The Supply of water in Bua District based on spatial planning of Luwu Regency at the 2030s

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Abstract. Land cover in a watershed area has an impact on the infiltration capacity related to the water supply. Water needed for irrigation of rice fields in Bua District, especially in the Bua, Malenggang, and Salu Beroa watersheds are experiencing drought each year. This means that water needs are not in accordance with the existing water supply, so research needs to be done related to water supply and rice field irrigation water needs. This study aims to determine the water supply of Bua, Malenggang, and Salu Beroa watersheds based on the existing land cover and the spatial pattern of the Luwu Regency in 2030 and the need for water for rice fields in this area. Data was used in this study include existing land cover maps, Luwu Regency spatial pattern maps in 2030, soil type maps, Digital Elevation Model (DEM) data, and daily climate data analyzed by using the SWAT model. The results of SWAT model analysis based on existing land cover found that water supply in Bua watershed is 40,291.452 m³/year, Malenggang watershed is 19,467.893 m³/year, and Salu Beroa watershed is 2,685.224 m³/ year. Meanwhile, based on the spatial pattern in 2030 found that water supply in Bua watershed is 40,076.558 m³/year, Malenggang watershed is 19,396.958 m³/year, and Salu Beroa watershed is 2,689.116 m³/year. The amount of water needed for irrigating these watersheds is 50.848.015.7 m³/year or 81% out of the total water supply of existing land cover and 82% out of the total of spatial pattern water supply in 2030. It is showed that if the spatial pattern plan is implemented and simulated by using a watershed-based SWAT model, the water supply in the study area will be reduced or lower than 281.937 m³ at the end of the planning year, which are the total water supply based on existing land cover is 62,444.569 m³ while the water supply based on the spatial pattern is 62,162.632 m³. Therefore, an evaluation of the implementation of the Luwu Regency spatial plan is needed. The monthly demand of rice fields is 4,237.335 m³ while water supply in August is 3,377.597 m³, September is 3,340.444 m³, and October is 3,484.457 m³. It means that the demand for rice fields is not fulfilled in August, September, and October. Thus, in that month, Drought occurs.

1. Introduction

Regional development in an area will cause water demand to increase as well as the increase in population growth rate. The need for water is always closely related to the food needs and activities of the population [1]. These demands cannot be avoided, but they must be predicted and planned for their best use. Specifically, for water needs for irrigation, it is necessary to study and plan the unit of water needs carefully and thoroughly, this is important because water needs for irrigation are the highest component of water demand [2].

Rainfall water that should be infiltrated into the ground (as infiltration and percolation) will turn into the surface runoff, which generally flows into rivers and lakes due to changes in land use on a massive scale (for example, the opening of large-scale plantation areas). So that it can affect the water
balance and the surrounding environment [3], changes in land use that are relatively extensive in the watershed area can cause disruption of the hydrological cycle. This can disturb the balance of water resources in a watershed [3].

A good watershed ecosystem provides many roles and benefits (environmental services) to humans and living things around them. A good watershed is able to reduce surges in surface flow fluctuation and is able to stabilize the amount of river flow so that water supply, especially in the dry season, can be guaranteed [4]. In the tropics, water resources come from rainfall water, both local and falling, at the upstream. Theoretically, the amount and fluctuation of water supply in an area can be estimated based on the amount of rainfall and frequent rainfall. While determining the distribution and flow velocity is influenced by other hydrological factors, such as the shape of the region, geology, soil and cover, and land use [5]. Water supply in a watershed is the amount of water stored in the soil (water recharge) and exit (water discharge) within a certain period of time [6].

Hundreds of hectares of rice fields in Bua District, South Sulawesi are threatened with death. This condition makes farmers fail to harvest and lose money. A total of 500 hectares of rice fields spread across seven villages in Bua Subdistrict, Luwu Regency, South Sulawesi, died due to drought. There is no water to irrigate the rice fields because the irrigation of rice fields is also experiencing drought. Even some of the paddy soil starts to dry and crack. As reported by tribunnews.com on October 29, 2018, with the title "Hundreds of hectares of Rice fields in Bua Luwu Subdistrict Threatened with Failure to Harvest," according to Hairuddin, Head of Lare-Lare Village, that the drought in this area has occurred since three months ago. Rice plants lack water supply from irrigation due to lack of water discharge. Based on this problem, it is necessary to analyze the water supply in the watershed in Bua District.

The pattern of uneven water distribution is caused by a decrease in soil infiltration capacity and an increase in surface runoff so that there are certain times when excess water is not utilized, and in other times there is a lack of water. Efforts that can be made to addressing this problem are by optimizing the amount of rainfall water that enters the soil during the rainy season through increased soil infiltration capacity. This effort is expected to save rainfall water that falls in the rainy season, and then the water will flow slowly back through the base flow in the dry season. In the context of the relationship between land-use change and water supply [7]. Based on these conditions, this study was conducted to determine the level of water supply and irrigation needs of rice fields with the stages of analysis by using the Soil and Water Assessment Tool (SWAT) model. This research is expected to provide information in management planning in the Bua, Malenggang, and Salu Beroa watersheds.

2. Research methods
This study focuses on the prediction of watershed hydrological characteristics by considering aspects of climate, soil, slopes, and existing land cover and spatial patterns by using the Soil and Water Assessment Tool (SWAT) model to analyze water supply and rice field requirements in a watershed as a reference for watershed management.

2.1. Determination of research location boundary
The determination of the boundaries of the study location was obtained from the boundaries of the Bua, Malenggang, and Salu Beroa watersheds made from the extraction of DEMNAS data on SWAT, which determined the boundaries by looking at the watershed outlets (See Figure 1).
2.2. Data source
The data was used in this study include primary and secondary data. Primary data is obtained directly through image interpretation activities to create a land cover map. Checking land cover data in the field is done by adjusting the classification of land cover in the field with the result of image interpretation by purposive sampling based on accessibility and contour data obtained from the Extraction of Digital Digital Elevation Model (DEM) data. Secondary data is data that includes the general condition of the research location obtained from literature studies as well as other data related to the research. This data includes watershed boundary maps, administrative maps, soil types maps, and daily climate data.

2.3. SWAT data Input

2.3.1. Digital Elevation Model Data. DEM data analysis in SWAT model includes the stages of extraction of the watershed and sub-watershed boundaries as well as the creation of slope grade classes. DEM data are used to ensure the structure of connected river networks, and river segments and tributaries are well-drawn according to the actual condition in the drawing of the watershed and sub-watershed boundaries. As for the slope data which is the result of running the ArcSWAT program which then divided into 5 slope class classifications, those are 0-8% (flat), 8-15% (sloping), 15-25% (moderately steep), 25-40% (steep), and >40% (very steep).

2.3.2. Land Cover Data

2.3.2.1. Existing Land Cover. Land cover data for Bua watershed, Malenggang watershed, and Salu Beroa watershed were obtained by interpreting the SPOT 7 2018 images obtained from LAPAN. Visual delineation method was used to determine the land cover class based on patterns and characteristics, known as hue or color, size, shape, texture, pattern, height, shadow, site, and association in the image. Then the field check was conducted, with the aim to make a correction to the results of land cover classification on a scale of 1: 5,000. The coordinate point was determined by purposive sampling, which is choosing a location that is used as a sampling point that represents each form of land cover. This process was done by considering the accessibility factor with a maximum

![Figure 1. Research Location](image-url)
distance from the access that is 500 m.

After the field check was completed, the image accuracy test is performed to find the accuracy of image interpretation. Accuracy is a comparison between interpretation data results with field condition. Calculation of the accuracy of image interpretation is done with a confusion matrix table. In the confusion matrix, the data resulting from image interpretation and data from field checking results were arranged in a percentage comparison table. The result of the image interpretation that has fulfilled is then changed its naming database in accordance with the naming in the SWAT model land cover. The classification of land cover naming for the SWAT model shown in Table 1.

### Table 1. Existing Land Cover Classification

| No. | Land Cover (SWAT Classification)                | SWAT Code | The ID |
|-----|------------------------------------------------|-----------|--------|
| 1   | Secondary Forest (Forest-Mixed)                 | FRST      | 1      |
| 2   | Secondary Mangrove Forests (Wetlands-Forested)  | WETF      | 2      |
| 3   | Agriculture Land-Generic                        | AGRL      | 4      |
| 4   | Rice field                                      | RICE      | 5      |
| 5   | Plantation (Orchard)                            | ORCD      | 6      |
| 6   | Shrubs (Range-Brush)                            | RNGB      | 7      |
| 7   | Meadow / Sava (Pasture)                         | PAST      | 9      |
| 8   | Opened Land (Oak)                               | OAK       | 10     |
| 9   | Pond                                            | WATR      | 11     |
| 10  | Waterbody                                       | WATR      | 11     |
| 11  | Settlement (Residential)                        | URBN      | 12     |
| 12  | Airport (Transportation)                        | UTRN      | 14     |
| 13  | Port (Transportation)                           | UTRN      | 14     |

2.3.2.2. Spatial Pattern. The spatial pattern provides an overview of land use in the coming years in accordance with the projected regional spatial planning year. The data used in obtaining projected land cover is a map of the regional spatial plan, then the naming database is modified according to the naming in the spatial pattern of the SWAT model. The land cover classification of the SWAT Model using the Spatial Plan Pattern shown in Table 2.

### Table 2. Land Use/Cover Classification of SWAT model uses Spatial Pattern

| No. | Spatial Pattern (SWAT Classification)                      | SWAT Code | The ID |
|-----|-----------------------------------------------------------|-----------|--------|
| 1   | Agriculture Land-Generic                                  | AGRL      | 4      |
| 2   | Forest-Evergreen Production Zone                          | FRSE      | 3      |
| 3   | Production Forest Areas can be converted (Forest-Mixed)   | FRST      | 1      |
| 4   | Forest-Mixed Area                                         | FRST      | 1      |
| 5   | Plantation Cultivation Area (Orchard)                     | ORCD      | 6      |
| 6   | Wetland Agricultural Cultivation Area (Rice)              | RICE      | 5      |
| 7   | Aquaculture Area (Water)                                  | WATR      | 11     |
| 8   | Residential Area                                          | URBN      | 12     |
| 9   | Water Region                                              | WATR      | 11     |
| 10  | Coastal Border Region (Wetlands-Forested)                 | WETF      | 2      |

2.3.3. Soil Type Data. Soil data parameter input is performed to meet the needs of SWAT model analysis. The required soil data are soil type, soil physical and chemical characteristics parameters which obtained from the landscapes of the Regional Physical Planning Program for Transmigration (RePPProt) National Coordinating Agency for Survey and Mapping in 1987 and the USDA National Resource Conservation Service Web Soil data. The result of soil data analysis of Bua, Malenggang,
and Salu Beroa watersheds can be correlated with user soil data that has been added in the SWAT model. The input parameters of the type of soil needed to run ArcSWAT shown in Table 3.

| No | Soil Parameters                          | SWAT Code   |
|----|----------------------------------------|-------------|
| 1  | Number of Soil layer                   | NLAYERS     |
| 2  | Soil Hydrology Group                   | HYDGRP      |
| 3  | Plant Root Depth (mm)                   | SOL_ZMX     |
| 4  | Land Porosity (fraction)               | ANION_EXCL  |
| 5  | Land Crack Volume (m3 / m3)            | SOL_CRK     |
| 6  | Texture                                | TEXTURE     |
| 7  | Land Depth (mm)                        | SOL_Z       |
| 8  | Bulk Density (g / cm3)                 | SOL_BD      |
| 9  | Available water capacity (mm / mm)     | SOL_AWC     |
| 10 | Organic C content (%)                  | SOL_CBN     |
| 11 | Saturated Hydraulic Conductivity (mm / day) | SOL_K         |
| 12 | Clay Percentage (%)                    | CLAY        |
| 13 | Dust Percentage (%)                    | SILT        |
| 14 | Sand Percentage (%)                    | SAND        |
| 15 | Percentage of Surface Stone (%)        | ROCK        |
| 16 | Albedo Land (fraction)                 | SOL_ALB     |
| 17 | Land Erodibility                       | USLE_K      |
| 18 | Electrical Conductivity (ds/m)         | SOL_EC      |
| 19 | Calcium carbonate (%)                  | SOL_CAL     |
| 20 | pH                                     | SOL_PH      |

2.3.4. Climate data. Climate data were obtained from the Great Hall of the Pompengan River Region (BBWSPJ) with station number 04-067-00-01 with coordinates of 3°14′35″ latitude and 120°17′58.58″ east longitude. Climate data used are rainfall data (mm/day), air temperature (°C), solar radiation (MJ/m²/day), air humidity (%), and wind speed (m/s), which is a daily calculation data period 2009-2018. The data is then collected into PCP, TMP, SOLAR, RH, and WIND files with the txt extension.

2.4. Water Supply Analysis based on Existing Land Cover

The water supply is analyzed in the analysis of the SWAT model by using collected data. The data include DEM data with raster format, land cover data with raster format that has been defined according to the classification of land cover classification SWAT model, land type data with raster format that has been equipped with physical and chemical soil parameters required classification of SWAT models and climate data with a text format that has been adapted to the classification of the SWAT model. Furthermore, the process of forming/analyzing HRU, combining HRU with climate data, SWAT model simulation, and defining the output of water supply.

2.4.1. Formation Hydrological Response Unit (HRU). HRU is the smallest unit in the scale of analysis performed on SWAT modeling. HRU formation is done by overlaying land cover maps, land type maps, and slope maps. Each HRU that is formed contains specific information about the land, which includes land cover, soil type, and slope. Land cover data and soil types used in the HRU analysis are in the ESRI raster format, while the slope class classification is derived from the DEM dataset used to delineate watershed boundaries (Directorate General of Watershed Management and Social Forestry Management, 2014).
2.4.2. **Combining HRU with Climate Data.** The merging of HRU with climate data is done after the HRU analysis was completed. At this stage, the WGN file (Weather Generator Data) collected is rainfall data, air temperature, solar radiation, air humidity, and wind speed. The data is collected into PCP files for rainfall, TMP for temperature, SOLAR for solar radiation, RH for humidity, and WIND for wind speeds with the extension .txt.

2.4.3. **SWAT Model Simulation.** SWAT model simulation is done after the merger of the HRU process with climate data was completed. In this study the simulation process is run based on a monthly period. The SWAT model can be run in ArcSWAT with the SWAT Simulation menu with the condition that the Watershed Delineation, HRU Analysis, and Write Input Tables stages are completed properly. After the simulation stage has been carried out by using the Running SWAT process, the next step is to display the output result of the simulation. The process is carried out using the Read SWAT Output sub menu by inputting the output.rch, output.sub and output.hru files. The output from the simulation is then stored for the next analysis.

2.4.4. **Water Supply Output.** At this stage, the simulation output of the SWAT model is defined. In the SWAT model, the water supply is termed a WYLD or water yield obtained in each sub-watershed in mm. Water yield is obtained from the calculation using the following formula [8]:

\[
    \text{WYLD} = \text{SURQ} + \text{LATQ} + \text{GWQ} - \text{TLOSS} - \text{pond abstractions} \quad \ldots \ldots . \quad (1)
\]

Where:
- \( \text{WYLD} \) = The amount of effective water available in a watershed (mm)
- \( \text{SURQ} \) = Amount of surface runoff reaching the main river (mm)
- \( \text{LATQ} \) = The amount of water flowing laterally beneath the surface which contributes to river discharge (mm)
- \( \text{GWQ} \) = The amount of water flowing in the aquifer that contributes towards river discharge (mm)
- \( \text{TLOSS} \) = Total water loss to the aquifer (mm)

2.5. **Water Supply Analysis based on Spatial Pattern**

Analysis of water supply based on the land uses spatial pattern is made by looking at the condition of the year of analysis and comparing with the result of the analysis of the spatial pattern as for the stages of analysis in the SWAT model that is the same way as the analysis of existing land cover but replacing the existing land cover input with the spatial pattern input. The result of the comparative analysis is then carried out further analysis to see the spatial pattern that needs to be considered for the direction of the regional spatial planning. Where the direction is sought to overcome the problem of drought in Bua district. The directives are adjusted to the regional spatial planning set by the Luwu Regency government.

2.6. **Water Supply Analysis based on Spatial Pattern**

After the water supply output is defined, the next step is to create a range of water supply classes to determine the level of water supply in each watershed. The range of water supply class is obtained from the Sturgess method with the class interval formula, which is subtracting the highest value and the lowest value then dividing according to the desired class so that the interval value is obtained. The interval classes used are low, medium, and high. After obtaining interval class data, then map the level of water supply using geographic information system software.
3. Results and Discussion

3.1. Land Cover

3.1.1. Existing Land Cover. The result of the interpretation of the SPOT 7 image, then conducted a ground check, then an accuracy test that shows that in Bua watershed, there are 13 types of land cover, where the land cover that dominates are Shrubs and Secondary Forests as shown in table 4. In the Malenggang watershed, there are 12 types which dominated by Secondary Forest and Plantation, as shown in table 5. While in the Salu Beroa watershed, there are seven types of land cover, where its dominated by rice field and Plantation, as shown in table 6. In the 2019 land cover classification, those with forest vegetation were only 21.24% in Bua watershed, 40.92% in Malenggang watershed, and 7.03% in Salu Beroa watershed. The forest area in Bua and Salu Beroa watersheds is still far below the minimum standard stipulated in Law Number 41 of 1999 concerning Forestry that the minimum area of forest in a watershed is 30%.

Table 4. Land cover of Bua Watershed

| No. | Land Cover               | Area (ha) | Percentage (%) |
|-----|--------------------------|-----------|----------------|
| 1   | Airport                  | 77.26     | 0.62           |
| 2   | Secondary Mangrove Forests | 28.17   | 0.22           |
| 3   | Secondary Forest         | 2,606.43  | 21.02          |
| 4   | Open Land                | 35.33     | 0.28           |
| 5   | Port                     | 22.15     | 0.17           |
| 6   | Settlement               | 417.68    | 3.36           |
| 7   | Plantation               | 1,049.16  | 8.46           |
| 8   | Dryland farming          | 609.07    | 4.91           |
| 9   | Savana                   | 66.94     | 0.53           |
| 10  | Rice fields              | 758.91    | 6.12           |
| 11  | Shrubs                   | 6,147.34  | 49.59          |
| 12  | Pond                     | 481.56    | 3.88           |
| 13  | Waterbody                | 102.58    | 0.83           |
|     | Total                    | 12,404.12 | 100            |

Figure 2. Map of Landcover Bua Watershed
Table 5. Land cover of Malenggang Watershed

| No. | Land Cover                  | Area (ha) | Percentage (%) |
|-----|-----------------------------|-----------|----------------|
| 1   | Airport                     | 27.3      | 0.48           |
| 2   | Secondary Mangrove Forests  | 15.47     | 0.27           |
| 3   | Secondary Forest            | 2,313.71  | 40.65          |
| 4   | Open Land                   | 106.66    | 1.87           |
| 5   | Settlement                  | 178.82    | 3.14           |
| 6   | Plantation                  | 1,461.54  | 25.89          |
| 7   | Dryland farming             | 51.34     | 0.90           |
| 8   | Savana                      | 112.62    | 1.98           |
| 9   | Rice fields                 | 423       | 7.43           |
| 10  | Shrub                       | 799.92    | 14.05          |
| 11  | Pond                        | 114.75    | 2.19           |
| 12  | Waterbody                   | 55.03     | 1.14           |
|     | **Total**                   | **5,659.96** | **100**       |

Figure 3. Map of Land Cover in Malenggang watershed

Table 6. Land Cover of Salu Berua Watershed

| No. | Land Cover                  | Area (ha) | Percentage (%) |
|-----|-----------------------------|-----------|----------------|
| 1   | Secondary Mangrove Forests  | 10.99     | 1.16           |
| 2   | Secondary Forest            | 55.62     | 5.87           |
| 3   | Open Land                   | 2.85      | 0.31           |
| 4   | Settlement                  | 94.88     | 10.01          |
| 5   | Plantation                  | 344.35    | 36.32          |
| 6   | Rice fields                 | 430.47    | 45.40          |
| 7   | Pond                        | 8.92      | 0.94           |
|     | **Total**                   | **948.08** | **100**       |
In order for the land cover data can be used in the SWAT model, then the data must be adjusted to the naming of the land cover classification of SWAT model. The result of the SWAT classification in each catchment shown in tables 7, 8, and 9.

**Table 7.** Classification of Existing Land Cover of Bua Watershed SWAT model

| No. | Land Cover           | SWAT Classification   | SWAT Code |
|-----|----------------------|-----------------------|-----------|
| 1   | Airport              | Transportation        | UTRN      |
| 2   | Secondary Mangrove   | Wetlands-Forested     | WETF      |
| 3   | Forest              | Forest-Mixed          | FRST      |
| 4   | Open Land            | Oak                   | OAK       |
| 5   | Port                 | Transportation        | UTRN      |
| 6   | Settlement           | Residential           | URBN      |
| 7   | Plantation           | Orchard               | ORCD      |
| 8   | Dryland farming      | Agriculture Land-Generic | AGRL   |
| 9   | Savana               | Pasture               | PAST      |
| 10  | Rice fields          | Rice                  | RICE      |
| 11  | Shrubs               | Range-Brush           | RNGB      |
| 12  | Pond                 | Water                 | WATR      |
| 13  | Waterbody            | Water                 | WATR      |

**Table 8.** Classification of Existing Land Cover of Malenggang watershed SWAT model

| No. | Land Cover           | SWAT Classification   | SWAT Code |
|-----|----------------------|-----------------------|-----------|
| 1   | Airport              | Transportation        | UTRN      |
| 2   | Secondary Mangrove   | Wetlands-Forested     | WETF      |
| 3   | Forest              | Forest-Mixed          | FRST      |
| 4   | Open Land            | Oak                   | OAK       |
| 5   | Settlement           | Residential           | URBN      |
| 6   | Plantation           | Orchard               | ORCD      |
| 7   | Dryland farming      | Agriculture Land-Generic | AGRL   |
| 8   | Savana               | Pasture               | PAST      |
| 9   | Rice fields          | Rice                  | RICE      |
Based on land cover data from SPOT 7 Image interpretation results from the three watersheds, it is necessary to test the accuracy of the results of image interpretation. This accuracy test is carried out to determine the accuracy of image interpretation that has been made. The result of the confusion matrix ground checkpoints for each land cover class in the Bua, Malenggang, and Salu Beroa watersheds, are 84 sample points (N). The number of points that were proven to be correct in the field was 78 points (X). From these results, an accuracy test of overall accuracy is performed to determine the percentage level of accuracy of each land cover class, to determine the percentage accuracy of image interpretation, namely:

\[
\text{OA} = \frac{X}{N} \times 100\% \\
\text{OA} = \frac{76}{84} \times 100\% \\
= 90.47\%
\]

The image accuracy-test results from the confusion matrix and the overall accuracy table is 90.47%, which shows that the classification result is acceptable. This is in line with the opinion of Lillesand and Kiefer, which states that image interpretation data in various regions with accuracy > 85% can be accepted [9]

3.1.2. Land Cover Spatial Pattern. Regional spatial plans or spatial patterns are part of the development of an area that is expected to be able to provide the best plan to increase the productivity of an area. The land use space pattern in this study translates the spatial pattern for the next 20 years into actual land use. The land use translation is done to simulate water supply. The result of this interpretation is then classified into the SWAT model so that it can be used for simulation. The simulation result can assess the suitability of spatial patterns with respect to environmental aspects. The classification of land use spatial pattern can be seen in tables 10, 11, and 12.

Table 10. The Spatial Pattern of Bua Watershed

| No. | Spatial Pattern                      | Area (ha) | Percentage (%) |
|-----|--------------------------------------|-----------|----------------|
| 1   | Protected area                       | 93.17     | 0.75           |
| 2   | Dry Land Agriculture and Plantation  | 5755.69   | 46.40          |
| 3   | Fishery                              | 368.75    | 2.97           |
| 4   | Wetland Agriculture                  | 1257.43   | 10.14          |
| 5   | Production forest                    | 2465.65   | 19.88          |
| 6   | Limited production forest            | 1280.8    | 10.33          |
| No. | Spatial Pattern                   | Area (ha) | Percentage (%) |
|-----|----------------------------------|-----------|----------------|
| 1   | Production forest                | 3908.54   | 69.06          |
| 2   | Dry Land Agriculture and Plantation | 580.19  | 10.25          |
| 3   | Fishery                          | 91.6      | 1.62           |
| 4   | Wetland Agriculture              | 762.92    | 13.48          |
| 5   | Beach border                     | 46.48     | 0.82           |
| 6   | Industrial area                  | 133.48    | 2.36           |
| 7   | River Border                     | 136.75    | 2.42           |
|     | **Total**                        | **5659.96** | **100**       |

**Table 11. The Spatial Pattern of Malanggang watershed**

**Figure 5. Map of Spatial Pattern of Bua Watershed**
Table 12. The Spatial Pattern of Salu Beroa Watershed

| No. | Spatial Pattern                  | Area (ha) | Percentage (%) |
|-----|----------------------------------|-----------|----------------|
| 1   | Production forest                | 53.3      | 5.61           |
| 2   | Dry Land Agriculture and Plantation | 130.72   | 13.79          |
| 3   | Fishery                          | 25.48     | 2.69           |
| 4   | Wetland Agriculture              | 704.32    | 74.28          |
| 5   | Beach border                     | 34.52     | 3.64           |
|     | Total                            | 948.08    | 100            |

Figure 6. Map of Spatial Pattern of Malenggang Watershed

Figure 7. Map of Spatial Pattern of Salu Beroa Watershed
In order, the spatial pattern data can be used in the SWAT model, then the data must be adjusted to the naming of land cover and then classified into the SWAT model. The result of the SWAT classification for each catchment can be seen in table 13, 14 and 15.

### Table 13. Classification of the spatial pattern of Bua Watershed SWAT models

| No. | Spatial Pattern                      | Land Cover Classification                          | SWAT Classification      | SWAT Code |
|-----|--------------------------------------|---------------------------------------------------|--------------------------|-----------|
| 1   | Protected forest                     | High-Density Dry Land Forest                       | Forest-Mixed             | FRST      |
| 2   | Dry Land Agriculture and Plantation  | Plantation                                        | Orchard                  | ORCD      |
| 3   | Fishery                              | Pond                                              | Water                    | WATR      |
| 4   | Wetland Agriculture                  | Rice fields                                       | Rice                     | RICE      |
| 5   | Production forest                    | Plantation Forest                                 | Forest-Evergreen         | FRSE      |
| 6   | Limited production forest            | Plantation Forest                                 | Forest-Evergreen         | FRSE      |
| 7   | Rural Settlements                    | Settlement                                        | Residential              | URBN      |
| 8   | Industrial area                      | Settlement                                        | Residential              | URBN      |
| 9   | Beach border                         | Waterbody                                         | Water                    | WATR      |

### Table 14. Classification of the spatial pattern of Malenggang Watershed SWAT model

| No. | Spatial Pattern                      | Land Cover Classification                          | SWAT Classification      | SWAT Code |
|-----|--------------------------------------|---------------------------------------------------|--------------------------|-----------|
| 1   | Production forest                    | High-Density Dry Land Forest                       | Forest-Mixed             | FRST      |
| 2   | Dry Land Agriculture and Plantation  | Plantation                                        | Orchard                  | ORCD      |
| 3   | Fishery                              | Pond                                              | Water                    | WATR      |
| 4   | Wetland Agriculture                  | Rice fields                                       | Rice                     | RICE      |
| 5   | Beach border                         | Waterbody                                         | Water                    | WATR      |
| 6   | Industrial area                      | Settlement                                        | Residential              | URBN      |

### Table 15. Classification of the spatial pattern of Salu Beroa Watershed SWAT model

| No. | Spatial Pattern                      | Land Cover Classification                          | SWAT Classification      | SWAT Code |
|-----|--------------------------------------|---------------------------------------------------|--------------------------|-----------|
| 1   | Production forest                    | High-Density Dry Land Forest                       | Forest-Mixed             | FRST      |
| 2   | Dry Land Agriculture and Plantation  | Plantation                                        | Orchard                  | ORCD      |
| 3   | Fishery                              | Pond                                              | Water                    | WATR      |
| 4   | Wetland Agriculture                  | Rice fields                                       | Rice                     | RICE      |
| 5   | Beach border                         | Waterbody                                         | Water                    | WATR      |

Allotment of space in the spatial pattern is only divided into two functions, both for protection and cultivation function. Of the three watersheds analyzed, only Bua Watershed has both spatial functions, while the other two watersheds, Malenggang watershed, and the Salu Beroa watershed, only has one cultivation function. However, based on the results of the translation of spatial patterns into land cover classifications it can be seen that the forest vegetation in Bua watershed is 29.42%, 70.29% in Malenggang watershed, and 5.61% areas that have forest vegetation in Salu Beroa watershed.
3.2. Water Supply

The amount of water supply is obtained from two types of land cover, existing land cover and land cover based on the spatial pattern of Luwu Regency in 2030, which is the result of simulation by using the SWAT model. SWAT model analysis uses HRU, where the parameters used are land cover data, soil type data, slope data, and climate data. After the DEM data, land cover, and physical chemistry of the soil have been prepared. The next process is the formation of HRU, which is the process of overlaying the three spatial data to form the smallest unit and grouped in sub-watersheds. Furthermore, the process of combining HRU with daily climate data for 2009-2018 in the form of rainfall data (mm), temperature (°C), air humidity (%), wind speed (m/s), and solar radiation (MJ/m²).

3.2.1. Water Supply based on Existing Land Cover. The watershed as an ecological area is often used as an observation unit in terms of water resources related to the water supply. As a fairly complex hydrological system, in the watershed, there are various system elements, including climate, land (soil and its constituent rocks), vegetation (forests, gardens, rice fields), and humans. The watershed provides a major contribution to the supply of water in an area. The land cover is very influential on the water supply of a watershed so that the great land-use change in a watershed has an impact on the imbalance of the watershed hydrological system.

The result of the simulation of the hydrological condition of Bua, Malenggang, and Salu Beroa watersheds by using the SWAT model based on existing land cover are classified into three water supply classes, called low grade (23.5 - 648.150,9 m³), moderate (648.150,9 - 1,296.278,3 m³), and high (1,296.278,3 – 1,944.405,7 m³). The results of the analysis of water supply can be seen in Figures 8, 9, and 10.

a. Bua Watershed

![Figure 8. Monthly Period of Water Supply in Bua watershed](image)

b. Malenggang watershed

![Figure 9. Monthly Period of Water Supply in Malenggang watershed](image)
3.2.2. Water Supply Based on Spatial Pattern in 2030. Based on the hydrological condition simulation result of Bua, Malenggang and Salu Beroa watersheds by using the SWAT model, the amount of water supply based on the spatial pattern of 2030 was classified into three classes, called low grade (23.5 - 648.150.9 m$^3$), moderate (648.150.9 - 1.296.278.3 m$^3$), and high (1.296.278.3 – 1.944.405.7 m$^3$). The results of the analysis shown in Figures 11, 12, and 13. The implementation of the spatial plan in the study area is expected to guarantee the balance of water supply. However, in reality, if the spatial pattern plan in the watershed area is implemented and simulated using a watershed-based SWAT model, the water supply in the area will be reduced or lower at the end of the planning year.

a. Bua Watershed

Figure 11. Monthly Period of Water Supply in Bua watershed
b. Malenggang watershed

![Figure 12. Monthly Period of Water Supply in Malenggang watershed](image)

3.2.3. Comparison of Water Supply based on Existing Land Cover and Spatial Pattern in 2030.

Based on the results of the two analyzes, the water supply of existing land cover and the spatial pattern in 2030, it can be seen that the amount of water supply based on the existing land cover is almost the same as the water supply of the spatial pattern in 2030. In Bua watershed the amount of water supply of the existing land cover is higher 0.54%, in the watershed Malenggang the amount of existing land cover water supply is higher 0.35%, while in the Salu Beroa watershed the amount of water supply pattern is higher 0.15%, it can be seen in figures 14, 15, and 16.

c. Salu Beroa watershed

![Figure 13. Monthly Period of Water Supply in Salu Beroa watershed](image)
a. Bua Watershed

![Comparison of Water Yield in Bua Watershed based on Existing Land Cover and Spatial Pattern in 2030](image)

**Figure 14.** Comparison of Water Yield in Bua Watershed

b. Malenggang watershed

![Comparison of Water Yield in Malenggang Watershed based on Existing Land Cover and Spatial Pattern in 2030](image)

**Figure 15.** Comparison of Water Yield in Malenggang Watershed
c. Salu Beroa watershed

The cause of lower or higher water supply in a watershed is influenced by land cover and land cover area. Where climate data, soil data, and slope data used in this study use the same data in the two analyzes and use different land cover data in each analysis. Land cover data used are existing land cover data and land cover data based on the spatial pattern. The two analyzes produced different amounts of water. The total water supply in the three watersheds is 62,444.569 m³/year based on existing land cover and 62,162.632 m³/year based on the spatial pattern in 2030. Land covers that dominate in the existing land cover in Bua watershed are shrubs and secondary forest, in Malenggang watershed are secondary forest and plantation, and in Salu Beroa watershed, are rice fields and plantation, while based on the spatial pattern in Bua watershed dominated by dry land and plantation, in Malenggang watershed, dominated by production forest and wetland agriculture, and in Salu Beroa Watershed dominated by wet and dryland agriculture. The infiltration capacity of forest land cover is higher than the agricultural land cover.

The utilization of water for agriculture is calculated by looking at the type of irrigated rice fields. The more basic agricultural water needs for irrigation already exist in each Provincial or District Public Works Agency. The use of water for irrigated rice fields is calculated based on the area of technical irrigated rice fields with a standard of 1 liter/second/hectare [10]. The total area of agriculture (rice fields) in the three watersheds is 1.612 ha, which needs 50,848.016 m³/year of water. So that from 100% water supply of a watershed, 81% of water supply needed for irrigated rice fields is based on existing land cover and 82% if based on the spatial pattern of 2030. If the spatial pattern is applied, then the water supply in the Bua and Malenggang watersheds will decrease, as many as 214,898 m³ in Bua watershed and 70,935 m³ in Malenggang watershed. Water supply increases if the spatial pattern is applied to Salu Beroa watershed, it will increase by 3,892 m³. Details of the total water supply shown in table 16.

| Name of watershed | Land Cover (m³) | Spatial Pattern (m³) | Difference (m³) |
|-------------------|----------------|---------------------|-----------------|
| Bua               | 40,291.452     | 40,076.558          | -214,894        |
| Malenggang        | 19,467.893     | 19,396.958          | -70,935         |
| Salu Beroa        | 2,685.224      | 2,689.116           | 3,892           |
| Total             | 62,444.569     | 62,162.632          | -281,937        |
At the research location, farmers plant rice twice a year. The first planting period is November to April, where the water supply is 36,877.248 m$^3$ in the period. In the second planting period, from May to October, the water supply is 25,567.321 m$^3$. Water demand for one planting period (6 months) is 25,424.007 m$^3$ so that according to the water needs the water supply period are fulfilled, but according to the monthly water supply, it lacks in August, September, and October where the monthly water demand is 4,237.335 m$^3$, while water supply in August was 3,377.597 m$^3$, September was 3,340.444 m$^3$, and October was 3,484.457 m$^3$. The total monthly water supply each month can be seen in table 17. This is consistent with the drought problem reported on tribunnews.com that there was a rice field drought in Bua District in August, September, and October.

Table 17. Total Water Supply for three subwatershed (Bua, Malenggang, Salu Beroa)

| Month    | Water Supply (m$^3$) | Land Cover | Spatial Pattern |
|----------|----------------------|------------|-----------------|
| January  | 5,195.115            | 5,199.577  |                 |
| February | 5,258.220            | 5,257,805  |                 |
| March    | 6,731.424            | 6,734,827  |                 |
| April    | 6,307,825            | 6,304,189  |                 |
| May      | 5,559.774            | 5,514,590  |                 |
| June     | 5,169,817            | 5,053,089  |                 |
| July     | 4,635,231            | 4,565,943  |                 |
| August   | 3,377,597            | 3,334,660  |                 |
| September| 3,340,444            | 3,319,596  |                 |
| October  | 3,484,457            | 3,485,228  |                 |
| November | 5,876,039            | 5,879,732  |                 |
| December | 7,506,625            | 7,513,397  |                 |
| **Total** | **62,444,569**     | **62,162,632** |               |

The amount needs of the water supply of rice fields for three watersheds is 81% of the amount of water supply, of course, it still lacks where the rice fields are only 8%. This means the condition of the watershed is not good in the rainy season, the water that enters the soil (infiltration) is small so that in the dry season there is drought. The first planting period in the rainy season, where the fulfillment of rice field needs can be met from both rain-fed water and irrigation water. The second planting period in the dry season so that the rice fields experience drought because besides there is no rain, irrigation water also experiences drought, which impacts rice plants. The longer it is left, it will make the plants die so that farmers fail to harvest and lose.

To addressing the problem of drought, farmers should make a water reservoir or village reservoir and irrigation water distribution from the watershed around the study site. The need for knowledge of farmers about crop types based on climate types. The climate in Indonesia is a type of tropical climate that divides each year into two types of season. Those are rainy season and dry season. Each plant will grow well if the type of plant matches the type of climate or has a good irrigation system. If both are not fulfilled, it is only natural that drought occurs. So, by looking at these conditions, the Oldeman agro-climate planting system can be applied which states that rice can only be planted once (one period), namely in the rainy season, and can be planted with secondary crops twice during the dry season. This can be done to reduce losses due to crop failure. The planting of rice for two periods or even three periods can be done if the irrigation system is good.

4. Conclusion
The conclusions of this study are based on the research objectives, the supply of water based on the existing land cover of Bua Watershed is 40,291.425 m$^3$/year, Malenggang watershed is 19,467.893 m$^3$/year, and Salu Beroa watershed is 2,685.224 m$^3$/year. Whereas water supply is based on the spatial pattern in 2030 in Bua watershed is 40,076.558 m$^3$/year, Malenggang watershed is 19,396.958 m$^3$/year, and Salu Beroa watershed is 2,689.116 m$^3$/year. The amount of water needed for irrigating
the Bua, Malenggang, and Salu Beroa watersheds is 50,848.015,7 m$^3$/year or 81% of the total water supply of existing land cover and 82% of spatial pattern in 2030.

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