Identification of Potential Surface Water Sources Using Digital Elevation Model in District of North Buton

Mukhsan Putra Hatta, Farouk Maricar, Arham Samauna

Abstract: District of North Buton is a dry area with low rainfall and the region is immeasurable. Therefore, the use of spatial data from scientific research institutions (NASA and BIG) can be done as an alternative to analyze the potential of surface water sources in North Buton District. The purpose of this research is to identify the location of surface water resource in the District of North Buton, so that it can be known whether the location of the catchment area and the amount of discharge. The method used in this study is simulated using open source software-based Geographic Information System (GIS). Based on the catchment area, rainfall distribution value and runoff coefficient value, the mean annual discharge can be determine which is a potential source of surface water. This research resulted in the potential for surface water sources North Buton is a potential point 1 to point potential Catchment 32 with the highest discharge value is 15.1222 m³ / sec (Catchment potential point 10) and the lowest discharge value is 0.525 m³ / sec (Catchment potential point 29).

Keywords: Geographic Information System (GIS), Surface water resource

I. INTRODUCTION

Water has an important role in supporting all human activities. With the increasing rate of population growth and the development of all aspects, the demand of water is also increasing [1]. Effective utilizing the water resources give significant impact toward the nation economy, social and environment [2, 3]. North Buton District is an area that can be said to be less water but is a potential agricultural area. There are several large rivers in North Buton District include the lambale river, langkumbe river, kioko river, bubu river, kambowa river, lahumoko river and lagito river. In addition to being a source of water which is potentially sufficient for irrigation purposes, it is also used as a transportation route that carries agricultural and forest products [1]. Geographic Information Systems (GIS) can be used in water management and analyze the spatial distribution of potential locations and determine the potential of surface water [4- 7].

Revised Manuscript Received on February 05, 2019.

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The detail for analysis of hydrology and weather, require spatial data (cross section of river, depth of river, geological structure, soil data etc.) and temporal (i.e. rainfall and river discharge data in time series) complete. However, the lack of availability of data in unmeasured areas (the absence of a rainfall measuring post) makes it difficult to conduct the analysis. The data format used in GIS analysis is using DEM (Digital Elevation Model) raster data and some supporting spatial data such as catchment area and slope [8, 9]. By knowing the catchment area, the value of rain distribution and runoff coefficient value, it can be known the average annual discharge which is a potential surface water source. Therefore, this study utilize the limited data to identify and estimate the potential of surface water sources for areas that have not been measured by utilizing software and Geographic Information Systems (SIG / GIS).

II. METHODOLOGY

This study analysis and determine the potential of surface water sources based on total discharge of each potential point and the relationship between the amount of total discharge area, runoff coefficient and rainfall.The data used in this study are from Digital Elevation Model (DEM) topography data, TRMM global rainfall data (Tropical Rainfall Measuring Mission), and a digital version of the RBI map issued by the Geospatial Information Agency. The equipment used in this study is hardware in the form of laptops (Core i5 2nd Gen, AMD Radeon 8x, 8 GB RAM, 120 GB SSD) and SAGA GIS software combined with QGIS 2.14.2, which is open-source software that capable for hydrological simulations.

Input Data Process

The input data is processed using SAGA GIS and QGIS. The rain (I) data, runoff coefficient (C) and area (A) in the form of grid by inputting data on map attribute data.

Processing Runoff Coefficient (C)

In processing runoff coefficient data, 2 parameters are used to determine the average runoff coefficient. First, the slope parameter (Cslope) and the second is the land cover parameter (Ccover) then the Grid Calculator process is performed on the SAGA GIS device to find the average C value which will be in the form of a grid later. This grid data is then executed by a resampling process to adjust the pixel size according to the main data, which is DEM data (30 m pixel size)

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Rain Data Processing (I)

In the processing of rain data (TRMM data grid), the data resampling process is conducted by adjusting the grid size and the rain data projection system to match the DEM data.

Data Catchment Area (A) Processing

The parameters of the catchment area (A) we divide into two which is vector map of catchment area (A1) extracted from DEM data, and second (A2) is the determination of catchment area based on the standard pixel size used in this study (DEM pixel = 30 m) which will later be used to determine the dischargedistribution map.

Simulation

The simulation using SAGA GIS aims to obtain an average annual discharge value in each pixel that has the potential to be a source of surface water. The formula used to calculate the average discharge is:

$$Q = C.I.A \qquad (1)$$

Whereby, Q, C I and A denoted the average annual discharge(m^3 / s), runoff coefficient, rain intensity (mm / hour) and area (km^2) / pixel 0.0009 km^2

III. RESULTS AND DISCUSSION

Runoff Coefficient (C)

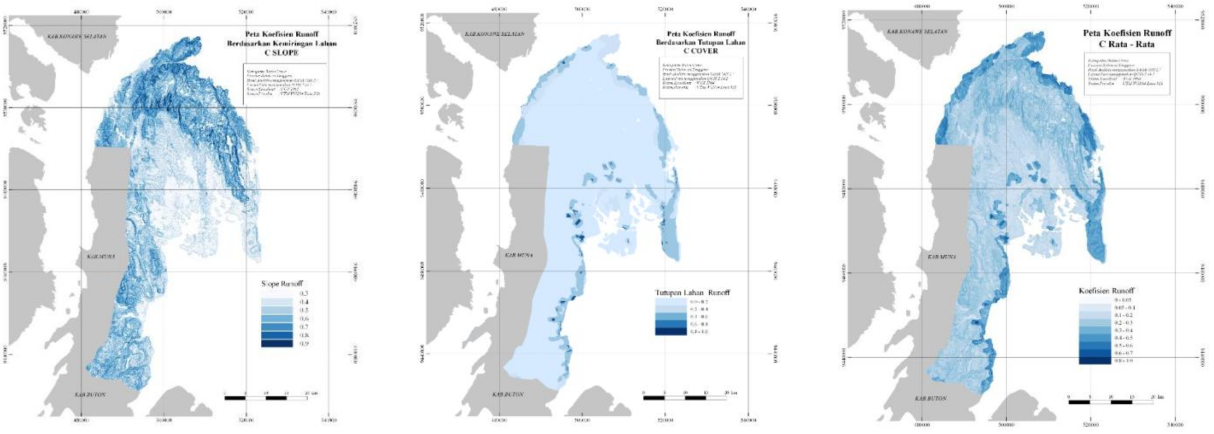
The runoff coefficient value in North ButonDistrict for scoring process according to land use and land slope are shown in the Table 1 and Table 2. The grid maps areobtained and shown in Figure 1(a), (b) and (c).

Table. 1 Runoff coefficient Land cover

No.	Land cover	Value C	No.	Land cover	Value C
1	Hutan Primer	0.01	6	SemakBelukar	0.3
2	HutanSekunder	0.05	7	Sawah	0.2
3	KebunCampuran	0.5	8	JalanAspal	0.7
4	Ladang – Tegalan	0.5	9	Lahan Terbuka	0.95
5	Perkebunan	0.5	10	Pemukiman	0.9

Table. 2 Runoff coefficient based on land slope

No.	Slope Class (%)	Value C
1	0 – 3	0.3
2	3 – 8	0.4
3	8 - 15	0.5
4	15 – 30	0.6
5	> 30	0.7



(a) (b) (C)

Fig. 1 Grid map (a) Grid C Slope Map, (b) Grid C cover map and (c) Average Grid C Map

Rain Intensity (I)

Figure 2 displays the TRMM data from 2005 to 2015 in the form of Time Series and the distribution maps and the TRMM data in distribution form are shown in Figure 3 (a). The results of the rainfall data can be seen in Figure 3 (b).

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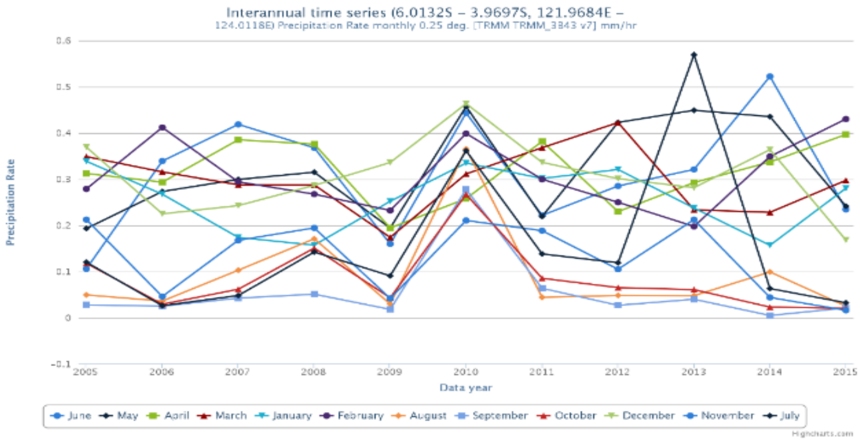
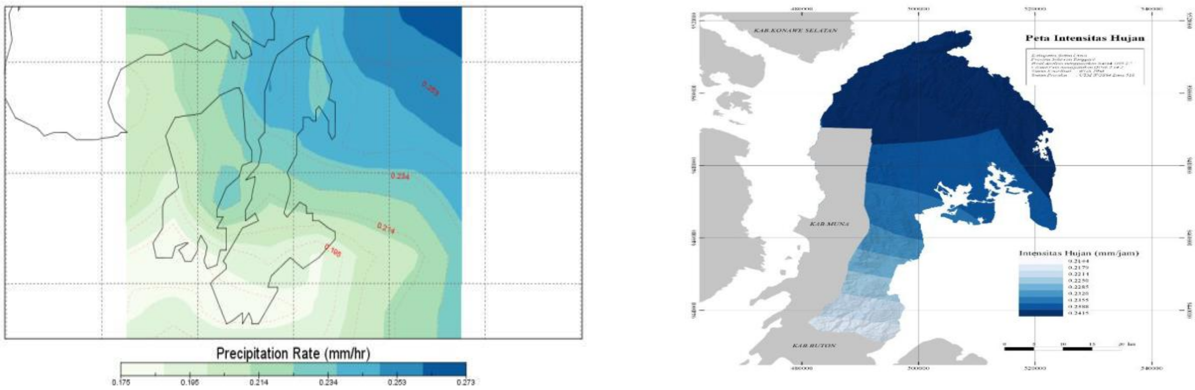


Fig. 2 Average Monthly Rainfall of TRMM, Time Series



(a) (b)

Fig. 3 (a) TRMM Data in the Form of Distribution Map and (b) Grid Rain Intensity Grid

Catchment Area (A)

Figure 4 (a) demonstrates the results of data processing for determining the catchment area (A1). Based on Table 3, thedata processing using SAGA GIS indicated there are 32 Catchment Area points that were successfully extracted using SRTM DEM data. The largest catchment area is 252.06 km^2 (No. 10) and the smallest is 6.1 km^2 (No. 29). Furthermore, this data will be used to obtain potential surface water sources for each catchment area.

Surface Flow Distribution Grid Map (Q)

Figure 4 (b) illustrates the map of surface flow discharge distribution. From the results of pixel multiplication using a grid calculator shows the distribution grid map of surface flow discharge (Q) has a pattern similar to the runoff coefficient distribution grid map (C). This shows that the greater the value of C, the greater the Q value.Figure 5 (a) and (b) show the Runoff Coefficient and Surface Flow discharge respectively.

(a) (b)

Fig. 4 (a) Area Catchment Numbers and (b) Map of Surface Flow Discharge Distribution

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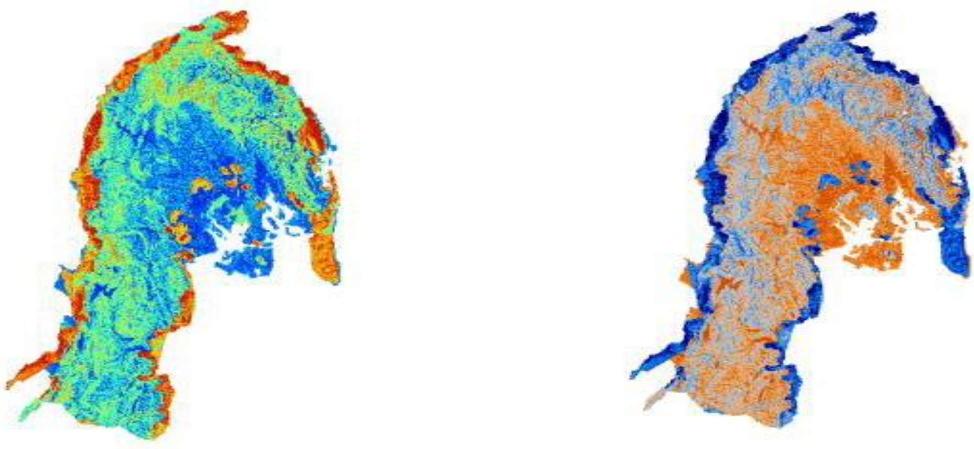

(a) (b)

Fig. 5 (a) Runoff Coefficient and (b) Surface Flow discharge (right)

Analysis of Potential Surface Water Resources

The potential of surface water sources in this study was obtained by accumulating the total discharge values from the surface flow distribution grid maps covered by each catchment area. The simulation module uses two input data. First, for grid input data, the writer uses surface discharge distribution grid (Q), second for polygon input data using catchment area (A) vector map. Table 3 tabulates the results from the analysis using SAGA GIS software.

Table. 3 Table of Discharge Value of Analysis Results

CATCHMENT POINT	CATCHMENT AREA (KM^2)	Discharge (m^3 / s)	CATCHMENT POINT	CATCHMENT AREA (KM^2)	Discharge (m^3 / s)
Catchment 1	32.34	1.8743	**Catchment 17**	28.95	1.9679
Catchment 2	85.14	5.1148	**Catchment 18**	26.07	2.4294
Catchment 3	47.4	3.0373	**Catchment 19**	10.89	1.0915
Catchment 4	100.42	6.4332	**Catchment 20**	37.51	2.3143
Catchment 5	79.89	4.8601	**Catchment 21**	43.46	2.6964
Catchment 6	83.92	5.2833	**Catchment 22**	59.29	3.9941
Catchment 7	6.34	0.6468	**Catchment 23**	6.25	0.5819
Catchment 8	25.6	1.6276	**Catchment 24**	7.93	0.6234
Catchment 9	12.64	1.0271	**Catchment 25**	14.96	1.1645
Catchment 10	**252.06**	**15.1222**	**Catchment 26**	52.03	3.5626
Catchment 11	179.81	9.7029	**Catchment 27**	17.08	1.4399
Catchment 12	11.68	0.8794	**Catchment 28**	11.23	0.8574
Catchment 13	11.51	0.8574	**Catchment 29**	**6.1**	**0.525**
Catchment 14	10.37	0.587	**Catchment 30**	26.82	2.134
Catchment 15	70.61	4.1238	**Catchment 31**	10.37	0.807
Catchment 16	11.7	0.7122	**Catchment 32**	7.03	0.5538

Based on the results of the analysis using SAGA GIS as shown in Table 3, the greatest potential is in Catchment 10 with an area of 252.06 6 km² and a total dischargeof 15.1222 m^3 / sec, while the lowest potential is at the Catchment 29 point with an area of 6.1 km^2 and a dischargeof 0.525 m^3 / sec. So it can be concluded that the dischargeis directly proportional to the area, this is in accordance with the mainstay discharge formula that the discharge is directly proportional to the area, runoff coefficient and rainfall intensity.

IV. CONCLUSION

This study identified the potential surface water source of North Buton District, Southeast Sulawesi Province, which is the potential catchment point 1 to Catchment 32 potential point with the highest discharge value of 15.1222 m^3 / second (Catchment 10 potential point) and the lowest discharge value of 0.525 m^3 / sec (potential point Catchment 29).The use of DEM (Digital Elevation Model) data to identify potential surface water sources can be done by adding several basic parameters, such as TRMM satellite rainfall data for value I, land cover type data for C1 values (Runoff coefficient based on land cover), and data DEM (Digital Elevation Model) to extract slope parameters for C2 value (Runoff coefficient based on slope) and determination of area A. Spatial data output from scientific research institutions such as NASA and BIG can produce a potential surface flow analysis, which is the value of surface flow discharge.

ACKNOWLEDGEMENT

The author extends the appreciation to Civil Engineering Department, University of Hasanuddin for unconditional support.

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