



## Drought Index Determination Using the Batulayar Watershed Hydrology Model

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### Article Info

#### Article history:

Received 9 March 2022

Received in revised form 28 March 2022

Accepted 30 March 2022

#### Keywords:

SWAT

Drought

Batulayar Watershed

### Abstract

The Batulayar sub-watershed, also known as the Bongomeme sub-watershed, is one of the most important sub-watersheds in the Limboto watershed. Because there are oil palm and other plants in the Batulayar Sub-upstream watershed's area that cause drought and natural harm. The goal of this study was to assess the severity of the drought and develop a hydrological model for calculating the drought index in the Batulayar sub-upstream watershed's area. The mix approach was utilized, which combines Soil and Water Assessment Tool (SWAT) modeling with field survey methodologies. The study's findings suggest that land conversion in the Batulayar Sub-upstream watershed's area may have an impact on the watershed's function. The Batulayar Sub-SMDI watershed's value in the SWAT Model results shows that it ranges from -0.50 to -2.99 in March, April, May, November, and December over a 10-year period, and is classified as "Slightly Dry" and "Slightly Dry." The Hydrological Model's role in determining the drought index can be seen in the results of calibration and validation using the NSE Model (Nash Sutcliffe Coefficient of Efficiency). An NSE value of 0.9 is obtained in calibration and validation, implying that the NSE value obtained belongs to the "good" class or that the discharge model and research observation discharge are similar.

## Introduction

Drought is a common occurrence in numerous parts of Indonesia, but the exact timing of the drought is unknown (Syarial et al., 2017). According to the National Disaster Management Agency, there were 1752 drought incidents in Indonesia between 1815 and 2015, accounting for 10% of all catastrophes (BNPB, 2015 in Purnamasari. Etc., 2017).

A watershed, hereinafter referred to as a watershed, is a land area that is a unit with a river and its tributaries, and functions to accommodate, store, and drain water from rainfall to lakes or rivers, according to Government Regulation (PP) No. 37 of 2012 about Watershed Management.

Where the land boundary is a topographical separator and the sea boundary with water areas that are still affected by land activities, the water flows naturally into the sea. The Sulawesi River Region II Hall, Gorontalo Province, manages the Limboto Bone Bolango Watershed (DAS), which is located in Gorontalo Province.

The Limboto Bone Bolango Watershed (DAS) has been recognized as a watershed in critical status and requires immediate remediation, according to SK.328/MenhutII/2009 concerning the Determination of Priority Watersheds (DAS) in the Framework of the 2010-2014 Medium

Term Development Plan (RPJM). In all watershed areas, the Limboto Watershed (DAS) is one of the watersheds that is vulnerable to drought (BPS Kabupaten Gorontalo 2018).

The Batu Layar sub-watershed is one of the Limboto watershed's most important sub-watersheds. There are oil palm plantations and other plants in the area upstream of the Batu Layar sub-watershed that cause drought and damage to the environment. When it rains and droughts in the Batu Layar Sub-watershed during the dry season, the excessive volume of rainwater often causes flooding in areas located in the middle and downstream areas of the Sub-watershed, while the volume of water is small during the dry season, causing reduced water in the sub-watershed.

The region One of the sub-watersheds in the Limboto watershed area is the Batulayar sub-watershed. Batulayar sub-watershed is located in Bongomeme District, which borders Dungaliyo District and Biluhu District, according to the administration. According to BPS data from 2018 (Bongomeme District in Figures), the population of Bongomeme District is 19,360 thousand people, with 7,007 thousand people living in the Batu Layar Sub-watershed. The agriculture industry provides the majority of the livelihoods for the population of Bongomeme District. Agricultural activities in the Batu Layar Sub-upstream watershed's area have a direct impact on the damage to the Batu Layar Sub-upstream watershed's area. The watershed has been designated as "vulnerable" (Ayuba, et al. 2018).

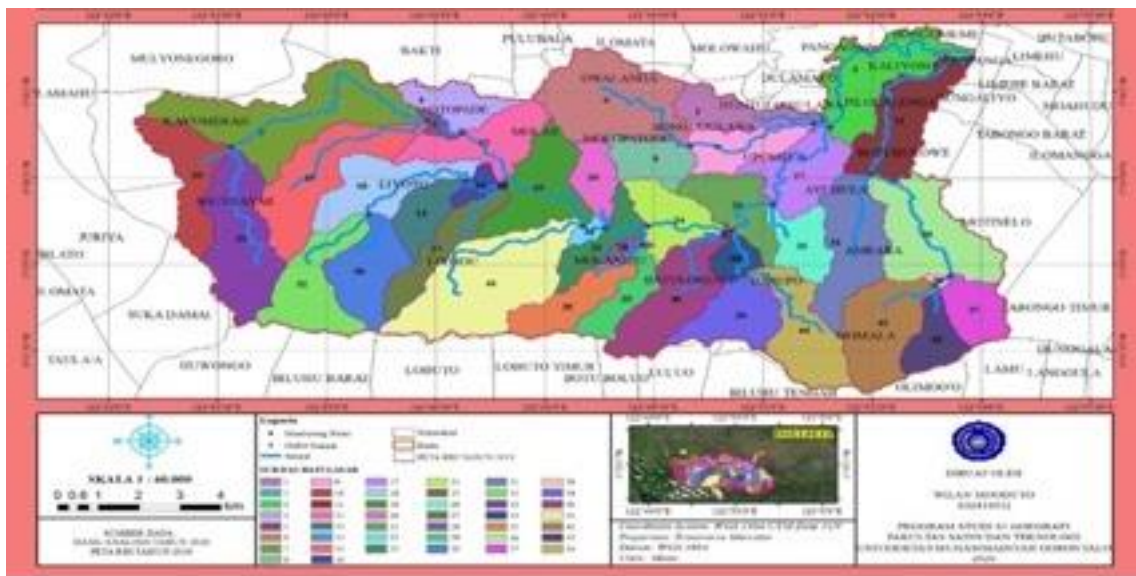


Figure 1. Location Map of Batulayar Sub-watershed Limboto Watershed

The Soil and Water Assessment Tool (SWAT) model was used in this investigation. SWAT is a physics-based continuous events hydrological model that was created to anticipate the impact of land management methods on water, sediment, and agricultural chemistry on a large scale, specifically complex watersheds with varying soil types, land use, and management conditions across time (Nursaputra, 2015).

SWAT estimates water yields, transported sediments, pesticide waste, and other things using climatic data and geographically dispersed data on topography, soil, land cover, and land management (Hidayat, et al. 2016).

A watershed is divided into multiple sub-watersheds or sub-basins for modeling purposes based on the similarity of land cover, slopes, or other hydrologically influenced qualities, and each sub-watershed or sub-basin is made up of various HRUs (Hydrologic Response Units) (Ayuba,

2016). According to Ayuba (2016), the simulated watershed hydrological process in SWAT is divided into two parts: the process on land and the process in the river.

The Batulayar sub-watershed is part of the Limboto watershed, which has a "vulnerable" drought category that affects the entire watershed. There is no "extremely vulnerable" category in the Limboto watershed, which means that the average SD (Soil Deficit) only ranges from -1.99 to 4, and all sub-watersheds are in the "vulnerable" category (Ayuba, et al. 2018). In addition, according to Ayuba (2016), the level of drought in the Batu Layar sub-watershed is included in the vulnerable categorization.

The goal of this study was to assess the severity of drought in the Batu Layar Sub-watershed and develop a hydrological model for calculating the drought index in the Batu Layar Sub-upstream watershed's area. This study is expected to serve as a guide for local governments in carrying out regional development, particularly in the management of the Limboto Watershed (DAS), particularly in the upstream area of the "vulnerable" Batu Layar Sub-watershed.

## Methods

### Sites for Research

This study is administratively limited to Bongomeme Subdistrict and a portion of Dungaliyo Subdistrict in the Batu Layar sub-watershed, which covers 17,130,931 hectares. Figure 1 depicts the research location.

### Data and Tools

Smartphones, computers, GIS programs (Geographical Information Systems), SWAT, and writing instruments were employed in the study. DEMNAS, land cover data, climate data, soil type data, slope data, and water discharge data were all employed.

### Methods of Investigation

The implementation of the Batulayar hydrological model in determining the Drought Index utilizing a mixed method, i.e. a combination of qualitative and quantitative methodologies, is the method adopted in this study (SWAT modeling and survey methods). A field survey method was utilized to obtain water discharge data in the Batu Layar sub-watershed before the method used in this study. Then, using the SWAT (Soil and Water Assessment Tool) application, which is coupled with the GIS (Geographical Information System) application, apply the SWAT approach.

### Methodology for Gathering Data

The acquisition of secondary data is included in this stage. Water discharge data (for validation and calibration of model discharge generated from SWAT output), land cover data (to be detailed into land use data), soil type data (from RePPPProt 1984), slope data (from <http://tides.demnas.go.id>), and climate data (from <http://swat.edu.tamu>) are all examples of secondary data. The secondary data in this study as a whole (land cover data, soil type data, slope data, and climate data) provide input data for the SWAT model categorization.

### Techniques for Data Analysis

The Soil Moisture Deficit Index was utilized in the analysis to determine the watershed's drought vulnerability (SMDI). Using the SWAT model's output data, specifically Soil Water / SWAT (Ground Water Content). The SW value is then converted to an SMDI value in ArcGIS, which is subsequently classed in the SMDI classification (see Table 1). The following are the formulas that were used:

$$\text{If } SW \leq MSW \quad (1)$$

$$\text{is true, then } SD = \frac{SW - MSW}{MSW - \min SW} \times 100 \quad (2)$$

$$\text{is true, and if } SW > MSW \quad (3)$$

$$\text{is true, therefore } SD = \frac{SW - MSW}{\max SW - MSW} \times 100 \quad (4)$$

Information:

SD : Water deficiency in the soil ( percent )

SW : Soil total water content in the year of analysis.

MSW : Median value of total water content in the soil during the course of the analysis year.

Max SW : The maximum total water content in the soil over the course of the analysis year.

Min SW : The soil's total water content at its lowest point throughout the analysis year.

The value of the soil moisture deficit (SD) is then calculated in the index value, which is the Soil Moisture Deficit Index (SMDI), using the formula:

$$SMDI_i = 0,5SMDI_{i-1} + \frac{SD}{50} \quad (5)$$

After that, the index categorization is categorized as shown in Table 1

Table 1. shows the categorization weighting of the SMDI index.

Num	Value Index	Category	Weight/Score
1	$\geq 4,00$	Extremely Wet	1
2	3,00 sd 3,99	Wet	2
3	2,00 sd 2,99	Slightly Wet	3
4	0,50 sd 1,99	Wet a Little	4
5	0,49 sd -0,49	Normal	5
6	-0,50 sd -1,99	Dry to a degree	6
7	-2,00 sd -2,99	Dry to a point	7
8	-3,00 sd -3,99	Dry	8
9	$\leq -4,00$	Dry as a bone	9

Source: Ramanarayanan et al, 2005

## Results and Discussion

To establish a drought index in the Batulayar sub-watershed, the SWAT method, which is integrated with the GIS application, is used. In each sub basin, the output from this approach is processed using equations 1 to 5. The SWAT output is obtained using SWAT, which is coupled with a GIS program that uses the SWAT Simulation menu, during the running process during the SWAT analysis stage. If the Watershed Delineator, HRU Analysis, and Write Input Table stages have been performed correctly, this analysis stage can be finished. The data that is simulated is 10 years of data following the climate data format. The outcome of the running procedure is then assessed in the Batulayar sub-watershed utilizing the SW (Soil Water) value

as a parameter in determining the drought index. The analytical stage is divided into two sections:

### **Integration of the Soil and Water Assessment Tool (SWAT) Model with Geographic Information Systems (GIS) Applications.**

Based on the SWAT classification, the SWAT method that is integrated with the GIS application can be described in several stages of data input. The stages of data entry in the SWAT method are as follows:

#### **The Batulayar Sub-watershed Boundary Delineation**

Delineation of sub-watershed borders using Digital Elevation Model (DEM) data based on the researched sub-watershed area is the initial stage. The National DEM Data was used as the DEM data. Because slope data was used in the delineation stage of the Batulayar Sub-watershed, the parameters employed were the SWAT-calculated Subbasin parameters. Delineation of the Batulayar Sub-watershed is based on the Sub-principal watershed's outlet.

#### **Batulayar Sub-watershed Land Use**

In 2016, BPKH provided land use data, which was then verified on the ground at the research site. The Raster format is utilized for SWAT input data, which is one of the most important needs for inputting land use data from the ground check. The classification of SWAT input data for land use data is as follows:

Table 2. Batulayar Sub-watershed Land Use

No	Land Use	Area (Ha)	Percentage (%)
1	FRST (Secondary Dry Land Forest)	1.460,23	8,52
2	ORCD (Plantation)	176,89	1,03
3	URBN (Settlement)	918,02	5,36
4	AGRL (Dry Land Farming and Mixed Shrubs)	14.239,41	83,12
5	RICE (Paddy)	174,69	1,02
6	RNGB (Shrubs)	161,72	0,94
<b>Total</b>		<b>17130.931</b>	<b>100</b>

Source : Results of the 2019 analysis

#### **Type of Soil**

Soil type data was derived from land system data from the 1987 National Survey and Mapping Coordination Agency's Regional Physical Project for Transmigration (RePPPProt). The data was then analyzed using a GIS tool, with the Classification from the USDA (United States Department of Agriculture) being used to name Soil Great. The classification of SWAT input data for soil type data is as follows:

Table 3. shows the soil types found in the Batulayar sub-watershed.

No.	SOIL GREAT	IDSOIL	Area (Ha)	Percentage(%)
1	Dystropepts; Humitropepts; Tropohumults	SOIL06	5.589,64	32,63
2	Dystropepts; Tropudalfs; Tropudults	SOIL10	319,91	1,87
3	Dystropepts; Tropudults; Troperthents	SOIL14	5.082,93	29,67
4	Dystropepts; Tropudults; Tropudalfs	SOIL15	0,22	0,00
5	Eutropepts	SOIL18	885,84	5,17
6	Eutropepts; Tropudalfs	SOIL21	2.498,81	14,59

7	Rendolls; Eutropepts	SOIL32	1.015,49	5,93
8	Tropaquepts; Fluvaquents	SOIL36	444,36	2,59
9	Tropaquepts; Tropofluvents	SOIL39	548,07	3,20
10	Tropaquepts; Tropofluvents; Fluvaquents	SOIL40	433,24	2,53
11	Tropudults; Tropudalfs; Eutropepts	SOIL59	312,38	1,82
<b>Total</b>			<b>17.130,93</b>	<b>100</b>

Source: REPPROT map and analysis results, 2019

### The formation of a hydrological response unit (HRU)

The smallest unit in the scale of analysis used to model SWAT is the HRU. Each HRU location responds differently to hydrologic conditions, such as runoff, erosion, groundwater storage, subsurface flow, water balance, and so on (Nursaputra, 2015). Each HRU is built with unique information about the terrain, such as land cover, soil type, and slope. The HRU analysis uses ESRI raster data for land cover and soil types, while the slope class classification is generated from the DEM dataset (Mandy 2018).

In the Batulayar sub-watershed, the HRU development process begins after the watershed borders have been defined. Formation This is done in order to receive the findings of the Sub-watershed analysis, which will be performed throughout the SWAT running procedure. Slope data, soil type data, and land use data are all overlaid throughout the HRU generation process. The slope, soil type, land use, area of the resulting Sub-watershed, and percentage of HRU area in the Sub-watershed are all included in the HRU formation results. There were 746 HRUs and 44 Sub Basins in the Batulayar Sub-watershed HRU, with a total area of 17,130.93 hectares. The establishment of the Batulayar Sub-watershed HRU is depicted on the map below:

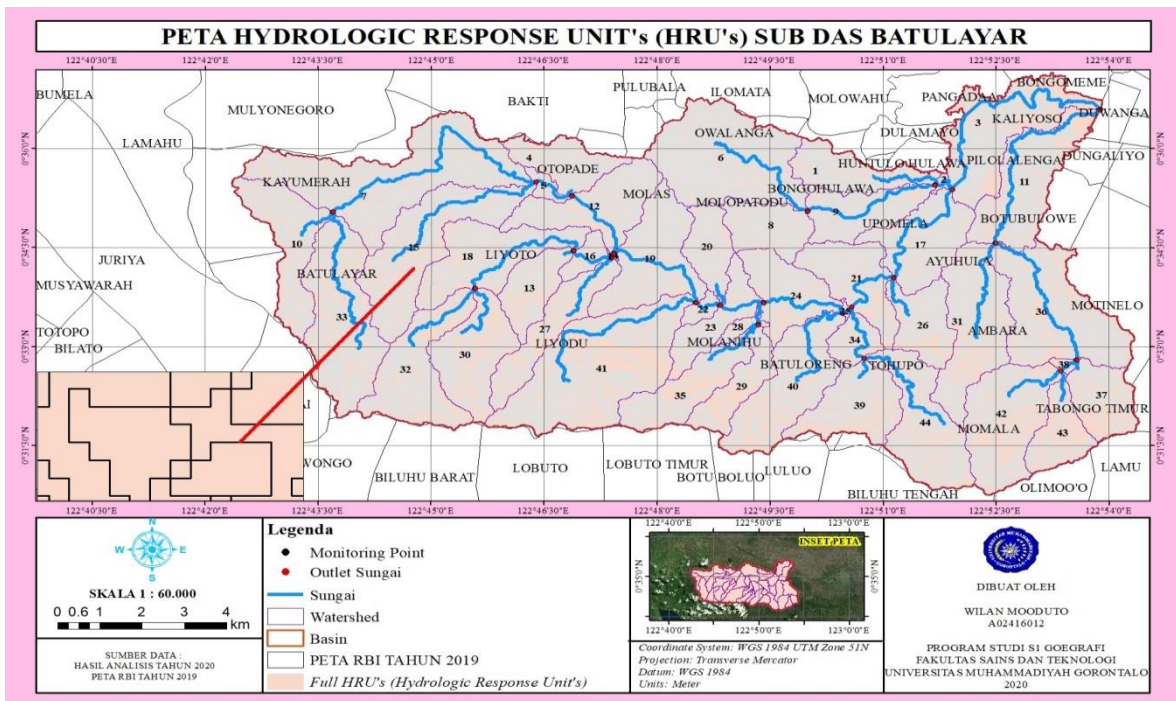


Figure 2. Map of the results of the formation of the Batulayar Sub-watershed HRU

Source: Analysis results, 2020

## Climate Data and the Execution Process

The SWAT procedure is run with climatic data to provide SWAT output in the form of monthly simulation data. The SWAT simulation incorporates climate data from stations representing the sub-watershed area, as well as Weather Generator data from the Batulayar sub-watershed, such as wind speed, solar radiation, rainfall, temperature, and air humidity. After you've entered your climatic data, use the SWAT Simulation menu on the SWAT tool to start the Running SWAT procedure (Douglas-Mankin et al., 2010).

## Calibration and Validation

Are two terms that are often used interchangeably. River discharge data from the Sulawesi II River Region Hall, Gorontalo Province, was used in the calibration and validation stage, and it was calibrated using model discharge data acquired from the SWAT Model results. Microsoft Excel is used to calculate the model and observation discharges. The NSE (Nash Sutcliffe Coefficient of Efficiency) value for the discharge data model is calculated using the following equation, according to Nursaputra (2015):

$$NSE = 1 - \frac{\sum_{i=1}^n (Q_{Obsi} - Q_{Modi})^2}{\sum_{i=1}^n (Q_{Obsi} - \bar{Q}_{Modi})^2} \quad (6)$$

$$NSE = 1 - \frac{(4041413.825)^2}{(173830.7104)^2}$$

$$NSE = 0.999866254$$

$$NSE = 0.99$$

The NSE (Nash Sutcliffe Coefficient of Efficiency) model is divided into three categories: "excellent" if the NSE is 0.75, "satisfactory" if the NSE is 0.75 > 0.36, and "unsatisfactory" if the NSE is less than 0.36. (Nursaputra, 2015 in Ayuba, et al. 2018). The NSE value acquired in calibration and validation is 0.9, which indicates that the NSE value obtained belongs to the "good" class or that the model discharge and the research observation discharge are similar.

## Analysis of SWAT Output

The drought index in the Batulayar sub-watershed is calculated by employing the Soil Water (SW) parameter in many equations in Microsoft Office software to analyze the SWAT model output data. Equations 1 to 5 are utilized at this point to calculate the values for each subbasin. The findings obtained in this study indicate that the drought index has two classification categories, "Slightly Dry" and "Dry to a degree," as shown in Table 4.

Table 4. Recapitulation of drought classification in the Batulayar sub-watershed

No	Subbasin	Average SW	Average SD	Average SMDI	Drought classification	Area (Ha)
1	1	53.3846333	-48.98713383	-1.722915055	Dry to a degree	294,70
2	2	31.622675	-49.28701701	-1.75822703	Dry to a degree	14,86
3	3	60.7200333	-47.57231257	-1.682005406	Dry to a degree	632,58
4	4	164.231717	-42.75904471	-1.517116322	Dry to a degree	267,49
5	5	152.459433	-43.31380184	-1.540372433	Dry to a degree	49,76
6	6	108.956458	-57.17402858	-2.024413519	Dry to a point	842,01
7	7	161.072875	-51.55284925	-1.822421097	Dry to a degree	1044,21
8	8	124.4998	-55.31831424	-1.957323895	Dry to a degree	276,58

9	9	66.7212667	-57.98192908	-2.054082474	Dry to a point	337,44
10	10	199.720683	-55.54570854	-1.968440612	Dry to a degree	443,84
11	11	86.3057583	-49.92613054	-1.77457201	Dry to a degree	557,59
12	12	138.215233	-50.25133947	-1.767906594	Dry to a degree	449,68
13	13	140.826075	-54.68368375	-1.945257822	Dry to a degree	251,44
14	14	106.666983	-52.33538792	-1.855320255	Dry to a degree	3,56
15	15	148.0851	-55.91249038	-1.993641565	Dry to a degree	698,35
16	16	126.300167	-54.17703772	-1.908376391	Dry to a degree	87,52
17	17	59.4780833	-51.90938393	-1.834026583	Dry to a degree	434,69
18	18	138.623025	-55.78214085	-1.991107855	Dry to a degree	508,63
19	19	127.356975	-56.19432086	-1.988144299	Dry to a degree	539,10
20	20	126.052617	-55.73789466	-1.97205477	Dry to a degree	224,75
21	21	108.356675	-53.64236894	-1.893338753	Dry to a degree	383,01
22	22	147.471	-43.3560663	-1.540995674	Dry to a degree	51,41
23	23	146.370883	-46.86624895	-1.646365755	Dry to a degree	247,72
24	24	107.7758	-41.54117183	-1.444600541	Dry to a degree	347,74
25	25	58.887425	-36.71484436	-1.312892307	Dry to a degree	8,23
26	26	107.818767	-49.74939576	-1.762155019	Dry to a degree	284,20
27	27	160.647925	-32.5092221	-1.066496263	Dry to a degree	351,05
28	28	124.93805	-44.74950267	-1.597942857	Dry to a degree	46,06
29	29	165.676475	-48.45764377	-1.7199049	Dry to a degree	239,69
30	30	184.094717	-49.1042882	-1.737111457	Dry to a degree	447,18
31	31	111.22695	-49.14425398	-1.738694422	Dry to a degree	595,40
32	32	183.92215	-54.64730714	-1.942690407	Dry to a degree	534,51
33	33	179.706325	-56.79539599	-2.011504724	Dry to a point	729,87
34	34	124.346375	-45.19713568	-1.592040469	Dry to a degree	132,45
35	35	185.455375	-56.38618066	-2.000115977	Dry to a point	362,42
36	36	97.3249417	-47.38644411	-1.685613899	Dry to a degree	743,32
37	37	142.260125	-56.79338218	-2.020482603	Dry to a point	281,56
38	38	104.485558	-48.24109247	-1.718599251	Dry to a degree	19,55
39	39	180.922842	-52.90539132	-1.865198282	Dry to a degree	397,50
40	40	164.719908	-54.58358403	-1.935513151	Dry to a degree	568,07
41	41	182.945433	-53.08565056	-1.888501875	Dry to a degree	1037,48
42	42	165.333758	-54.77969836	-1.937447978	Dry to a degree	588,52
43	43	173.353308	-52.79999235	-1.892134828	Dry to a degree	246,57
44	44	180.826992	-55.27201866	-1.853282721	Dry to a degree	528,40
<b>Total</b>						<b>17.130,931</b>

Source: Analysis results, 2020

Table 5. The Drought Index's Distribution

Name of the sub-watershed	Classification of Drought	Area (Ha)	Subbasins and villages are spread out.
Sub-watershed of Batulayar	Dry to a point	2.553,3	There are 16 subbasins (6, 9, 33, 35, 37) in all (Owalanga Village, Molopatodu Village, Bongohulawa Village, Upomela Village, Molanihu Village, Motinelo Village, and Batulayar Village)
	Dry to a degree	14577.39	There are 28 subbasins (1, 2, 3, 4, 5, 7, 8, 10, 11, 12, 13, 14,15, 17,18, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 34, 36, 38, 39, 40, 41, 42, 43, 44) in all (Bongohulawa Village, Huntulohulawa Village, Dulamayo Village, Pilolalenga Village, Kaliyoso Village, Bongomeme Village, Pangadaa Village, Desa Otopade, Batulayar Village, Kayumerah Village, Molopatodu Village, Dungaliyo Village, Botubulowe Village, Ayuhula Village, Liyoto Village, Liyodu Village, Molas Village, Upomela Village, Molanihu Village, Batuloreng Village, Tohupo Village, Ambara Village, Motinelo Village, East Tabongo Village and Momala Village)
<b>Total</b>		<b>17.130,93</b>	

Source: Analysis results, 2020

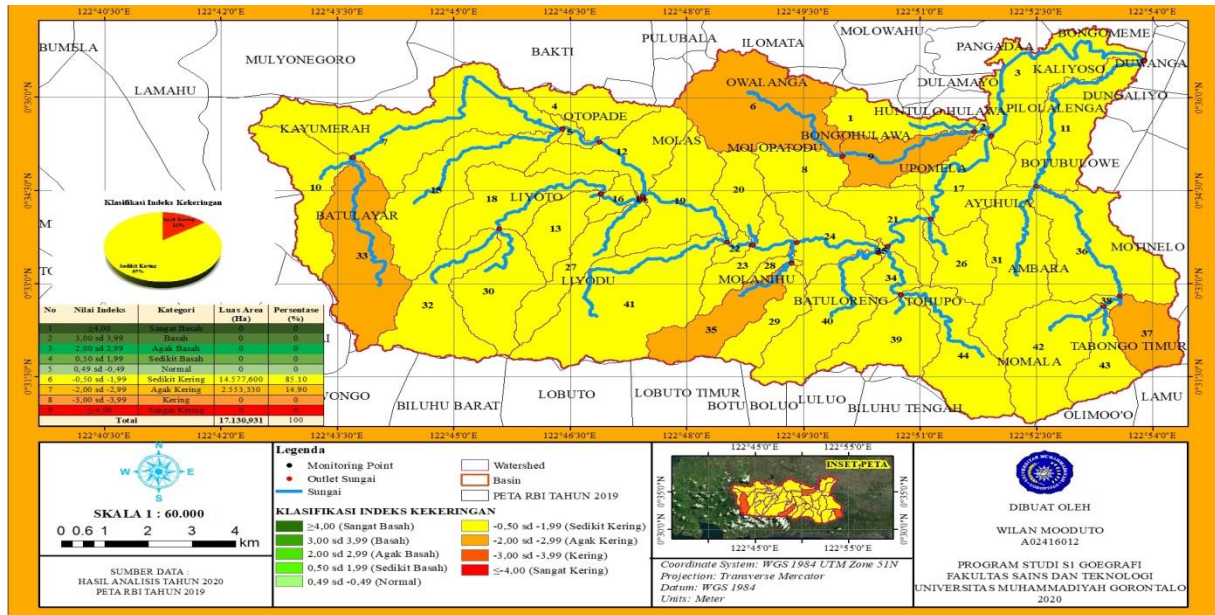


Figure 3. Drought index distribution map in Batulayar sub-watershed

Source: Analysis results, 2020

Due to a shortage or reduction in water supplies, the function and quality of a watershed has deteriorated. The Soil Moisture Deficit Index (SMDI) and the Soil Water (SW) parameters are used to calculate the drought index in the Batulayar sub-watershed. The condition of water

supply in the Batulayar Sub-watershed has been able to be characterized in the SWAT output using soil water (SW) parameters acquired from the SWAT output.

There are nine classifications of SMDI, according to Narasimhan & Srinivasan et al. (2005). The Batulayar sub-watershed is divided into two categories: "Slightly Dry" and "Slightly Dry," which means that the average SD (Soil Deficit) value ranges from -0.50 to -2.99, indicating that the Batulayar sub-watershed is below normal in all locations. The SWAT Model results suggest that the Batulayar Sub-SMDI watershed's value ranges from -2.00 to -3.99 in March, April, May, November, and December over a 10-year period, and this value is classed as "Dry to a degree" and "Slightly Dry" by Ramanarayanan et al. (2005).

The diversity of HRUs found in each Sub Basin indicates that the drought that occurred in the Batulayar Sub-watershed is due to the dominant use of dry land agricultural land, the slope is very steep, and the soil types are ultisol, alfisol, inceptisol, and Molisols, which have various contents found in these soil types in areas that are classified as "Slightly Dry."

Drought in the Batulayar Sub-watershed arises as a result of the local community's change of land functions, resulting in the upstream watershed's ability to accommodate water no longer operating efficiently. As a result, the risk of drought in this area is extremely high. In the slope class 25 percent s/d > 40 percent, secondary forest land is divided into dry land and mixed bush farming, with a total area of 14,908.54 ha and an area percentage of 87.03 percent, compared to secondary forest land, which has an area of 1,460.13 ha and an area percentage of 8.52 percent.

The drought index in the Batulayar sub-watershed is calculated using the SWAT simulation results with the SW value in the SWAT modeling, and the average value of SW (Soil Water) is calculated every month for a period of ten years. The average Soil Deficit (SD) and Soil Moisture Deficit Index (SMDI) values are calculated from the SW average value, resulting in the drought index.

The results of river flow calibration and validation reveal the hydrological model of the Batulayar sub-watershed; in this example, the flow rate utilized is the observed flow rate calibrated with the model flow rate. Flow rates obtained from the Sulawesi River Region II Center, Gorontalo Province, utilizing measurements for 1 (one) year and calibrated with flow models using SWAT output discharge data are used in observational river flow discharges. Using Microsoft Excel, the observed river flow discharge and the model flow discharge were estimated using data from the same year. The NSE value of 0.9 is achieved in this validation using the NSE (Nash Sutcliffe Coefficient of Efficiency) equation and the outcomes of these calculations. Based on the NSE results, it was determined that there was no difference between the observed and model discharges, indicating that the modeling was "good" or that the observation discharge and the SWAT model discharge in the Batulayar sub-watershed were in the "good" category.

## Conclusion

The following conclusions can be drawn from the analysis of the Batulayar sub-hydrological watershed's model in determining the drought index; (1) The level of drought in the upstream area of the Batulayar Sub-watershed is categorized as "Dry to a degree" and "Slightly Dry" with an average SMDI (Soil Moisture Deficit Index) value ranging from -0.50 to -2.99, indicating that the upstream area of the Batulayar; (2) The outcomes of the calibration and validation of the SWAT model, which simulates the hydrological processes that occur in the Batulayar sub-watershed, can be seen in determining the dryness index. The observed discharge and the model discharge were determined to be identical, hence the modeling was categorized as "excellent"

or "near to the true condition in the field" based on the NSE value. The NSE value for the SWAT model in watershed modeling in the Batulayar sub-watershed is 0.99 during the verification stage, suggesting that it is rated as "good."

### Acknowledgements

Thanks to the Faculty of Science and Technology University of Muhammadiyah Gorontalo's Geography Study Program. The Sulawesi River Region II Center, Gorontalo Province, and Mr. Munajat Nursaputra, S.Hut, M.Sc., who has greatly aided in the completion of this research.

### Conflict of Interest

The author declares that there are no financial, personal, other people, or organizations with a financial or personal interest in the material in this study

### References

- Ayuba, Rahayu, S, Nurshaputra, Munajat, & Tisen. (2018). "Klasifikasi Tingkat Kekeringan Pada Daerah Aliran Sungai (DAS) Limboto." *Jurnal Sains Informasi Geografi 1* (ISSN 2614-1671): 9–17. <https://doi.org/10.31314/jsig.v1i2.177>
- Ayuba, Sri Rahayu. (2016). *Arahan Penggunaan Lahan Pada DAS Limboto Bolango Bone*. (Thesis: Universitas Hasanuddin Makassar).
- Douglas-Mankin, K. R., Srinivasan, R., & Arnold, J. G. (2010). Soil and Water Assessment Tool (SWAT) model: Current developments and applications. *Transactions of the ASABE*, 53(5), 1423-1431.
- Hidayat, Lukman, Sudira, P., Susanto, S., & Jayadi R.,. (2017). "Validasi Model Hidrologi SWAT Di Daerah Tangkapan Air Waduk Mrica (Validation of The SWAT Hydrological Model on The Catchment Area of Mrica Reservoir)." *Agritech 36* (4): 467. <https://doi.org/10.22146/agritech.16772>
- Mandy, D. A. (2018). *Perbandingan Ketersediaan Air Tahun 2015 Dan Tahun 2022 Berdasarkan Penutupan Lahan Di Daerah Aliran Sungai Maros*. Thesis: Univeristas Hasanuddin Indonesia.
- Ramanarayanan, T., Narasimhan, B., & Srinivasan, R. (2005). Characterization of fate and transport of isoxaflutole, a soil-applied corn herbicide, in surface water using a watershed model. *Journal of agricultural and food chemistry*, 53(22), 8848-8858.
- Syahrial, A., Azmeri, A., & Meilianda, E. (2017). Analisis Kekeringan Menggunakan Metode Theory of Run di DAS Krueng Aceh. *J. Civ. Eng*, 24(2), 167-172