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 International Journal of Engineering & Technology, 7 (4.36) (2018) 112-116 International Journal of Engineering & Technology Website: www.sciencepubco.com/index.php/IJET Research paper Analysis of the Water Availability to Irrigation Needs in Irrigation Areas Jambo Aye Wesli1), Said Jalalul Akbar2) Department of Civil Engineering, Universitas Malikussaleh, Province of Aceh, Indonesia Cot Tengku Nie, Muara Batu sub-district Postal code 24355, North Aceh District, Aceh, Indonesia Telephone +62645-41373, Fax +6245-44450; Mobile Phone +62811671918 *Corresponding author: wesli@unimal.ac.id 1) Abstract Jambo Aye Irrigation Area serves cross-district irrigation water needs, namely North Aceh district and East Aceh district with a service area of 19,360 Ha and in accordance with the Regulation of the Minister of Public Works and Public Housing of the Republic of Indonesia Number 14/PRT/M/2015, criteria and determination of the status of irrigation areas is the authority of the Central Government.

Complaints of farmers' communities, especially in North Aceh, there is always a shortage of water for the needs of rice fields, this can be caused by a lack of water supply or it could be caused by damage to irrigation infrastructure. In this study, the availability of water was analyzed from sources for irrigation needs by looking at the water balance.

The research method uses the Mock method because there is no discharge measurement data in the study area. The results of the study illustrate that monthly water demand is smaller than the available water called monthly reliable discharge. Water shortages experienced by farmers are not due to supply shortages that are considered possible due to damage to irrigation infrastructure Keyword: Water

availability, water demand 1.

Introduction Jambo Aye Irrigation Area is in 2 districts, namely North Aceh District and East Aceh District which is ± 310 Km from Banda Aceh City, Aceh Province. Jambo Aye Dam is located in Jambo Aye River, Langkahan sub-District, and North Aceh District. This dam was built in 1982 with a width of 99.5 m and a service discharge of 27.31 m3/second. The research location is shown in Figure 1.

Figure 1 Research Location - - river with the area of the River reaches 776,383.04 Ha, has a maximum water level of ± 7 meters during floods and a minimum height of surface ± 4.5 meters during the dry season. The Jambo Aye Irrigation Area is divided into five sub-Irrigation area, namely the Lueng Baro sub-Irrigation area, the Lhoksukon sub-irrigation area, the Mon Sukon sub-Irrigation area, the Panton Labu sub- irrigation area, and the Arakundo sub-irrigation area.

Irrigation areas serve irrigation in parts of North Aceh and East Aceh amounting to 19,360 Ha based on service area is the authority of the central government Housing of the Republic of Indonesia, 2015). The problem in this research is the complaints of farmers who lack water in the process of rice cultivation so as to disrupt the harvest that the results are not maximal. Water shortages can be caused by a lack of discharge available in irrigation water needs, or it could be due to infrastructure damage in irrigation areas.

This study aims to evaluate the availability of discharge through the water balance by assessing the adequacy of water in Jambo Aye dam in meeting the needs of irrigation water based on the comparison between mainstay discharges and need discharge. 2. Material and Method 2.1 Water Demand Agricultural water use accounts for around 70% of the total water that is withdrawn from surface water and groundwater (Wisser et al., 2008).

Irrigation water demand is highly dependent on the area of Irrigation Area. The criteria and stipulation of the status of Irrigation Area and its management authority shall be regulated in the legislation of the Indonesian government (Ministry of Public Based on rainfall data for 11 months from 2006 to 2016 the maximum data is sorted every year from January to December, the largest data is chosen.

The rainfall maximum is shown in Table 1 Research location of Irrigation Area Jambo Aye International Journal of Engineering & Technology 113 Table 1 Rainfall maximum Year Monthly Rainfall Maximum (mm) 2006 388 2007 418 2008 439 2009 372 2010 204.5 2011 326 2012 582 2013 393 2014 214 2015 290 2016 344 2.1.1 Potential evapotranspiration Monthly Potential evapotranspiration is calculated based on climatologically data using the Modified Penman method (Yulianur, 2005).

This formula produces ET0 from a reference plant of short grass with albedo 0.25. The Penman modification formula of the FAO Method is more commonly used as follows: (1) The water requirement for crop consumptive is the depth of water required to meet the evapotranspiration of disease-free crops, grows in agricultural areas under sufficient water conditions from soil fertility with good growth potential and good growth environment levels.

To calculate the water needs of consumptive use crop used the equation: (2) Where: ET0 : Reference plant evapotranspiration (mm/day); c : Factors that show the effect of the difference in wind speed during the day and night; If there is no data that distinguishes wind speed during the day and night during the day, then the value of c is considered 1 W : Weighting factor; Rn : Clean radiation energy which results in evaporation (mm/day); f (u) : the average wind speed function measured at a height of 2 m with a unit of wind speed (km/day); (ea-ed) : Difference in vapor pressure saturated with actual vapor pressure, (mbar).

f (u) : Wind velocity ETc : Water requirements for consumptive use of plants (mm/day); kc : coefficient of a plant; 2.1.2 Net Water Requirement (NFR) Another opinion expressed by (Conferiana, 2010) the water requirement for plants on an irrigation network is the water required for plants for optimal growth without water shortage expressed in Net Field Requirement (NFR).

The amount of water needed for crops in the fields is determined by several factors, namely land preparation, consumptive use, percolation and seepage, water change and rainfall. The need for net water (NFR) for rice is calculated by the formula: (3) Where: NFR : The need for net water ETc : water requirement for consumptive use of plants (mm/day); WLR : water requirement for change of water layer (mm/day); P : water requirement for percolation and seepage (mm/day).

Re : effective rainfall (mm/day); Water requirements during land preparation are used methods developed by van de Goor and Zijlstra (Goor and Zijlstra, 1968). The method is based on the constant water rate in liter/sec during the land preparation period. Percolation is the movement of water flowing in the soil that its speed depends on the nature and type of soil.

In clay soils, percolation rates and seepage on embankments inflicted with P are estimated to range from 1-3 mm/day. In soils containing lots of sand, the rate of percolation and seepage can reach higher numbers. Changes water layer were performed twice, one month after transplant and two months after transplant.

50 mm change of water layer caused by WLR and can be given: 1) For half a month, the meaning is given ; Or 2) for a month, its meaning is given Rainfall is not fully utilized by plants, some of which may become surface runoff, percolate or evaporate. Only a portion of the rain with high intensity can enter and be stored in the root zone which can then be utilized by the plant.

The amount of rainfall is called effective rainfall. Effective rainfall is the rainfall that plummets in an area and is used for crops for growth. The determination of effective rainfall is based on basic month rainfall, with the possibility of 80% (R80) for rice crops. For rice crops, the amount of effective rainfall is estimated at 70% of the monthly rainfall monthly with probability 80% (Directorate General of Irrigation, 2010).

Needs intake (DR) is the amount of water needed by one hectare of rice field (liter/sec/ha), calculated by the formula: (4) Where: DR : Retrieval requirement (liter/sec/ha); NFR : The need for net water (mm/day); ef : Efficiency of irrigation, usually taken at 65%; 8.64 : Unit conversion rate mm/day to liter/sec/ha. The intake discharge for rice is the tapped discharge and then flowed into the irrigation canal to meet the irrigation water requirement when planting the rice.

This intake discharge unit is m3/sec and can be calculated by the formula below: (5) Where: Q : discharge intake (m3/sec); DR : retrieval requirement (liter/sec/ha) A : Irrigation area (Ha); 1000 : Unit conversion rate liter to m3. 2.2 Water Availability (Water Supply) The calculation of water availability is conducted to determine the water available from the main irrigation water source, to meet the planned irrigation water needs.

The methods that can be used to calculate water availability include Mock and NRECA methods (Directorate General of Irrigation, 2010). Rainy is an important aspect in analyzing water availability. Rainfall data is needed to 114 International Journal of Engineering & Technology calculate the Mainstay Discharge and Water Balance Analysis.

The location of the rainfall post is located at Langkahan Rainfall Post North Aceh District. Water availability was analyzed in the Mock method. Using data in the form of Area Catchment (A) and monthly rainfall (Isnin et al., 2012). 2.2.1 Infiltration For irrigation Storage of soil moisture (SMS) is defined as the total amount of water stored in the soil in the plant root zone.

The soil texture and depth of rooting of the plant determine this. Deeper rooting depth means there is a larger volume of water stored in the soil for plants. The amount of infiltration is influenced by water supply and infiltration factors such as the following equation: (6) Where: WS : Water Surplus IF : Infiltration factor 0.4 2.2.2 Average monthly discharge Ground storage at the end of the month (G.STORt) can be calculated using the equation as follows: (7) (8) (9) (10) (11) Where: G.STORt : Groundwater capacity at time t (mm/month) G.STOR (t-1) : Groundwater capacity at time t-1 (mm/month) Inf : Infiltration Qbase : Basic runoff Qdirect : Surface runoff WS : Water Surplus IF : Infiltration factor 0.4 QStrom : Rainfall runoff moment Qtotal : Total Runoff Qs : Average monthly discharge A : Area of Watershed 2.2.3

Dependable Discharge At the weir location, there is no discharge gauge so the average monthly discharge is calculated by the Mock method (Mock and Fao, 1973). The data used are monthly rainfall data, a number of rainy days, potential evapotranspiration value and soil moisture. The rainfall data used is recorded in the raining post in Langkahan area with the data range from 2006 to 2016.

A reliable discharge calculation is performed by sorting the average monthly discharge calculation data from a large sequence into a small sequence to determine its probability. The mainstay discharge is calculated for wet discharge conditions (20% probability), normal discharge (50% probability) and dry discharge (80% probability). 2.3 Water Balance The water balance is conducted to check whether the water available is sufficient to meet the irrigation water needs.

Calculations are based on weekly or mid-month periods. Differentiated three main elements: Water Availability, Needs Water and Water balance. In water balance calculations, the yield requirements generated for the planting pattern used will be compared with the mainstay discharge for every half month and the area that can be irrigated.

If the river discharge is abundant, the area of irrigation is fixed because the maximum area of the service area (command area) and the project will be planned in accordance with the planting pattern used According to (Wesli, 2017) the difference between the discharge of water availability and the irrigation water demand is named as the result of water balance.

Sustainable use of irrigation water is achieved under conditions of water availability discharge greater than the discharge required for irrigation land. Conditions of water deficit should be avoided at any given time, especially during the cultivation of land on plant growth. 3. Result and Discussion 2.4 Evapotranspiration potential Monthly The potential evapotranspiration concept was first introduced in the late 1940s and 50s by Penman and it is defined as the amount of water transpired in a given time by a short green crop, completely shading the ground, of uniform height and with adequate water status in the soil profile (Irmak and Haman, 2003). Evapotranspiration potential is the amount of evaporation that would occur if a sufficient water source were available (Fetter, 2018).

If the actual evapotranspiration is considered the net result of atmospheric demand for moisture from a surface and the ability of the surface to supply moisture, then Evapotranspiration potential is a measure of the demand side. Evapotranspiration potential monthly data is shown in Table 2. Table 2 Evapotranspiration potential monthly Month evapotranspiration potential (mm/month) Month evapotranspiration potential (mm/month) Jan 156.44 July 154.74 Feb 147.23 August 165.91 March 187.77 Sept 175.57 April 167.50 Oct 163.47 May 156.20 Nov 167.33 June 164.60 Dec 148.59 From Table 2 the potential evapotranspiration average of 162.95 mm/month. The lowest potential evapotranspiration was 147.23 mm/month which occurred in February and the highest was 187.77 mm/month which occurred in March. 2.5

Retrieval Requirement (DR) The water needed by one hectare of rice fields is calculated using Equation 4. Water needs are calculated every half month and the highest in March II is 1.9 liters /second/ha. Water needs vary, most needs on March 2 are 1.90 liters/second/ha, while on July 2 to September 2 there is no need for water because this period is the harvest period.

Water requirement for rice crops seen from the maximum requirement that is at age of rice aged two months (Soumokil and Nara, n.d.). Calculation results as shown in Table 3. Table 3 Retrieval Requirement (DR) Month DR (Liter/Sec/Ha) Month DR (Liter/Sec/Ha) Jan I 0.93 July I 0.15 Jan II 0.84 July II 0.00 Feb I 0.57 August I 0.00 Feb II 0.80 August II 0.00 March I 1.26 Sept I 0.00 March II 1.90 Sept II 0.00 April I 1.69 Oct I 0.52 April II 1.66 Oct II 0.99 May I 1.37 Nov I 1.27 International Journal of Engineering & Technology 115 May II 1.25 Nov II 1.11 June I 1.08 Dec I 1.39 June II 0.54 Dec II 0.60 Monthly water requirements every semi-month are shown in Table 4 Table 4 Water Irrigation Needs Monthly Month Irrigation Need (m3/sec) Month Irrigation Need (m3/sec) Jan I 2.04 July I 0.00 Jan II 7.72 July II 0.00 Feb I 0.00 August I 0.00 Feb II 34.78 August II 0.00 March I 36.81 Sept I 0.00 March II 36.97 Sept II 0.00 April I 29.59 Oct I 30.51 April II 33.05 Oct II 29.06 May I 24.64 Nov I 24.72 May II 18.61 Nov II 18.27 June I 11.92 Dec I 27.52 June II 0.00 Dec II 9.68 2.6

Water Availability (Water Supply) 2.6.1 Average monthly discharge The average monthly discharge (Qs) is calculated using equation (11) based on the total runoff (Qtot) calculated from equation (10) proportional to the area of the watershed.

Total runoff is obtained based on the number of basic runoff (Qbase), surface runoff (Qdirect) and the moment of rain runoff (Qstrom) through equation (10). Determination based on data for 11 years from 2006 to 2016. The average discharge for each month for 11 years shows that the average discharge is 141,045m3/sec. The maximum average discharge occurs in December of 381.60m3/sec and the minimum average discharge occurs in October of 77.64 m3/sec.

The results are as shown in Table 5. Table 5 Monthly averages Discharge Year River discharge Jan Feb March Apr May Jun Jul August Sept Oct Nov Dec 2006 38.82 47.59 163.11 92.02 44.88 24.61 68.31 131.36 64.44 6.29 289.04 614.47 2007 129.85 89.55 36.45 30.51 296.36 325.20 171.66 99.81 119.90 108.69 109.04 650.44 2008 105.57 89.39 63.91 38.09 14.72 8.95 72.38 129.41 18.69 61.56 535.67 740.10 2009 406.78 103.27 176.54 238.34 233.05 54.99 51.28 69.97 526.65 119.08 314.70 72.52 2010 38.75 37.03 42.63 38.85 30.33 27.71 85.76 0.73 0.44 62.51 75.49 226.49 2011 140.17 57.44 89.32 71.50 119.92 17.62 40.63 41.91 78.75 137.39 434.50 101.84 2012 79.26 53.32 61.80 65.38 981.22 170.16 240.00 67.83 203.68 117.83 155.73 475.38 2013 364.97 262.18 63.82 301.76 71.24 62.78 61.96 190.24 94.42 107.37 95.36 596.49 2014 116.86 42.31 78.74 36.47 68.85 19.02 50.74 92.68 65.00 25.10 117.77 231.26 2015 183.52 25.25 35.75 37.17 40.34 59.77 70.55 92.74 40.85 48.06 58.52 403.57 2016 144.23 529.64 70.09 76.50 69.07 50.83 36.64 256.00 96.23 60.12 162.46 85.09 average 158.98 121.54 80.20 93.33 179.09 74.70 86.36 106.61 119.01 77.64 213.48 381.60 2.6.2

Dependable Discharge Dependable discharge is the minimum flow for a probability of meeting with probability 80%. The data are sorted from largest to smallest and then given a number as "m". The probability is calculated by the formula P=m/ (1+n) where "n" is the number of data. Values have seen an 80% probability of the sequence number “ m ” .

If the value is not exactly 80% probability is the number "m" then do interpolation to get an 80% probability Dependable Discharge (Qa) at 80% by probability is shown in Table 6 Table 6 Dependable Discharge m Dependable Discharge Pr = m/(n+1) Jan Feb March Apr May Jun Jul August Sept Oct Nov Dec 1 406.78 529.64 176.54 301.76 981.22 325.20 240.00 256.00 526.65 137.39 535.67 740.10 8.33 2 364.97 262.18 163.11 238.34 296.36 170.16 171.66 190.24 203.68 119.08 434.50 650.44 16.67 3 183.52 103.27 89.32 92.02 233.05 62.78 85.76 131.36 119.90 117.83 314.70 614.47 25.00 4 144.23 89.55 78.74 76.50 119.92 59.77 72.38 129.41 96.23 108.69 289.04 596.49 33.33 5 140.17 89.39 70.09 71.50 71.24 54.99 70.55 99.81 94.42 107.37 162.46 475.38 41.67 6 129.85 57.44 63.91 65.38 69.07 50.83 68.31 92.74 78.75 62.51 155.73 403.57 50.00 7 116.86 53.32 63.82 38.85

68.85 27.71 61.96 92.68 65.00 61.56 117.77 231.26 58.33 8 105.57 47.59 61.80 38.09 44.88 24.61 51.28 69.97 64.44 60.12 109.04 226.49 66.67 9 79.26 42.31 42.63 37.17 40.34 19.02 50.74 67.83 40.85 48.06 95.36 101.84 75.00 10 38.82 37.03 36.45 36.47 30.33 17.62 40.63 41.91 18.69 25.10 75.49 85.09 83.33 11 38.75 25.25 35.75 30.51 14.72 8.95 36.64 0.73 0.44 6.29 58.52 72.52 100.00 Qa (m3/sec) 55.00 39.14 38.92 36.75 34.33 18.18 44.67 52.28 27.56 34.28 83.44 91.79 2.7 Water Balance The water balance is conducted to check whether the water available is sufficient to meet the irrigation water needs.

Calculations are based on weekly or mid-month periods. Differentiated three main elements: Water Availability, Needs Water and Water balance. In water balance calculations, the yield requirements generated for the planting pattern used will be compared with the mainstay discharge for every half month and the area that can be irrigated.

If the river discharge is abundant, the area of irrigation is fixed because the maximum area of the service area (command area) and the project will be planned in accordance with the planting pattern used. Correlation dependable discharge with Irrigation needs water are shown in Table 7 Table 7 Dependable Discharge, Irrigation Need 116 International Journal of Engineering & Technology Month Dependable Discharge Irrigation Need Balance Jan I 55.00 2.04 52.96 Jan II 55.00 7.72 47.28 Feb I 39.14 - 39.14 Feb II 39.14 34.78 4.36 March I 38.92 36.81 2.11 March II 38.92 36.97 1.95 April I 36.75 29.59 7.16 April II 36.75 33.05 3.70 May I 34.33 24.64 9.69 May II 34.33 18.61 15.72 June I 18.18 11.92 6.26 June II 18.18 - 18.18 July I 44.67 - 44.67 July II 44.67 - 44.67 August I 52.28 - 52.28 August II 52.28 - 52.28 Sept I 27.56 - 27.56 Sept II 27.56 - 27.56 Oct I 34.28 30.51 3.77 Oct II 34.28 29.06 5.22 Nov I 83.44 24.72 58.72 Nov II 83.44 18.27 65.17 Dec I 91.79 27.52 64.27 Dec II 91.79 9.68 82.11 According to (Wesli, 2017) the difference between the discharge of water availability and the irrigation water demand is named as the result of water balance.

Sustainable use of irrigation water is achieved under conditions of water availability discharge greater than the discharge required for irrigation land. Conditions of water deficit should be avoided at any given time, especially during the cultivation of land on plant growth. The main problem with regulating water resources is that the amount of water demand always changes with time and place.

Therefore, an arrangement is needed so that the available water can meet the existing needs. In the fulfillment of existing needs, of course, must be determined which needs are more prioritized. If the river discharge is abundant, the area of the irrigation project is fixed because the maximum area of service (command area) and the project will be planned according to the planting pattern used.

If the river flow is not abundant and sometimes there is a shortage of discharges then there are 3 options that can be considered (Directorate General of Irrigation, 2010): a. The total area of irrigation is reduced b. Modify in cropping pattern c. Group technical rotation. The complete water balance is shown in Figure 2 Figure 2 Water Balance 4.

Conclusions Available water is very adequate for the supply of water needs, even water is still excessive. The high water demand is in February until June, according to the applied cropping pattern. The results of the study illustrate that monthly water demand is smaller than the available water called monthly reliable discharge.

Water shortages experienced by farmers are not due to supply shortages that are considered possible due to damage to irrigation infrastructure References [1] Conferiana, A., 2010. Optimalization Study of Plant Pattern in Menturus Irrigation Area by Using Linear Programming. Institut Teknologi Sepuluh November, Surabaya. [2] Directorate General of Irrigation, 2010. Standard Irrigation Design, Criteria Design Section Irrigation Networks. Public Works Department. [3] Fetter, C.W.,

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