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The direction of land-use for hydrology balance and development of low-carbon emissions in the Jenelata Catchment area

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Abstract The catchment area is part of the Jeneberang watershed. Based on Presidential Regulation No. 3 of 2016 concerning the Acceleration of the Implementation of National Strategic Projects, the Jenelata catchment area is one of the acceleration programs for the construction of the Jenelata Dam. Changes in land-use that continue to increase in the Jeneberang watershed, especially in the Jenelata catchment area, have resulted in the conversion of vegetated land cover to non-vegetation. Related to the threat of the sustainability of the Jenelata Dam function after it has been built, it is necessary to study the right direction of land-use to maintain the equilibrium of hydrological conditions and the level of carbon emissions in the future. The hydrological analysis was carried out using the SWAT hydrological model and to determine the level of carbon emissions calculated by the LUMENS software using the QUES (Quantification of Environmental Services) module of the actual land-use scenario in 2018, the land-use scenario in 2023 (if the dam operates there will be land flooded areas) and land-use scenarios in 2032 (based on regional spatial plans at the end of the planning year). The result shows that from the impact of land-use changes, the Jenelata Dam hydrological condition in terms of water availability will be decreased by 323,74 million m^3 in actual condition, 275,83 million m^3 in the period 2023 and 274,66 million m^3 in period 2032. While the level of carbon emissions is known to be increased by 314.052,00 Tons CO2-eq in actual condition, 358.237,16 Tons CO2-eq inland changes condition 2019-2023 and 1.595.972,83 Tons CO2-eq in land change condition 2023-2032. Thus, it is necessary to make the direction of land-use by concerning the conditions of determination of the forest area function.

1. Introduction

A watershed is a storage of a variety of natural resources, especially vegetation, soil, and water, as well as a place of human life in managing these natural resources to meet their needs [1,2]. In Government Regulation Number 37 of 2012 [3], watershed management is described as a human effort to regulate reciprocal relations with natural resources. To optimize the management of natural resources, especially water resources, it can be done by building dams. The function of the dam in storing excess water during the rainy season so that it can be used to meet the needs of water and water power when needed, and to control the power of water damage, which is intended for public welfare and safety [4]. Apart from being a reservoir of water, basically, the dam has a function as a safety controller area underneath from flooding and erosion.

However, rapid population growth has led to an increase in land requirements, including in the dam catchment area . The use of land by the community is carried out as an effort to utilize and manage the land to support its survival. The economic potential of the land is often a major factor in determining the type of land use. So that community land-use often ignores hydrological balance and carbon emissions. Poor ctachment area conditions result in the role of the dam not being optimal. The main problem of a dam is the large amount of sedimentation caused by high erosion rates in the dam catchment. The main factor causing erosion is land-use change [5]. Dams that have sedimentation problems can make the operational life of the dam will end before the planned life is reached. In addition, the sediment contained in the dam results in a decrease in the volume of water that can be stored by the dam.

Jenelata sub-watershed is part of the Jeneberang watershed, which located in South Sulawesi Province. Based on Presidential Regulation No. 3 of 2016 concerning the Acceleration of the Implementation of National Strategic Projects [6], Jenelata Sub-watershed is one of the acceleration programs for the construction of the Jenelata Dam. Jenelata Dam is planned as a supplier of various water needs for the Gowa Regency area, such as for irrigation purposes, power plants, domestic and industrial needs. Gowa Regency actually has Bili-Bili Dam as a supplier of various water needs for Gowa Regency, but this dam is also a supplier for Makassar City so that its existence cannot cover all needs in Gowa Regency.

Changes in land-use that continue to increase in Jeneberang watershed, especially in the Jenelata sub-watershed, have resulted in the conversion of vegetated land cover to non-vegetation. In addition, based on data from the Jeneberang-Walanae Watershed Management Center in 2003, the level of land criticality in general in the Jeneberang watershed has reached 53.471 ha and tends to increase [7]. So that in the last few years, the condition of the Jeneberang watershed shows a declining trend. This resulted in a decrease in hydrological function in Jeneberang watershed.

Changes in land-use at the DTA level also affect the amount of carbon stored in the DTA. Changes in land-use can indicate the dynamics (change) of carbon stocks in the region. For example, the activity of converting forests to other forms of land-use (settlement and agriculture) causes carbon emissions to increase. This makes land-based sectors such as forestry, peatlands, and agriculture, the biggest contributors to carbon emissions in Indonesia. Aside from being a provider of water resources, dam catchment certainly can also play a major role in efforts to reduce carbon emissions.

Therefore the Government has included a program of land rehabilitation in priority watersheds in the national action plan for reducing land-based greenhouse gas (RAN GRK) emissions [8]. This effort can be a driving factor in achieving the carbon emission reduction target set by the Government, voluntarily by 29 % with its own strength or 41% with international assistance until 2030. Related to the threat of the sustainability of the Jenelata dam function after construction, it is necessary to study about appropriate land-use guidelines to maintain hydrological balance conditions and future levels of carbon emissions where this study can be used as a policy intervention for the local Government, in order to secure the Jenelata dam infrastructure.

2. Materials and method

This research was conducted by studying the Jenelata Dam catchment area located in Jeneberang watershed with an area of 20.580,89 ha. Jeneberang watershed itself is one of the critical watersheds in South Sulawesi Province and included in the 108 Priority Watersheds [9]. This catchment has a large role in the hydrological system in Gowa Regency. So that its existence is very concerned, especially related to land-use planning. Determination of the research boundary is done by extracting DEM modification data with a resolution of 5 x 5 meters by using Geographic Information System (GIS) technology, the Topo to Raster tool. Basically, determining the boundaries is only in the form of detailed watershed boundaries that have been determined through an SK Men-LHK No. 304 of 2018 concerning the Determination of Watershed Maps.

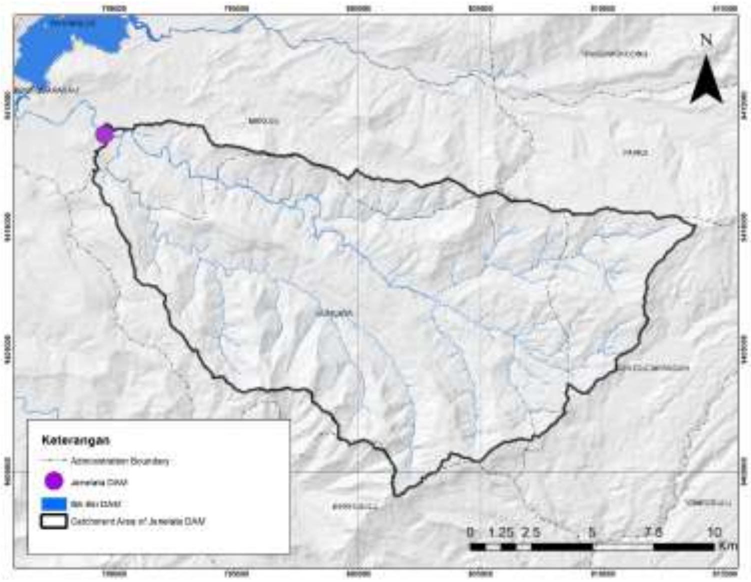

Figure1. Map of Jenelata Dam Catchment Area.

This research was prepared based on the results of an integrated study on the topic of change and direction of land use, estimation of potential carbon emissions uptake, and watershed management for monitoring and evaluating hydrological conditions. The method used in this study is a survey method that emphasizes the survey of regional physical data and is equipped with secondary data that supports the aims and objectives of the study. Furthermore, the data were analyzed using carbon emission assessment instruments and hydrological models to get a real picture of carbon emission levels and hydrological characteristics in multitemporal land-use and land-use referral scenarios.

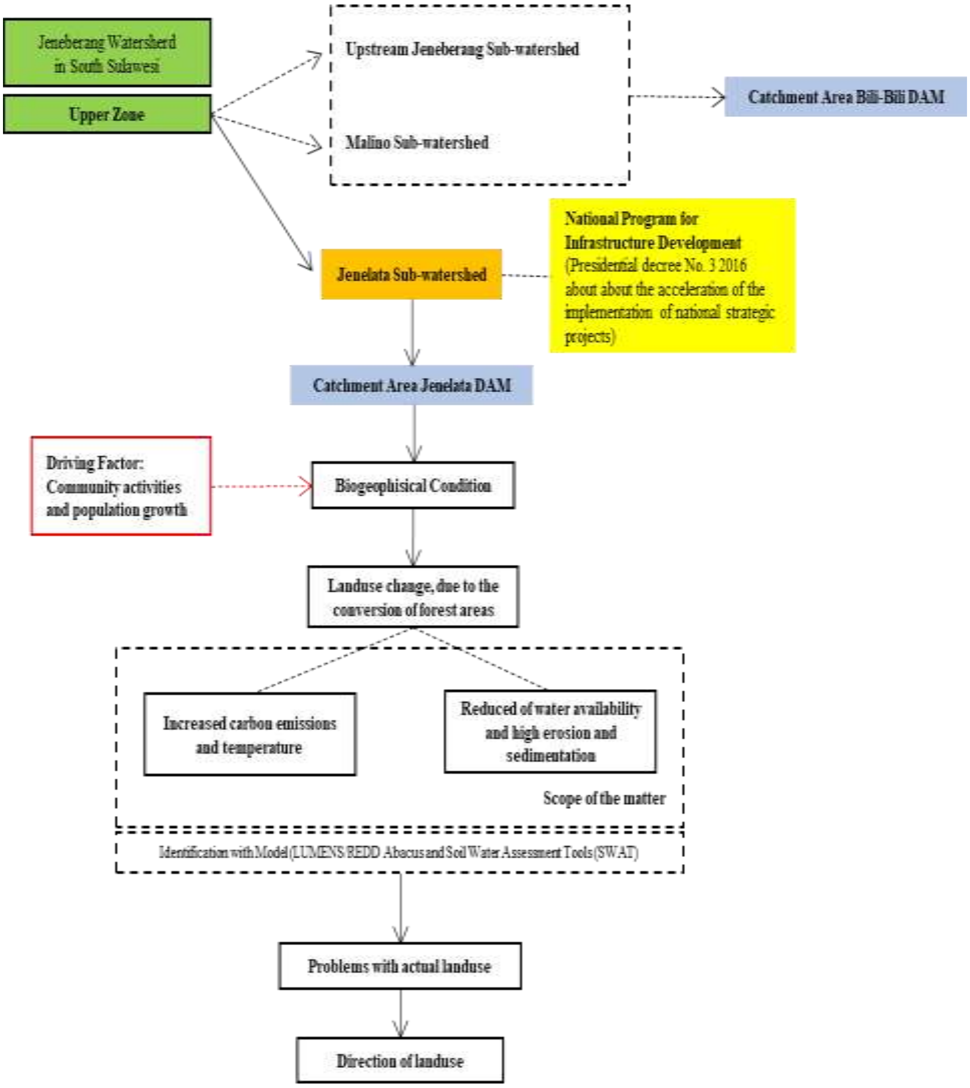

Figure 2. Research Framework.

To get information related to carbon emission levels and hydrological conditions on land-use in Jenelata Dam catchment area, identification is needed to determine the characteristics of the area. The stages of identifying the characteristics of the catchment area are explained in detail as follows:

2.1. Hydrological Condition Analysis

Watershed conditions are analyzed by using GIS technology and utilize hydrological models to illustrate the complexity of a watershed. The hydrological model used is the Soil and Water Assessment Tool (SWAT) model. The SWAT model is a model that can be used to predict the effect of land-use on water availability in a watershed complex with different types of land, land-use, and management in a sustainable manner and over a long period of time.

The ability of SWAT to produce hydrological information on sub-watersheds in the analyzed watersheds can be a reference in controlling natural resource management and watershed environments. Sub-watersheds that have problems can be identified and evaluated to make efforts to improve the watershed-based environment.

Analysis of water availability using the SWAT model is carried out through the stages of data collection and preparation, the process of inputting data into the SWAT model, the watershed delineation process, the formation of HRU and the process of running the SWAT model to produce an output of the watershed hydrological conditions including surface flow condition, lateral flow, water flow soil, water availability to analyze the quantity of water in each watershed. The data prepared in the simulation of the SWAT model includes.

a. Digital elevation model (DEM) data, created by using the GIS Interpolation Topo to Raster approach with a resolution of 5 meters.
b. Data on land-use shapefile in 2018 (obtained from the interpretation of the 2018 SPOT Image), land-use in 2023 after the dam operates and land-use in 2032 based on the end of the Gowa Regency's Spatial Planning, which is then exported to Raster formatted data for the SWAT model simulation needs.
c. Soil type shapefile data from the RePPProt (Regional Physical Planning Project for Transmigration) Map, which is complemented with soil physical and chemical parameters obtained from the soil information database of the RePPProt Map and the USDA Natural Resource Conservation Service Soil Web Site and laboratory test results. This soil type data is then exported into Raster format data.
d. Daily climate data which includes rainfall data (mm), air temperature (^oC), air humidity (fraction), solar radiation (MJ/m^2), and wind speed (m/s).

2.2. Calculation of Carbon Emissions

Jenelata catchment area land-use carbon emissions are calculated by using the LUMENS software. LUMENS or Land-use Planning for Multiple Environmental Services (LUMENS) is a tool developed by Indonesia's World Agroforestry Center (ICRAF) to develop appropriate zones or planning units in landscapes that are suitable for the purpose of land-use planning to achieve sustainable landscapes. The LUMENS instrument used to calculate carbon emissions is using the QUES (Quantification of Environmental Services) module.

This module calculates the carbon emission level and uptake based on land-use changes, from 2018 to 2023 and from 2023 to 2032. Each land-use has a carbon stock value standard, so changes in land-use from other land uses will give a good picture of an increase or a decrease in the value of carbon stocks.

The value of carbon stocks in each type of land-use obtained from the results of research conducted by government agencies, the private sector, international and national research institutions, and universities that provide sources of information as an approach to the value of carbon stock data on each type of land cover/use are presented in Table 1.

Table 1. Carbon Reserve Value per Each Land-use [10,11]

No	Land Use	Carbon Reserves (ton/ha)
1	Primary Dry Land Forest*	261,52
2	Secondary Dry Land Forest*	192,81
3	Primary Mangrove Forest*	142,6
4	Secondary Mangrove Forest*	57,5
5	Primary Swamp Forest*	193,2
6	Secondary Swamp Forest*	120
7	Plantation Forest*	64
8	Shrubs*	15
9	Swamp Thicket*	15
10	Plantation*	63
11	Settlement*	4,1
12	Open Land *	3,4
13	Meadow*	4.5
14	Dryland farming*	8
15	Rice fields *	5
16	Pond *	0

No	Land Use	Carbon Reserves (ton/ha)
17	Waterbody *	0
18	Airport / Port *	5
19	Mining*	0
20	Swamp *	0
21	Agroforestry **	80,2
22	Community Forestry **	194,97

The values in the table above are only based on estimated carbon stocks in the tree or its constituent plants. Carbon reserves in the table above are not absolute values. This value can change according to data availability, or it can even be adjusted to the latest value based on the measurement of carbon stocks at the location where land change analysis is carried out.

2.3. Land-use Planning

Land-use planning is a systematic activity evaluating the potential of land (including water) in order to select, adapt and determine the best land-use option in space based on biophysical, economic, and social potential and condition to increase productivity and equity and preserve the environment [12].

The land-use direction scenario is carried out by considering the biogeophysical condition of the Jenelata catchment arra, such as the status of the land and the existing condition of the land to be directed. This is done so that the directives are more planned and can be applied. The direction of land-use based on low carbon emissions and maintaining hydrological balance is done by overlaying the existing condition of land-use with the status of forest areas that have been determined in the study area based on the Minister of Forestry's decision regarding the Designation of Forest Areas and Water Conservation in the South Sulawesi Province. The direction scenarios carried out are afforestation (addition of forest area) and reforestation (optimization of forest area) of lands that should be forests based on the status of forest areas. Afforestation is a series of tree planting activities in large numbers on land with absolutely no trees, while reforestation is a tree planting activity on land where there were previously trees or land that is bare and few trees [13].

3. Result and discussion

To analyze the hydrological conditions and potential carbon emissions in the Jenelata watershed, the stages of identifying the land-use condition in the area were carried out. The existing land-use data were interpreted using the 2018 SPOT imagery. The result of the land-use interpretation obtained the conditions of land cover and use consists of shrubs (37,54%), forest (36,07%), rice field (14,03%), dryland agriculture (9,64%), plantation (1,37%), settlement (0,56%), bare land (0,51%) and water bodies (0,29%) (percentage of area compared to DTA area). In addition to the actual land-use data for 2018, a future land-use change scenario will also be developed if the Jenelata dam is operational. Where the land-use scenario prepared is the 2023 scenario (adjusted to the target of dam completion) where there is actual land in 2018 that will be flooded and the land-use scenario in 2032 adjusted to the end of the Gowa Regency spatial planning year (2012-2032). The land-use conditions in each of these scenarios are presented as follows.

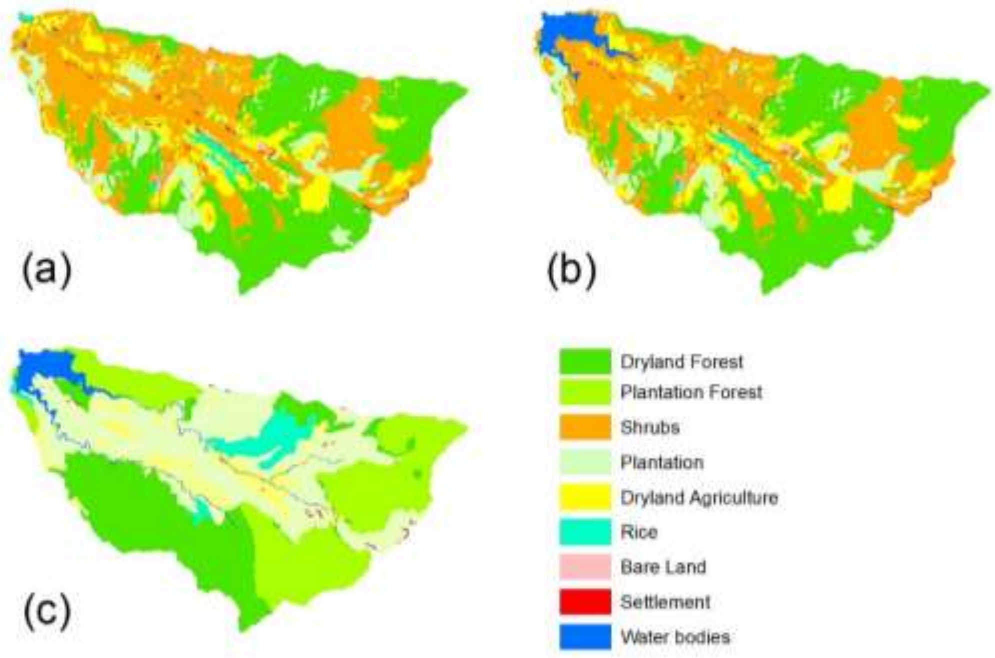

Figure 3. Land-use in Jenelata catchment area(a) 2018, (b) 2023, and (c) 2032.

Table 2. Trends of Land-use of Jenelata catchment area in each scenario.

No	Land Use	2018	2023	2032
1	Dryland Forest	36,07%	36,06%	24,48%
2	Plantation Forest	-	-	28,25%
3	Shrubs	37,54%	35,90%	-
4	Plantation	1,37%	1,24%	4,27%
5	Dryland Agriculture	9,64%	9,44%	32,10%
6	Rice	14,03%	13,23%	6,96%
7	Bare Land	0,51%	0,50%	-
8	Settlement	0,56%	0,52%	0,22%
9	Water Bodies	0,29%	3,10%	3,72%

Source: GIS Analysis Results, 2019.

Based on land-use scenarios in the three conditions shown in Figure 3, they are then used as a basis in analyzing the hydrological condition and carbon emission levels that occur if land-use changes occur. From the results of the analysis of the hydrological condition of Jenelata catchment areausing the SWAT model, data and information on the level of water availability in each sub-watershed are obtained, those are the accumulation of surface runoff, groundwater flow, and lateral flow. This condition determines the sustainability of the Jenelata catchment areadevelopment in the future from water resources and dam construction aspects

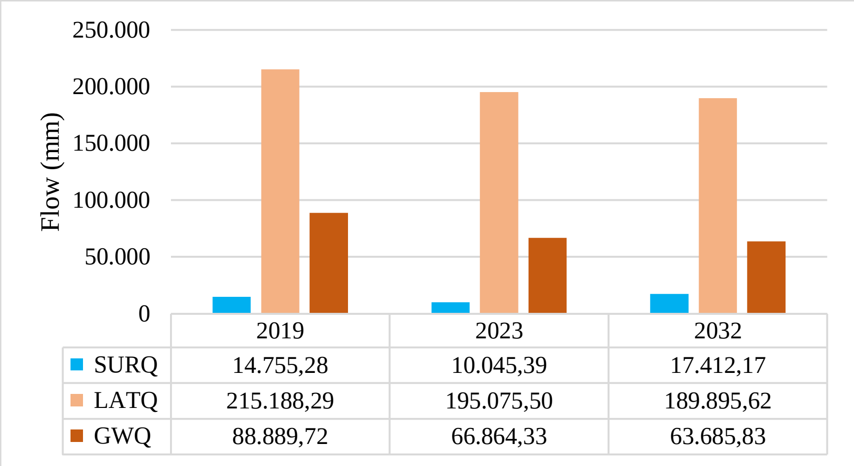

Figure 4. Surface flow condition (SURQ), lateral flow (LATQ), and groundwater flow (GWQ) under conditions (a) the actual period of 2018, (b) projections of 2023, and (c) projections of 2032.

Based on the three water flow conditions that describe the hydrological conditions of the Jenelata catchment areaduring the three observation periods using ten-year climate data, it was found that in the future, with the land-use scenario that occurred, the water potential in the Jenelata catchment areawill decrease. Where, if calculated into the amount of water availability or water yield (WYLD), the amount of water availability in the actual period (2018) is 323,74 million m^3, the projection for the period of 2023 is 275,83 million m^3 and the projection in the period of 2032 is 274,66 million m^3. Water yield in SWAT terms is the availability of water which is influenced by the accumulation of surface runoff (SWAT Code: SURQ), lateral flow (SWAT code: LATQ), and base flow or groundwater flow (baseflow / SWAT code:

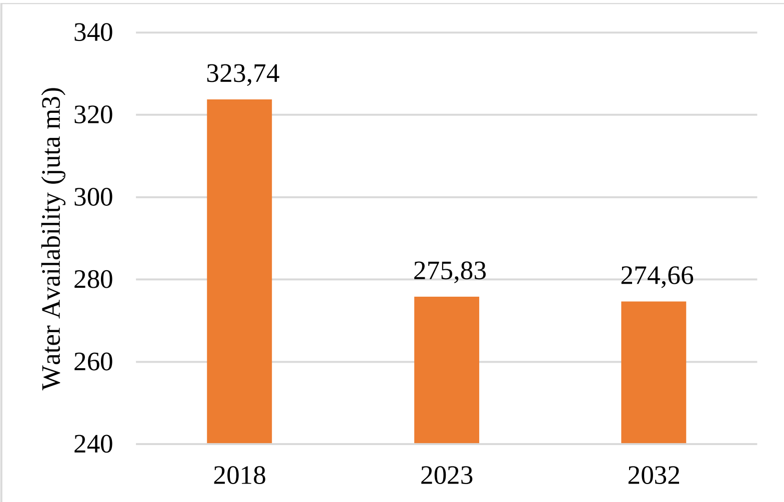

Figure 5. Water Potential in Jenelata catchment areaunder conditions of (a) the actual period of 2018, (b) projections of 2023, and (c) projections of 2032.

These conditions illustrate that if land-use remains as in existing conditions and the direction of regional spatial planning, it can be ensured that the availability of water in the future will decrease, which will certainly affect the function of the dam as water resources infrastructure.

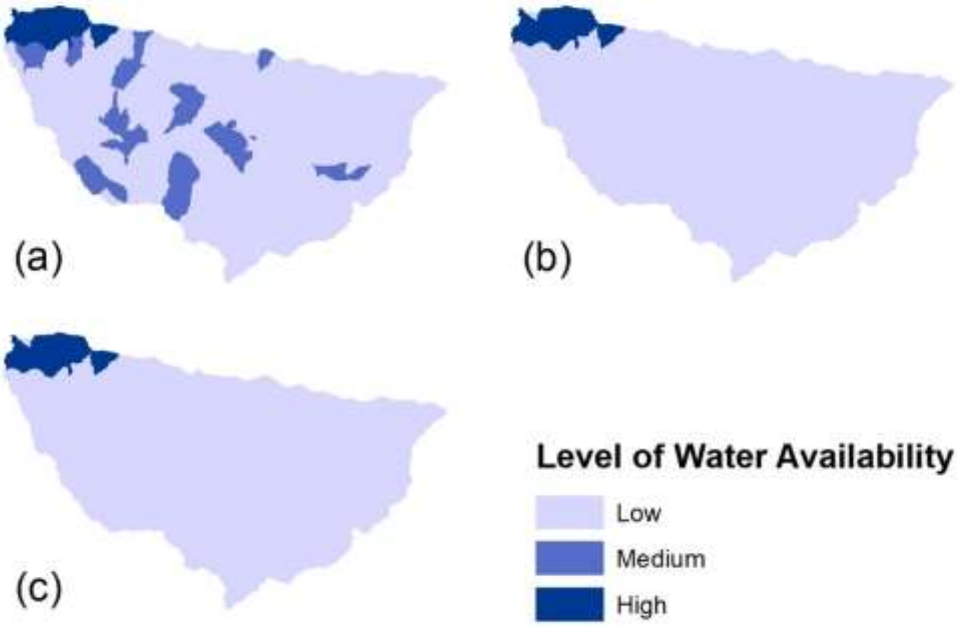

Figure 6. The level of water availability in Jenelata catchments area in conditions of (a) the actual period of 2018, (b) projections of 2023, and (c) projections of 2032.

Figure 6 illustrates that in the future the potential of water availability that supplies to the dam will decrease wherein 2023 there will be a decrease of 14,80% out of the current water availability, and if the regional spatial plan is implemented at the end of the 2032 plan, the availability of water will also decrease but in a small quantity which is 0,42% from the condition in 2023. The decrease in the level of water availability in the Jenelata catchment areais influenced by changes in land use, such as forest become agricultural land, plantation becomes agricultural land, agricultural land, and rice fields change into the settlement, and shrubs into agricultural land, rice fields, and settlement.

This can illustrate that from the hydrological aspect of the land-use change scenario that will occur in the Jenelata catchment areain the future. It will have an adverse effect on the hydrological balance of the dam. In addition, what needs to be assessed is the impact of land-use changes on carbon emission levels. This can give an idea of the level of emission released and the level of carbon uptake that occurs from land-use conditions. Calculation of land-based carbon stocks by using the QUES module in the LUMENS software. The carbon calculation on this instrument is based on land-use changes so that it will produce an emission factor for each land-use change. Emission factors are formed by the value of carbon stocks in various types of land use.

Carbon reserves in the land are various depending on the diversity and density of existing plants, soil types, and management. Carbon storage in the land becomes bigger if the soil fertility is good because tree biomass increases. The ability of carbon storage that affects carbon stocks in a watershed is largely determined by the type of land-use in the watershed. So that the ability of a watershed to reduce the number of carbon emissions is greatly influenced by land-use and activities that occur on the land.

Naturally, carbon emissions to the atmosphere occur through mechanisms such as respiration, decomposition of organic matter, and biomass burning. But as forest damage occurs, carbon emissions to the atmosphere also occur as much as the level of forest damage that occurs. This can lead to climate change, which is a big threat to human life. Forest damage has a major effect on climate change in two ways: first, encroachment and burning of forests release carbon dioxide into the atmosphere, and second, forest destruction will reduce the area of forest that absorb carbon dioxide. Therefore, it is very important to maintain the existence of forests because protecting it means stopping climate change. Forest is the largest storage of carbon stocks and carbon uptake compared to other land-use systems such as agriculture.

If the forest is converted into agricultural and plantation, the amount of carbon stock will decrease. Forest, especially natural forest, are the largest storage of carbon stocks because they have a variety of species of long-lived trees and litter, which is the largest storehouse of carbon. Not only storing carbon stocks and absorbing carbon dioxide, but forests also release carbon through respiration and decomposition of litter, but the release process occurs gradually, not as much as if there is burning and conversion of forest that release carbon dioxide at once in large quantities [14].

Based on changes in land-use in the Jenelata watershed, it can be seen the condition of emissions and carbon sequestration (sequences) in the study area with conditions in 2018, from 2018 to 2023, and from 2023 to 2032. The results of calculation by using the QUES module on the LUMENS software are known that changes in land-use in the analysis period in the Jenelata catchment areawill cause an increase in total emissions and decrease the total carbon concentration so that it can be indicated that the level of carbon stock in the study area going forward will decrease further.

Table 3. Total Emission and Carbon Sequence based on Changes in Land-use in Jenelata Watershed.

Period	Total Emissions (Tons of CO2-eq)	Total Sequestration (Tons of CO2-eq)
Period 2018	314.052,00	2.190.810,63
Period 2018-2023	358.237,16	2.146.625,46
Period of 2023-2032	1.595.972,83	1.859.612,45

Source: QUES Module Calculation Results, 2019

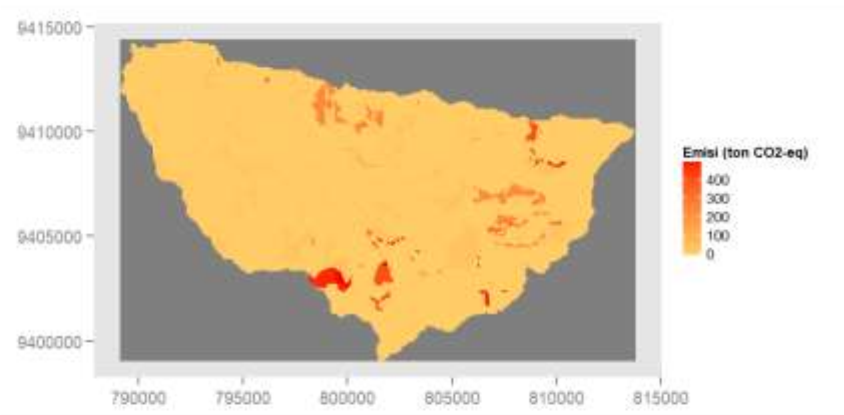

Figure 7. Level of Carbon Emissions in the Actual Period of 2018

The result of the calculation of emissions under the actual condition describes that some places of land change can increase the rate of carbon emissions, which is known that the emission rate per unit area is 18,238 tons CO_2-eq/ha.year. This increase in carbon emissions is known to be due to changes in land-use as follows.

Table 4. Emissions due to Land Changes in Actual Condition in Jenelata catchment area

Land Change	Total Emission (Tons of CO2-eq)
Plantation Forest to Shrubs	85.421,922
Forest to Agriculture	58.114,778
Forest to Shrubs	57.072,500
Farm to Rice Fields	48.747,509
Forest to Rice Fields	30.311,477
Plantation Forest to Agriculture	15.888,190
Plantation Forest to Rice Fields	5.210,687
Shrubs to Rice Fields	3.305,532
Forest to Plantation	2.154,557
Shrubs to Agriculture	1.995,379

Source: QUES Module Calculation Results, 2019

There is a plan to build a dam on the Jenelata river which will operate in 2023, in the future it will certainly affect land-use in the watershed. It is known that the flooded area is 607,89 ha. The result of carbon calculation using the QUES model shows that changing these conditions will increase carbon emissions in the Jenelata catchment areaby 44,185,162 tons of CO2-eq, which is sourced from land changes as follows.

Table 5. Emissions due to Land Changes in 2018-2023 Period Conditions in Jenelata Watershed

Land Change	Total Emissions (Tons of CO2-eq)
Shrubs to Water Bodies	35,820,613
Plantation to Water Bodies	6,087,264
Agriculture to Water Bodies	1,336,393
Rice fields to Water Bodies	606,119
Forest to Water Bodies	234,402
Settlement to Water Bodies	93,200
Bare Land to Water Bodies	7,170

Source: QUES Module Calculation Result, 2019

Increases in total emissions that occur need to be anticipated in order to anticipate the impacts of climate change that are happening now. Control of increased emissions can be done with the direction of land-use in an area. Planning for the use of an area has been regulated in a regional spatial planning so that the direction of land-use in an area must be referred to the direction of the spatial planning. Jenelata catchment area is in the administrative area of Gowa Regency, so the direction of land-use in the region needs to refer to the direction of the Gowa Regency Spatial Planning. The result of the carbon calculation using the QUES model shows that if the land-use direction in the Jenelata catchment follows the direction of the Gowa Regency Spatial Planning until the end of the planning year in 2032, the total carbon emissions that will occur will increase. The increase in carbon emissions is caused by the presence of land-use directives that reduce the level of carbon sequestration, such as the change from forest to agriculture and plantation. As for land-use changes that cause an increase in total emissions if the direction of the spatial planning is applied as follows.

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Table 6. Emissions due to Land Changes in the Conditions of the Period of 2023-2032 in Jenelata Watershed

Land Change	Total Emissions (Tons of CO2-eq)
Forest to Plantation Forest	539.578,149
Forest to Agriculture	447.759,664
Shrubs to Agriculture	292.492,946
Forest to Plantation	161.744,476
Forest to Rice Fields	57.036,843
Shrubs to the Rice Fields	33.501,044
Plantation to Agriculture	32.110,683
Shrubs to Water Bodies	7.179,502
Forests to Water Bodies	6.924,271
Agriculture to Rice Fields	6.145,488

Source: QUES Module Calculation Results, 2019

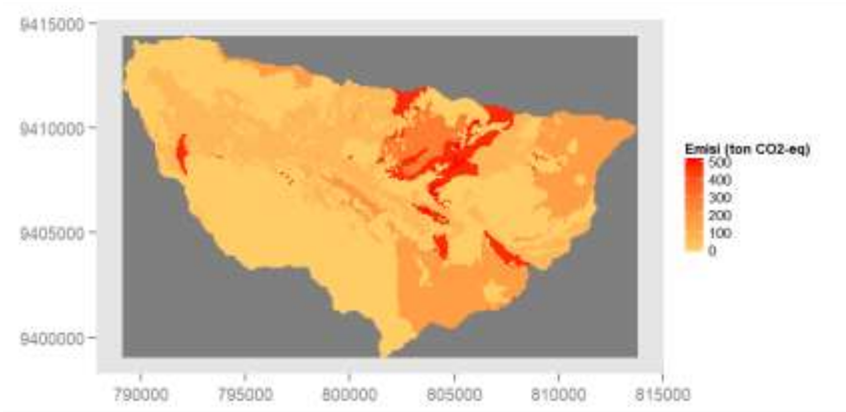

Figure 8. Carbon Emission Levels in the Period of 2023-2032

From the description of hydrological conditions and the level of carbon emissions that occur due to changes in land-use in the Jenelata catchment areain the future, it has provided an illustration that land-use in the region needs to be directed in order to maintain hydrological balance and increase the level of carbon sequestration. It is well known that directives that can maintain the balance of a watershed are foresting areas that are supposed to be forest areas, as well as to increase carbon sequestration, it is necessary to increase the area of forest. Based on data on forest areas in the Jenelata catchment areasourced from Men-LHK Decree No. 362 in 2019, there were functions of protected forest areas, limited production forest, and production forest in the Jenelata watershed. Existing functions of the area are no longer in line with their function, so they need to be given direction by changing the direction of the Gowa Regency Spatial Planning located in the Jenelata catchment area based on actual conditions with the activities of optimizing the function of the forest area through reforestation directed at village administration is Bissoloro, Buakkang, Jenebatu, Paladingan, Rannaloe, Sapaya, Sicini, Tassese, and Ulujangang. The direction of the plan is directed at the condition of the forest area as follows.

Table 7. Directions for Optimizing Land-use in Jenelata Catchment Area through Reforestation activities

Forest Function	Spatial Planning Directive	Actual Condition	Area (Ha)
Protected forest	Plantation	Dry Agriculture	1.53
		Rice fields	.001
		Shrubs	0.14
	Wetland Agriculture	Dry Agriculture	1.34
		Rice fields	0.06
		Shrubs	.37
	Dryland Agriculture	Dry Agriculture	7.92
		Rice fields	1.32
		Shrubs	3.53
Production forest	Agroforestry	Dry Agriculture	2.29
		Rice fields	2.65
		Shrubs	8.89
	Plantation	Dry Agriculture	1.31
	Wetland Agriculture	Dry Agriculture	1.64
	Dryland Agriculture	Dry Agriculture	17.36
		Rice fields	3.33
		Shrubs	3.67
Limited production forest	Agroforestry	Rice fields	3.65
		Shrubs	34.90
	Dryland Agriculture	Rice fields	3.74
		Shrubs	21.35
Total			121.01

The change of land into a forest in Jenelata catchment areais not merely to keep the area from having an environmental impact, but the value of land-use can also be increased if the people in Jenelata catchment use and manage land appropriately such as the selection of forest species that have high economic value but adjusted to market needs, with the condition to pay attention to the composition of species and soil conservation measures that are appropriate so that land productivity continues to increase. Therefore, the value of a land-use benefit needs to be taken into consideration in land-use planning.

4. Conclusion

The impact of land-use change in the Jenelata catchment areasignificantly affects the hydrological condition analyzed by using the SWAT model and influences the level of carbon emissions analyzed by using the QUES module in LUMENS software. The result shows that the Jenelata Dam hydrological conditions in terms of water availability will be decreased by 323,74 million m^3 in actual condition, 275,83 million m^3 in the period 2023, and 274,66 million m^3 in period 2032. While the level of carbon emissions is known to be increased by 314.052,00 Tons CO2-eq in actual condition, 358.237,16 Tons CO2-eq inland changes condition 2019-2023 and 1.595.972,83 Tons CO2-eq in land change condition 2023-2032. Based on these conditions, it is necessary to make the direction of land-use by concerning the conditions of determination of the forest area function. In the LUMENS concept, land planning is built by maintaining economic growth so that there is no trade-off between efforts to maintain hydrological balance and reducing carbon emissions with economic interests. This is what will be done in the future to find out the intensity level of emissions from land use, not only reducing the environmental impact but how domestic income can also increase so that the area that implements sustainable development or planning is an area with lower emission intensity values.

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