Adaptation of Climate Change to Vulnerability of Raw Water Availability in Bantaeng, South Sulawesi

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Abstract. Various processes triggering global climate change and climate change have been accepted by many parties as a necessity characterized by global warming, with a direct impact on the hydrological cycle, so that climate change is believed to have a real impact on water resources. Taking into account the possible consequences of climate change, it will be extremely important to examine how fluctuation in temperature and rainfall pattern shift will affect the water supply system. With this climate change, it will lead to vulnerability to the availability of raw water. The vulnerability referred to in Bantaeng was simply determined by three factors that were considered dominant, namely water needs, water sources, and community welfare. The analysis results showed that there was a higher risk increase which was influenced by hydrogeological conditions related to groundwater potential. Optimal groundwater management was expected to contribute as an adaptation effort to climate change risks to water sources.

Keywords: climate change, raw water, Bantaeng

1. Introduction
The Inter-governmental Panel on Climate Change (IPCC) and The United Nations Framework Convention on Climate Change (UNFCCC) have reported that along with the evidence that climate change is currently happening globally. Climate change has and will cause immediate harm in the form of changes in rainfall patterns, rising temperatures, rising water levels and leading to extreme climatic events. The various processes triggering global climate change have been accepted by many people as a necessity characterized by global warming, with a direct impact on the hydrological cycle, so that climate change is believed to have a real impact on water resources in many regions of the world with broad consequences on people's lives and the environment. Taking into account the possible consequences of climate change, it is important for the Government and Municipal Waterworks to manage the supply of drinking water, to start assessing how temperature fluctuation and rainfall patterns shift will affect the drinking water supply system and then integrate these adaptation efforts into planning mechanisms and documents to anticipate future climate change risks.

Researches show that there has been an increase in surface temperature of 0.7°C since 1900. Over the past 30 years, there has been a rapid and a consistent increase in global temperature of 0.2°C per decade. The ten warmest years occurred in the period after 1990. The signs of change can be seen in physical and biological mechanisms; for instance, the displacement of various species as far as 6 km towards the poles every decade during the last 30-40 years. Another indicator is the change in seasonal events such
as the process of flowering and egg laying which is 2-3 days faster in each decade in temperate regions [1]. In Indonesia, the impact of climate change is indicated by an increase in the frequency of climate phenomena that can cause drought and flooding. The climate phenomenon known as ENSO (El-Nino-Southern Oscillation) consisting of El Nino and La Nina events extremely affect the distribution of rainfall in Indonesia. El Nino event is identified with drought, while La Nina is identified with flood. It is informed that global warming could have an impact on increasing the frequency of ENSO events. This indication is associated with reports of an increase in the frequency of drought occurrences in Indonesia in the last four decades [2] and flood events in various regions in Indonesia in the 2001-2004 periods (MoE 2007). In the document of the National Action Plan for Climate Change Adaptation (hereinafter referred to as RAN-API) (The Ministry of National Development Planning 2012) and the Indonesia Country Report (MoE 2007), the various potential impacts of climate change on various economic sectors, for example: agriculture, forestry, fisheries, health, coastal areas, water resources are summarized and reported [3]. The current condition in Bantaeng, based on information from the Municipal Waterworks, reveals that during the dry season, this raw water source is experiencing a decline in the flow of water produced from springs and surface water. Therefore, people are asked to keep maintaining the volume of water use. This is because the Municipal Waterworks cannot predict when a decline will occur, which could have an impact on the lack of water supply that flows through the pipeline to the community. Thus, this study aims to analyze the level of vulnerability of water sources and mitigate the prevention of climate change impacts which will result in declined raw water resources that will be processed into drinking water in Bantaeng regency.

2. Research Method

In accordance with the problems and final objectives in this research, this type of study emphasizes the observational method carried out in the watershed area in Bantaeng Regency, using a qualitative - quantitative cross sectional approach. Data collection was obtained from two data sources, namely primary and secondary. Primary data were obtained from interviews with a group of people who were considered competent to provide an overview of the problems that needed to be solved and data were taken directly in the field. Secondary data were obtained from literature data, both from agencies and website searches. The study population was divided into two categories, namely a qualitative population consisting of stakeholders related to the provision of drinking water at the research location (Public Works Office, Development Planning Agency at Sub-national Level, district, sub-district) and a quantitative category consisting of Hamlet, Neighborhood, and Community Empowerment Group administrators (for analysis variables of readiness of communities, institutions and valuations), as well as communities (analysis variables of readiness of families and valuations).

3. Theoretical Basis

Climate change, based on the definition of the Ministry of the Environment, is a change in the physical conditions of the earth's atmosphere, including temperature and rainfall distribution, which has a wide impact on various sectors of human life (The Ministry of Environment 2001). The consequences of climate change related to human life namely an increase in temperature of up to 3° C over the last hundred years which affects the ecosystems that provide food and water and the increase of precipitation in high latitudes. Reduction of precipitation in subtropical areas, rising sea levels due to expanding oceans and melting glaciers. Climate change also impacts water, namely accelerating the hydrological cycle due to warming. An increase in atmospheric temperature causes an increase in water supply which increases the potential for precipitation in the form of heavy rain. The increase in temperature can accelerate the evaporation process. This can reduce the quantity and quality of clean water. Global condition change also affects the spread of the malaria mosquito and other diseases. Uncontrolled use of underground water reduces groundwater discharge which can cause accelerated intrusion of sea water to land. Climate change events can also increase water crises, which are caused by long dry season in areas with low water characteristics. This water crisis is triggered by an unstable change of season.
Another threat in arid subtropical and tropical regions is the prediction of a water shortage of up to 10-30% which can cause catastrophic drought. The impact on the water sector, which is affected by climate change, can affect human social life. The influence pattern of climate change from its causes returns to human life.

Climate change is an extremely important issue that is widely discussed at the world level today. Earth's climate is changing rapidly due to increasing greenhouse gas (GHG) emissions as a result of human activities. Increasing the GHG level causes GHG effects in the atmosphere. This GHG effect absorbs long wave radiation which causes the earth's temperature to increase. In the Kyoto Protocol, gases classified as GHG are Carbon Dioxide (CO2), Methane (CH4), Nitric Oxide (N2O), Hydrofluorocarbons (HFC), Perfluorocarbons (PFC), and Sulfate Hexafluoride (SF6) [2]. Global Warming causes disruption of various air circulations in the atmosphere which leads to increased intensity of extreme climatic events and seasonal irregularities. Future global climate change is predicted to cause the frequency and intensity of extreme climate events to increase. Since 1844, Indonesia has been experiencing no less than 43 drought events. Of the 43 events, only 6 did not coincide with the ENSO phenomenon [2]. Global warming is no longer a problem for the future, but has become a problem that is being faced nowadays. The results of searching for the international natural disaster database (International Disaster Database) show that there are 345 natural disasters that fall into the category of global disasters [2]. This finding is in line with the results of the study by the Intergovernmental Panel on Climate Change [4] that global warming will increase the frequency and intensity of extreme climate events. Season in Java Island has been carried out by [5]. Their research results show that in the next 40 years, global warming will cause the start of the rainy season in Central Java to decline while the end of the rainy season will be faster, which means that the length of the rainy season will be shorter. On the other hand, the rainy season rainfall will tend to increase, while the dry season rainfall will tend to decrease. This has implications for the increased risk of drought in the dry season and the risk of flooding or landslides in the rainy season [6].

4. Results and Discussion

4.1. Approach in Adaptation Planning
Based on the Inter-governmental Panel on Climate Change, IPCC (2012), climate change adaptation is “the process of adjusting to real/actual climate or predictable results and impacts, in order to reduce harm or take advantage of opportunities”. Types of adaptation actions can be in a variety of ways and techniques that can be carried out, including modification of plans that have been made (such as providing a wider distance between the plan of Municipal Waterworks treatment building and adjacent waterbody), “light” adaptation actions (such as rehabilitation of water catchment areas through planting and construction of technical civil building), or “hard” adaptation actions. Alternatively, Municipal Waterworks management needs to prioritize adaptation actions "without regrets, namely the choice of adaptation activities that will still provide good benefits even though the negative impacts of climate change do not occur in the future (IPCC, 2012)".

The process of identifying and determining general and specific adaptation options will be carried out through several stages of decision making by Municipal Waterworks and local governments. Furthermore, based on the results of the assessment of various vulnerabilities in the natural aspects and built aspects of the Municipal Waterworks, various types of adaptation activities will be determined and agreed upon by the existing stakeholders (including the Municipal Waterworks and local governments), where these stakeholders will compile a long list of various alternatives of adaptation plans deemed appropriate and implementable. Besides, by considering various aspects such as total cost requirement, implementation complexity (technical and non-technical), political support, rapidity of implementation and the impacts/benefits, the long list will be reduced to a short list of options for mitigation actions. In addition, the short list will be in priority weight in its implementation based on its urgency, namely the short term, medium term, and long term.
4.2 Vulnerability Points

As a continuation of the vulnerability assessment process, the following vulnerability points (Figure 1) are emphasized for further analysis and adaptation planning:

- **Kulepang River:** The Kulepang River needs serious attention as the main source of raw water for Municipal Waterworks of Bantaeng Regency, especially since its intake location is in a river valley with both sides of a steep valley which is prone to landslides.

- **Eremerasa Spring:** The potential of this spring is extremely large but only a small part of it has been used by Municipal Waterworks as raw water. The rest of the discharge from this spring is used as a tourist bath and part of it flows into the Biangloe River and is used for other purposes. In addition to its large potential, this spring also has problems because it is located in a valley with a steep slope both upstream and downstream; therefore, it is potentially exposed to the danger of landslides. Tourism activities around the spring have the potential to become a source of water pollution because there is no boundary between the spring and the tourism bath. The use of land in the upstream area of the spring has also been converted into plantations, so that it has the potential to affect the sustainability and the preservation of spring discharge. Various efforts to protect the upstream area and infiltration well construction need to be done immediately to avoid reducing the discharge of this Eremerasa Spring.

- **Mandaraki Spring:** The location of the spring and the reservoir building is right in the middle of a steep slope that is prone to landslides; the retaining walls are made extremely simple, and it is predicted that they will not be able to withstand loads for a long time. Based on field observations, erosion has occurred around the spring which has caused the entry of soil material into the storage pool. Erosion has also caused some plant roots to be exposed, which has the potential for tree fall that can fall on the reservoir building.

- **Biangloe River:** The intake location is in the river flow and is inside a dam building that has undergone silting due to sedimentation; the average depth of water bodies in the upstream area of the dam is only 29 cm (0.29 meters). This sedimentation also causes disruption of riverflow, thereby eroding the intake building.

- **Dammu Spring:** The physical condition of the water from the spring is actually of good quality, but because of the run off on the slopes around the intake and into the storage pool, the raw water used by the Municipal Waterworks becomes turbid. Steep slopes and thick topsoil are the factors that trigger landslides and disrupt spring and intake building.

- **Bissapu River or Salluang River:** The intake plan location is on a river with both sides in the form of a fairly steep sloping valley that has the potential for landslides. This condition needs to be taken into account when developing Municipal Waterworks infrastructure. The location of the intake building plan that is close to the settlement also needs attention because of the potential for pollution from domestic waste besides waste from waterfall tourism activities upstream of the river.
4.3 Adaptation Options for Climate Change
Based on identification of vulnerability points and consideration of options for adaptation actions, the Municipal Waterworks and other stakeholders (including the Bantaeng Local Government), several adaptation activities are as follows:

- The Municipal Waterworks must monitor the quantity, quality, and continuity of raw water and the affordability of the public's purchasing power on the price of drinking water produced by the Municipal Waterworks regularly. The monitoring result data can be used as evaluation material to further form the basis for planning the Municipal Waterworks service improvement program.
- The Municipal Waterworks must increase production capacity in order to meet the drinking water needs of the community, including intensive efforts to find a planned intake location as a new source of raw water intake for development. This is absolutely necessary due to the Municipal Waterworks obligation to be able to meet the drinking water needs of all communities whose needs are projected to continue to increase. The need for drinking water from the industrial side must also be considered in the projected increase in demand.
- The Municipal Waterworks must improve the quality of the clean water treatment system in order to produce drinking water quality according to predetermined standards. The need for clean water not only focuses on the quantity which is always increasing but also on the quality aspects which are also required to be constantly improved. It should be kept in mind that climate change not only has the potential to change the quantity of raw water but also allows disruption to the quality of raw water. This means that there is a demand for raw water treatment to meet drinking water standards.
- The Municipal Waterworks of Bantaeng Regency has used GIS as a database management tool in spatial format. The consequence of using GIS is that database management is required so that it can continue to be used optimally. Data update is absolutely necessary related to the Municipal Waterworks operational data which is dynamic and is changing over time.

Figure 1: Locations of vulnerability points for raw water sources in Bantaeng

![Locations of vulnerability points for raw water sources in Bantaeng](image)
● The annulment of the Natural Resources Law demands that the priority of water resources management be with state-owned enterprises (BUMN) and regional-owned enterprises (BUMD). This condition must be addressed as a momentum for the Municipal Waterworks to be further supported and developed.
● On the other hand, the Municipal Waterworks can re-explore local governments to care more about clean water by providing investment funds. On the contrary, the local governments must respond in the form of funding allocations for the Municipal Waterworks in the Local Government Budget sustainably.

5. Conclusions
● The characteristics of the Bantaeng Regency area greatly influence the condition of the water resources that are the source of the Municipal Waterworks raw water. Some of the characteristics of the area are extremely beneficial, but several other things have the potential to make obstacles or threats to the availability of water resources.
● Climate change is predicted to have a significant impact and will be perceived more and more if changes in land use, especially in the upstream watershed, are carried out without an environmental perspective. Based on the climate change model,
● The increase in temperature which is estimated to be constant will affect the rate of evaporation and the rise of sea level. The change in potential evaporation from the model results in the 2030s will increase by around 10% and occurs evenly in almost all Bantaeng Regency. This increase in evaporation can lead to a reduction in the supply of water resources in Bantaeng area.
● In the rainy season, the rainfall is higher and in the dry season, the rainfall is less. On one side, the extreme rainy season will ensure the supply of raw water resources in terms of quantity, but on the other hand, it will have the potential to cause floods and landslides and increase the turbidity level of river water. Discharge from water sources during the dry season will tend to decrease between 15-25% of the discharge without climate change.

6. Recommendations
Some of the things that are recommended from the results of the present research that have been done are as follows:
● It is necessary to make a grand design plan for the conservation and protection of groundwater resources for Bantaeng area in general and for the spring recharge area in particular in an integrated manner by involving all stakeholders.
● It is essential to master and understand simple technology related to water management and conservation activities in Bantaeng area, such as techniques for making infiltration wells, exploiting and harvesting rainwater, embung technique (type of water harvesting), serial dam checking, mounds and vegetation conservation adapted to the situation, conditions, and characteristics of each site.

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