Assessing drought vulnerability using climate change models around Bantimurung Bulusaraung National Park, Indonesia

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Abstract Climate variability causes increased rainfall intensity in the rainy season and an increase in the number of dry season days. This condition almost occurs in all parts of Indonesia, especially in the southern part of South Sulawesi Province, which has a fairly complex ecosystem characteristics, one of which is the Bantimurung Bulusaraung National Park ecosystem which has the character of a special landscape in the form of karst area and many community activities in several buffer villages. In Maros, Pangkep and Bone Regencies depend on their livelihood in the region. One of the impacts of climate change occurring around the Bantimurung Bulusaraung National Park area is the increasing potential for drought. Drought occurrences in Bantimurung Bulusaraung National Park mostly occur due to the low rainfall in the dry season which is facilitated by the characteristics of the land in the form of karst area which very quickly passes water down the surface so that the water concentration in the surface is very low. Drought hazard analysis in the Bantimurung Bulusaraung National Park Area was studied using the Soil and Water Assessment Tools (SWAT) model by analyzing the Soil Moisture Deficit Index (groundwater content) in actual conditions (climate period 2004-2013) and projected climate change in the 2030s period, using RCP 4.5 scenario (rainfall scenario tends to decrease) and RCP 6.0 (rainfall scenario tends to increase). Based on the analysis of the vulnerability model, it was found that some regions of the buffer villages of Bantimurung Balasarauang National Park had very high levels of vulnerability to drought hazards. The high level of vulnerability in actual conditions covers an area of 22,727.75 ha, and in the climate change scenario, 4.5 RCP covers 24,584.08 ha and RCP 6.0 scenarios covering an area of 20,642.81 ha.

1. Introduction

Climate change has become a sensitive theme because various community groups feel it. Climate change has and will improve various problems supported by anthropogenic factors, such as increasing negative impacts, including the impact on human sustainability and ecosystems that support them such as the life of flora and fauna. World Bank Report 2010 entitled Natural Hazards, Unnatural Disasters stated that climate-related natural disasters occur almost throughout the world and in Asia, including Indonesia, around 80% of the disasters that occur are climate-affected [1]. Data release of The International Disaster Database, most of the disasters that occurred during the period 1900 to 2015 were related to climate change, such as floods and droughts [2]. Floods and drought disasters are hydrometeorological disasters that are influenced by climate factors. Landscape characteristics of a region greatly affect the climate dynamics that occur in the region. Various regions in Indonesia have unique regional characteristics and cause different climate
variability. Variability in an area can cause increased rainfall intensity in the rainy season, decreasing the number of rainy days and increasing the length of the dry season. This phenomenon also occurs in the region of South Sulawesi Province, including in the Bantimurung-Bulusaraung National Park Area which has a unique ecosystem and is a habitat for a variety of endemic endangered flora and fauna. The phenomenon of decreasing rainfall intensity in the Bantimurung-Bulusaraung National Park area in the dry season results in drought in various locations supported by the landscape characteristics of the Bantimurung Bulusaraung National Park in the form of karst which is very easy to pass water (low water storage capacity). Drought can be defined as a recurrent climate phenomenon above the ground which is characterized by a water deficit for several months. Extreme drought conditions greatly affect agriculture, the environment, and health, the perceived impact will greatly depend on the level of adaptability of the area affected such as the socio-economic ability of the community and the level of exposure of the ecosystem [3,4,5]. In general, disasters will have a significant impact if there are important groups/individuals that influence and are affected by their habitat ecosystem.

The study of the impacts of climate change on drought and biodiversity in Bantimurung-Bulusaraung National Park is the result of research by the Center for Research and Development "Natural Heritage, Biodiversity and Climate Change," LP2M Hasanuddin University. This activity was coordinated by the Ministry of Environment and Forestry and was funded by the United Nations Development Program (UNDP). This activity is part of the preparation of the Third National Communication as a commitment of the Indonesian Government to reduce emissions. Through the Third National Communication, it is possible for the Government of Indonesia to design general policies and measure the impact of climate change mitigation and adaptation through strengthening technical capacity and institutional arrangements at national and local levels and measuring environmental, social and economic impacts of the implementation of mitigation and adaptation policies.

This impact assessment is expected to provide an overview of the potential "problems" faced by an area against climate change events and anticipation programs that can be developed jointly by stakeholders. The purpose of this study was to develop climate change scenarios through several models and assess the level of drought hazard in the Bantimurung-Bulusaraung National Park due to climate change for protected flora and fauna in Bantimurung Bulusaraung National Park, as a direction for further biodiversity research.

2. Materials and Methods

2.1. Research Location

Bantimurung Bulusaraung National Park Area is a conservation area determined based on the Decree of the Minister of Forestry Number: SK. 398 / Menhut-II / 2004 dated October 18, 2004. This area is divided into 7 zones which are based on its function. Zone division or commonly known as national park zoning is a process of space controlling into zones that have different designation functions. The zoning of Bantimurung Bulusaraung National Park shown in Figure 1.
Based on the results of the study and the results of an understanding of the improvement of the zoning revision, the distribution of zoning for the Bantimurung Balasaraung National Park shown in Table 1.

| No. | Zone Type (Code)                         | Area of Zone (ha) | (%)  |
|-----|-----------------------------------------|-------------------|------|
| 1.  | Core Zone                               | 22,849.73         | 52.23|
| 2.  | Forest Zone                             | 10,435.84         | 23.85|
| 3.  | Utilization Zone                        | 374.43            | 0.86 |
| 4.  | Traditional Zone                        | 4,374.05          | 10   |
| 5.  | Rehabilitation Zone                     | 1,331.38          | 3.04 |
| 6.  | Religious, Cultural and Historical Zones| 191.49            | 0.44 |
| 7.  | Special Zone                            | 4,193.08          | 9.58 |
|     | Total                                   | 43,433.85         | 100  |

Both in Figure 1 and Table 1 shown that Bantimurung Balasaraung National Park is dominated by the Core Zone and Forest Zone. This National Park area is a part of the Maros-Pangkep Karst area. It makes this area become a part of the karst water system which is as the water resources for the community around Maros and Pangkep Regencies. The Bantimurung Balasaraung National Park area is the catchment area for several major rivers in South Sulawesi, including the Waianae river which is one of the rivers that affects the hydrological system of Lake Tempe, Pangkep River, Pute River and Bantimurung / Maros River, which shown in Figure 2.
2.2. Data Collecting

Data collection is needed as a basis or requirement in conducting a literature review to get a general region overview of the physical and socio-economic (non-physical), and materials for analyzing vulnerability and risk as a spatial impact of climate change. Data inventory activities were conducted through the collection of secondary data and primary data.

a. Secondary data collecting

Secondary data is the main data used in the analysis which is then strengthened and verified by using primary data. The main sources of spatial data related to data on the physical characteristics of the study area and non-spatial data come from various agencies such as the Bantimurung Balasaraung National Park Agency, South Sulawesi Government, Maros Regency Government, Pangkep Government and Bone Government. Therefore, secondary data collected is physical data and socio-economic data. Physical environment data includes actual daily climate data, land use data, watershed morphology data, slope / topographic data, road infrastructure data, landform data, geological data and soil types and spatial data on the distribution of flora and fauna in Bantimurung Balasaraung National Park. Socio-economic data includes population statistics such as the actual population and projection of population numbers to describe the social conditions of the community in the future which collected from village potential data and the Central Statistics Agency. In addition to population data, other data collected including population livelihood data and community economic component data in the study area. To assess adaptation options and the direction of regional development policies in response to
disaster risk due to climate change, data collection on the Regional Medium-Term Development Plan, Regional Spatial Planning and Regional Work Unit Strategic Plans from regional governments at the provincial level and districts including related technical agencies such as Regional Development Planning agency, Forestry agency, Environmental Management agency and Disaster Management agency were conducted.

2.3. Analysis of Climate Change Projections

Analysis of climate change projections around the Bantimurung Balasaraung National Park Area using Statistical Bias Correction for Climate Scenarios (SiBiaS) software version 1.1. SiBiaS is a software that is used to facilitate the use of GCM CMIP5 external data and the bias correction process. The statistical bias correction technique in this program consists of two choices, by using the Delta method and distribution correction method [7]. The delta method is the simplest and most widely used downscaling method in drafting the scenarios of climate for studies on a local scale. Another method that can be used in this program is biased correction method based on the correction of data distribution using the Gamma distribution approach [8]. The delta method is a bias correction process through the "addition" or "multiplication" approach of Δμta with the observation value in the baseline period, as shown in the following equation model:

\[ X_{\text{cor},i} = X_{o,i} \frac{\mu_p}{\mu_b} \]

\( X_{\text{cor},i} \) is the corrected model value and \( X_{o,i} \) is the observation value in the baseline period. \( \mu \) is an average value where \( b \) and \( p \) each indicates simulation data for the baseline period and projections from the model. Equations are used to correct rainfall data.

2.4. Climate Change Vulnerability and Risk Analysis

The concept of vulnerability is a condition of ability (capable of adapting or not adapting) of an area to face the environmental influences either due to natural disaster factors or other factors such as the dynamics of the global climate. The vulnerability analysis of Bantimurung Balasaraung National Park refers to the risk aspects of drought. The vulnerability assessment of Bantimurung Balasaraung National Park needs to be built in an analytical model that can illustrate the complex events that occur in the area. Vulnerability analysis and disaster risk are not only for the surrounding communities and related to the Bantimurung Balasaraung National Park, but also for the preservation of protected flora and fauna habitats.

The risk assessment method (Risk) is formulated as a function of threats/hazards and vulnerability. Hazards are potential natural phenomena that can cause harm (for example floods and landslides) due to diversity and climate change and human activities (land dysfunction due to regional development).
While the vulnerability is a function of exposure (sensitivity), sensitivity (Sensitivity) and adaptive capacity (Adaptive Capacity) of the area analyzed. The vulnerability risk assessment of Bantimurung Balasaraung National Park was conducted by analyzing vulnerability due to climate dynamics in actual conditions and analyzing climate change projections using several scenarios and models of climate change.

To analyze the vulnerability and risk of climate change in the Bantimurung Balasaraung National Park area, a unit analysis approach was used in the buffer villages of Bantimurung Balasaraung National Park and watershed boundaries. The watershed approach as a unit of analysis is intended because the study analyzed in Bantimurung Balasaraung National Park such as the component of hazard vulnerability is a type of hydrometeorological disaster that is influenced by climate such as rainfall, so that the ecological approach that can be used is by analyzing watersheds that affect and influence the Bantimurung Balasaraung National Park area while the approach of buffer villages in Bantimurung Balasaraung National Park is used as a vulnerability analysis of community groups that are vulnerable to climate dynamics.

In the 2014 Intergovernmental Panel on Climate Change (IPCC) document entitled "Climate Change 2014: Impacts, Adaptation, and Vulnerability" which adopts the concept of risk assessment in detail, the determining component in analyzing disaster-related risks consists of hazard components (hazard), exposure, sensitivity and adaptive capacity. The risk formula described in the Intergovernmental Panel on Climate Change (IPCC) \[9\] is:

\[ R = H \times E \times \frac{S}{C} \]

Dimana:
R : Risk
H : Hazard
E : Exposure
S : Sensitivity
C : Adaptive Capacity

The concept of risk applied in the IPCC is then used as a reference in analyzing the risk level of vulnerability in the disaster-affected Bantimurung Balasaraung National Park area. The mapping of risk components is done by the scoring method, by giving values for each parameter. Determination of component classification levels is divided into several class intervals by using the Sturgess equation. The description of the risk components analyzed in this study include:

a. Drought Hazard Analysis

Drought analysis of Bantimurung Balasaraung National Park was conducted by using the Soil Moisture Deficit Index (SMDI) using output data from the results of the Soil and Water Assessment Tool called Soil Water. This soil water content data were analyzed to obtain the dryness value of land using the Soil Moisture Deficit Index (SMDI) formula. The SMDI value indicates drought if the value obtained is below zero (0) or negative, while the value above zero or positive indicates the level of wetness. The more negative the SMDI value, the drier the area and conversely the more positive the area is said to be getting wetter. The classification of the index is categorized as follows (Table 2).

| No. | SMDI Index | Category     | Hazard Level |
|-----|------------|--------------|--------------|
| 1.  | ≥4,00      | Very wet     | Very low     |
| 2.  | 3,00 sd 3,99 | Wet         | Very low     |
| 3.  | 2,00 sd 2,99 | Medium wet  | Very low     |
| 4.  | 0,50 sd 1,99 | Low wet     | Very low     |
| 5.  | 0,49 sd -0,49 | Normal    | Very low     |
| 6.  | -0,50 sd -1,99 | Low dry    | Low          |
| 7.  | -2,00 sd -2,99 | Medium dry | Medium       |
b. Exposure Level Analysis

Level of exposure is the degree, duration and or opportunity of a system to contact with interference (danger or natural disaster) in an area. The level of exposure also represents the impact of changes in climate conditions over the long term or by changes in climate variability such as the frequency of extreme events. In Minister of Environment Regulation Number 33 of 2016 regarding Guidelines for Preparing Climate Change Adaptation Action, exposure is defined as human existence, livelihoods, species/ecosystems, environmental functions, services and resources, infrastructure, or economic, social and cultural assets in the region or location that can experience negative impacts. The mapping of the exposure level of the Bantimurung Balasaraung National Park area was conducted by using a scoring method with parameter ratio of the number of households living on the riverbank to the number of households in the village area, the ratio of the number of riverbanks to the river border area, drinking water sources, the ratio of poor population to total population ratio poor population to total population, actual population density (year 2015 [11-13]) and population density in the future (Year 2030) and community livelihoods [14].

c. Sensitivity Analysis

The level of sensitivity is an internal condition of a system that shows the degree of vulnerability to interference, or can also be interpreted the degree to which a system will be affected, or have a certain response to climate simulation. Mapping of the sensitivity level of the Bantimurung Balasaraung National Park ecosystem was conducted by analyzing the components which include the status of the flagship (Butterflies, Macaca Maura and other types of mammals), the status of protected or endangered species, ecosystem types, land use rates, and tourism activities [15].

d. Adaptation Capability Analysis

Adaptation ability shows the ability of a system to make adjustments to disturbances such as climate change or natural disasters so that the potential negative impacts can be reduced and positive impacts can be maximized. Adaptation ability also refers to the potential or ability of a system to adjust itself such as the internal capacity of a community group or an ecosystem in overcoming the adverse effects of a disaster that exposes it. The Bantimurung Balasaraung National Park adaptation capacity analysis study uses an information analysis unit of buffer villages in Bantimurung Balasaraung National Park by gathering information such as the ratio of the number of households that have electricity facilities, education facilities, health facilities and road infrastructure, seen from the road density level in a region [14].

3. Result and Discussion

3.1. Climate Change in the Bantimurung Balusaraung National Park Area.

Based on the results of the analysis using the Statistical Bias Correction for Climate Scenarios (SiBias) CMIP5 GCM output data from 24 models, one model that represents the predetermined scenario is RCP 4.5 scenario and RCP 6.0 scenario. The selection process is based on the smallest to the highest value of the total rainfall value, as well as the test for homogeneity of rainfall patterns that approach the baseline rainfall pattern, as a reference in the model selection method. The model data is used as input from the analysis of vulnerability and risk of climate change in the 2030s. Figure 3 is a comparison graph of actual rainfall patterns with models in each RCP 4.5 scenario and RCP 6.0 scenario.
Figure 3. Comparison of Actual Rainfall Patterns (Baseline) with RCP Scenario 4.5 and RCP 6.0 Based on GCM CMIP5 Monthly Average Rainfall Relationship Pattern (after correction)

Based on the data in Figure 3 above it is known that the type of rain in the Bantimurung Balasaraung National Park area is monsoonal. The type of monsoonal rain is characterized by a unimodal form of rain pattern, which has one peak in the rainy season (around December-April) with one peak in the dry season. This rain pattern has a marked difference between the rainy and dry seasons which usually occur for six months each [16]. In the RCP 4.5 scenario, the GFDL-ESM2M climate model is used which is a pessimistic climate model where rainfall is predicted to decline in the future. While the RCP 6.0 scenario is used by the GISS-E2-R climate model ** that is an optimistic climate model where rainfall is predicted to increase in the future. Changes in actual rainfall patterns and climate change scenarios in the Bantimurung Balasaraung National Park Area are presented in Table 3 and visualization of rainfall distribution is presented in Figure 4. Color gradation illustrates that the lighter the blue will be drier, the darker blue the area will be wet.

Figure 4. Actual Rainfall (A) and Rainfall Change Simulation based on RCP 6 Scenario, GISS-E2-R ** (B) Model and RCP Scenario 4.5, GFDL-ESM2M Model (C) (mean in mm/year)
Table 3. Changes in the Average Monthly Rainfall Pattern (mm) in Actual Conditions, RCP 4.5 Model GFDL-ESM2M and RCP 6, Model GISS-E2-R**.

| Month | Actual | RCP 4.5 Scenario | RCP 6.0 Scenario |
|-------|--------|------------------|------------------|
|       |        | GFDL-ESM2M | Rainfall Changes | GISS-E2-R** | Rainfall Changes |
| Jan   | 400.66 | 359.99 | -40.67 | 389.24 | -11.42 |
| Feb   | 328.91 | 260.87 | -68.04 | 303.27 | -25.64 |
| Mar   | 315.36 | 288.08 | -27.28 | 342.39 | 27.03 |
| Apr   | 295.76 | 274.25 | -21.51 | 304.06 | 8.3   |
| May   | 207.07 | 234.26 | 27.19  | 241.89 | 34.82 |
| Jun   | 176.34 | 144.83 | -31.51 | 195.1  | 18.76 |
| Jul   | 122.81 | 80.65  | -42.16 | 184.21 | 61.4  |
| Aug   | 61.81  | 36.42  | -25.39 | 71.83  | 10.02 |
| Sep   | 49.8   | 33.51  | -16.29 | 60.63  | 10.83 |
| Oct   | 132.03 | 67.81  | -64.22 | 167.97 | 35.94 |
| Nov   | 265.26 | 238.14 | -27.12 | 362.86 | 97.6  |
| Dec   | 403.29 | 366.93 | -36.36 | 464.85 | 61.56 |

3.2. The vulnerability of Bantimurung Bulusaraung National Park

The low rainfall in the dry season and the landscape factors in this region which are dominated by karst areas cause very low surface water potential. The occurrence of watershed degradation that experiences a land conversion from vegetation to non-vegetation also causes disruption of the groundwater recharge system in this area, so that the water reservoir capacity decreases sharply. The impact of the drought that has occurred so far is the lack of clean water and the occurrence of crop failure. Changes in the livelihoods of communities around the national park in the rainy season using agricultural land to grow crops, in the dry season switch to use the Bantimurung Balasaraung National Park area to look for forest products such as honey and sugar palm and also catch butterflies, so this condition affects the National Park ecosystem Bantimurung Balasaraung. An increase in the danger level of drought in the future based on RCP 4.5 scenario has a very serious impact on the level of risk of buffer villages and biological ecosystems in the Bantimurung Balasaraung National Park area. The results of the analysis found that in the future the level of drought risk would increase to 24,584.07 ha from the actual risk of 22,727.76 ha covering 20 villages (Details in Table 4). The distribution of the results of the drought risk analysis in Bantimurung Balasaraung National Park is presented in Figure 5.

Table 4. Buffer Villages of Bantimurung Bulusaraung National Park Area with Very High and High Drought Risk Actual Conditions, RCP Scenario 4.5 and RCP 6.0 Scenario.

| Climate Scenario | Regency | Location by Sub-district/Village | Area (Ha) |
|------------------|---------|---------------------------------|-----------|
| Actual           | Maros   | Bantimurung District (Village: Kalabibirang, and Leang-Leang), Camba District (Village: Patanyamang, and Timpuseng), Cenrana District (Village: Labuaja, Desa Laiya, and Lebbotenga), Mallawa District (Village: Bentenge, and Samaenre), Simbang District (Village: Samangki), Tompobulu District (Village: Bonto Manai, and Bonto Manurung) | 16,015.67 |
| Pangkep          | Balocci | Balocci District (Village: Balleangin, and Balocci Baru), Minasatene District (Village: Panaikang, and Biraeng), Tondong Tallasa District (Village: Bulu Tellue, and Malaka) | 6,499.73 |
| Bone             | Tellu Limpoe District (Village: Samaenre) | 212.35 |
| Climate Scenario   | Regency      | Location by Sub-district/Village                                                                                     | Area (Ha)    |
|-------------------|--------------|----------------------------------------------------------------------------------------------------------------------|--------------|
| RCP 4.5 Scen.... | Maros        | Bantimurung District (Village: Kalabbirang, and Leang-Leang), Camba District (Village: Patanyamang, and Timpuseng), Cenrana District (Village: Labuaja, Desa Laiya, and Lebbotengae), Mallawa District (Village: Bentenge, and Samaenre), Simbang District (Village: Samangki), Tompobulu District (Village: Bonto Manai, and Bonto Manurung) | 17,696.21    |
| Pangkep          | Balocci District (Village: Tompobulu, Balleangin, and Balocci Baru), Minasatene District (Village: Panaikang, and Biraeng), Tondong Tallasa District (Village: Bulo Tellue, and Malaka) | 6,603.05     |
| Bone             | Tellu Limpoe District (Village: Samaenre)                                                                         | 284.82       |
| RCP 6.0 Scen..... | Maros        | Bantimurung District (Village: Kalabbirang, and Leang-Leang), Camba District (Village: Patanyamang), Cenrana District (Village: Labuaja, Laiya, and Lebbotengae), Mallawa District (Village: Bentenge, and Samaenre), Simbang District (Village: Samangki), Tompobulu District (Village: Bonto Manai, and Bonto Manurung) | 14,918.18    |
| Pangkep          | Balocci District (Village: Balleangin, and Balocci Baru), Minasatene District (Village: Panaikang, and Biraeng), Tondong Tallasa District (Village: Bulo Tellue, and Malaka) | 5,576.20     |
| Bone             | Tellu Limpoe District (Village: Samaenre)                                                                         | 148.43       |

There are areas with high drought risk levels in Bantimurung Balasaraung National Park now and in the future, because they are influenced by the vulnerability of the region, where high exposure levels, high sensitivity levels and low community adaptability, and are supported by increased drought-affected areas in the category very high and high. From the results of the analysis, it is known that 20 villages that have high and very high risks are found in 10 sub-district administrative regions. If analyzed using the RCP 4.5 scenario, an increase in the level of drought risk in all sub-districts in the 2030s will occur. The distribution of regions with very high- and high-risk categories is presented in Figure 6.
Figure 5. Actual Drought Risk Map (A), Scenario Model GFDL-ESM2M RCP 4.5 (B) and GISS-E2-R Model ** Scenario RCP 6.0 (C)

Figure 6. Comparison Chart of the Area of Drought Risk in the Very High and High Categories of Actual Conditions and Projections for Climate Change in the 2030s.
Bantimurung Balasaraung National Park ecosystem is divided into three main ecosystem types, namely forest ecosystems in limestone (forest over limestone) or better known as karst ecosystems, non dipterocarpaceae pamah rainforest ecosystems, and lower montane forest ecosystems. The boundaries of these three types of ecosystems are clear because of the expanse of steep-walled karstic rocks with relatively flat towers, different from the lowland topography which has a flat to hilly topography, and mountainous forest ecosystem conditions characterized by steep or sometimes bumpy relief [17].

The results of the flora and fauna inventory in Bantimurung Balasaraung National Park provide data that there are 18 endemic flora and 397 endemic fauna species from Sulawesi, but which can only be monitored and are known are 7 fauna species such as Sulawesi Monkey (Macaca maura), Sulawesi Hornbill (Rhyticeros cassidix), Tarsius (Tarsius Fuscus), Angel Wings (Cethosia myrina sarnada), King Butterfly (Troides haliphron), Troides helena and Troides hypolitus cellularis (Figure 7).

Endemic flora in Bantimurung Balasaraung National Park is known to spread in several zones especially in the core zone and jungle zone. Of the 18 species of Sulawesi endemic flora found in Bantimurung Balasaraung National Park, there are 11 species identified scattered in the core zone of Bantimurung Balasaraung National Park which has an area of 22,849.73 ha which includes Appendicula laxifolia J.J.Sm. 1993, Arachnis celebica (Schltr) J.J. Sm 1912, Bulbophyllum agapethoides Schltr. 1911, Bulbophyllum minahassae Schltr. 1911, Bulbophyllum pachyneuron Schltr.
1911, Ceratostylis sima J.J. Sm 1908, Coelogynce celebensis J.J. Sm 1917, Dendrobium macrophyllum A. Richard 1834, Dendrobium rattii J.J. Sm 1934, Diospyros celebica Bakh., And Thrixspermum loogemanianum Schltr. 1911. The location of the 11 endemic flora species was not disseminated because, according to the manager of the Bantimurung Balasaraung National Park, it would have an impact on the existence of these endemic flora due to illegal logging and excessive taking of ornamental flora.

The results of studies relating to the impact of climate change on biodiversity are still very rare, so the very detailed impact of the presence of endemic flora and fauna needs to be studied more deeply. Regarding the effects of climate change due to drought, it can be attributed to the nature and behavior of flora and fauna in Bantimurung Balasaraung National Park to climate change. Where there are some flora and fauna characteristics in Bantimurung Balasaraung National Park including:

1. Some endemic plants such as ornamental flowers (orchids) are very susceptible to increasing temperatures.
2. Some endemic plants are tolerant plants that require shade so that an increase in drought will have serious consequences.
3. The increased drought has an impact on the availability of fauna food sources in the forest.
4. Some types of insects and butterflies endemic have a life cycle that is during the rainy season and the dry season. Changes in seasonal patterns will affect the life cycle of butterfly species so that it has an impact on population decline.

If analyzed between the characteristics of flora and fauna in the Bantimurung Balasaraung National Park area with the risk of climate change, it can be concluded that these flora and fauna are very vulnerable to increasing temperatures and decreasing rainfall levels or in other words very vulnerable to drought hazards. However, this still requires a more in-depth study specifically on the impacts of climate change on the characteristics and existence of flora and fauna. Based on the RCP 4.5 scenario with the GFDL-ESM2M model (pessimistic model), the level of drought around the Bantimurung Balasaraung National Park area will increase especially in the core zone. Increasing the danger level of drought in this core zone has a serious impact on the existence and habitat of several species of flora and fauna because most of flora and fauna are endemic. This condition needs to be taken seriously by the management of the Bantimurung Balasaraung National Park in particular or other Conservation Units to see an increase in the danger level of drought in the future. The description of the drought hazard level in the very high and high categories on the zoning of the Bantimurung Balasaraung National Park is presented in Figure 8.

![Figure 8. Distribution of Drought Vulnerability Levels in the Very High and High Categories of the Bantimurung Balasaraung National Park Zoning](image-url)
4. Conclusions
The results of the study of climate change around the Bantimurung Balasaraung National Park area resulted in a knowledge of the derivative impacts and risks of hydrometeorological disasters, namely drought. There are ecosystem components both flora and fauna which are quite vulnerable to drought; more in-depth studies are needed on the relationship of climate change with biodiversity in the region.

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