESULTS AND DISCUSSIONS

3.1 Efficiency Level Analysis

Irrigation efficiency is the ratio of the actual amount of irrigation water used for plant growth needs with the amount of water coming out of the intake gate. Irrigation efficiency consists of drainage efficiency which generally occurs in the main network and efficiency in the secondary network, namely from the dividing building to the rice fields. Irrigation efficiency is based on the assumption that some of the water taken will be lost both in the canal and in the paddy fields. The water loss that is calculated for irrigation operations includes water loss at the tertiary, secondary and primary levels. The amount of each water loss is influenced by the length of the channel, the surface area of the channel, the wet circumference of the channel and the position of ground water.

The value of irrigation efficiency is influenced by the amount of water lost during the trip. Efficiency of water loss in primary, secondary and tertiary channels varies in irrigation areas. The amount of water loss at the primary channel level is 80%, secondary 90% and tertiary 90%. So the total irrigation efficiency = 90% x 90% x 80% = 65%.

3.2 Hydrological Analysis

a. Regional Rainfall Calculation

The calculation of regional rainfall is intended to calculate the average rainfall that occurs in the Batang Angkola watershed, to determine the maximum and minimum rainfall that occurs in the Batang Angkola watershed every month. The data used are from dosing stations located around the irrigation areas of Paya Sordang, Pijorkoling, Padang Balangka, Hutaholbung, and Marpinggan, and the method used is the algebraic average method.

From the results of regional rainfall calculations above, it can be seen that the average maximum rainfall at the end of August is 54.7 mm and the lowest occurs in the middle of June at 7.57 mm.

b. Effective Rainfall

Effective rainfall is the portion of the total rainfall used by plants during their growth period. The amount of effective rainfall is influenced by the method of providing irrigation water, the rate of reduction of standing water, the depth of the water layer that is maintained, the type of plant and the level of plant resistance to water shortages. For irrigation of rice crops, the effective rainfall is taken 80% of the possibility of missed rainfall. Effective rainfall is obtained by sorting monthly rainfall data from the largest to the smallest recapitulation.

To calculate the effective rainfall for rice plants in other months, the same method is used as in the example above. The results of the calculation of effective rainfall on rice plants can be seen in Table 1.

Table 1. Effective Rainfall for Rice Plants

The .... month		R80	Effective Rainfall for Rice plants (mm/day)
	1	46.2	2.156
January	2	27.8	1.297
	1	28.8	1.344
February	2	33.2	1,549
March	1	25.4	1.185
April	1	22.4	1.045
	2	19.8	0.924
May	1	35.4	1,652
	2	38.8	1,811
June	1	5.4	0.252
	2	42.4	1979
July	1	25.4	1.185
	2	32.8	1,531
August	1	20.6	0.961
	2	50.8	2,371
September	1	26.4	1.232
	2	11.8	0.551
October	1	34.4	1,605
	2	42	1.960
November	1	32.6	1.521
	2	36.2	1,689
December	1	47	2,193
	2	45.4	2.119

3.3 Batang Angkola River Basin

A watershed is an area where all the water flows into the river. This area is generally limited by topographic boundaries which means it is defined by surface water flow. This limit is not set for groundwater, because the groundwater level always changes according to the season and level of use. The area of the Batang Angkola watershed is 331 km2. Meanwhile, the area of rice fields that are drained is 1,232 Ha.

a. Evapotranspiration

Evapotranspiration is a basic need for plants that must be met by the irrigation system concerned to ensure an expected level of production. Evapotranspiration is strongly influenced by climatic conditions.

Calculating the amount of evapotranspiration, climatological data is needed which includes:

1) Air temperature
2) Humidity,
3) Length of sunshine and
4) Wind velocity.

The table for recapitulation of potential evapotranspiration calculations can be seen in table 2 below.

Table 2. Recapitulation of Potential Evapotranspiration Calculations (mm/day)

Jan	Feb	Mar	April	May	Jun	Jul	Aug	Sep	Oct	Nov	Des
3.38	3.34	3.19	3.09	3.33	3.32	3.04	2.91	2.94	2.93	2.83	2.74

Source: BMKG Pinang Sori

b. Debit Mainstay Batang Angkola with the FJMock . method

In determining the amount of water availability or mainstay discharge in the Batang Gadis watershed, the FJMock method is used. The data that become the parameters in determining the mainstay discharge include:

1) Daily amount of rain
2) Average monthly rainfall data
3) Potential evapotranspiration data

The steps for calculating the availability of water or mainstay discharge in the Batang Angkola watershed using the FJMock method can be seen in the example calculation in August-2 as follows: Calculated mainstay debit for August-2

1) Meteorological Data
   a) Semi-monthly rainfall (R) = 50.8 mm/half month
   b) Number of rainy days (n) = 3 days
2) Actual evapotranspiration (Ea)
   a) Potential evapotranspiration (Eto) = 2.91 x 3 = 8.73 mm/15 days
   b) Open land surface (m) = 20%
   c) Eto/Ea = (m/20) x (18-n) = (20/20) x (18-3) = 15.0%
   d) Limited evapotranspiration (Ee)
      = Eto x (m/20) x (18-n)/100
      = 8.73 x (20/20) x (18-3)/100
      = 1.31 mm/15days
   e) Ea = Eto – Ee = 8.73 – 1.31 = 7.42 mm/15day
3) Water balance
   a) S = R – Ea = 50.8 – 7.42 = 43.38 mm/15day
   b) Storm Overflow (PF =5%). If S 0; PF= 0, if S 0;
      PF = R x 0.05 then PF = 0
   c) Soil water content (SS). If R>Ea; SS = 0, if R<Ea;

SS = S –PF then SS=0

4) Soil moisture capacity. If SS = 0, then soil moisture = 200, if SS 0 then soil moisture capacity = soil water content.
5) Excess water (WS) = S – SS = 43.38 – 0 = 43.38 mm/15 daysvRunoff and water storage
   a) Infiltration factor (i) is taken as 0.4
   b) Groundwater recession factor (k) is taken 0.6
   c) Infiltration (I) = ix WS = 0.40 x 43.38 = 17.35 mm/15days
   d) Groundwater volume (G) = 0.5 (1+k) I = 0.5(1+0.6)17.35 = 13.88 mm/15days
   e) Groundwater storage volume (L) = k(Vn-1) = 0.6 x 100 = 60.0
   f) Total volume of groundwater storage (Vn) = G + L = 13.88 + 60 = 73.88
   g) Changes in the volume of flow in the soil (Vn),Vn =Vn - Vn-1 = 73.88 – 100 = -26.1 Base flow (BF), with Equation 2-12

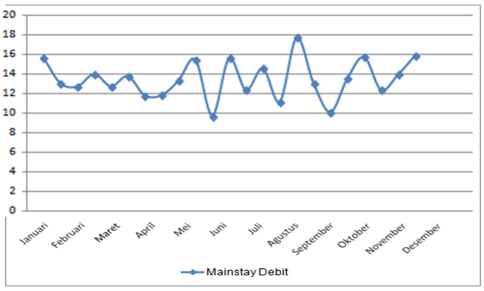

Figure 1. FJ Mock Mainstay Debit Method

From the figure above, it can be seen that the maximum reliable discharge is in August, which is 17.75 m3/s with a percentage of 80% and the minimum reliable discharge occurs in June, which is 9.68 m3/s with a percentage of 80%.

3.4 Water Needs in Paya Sordang Irrigation

Irrigation water requirements are the volume of water needed to meet the needs of evapotranspiration, water loss, water needs for plants by taking into account the amount of water provided by nature through rain and the contribution of ground water.

Rice field water requirements for rice are determined by the following factors:

a. Land preparation
b. Consumptive use
c. Percolation and seepage
d. Water layer replacement
e. Effective rainfall.

3.5 Analysis of Irrigation Channel Efficiency

The efficiency level of the irrigation network, especially in the secondary irrigation network, is obtained by calculating the water loss that occurs in the secondary canal. In calculating water loss, the first thing to do is to measure the channel discharge in the field, so that the amount of water entering and the amount of water leaving can be known.

Measurements made in the field are the dimensions of the Paya Sordang irrigation channel, namely, the width of the irrigation channel, the height of the irrigation channel, and the height of the water surface contained in the Paya Sordang irrigation canal.

In data processing is done by using the Manning equation to determine the flow velocity that occurs, and to measure the water flow equation 3-1 is used.

To measure the efficiency of the secondary irrigation network, equation 2-33 is used. So it can be known the amount of water loss that occurs. The magnitude of the efficiency at the channel level.

Table 2. Paya Sordang . Secondary Irrigation Channel Efficiency

Channel	Base Debit (m3/s)	Edge Discharge (m3/s)	Water Loss (m3/s)	Efficiency
CPM 12 - CPM 13	0.139	0.127	0.012	91.59684
CPM 13 - CPM 14	0.111	0.104	0.007	93.8588
CPM 14 - CPM 15	0.093	0.082	0.011	88.13297
			0.010	91.1962

In Table 2, the distribution efficiency in the Paya Sordang secondary channel is 91,1962 %. The water loss along the Paya Sordang secondary channel is 8,804% of the efficiency in the secondary channel under normal conditions of 90%. The loss in the Paya Sordang secondary channel is still classified as distribution efficiency. Factors that affect water loss in this secondary channel are evaporation, seepage and because the channel which is lined with waterproof material is damaged. Channel conditions also affect water loss where the longer the channel, the greater the water loss, as well as the width of the channel. In the vicinity of the secondary channel also found vegetation, and even entered the water surface in the channel.

4. CONCLUSION

From the results of the calculation of water requirements in the cropping pattern which began in early August, it was found that the maximum water requirement was 0.7 lt/sec/ha.

By using the FJ Mock method, the maximum reliable discharge value in the Batang Angkola watershed is 17.75 m^3/dt, available at the end of August.

From table 4.6, the efficiency of secondary channel in Paya Sordang irrigation is 91,196%. The water loss along the secondary channel is 8.804 %. From the efficiency under normal conditions in the secondary channel of 90%. So it meets efficiency standards.

From the calculation, the ratio or comparison of the irrigated area to the design area reached 28.322% of the area to be irrigated and there were 71.678 % that were not irrigated in the dry season, and for the rainy season 71.678 % of the irrigated area and 28.322% were not irrigated.

REFERENCES

Agus, indra. 2010. Penentuan Jenis Distribusi dan Uji Kesesuain Smirnov Kolmogorov Data Hujan Das Taratak Timbulun. Politeknik Negeri Padang.

Direktorat Jenderal Pengairan, 1986. *Standar Perencanaan Irigasi* (KP-01). Departemen Pekerjaan Umum, CV. Galang Persada : Bandung.

Direktorat Jenderal Pengairan, 1986. *Standar Perencanaan Irigasi* (KP-02). Departemen Pekerjaan Umum, CV. Galang Persada : Bandung.

Direktorat Jenderal Pengairan, 1986. *Standar Perencanaan Irigasi* (KP-03). Departemen Pekerjaan Umum, CV. Galang Persada : Bandung.

Hadihardjaja, Joetata. 2005. *Irigasi dan Bangunan Air*. Gunadarma:Jakarta. Hariany, Susi, dkk. 2011. *Evaluasi Kinerja Jaringan Irigasi Di Saluran Sekunder*

Pada Berbagai Tingkat Pemberian Air Di Pintu Ukur. Jurnal Rekayasa, Vol.15 Nomor 3: Lampung.

Hermawan, Bambang. 2003. *Analisis Perhitungan Harga Air Irigasi di Daerah Irigasi Kedungdowo Kramat Kabupaten Batang*. Master Theses Civil Engineering RTS 627.52. Digital Library ITS.

JF, Ortega, Tarjuelo JM, de Juan JA. 2002. Evaluation Of Irrigation Performance In Localized Irrigation Systems Of Semiarid Regions (Castilla-La Mancha, Spain). Agricultural Engineering International: The Cigr Journal of Scientific Research and Development Manuscript LW 01 007. Vol IV:Spain.

Limantara, Lily Montarcih. 1986. *Hidrologi Praktis*. Lubuk Agung:Bandung. Ludiana. 2015. *Evaluasi Kinerja Jaringan Irigasi Bendungan Tilong Kecamatan*

Kupang Tengah Kabupaten Kupang. Jurnal Teknik Sipil Vol.IV, No.1: Kupang.

Nurrochmad, Fatchan. 2007. *Analisis Kinerja Jaringan Irigasi*. AGRITECH, Vol.27 No.4:Yogya karta.

Subarkah, Ir. Iman. 1978. *Hidrologi untuk Perencanaan Bangunan Air*. Idea Dharma:Bandung.

Suroso. 2007. *Evaluasi Kinerja Jaringan Irigasi Banjaran Untuk Meningkatkan Efektifitas dan Efisiensi Pengelolaan Air Irigasi*. Purwokerto.

Triatmodjo, Bambang. 1993. *Hidraulika II*. BETA OFFSET:Yogyakarta.