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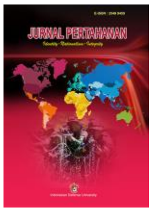

ROBUST DECISION MAKING (RDM) INVESTIGATION IN WATER RESOURCES PLANNING AND DISASTER MITIGATION IN MAKASSAR CITY, INDONESIA

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Abstract

The Kota Makassar water utility serving (*Perusahaan Daerah Air Minum* - PDAM) faces a significant problem in managing water resources for their drinking water supply. The problems comprise raw water supply, the vulnerability of water quality, infrastructures, costs, and climate change uncertainty. The availability of clean water is one of the problems in the field of national defense. Because water is the main source of life in all sectors, be it agriculture or livestock. This study is aimed at assisting officials in making an adaptive and resilient decision. It involves inter-and cross-disciplinary studies within Robust Decision-Making (RDM) in water resources management planning for drinking water supply and disaster mitigation in Makassar. This research applies a qualitative approach in data analysis; reviewing strategies used by the utility management to anticipate all uncertainty, long-term strategies feasibility from simulation models, analyzing potential vulnerability scenarios, and the trade-off for an adaptive and robust decision in water resources management planning for drinking water supply in Makassar through RDM. The novelty lies in the raw water management policy that is more adaptive toward potential vulnerability and presents a variety of raw water supply alternatives in the long term. Reviews against the document of drinking water Master Plan found that the absence of harmony along with a high level of anticipation towards the threat of climate change along with their impact, as well as the threat of the raw water supply limitations due to the exogenous problems beyond the reach of human beings capacity, will result in global and long-term impact.

INTRODUCTION

Common natural disasters such as floods, droughts, fires, and others are a problem in almost all countries. One of those countries is Indonesia. In this case, this study conducts research related to environmental problems that occurred in Makassar City, Indonesia. A total of 24 urban villages in 6 (six) sub-districts in Makassar City with an area of 2,761.84 ha become flooded areas during the rainy season. Celebes Research Center (2015) released data from August 2014 to August 2015 showing that as many as 40.3% of Makassar City residents admit that the most dominant natural disasters are floods during the rainy season and 10.5% house/building fires during the dry season (Abbas & Routray, 2014).

The condition of groundwater in the neighborhood where residents live experienced problems in August 2015, namely as many as 21.4% of residents reported that the groundwater around their residence was cloudy, 18.1% of the population acknowledged that groundwater smelled, 16% stated that groundwater was tasteless, 15, 2% found groundwater colored, and 7.6% of residents stated that groundwater was foamy (Prastowo et al., 2018). This data is related to a survey for the preparation of the population happiness index of Makassar City which has increased every year due to birth and urbanization. The Makassar City Government is challenged to meet the demand for land for housing, services, and city infrastructure (Wekke, Rajindra, et al., 2019). The demand for meeting these needs practically has an impact on decreasing environmental quality such as environmental degradation and natural disasters, especially in the eastern region where housing development is currently active (Bosschaart et al., 2016). Based on its topography (Figure 1), Makassar City has a land slope of 0-2º (flat) and a land slope of 3-15º (undulating) with a stretch of lowland with an altitude between 0-25 meters above sea level (BPBD, 2014). Makassar City is administratively the capital city of South Sulawesi province in the western part of the island of Sulawesi with an area of 175.77 km2 which is located along the coast of the Sulawesi Sea or Makassar Bay. The astronomical position of Makassar City is at 199º24'17'38 ''East Longitude and 5º8'6'19'' South Latitude. The highest temperature was recorded at 34.8ºC and the lowest at 20.10ºC.

Based on the description of the topographic, demographic, and social areas of the community, natural disasters in the form of floods and droughts, and fires are difficult to avoid (Sagala et al., 2019). The cause of flooding in Makassar City is a form of an accumulation from the relatively flat elevation of Makassar City, a coastal area, influenced by the tides of seawater, poor drainage conditions, high rainfall, and low public awareness in managing waste (Abbas & Routray, 2014). Citizens who lack awareness often throw garbage in the drainage channels or what is known by the people of Makassar City (Wekke, Sabara, et al., 2019).

The waters of Losari Beach, the estuary of the Tallo River, and the two estuaries of the Jeneberang River are contaminated by heavy metals, including iron (Fe) 0.00297 - 0.0324 ppm, lead (Pb) 0.64 - 1.39 ppm, and copper (Cu) 0.37 - 0.57 ppm. The presence of heavy metal content threatens the life of aquatic biota because the metal, apart from having chronic toxicity, is also acute (Prastowo et al., 2019). Heavy metal contamination in the three water areas

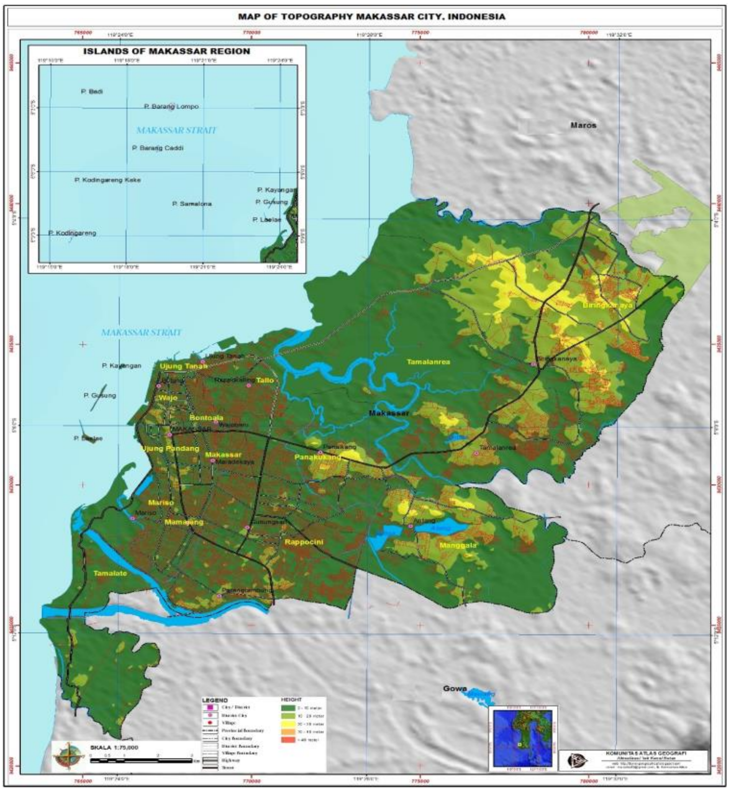

Figure 1. The topography of Makassar City
Source: Indonesia Geospatial Portal, 2017

comes from the coastal waters of Makassar City, river bodies, and the mainland generally in the form of industrial waste and urban waste. The heavy metal waste shows an increasing trend or trend from Pb of 18.01 ppm in 2006 to 27.23 ppm (Sudirman et al., 2018).

The problems above should not be delegated to the water manager alone, but the community and other stakeholders are also responsible. The increasing need for water supply due to population growth and increase, economic growth, increased agricultural irrigation needs, and the growing desire to provide water supply for the environment is very potential creating pressure in the water resources management system in Makassar City. This condition is exacerbated by a decrease in the potential for raw water supply caused by a variety of environmental problems, high levels of pollution to water resources, and long-term climate change (D. Groves et al., 2017). The phenomenon of wasteful water use, pipe leakage, watershed pollution, and other problems is not only due to mismanagement of water resources, but the patterns, behavior, and culture of the community (consumers) are not involved in a conservative and sustainable management system (Fischbach et al., 2017).

In the IPCC report (2007), it is stated that climate anomalies also affect the availability of water resources so that to preserve sustainable water resources, support, and cooperation from various parties such as government, environmental organizations, and the community is needed. Its management requires knowledge of its geo-hydrological characteristics, water resources management systems, culture, and local wisdom. Therefore, it requires a type of planning approach that is flexible and capable of providing accurate considerations in making decisions about the conservation and management of water resources in Makassar City and its surroundings.

Related to this problem, many scientists in the world have carried out various studies to solve the problem. Various domestic and foreign research results related to climate have also been produced and archived in various forms of journals or books. In this case, we conducted a study using primary and secondary data obtained from Regional Drinking Water Company (*Perusahaan Daerah Air Minum* - PDAM) of Indonesia. This research is expected to help answer problems or examples in handling water resources and disaster mitigation.

Robust Decision-Making (RDM) problem solving can be done by giving different importance weights to each Decision-Making (DM). Different weights for each DM have the chance to make better decisions (D. G. Groves et al., 2019). The process of determining the weight of DM's interests has its difficult level. The difficulty of determining DM importance weight has been resolved or resolved by the emergence of various methods for determining DM importance weight. Several methods of determining the weight of DM interests include determining the weight of DM interests which is based on the competence of DM. Another method that can be used to determine the weight of DM's interests is a method based on the evaluation of DM's assessment of alternatives in terms of maximum consensus. These two methods of determining the weight of the DM's interests have their respective advantages. The method of determining the weight of DM's interests based on competence has its advantages when compared to the method of determining the weight of DM's interests based on consensus (Kalra et al., 2015). The advantage of this method is that DMs who have high competence will receive high importance weight. Another advantage that this method has is the consistency test of the opinion of the DM. The more consistent the opinion given by a DM, the higher the weight of the DM's interests. The main emphasis of this method is on the competence of a DM based on consistency. Even though the contribution of a DM to the group also needs to be considered in group decision making. The contribution of a DM is important because it can influence the decisions made in an RDM (Lempert, 2019).

This study is aimed at assisting officials in making an adaptive and resilient decision. This study is expected to assist in reviewing strategies used by the utility management to anticipate all uncertainty, long-term strategies feasibility from simulation models, analyzing potential vulnerability scenarios, and the trade-off for an adaptive and robust decision in water resources management planning for drinking water supply in Makassar through RDM.

METHODS

Robust Decision-Making (RDM)

This study uses the RDM approach in making decisions on water resources management planning for drinking water in Makassar City. In general, this research will utilize data in the form of calculated figures as well as words or acknowledgments of people or writings from official documents from available sources as evaluation material in the RDM approach. Based on the characteristics of these data, this study will take advantage of the positivism view with quantitative methods and a small part will use the post-positivism view with qualitative methods. Both types of data will be used separately but will support each other as a form of reinforcement of the results so that the main method of analysis will use quantitative methods. The next quantitative method will color the research design that focuses on the steps or procedures for Robust Decision-Making or RDM related to decision making in water resources planning strategy policies.

The definition of Robust Decision-Making in this study is understood as the ability of the system to face obstacles in making decisions on water resource planning (Adji et al., 2016). The concepts that will be developed include the concept of ecosystem elasticity and can be increased by increasing the resistance scale which is measured based on the maximum amount of disturbance and threat needed to determine the resilience or flexibility of the system with the decisions taken (De Bruijn, 2005). Another concept that will also be developed is the resilience of economic systems and social systems as an integrated part of interdisciplinary studies.

This participatory scoping is a form of focusing attention on issues or problems that will be studied or resolved through brainstorming activities (in Bugis language it is known as Tudang Sipulung) or what is commonly called Focused-Group Discussion (FGD). Participants expected to attend this activity are stakeholders, policymakers, resource persons, and water users according to their respective capacities. This activity aims to define or limit the scope of objectives and measurement, the scope of the strategy that can be used to achieve the objectives, the scope of uncertainty that will affect the successful use of the strategy, and the scope of the relationship that will help demonstrate the process of using measurement (Haerudin et al., 2019).

Types of Data and Data Sources

The types of data that will be collected in the implementation of the research consist of primary data and secondary data. Primary data obtained from observations that are documented in the field, structured and unstructured interviews, filling out questionnaires, and multilevel FGDs on competent parties categorized into respondents and resource persons. This research was conducted for 12 [twelve months] in Makassar City and its surroundings and focused on the key locations of Regional Drinking Water Company (*Perusahaan Daerah Air Minum* - PDAM), Pompengan-Jeneberang River Basin Hall or BBWS-PJ (*Balai Besar Wilayah Sungai Pompengan-Jeneberang*), and the coast of Makassar City. The resource persons referred to are the parties institutionally (capacity of functions and positions) as well as individual capacities (special expertise) of the topic being studied. The speakers are divided into groups; main sources, companion sources, comparative sources, and expert sources. Respondents referred to are stakeholders, community drinking water users, or PDAM customers in Makassar City.

Secondary data is data and information obtained (sourced) from literature and library sources in the form of journals, books, pictures, videos, and others that are relevant to the research problem. Secondary data required include regional and national planning documents, PDAM Makassar City Strategic Plans, BBWS-PJ Strategic Plans (River area management is divided into cross-country river areas; trans provincial river area; national strategic river area; trans regency/municipal river area; and river areas within 1 district/city), PLN, Makassar City BPS, and relevant research results.

The data in Table 1 were analyzed in answering the four problems that will contribute to answering the main objectives of the research. Contribution after being faced with answers, data, and information from respondents and resource persons in a separate collection approach (technique). The technique is combined through various variables and indicators that are determined between the script and its existing conditions (Bosschaart et al., 2016).

Data Analysis Techniques

The analysis technique to be used in this study follows an iterative or iterative 4-step process and key RDM procedure. The four key steps are used to follow the research objectives, namely 1) Participatory Scoping, 2) Case Generation and Exploration, (3) Scenario Discovery, and, 4) Tradeoff Analysis. The key 4-step RDM process can be summarized in the scheme adapted from Groves et al (D. G. Groves et al., 2019).

Table 1. Stages of Data Collection

Topic	Study	Data collection technique	Source
Participatory Scoping	Step 1 Analysis of RDM	Literature Study, FGD, Interview, Observation	BBWS-PJ and PDAM Makassar City Government Strategic Plan Documents, Informants, Respondents
Case Generation & Exploration Models	Step 2 Analysis of RDM	Literature Study, FGD, Interview, Observation	Renstra Documents, Informants, Respondents, Resource Persons
Scenario Discovery	Step 3 Analysis of RDM	Literature Study, FGD, Interview, Observation	Renstra Documents, Informants, Respondents, Resource Persons
Tradeoff Analysis	Step 4 Analysis of RDM	Literature Study, FGD, Interview, Observation	Renstra Documents, Informants, Respondents, Resource Persons

Source: Bosschaart et al., 2016

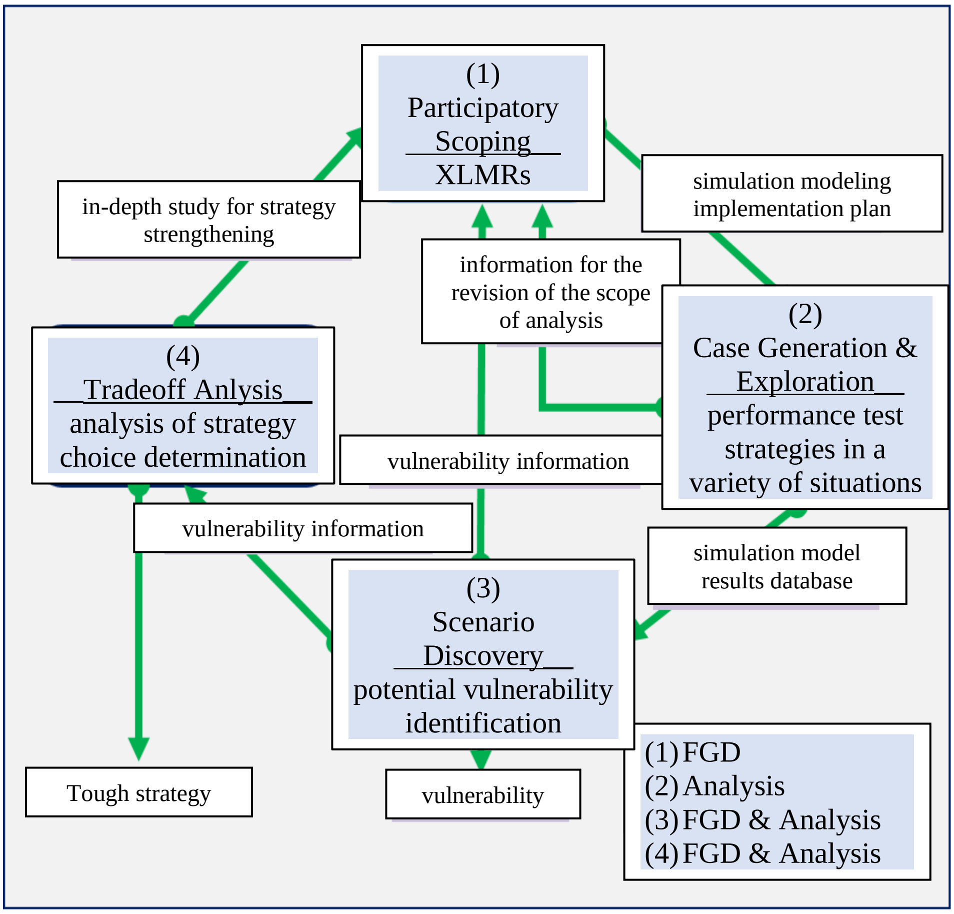

Figure 2. Schematic of the Iterative RDM 4-Step Analysis Design
Source: Lempert, R. J., 2019

The RDM analysis design scheme presented in the figure below serves as a guide in analyzing the four problems to answer the research objectives, namely, Objective 1: Describe analytically the results of goal setting and achievement strategies, forms of uncertainty, and the measurement and process of using them. Step 1: Participatory Scoping.

Qualitative data analysis will be carried out by descriptive analysis that describes the various observations and field analyzes. The data sources that were used as material for the review before the FGD were the

Makassar City PDAM Corporate Plan 2011-2036, the BBWS-PJ Long-Term Plan Document, BBWS-PJ Challenges and Opportunities Management, BBWS-PJ Master Plan, and other documents on BBWS-PJ. The steps are taken in qualitative data analysis according to Creswell (2014), are to categorize the information obtained (open coding), choose one category and place it in a theoretical model (axial coding), then compile a story of the relationship between categories (selective coding). The qualitative descriptive approach in document review refers to variables and indicators for each objective, namely 1) planning that anticipates climate change and 2) planning for long-term raw water availability.

Research Location

This research was conducted for 1 Year or 12 months in Makassar City and its surroundings and focused on the key locations of PDAM Makassar, BBWS-PJ, and the coast of Makassar City. This research involves parties with an interest in making decisions related to planning strategies for water resources management for drinking water in Makassar City at various levels and sectors at the central to regional levels as well as the customers of Makassar City PDAM, communities living around the Jeneberang River, academics, and NGOs. Researchers also made observations in several locations related to research topics, namely community settlements such as in Tanjung Bunga, Tallo, Lantebung, and the Bile-Bile dam as the main supplier of raw water to Makassar City and its surroundings.

Geographically, the position of Makassar City, which is located in the coastal area of South Sulawesi, is very sensitive to various threats of climate change. Uncertain climate changes will also affect the management of drinking water in Makassar City. Data obtained from the Regional Disaster Management Agency (BPBD) shows that the annual flood events in Makassar City occur every January and February. The nature of the January and February floods tends to recede within 48 hours but the area of land affected by flooding increases every year.

Historically, floods and strong winds that occurred almost every year caused losses and damage to Makassar City. According to BPBD (2013), between 1999–2013 there were 26 cases of flooding with damage to 324 houses and 6,476 people affected. The flood in January 2013 caused 5,763 people to become victims and was declared the worst flood incident in history in Makassar City. The worst-hit areas are in the lowlands with poor drainage and sanitation systems. New housing in the suburbs of a former agricultural area became the location of the main flood in January 2013. Strong winds average 2 cases a year. Reports of cases of strong winds that damaged 300 houses and killed 200 people occurred between 2003-2012. Drought, fire, large sea waves, endemic diseases, also colored problems that occurred in Makassar City. All occur due to climate change that is uncertain or difficult to predict and will have different impacts according to the geographical location of the area.

Along with its development, the need for clean water for the residents of Ujung Pandang Municipality continues to increase so that in 1977 PDAM KMUP built Installation II of Panaikang with a capacity of 500 liters/second, and continues to grow according to clean water needs until December 2011 following the installed production capacity of 2,337 liters/seconds, where the number of active subscribers is 154,500 SL and 14,580 SL active customers with a service coverage of 61.87% (828,635 people) of the total population of Makassar City 1,339,374 people (BPS data prediction) in 2010. Clean water processed by PDAM Kota Makassar utilizes raw water sources from surface water (rivers) but the problem is that the distribution system of clean water to customers is not full for 24 hours per day and the average water loss rate is 48.40% in

2010.

RESULT AND DISCUSSION

From the results of data collection, some information and types of data were obtained. Among them are research data consisting of 1) data on future climate change vulnerability and adaptation strategies, 2) Data on the planning of the Jeneberang River management system, 3) Data on the planning of drinking water management for PDAM Makassar City, and 4) Socio-economic data for the customers of Makassar City PDAM. Data were analyzed descriptively and the results were used to answer 4 key research questions that led to the achievement of research objectives using the steps in the RDM method. However, Lempert, R. J. (2019) stated that the steps that have not been carried out analytically in this research are measurement and testing models that are very technical such as measurement of rainfall, flood patterns, river flow, water discharge, and adaptation strategies that are in the adaptation strategy pattern. Jeneberang river area.

The Water Utility Serving (PDAM)

The main duties of Makassar City PDAM in carrying out its functions, 1) public services/services, 2) provides public benefits, and 3) generates income. Its operational activities are managing the distribution and service of drinking water that meets health requirements to the community evenly, orderly, and regularly, as well as implementing urban development and services.

The leakage prevention system carried out by PDAM Makassar City in collaboration with Japan is to overcome technical and non-technical (administrative) water loss figures. Technical leaks occur due to leaky pipes, abnormal water meters, and water theft. The way of handling it is fixing the network, replacing the water meter, installing the main water meter (district), and detecting illegal connections (bypass) made by customers with the help of several leak detection equipment that is owned by PDAM Makassar City, namely a) water leak detector, b) leak noise correlator, c) pipe locator, d) iron pipe and live cable locator, e) box locator, f) water pressure recorder, g) ultrasonic flow meter, h) metal pipe locator, i) non-metal pipe locator, j) digital sound detector, k) hammer drill, and l) distance meters.

For non-technical (administrative) leakage types, the administrative water loss rate occurs due to errors in recording water meters and data entry errors into water accounts. Active water loss prevention system, which has been implemented by Makassar City PDAM is a meter recording assistance system carried out by CV. Toddopuli Raya Makassar with PDAM Makassar City for 3 (three) consecutive months and was followed by the formation of a Customer Water Meter Reading Monitoring Team. Several benefits can be obtained from this assistance system, including a) Accuracy of meter recording, b) The water loss factor can be determined with certainty, c) The prevention of water loss can be directed directly at the causative factors, both technical and non-technical, d) Control over illegal connections (illegal) can be carried out completely, e) Customers' water usage can be determined through district meters and if a loss occurs it can be detected early, f) Cost of handling per house connection can be studied through several Pilot Projects which will be used as a reference, and g) Technology transfer and human resource improvement, for PDAM Makassar City employees. As an illustration of the results of the active leakage prevention Pilot Project, the document presents a table of 4 pilot project areas.

Based on the SWOT analysis and diagnostics of the Strengths, Weaknesses, Opportunities, and Threats identified in detail, the main factors that significantly influence the determination of the company's general policy are low production capacity and service coverage

Table 2. Projection of Makassar City Household Clean Water Needs until 2030

No	Description	Before	After	Unit (SL, BH, %)
A	**Pilot Project Phase I: Taman Kayangan Housing Complex**			
1	Number of Customers	538	538	SL
2	Unauthorized Line	1	0	SL
3	Leak Point	20	0	SL
4	Unsealed Meters	44	0	SL
5	Burst Meters	5	0	SL
6	Meter Blur / Blur	15	0	SL
7	Water meter ≥ 5 years old	271	0	SL
8	Number of Replacement Water Meters	0	362	BH
9	Water Loss Rate	11.16	3.53	%
B	**Pilot Project Phase II: Hartako Indah Housing Complex**			
1	Number of Customers	559	559	SL
2	Unauthorized Line	-	-	SL
3	Leak Point	70	-	SL
4	Unsealed Meters	-	-	SL
5	Burst Meters	-	21	SL
6	Meter Blur / Blur	-	5	SL
7	Water meter ≥ 5 years old	-	322	SL
8	Number of Replacement Water Meters	-	348	BH
9	Water Loss Rate	28,84	12,72	%

Source: (Data from PDAM Makassar City, 2017)

high levels of water loss, low accounts receivable collection rates, increased components. production costs, enormous debt, labor inefficiency, and less targeted investment policies. As for the supporting factors in implementing and supporting the main factors vary from law to enactment of the tariff review which is not timely.

Data from BMKG

Based on data from BMKG Makassar City, the average rainfall pattern in Makassar is constant but the rainy period or season will be shorter. The temperature in Makassar City has increased constantly and has an impact on increasing evaporation and rising sea level which causes tidal flooding. The following table shows that the lowest temperature occurs in July-September (20°C), the highest (31°C) in August-October with average temperatures. -an average of 26°C per month.

Based on the focus group discussions, the BMKG stated that the annual rainfall in Makassar City is expected to increase slightly and the intensity of the rain will be heavier but with a shorter time. Referring to the models presented (Figure 3), the projection for the start of the rainy season is still constant, but is expected to be delayed 12 days earlier. During the dry season, the rainfall is estimated to have decreased by an average of 36% and the trend of increasing the average temperature per year is 0.5°C. This is projected to continue due to global climate change.

In addition, it was also stated that sea level has increased by 7.5 cm per 10 years or 0.74 cm annually which has been monitored since 1993. In 2017, when focus group discussions were held, BMKG stated that the sea level had reached 82.16 cm. The simulation results conducted by the BMKG estimate the sea level rise in Makassar City will reach 88.16 cm in 2025, and 1.14m in 2050, then in 2100 it will reach 1.44m high. Strong winds along the coast that often endanger fishermen's life can reach 50 - 60 km/hour.

Public projections of the possibility of a disaster in Makassar City due to climate change are still dominated by the possibility

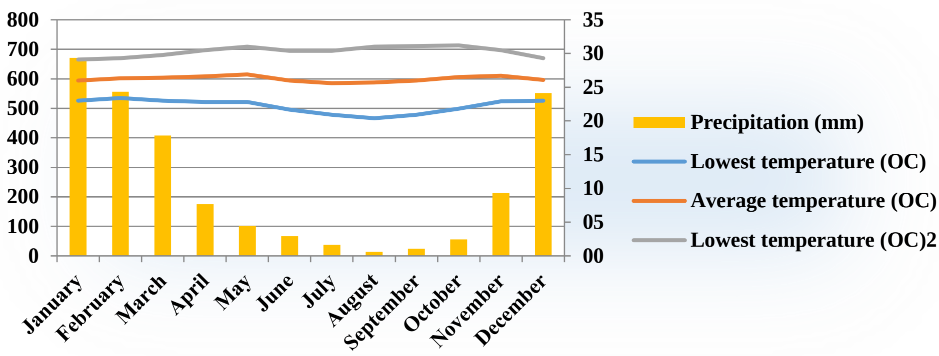

Figure 3. Temperature Conditions in Makassar City
Source: Makassar, 2017

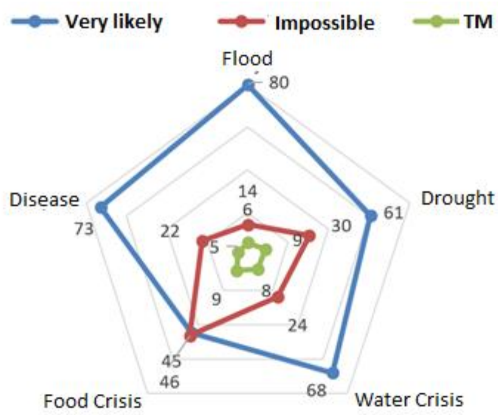

Figure 4. Prediction of Possible Disaster due to Climate Change Impacts in Makassar City
Source: Makassar, 2017

of flooding (80.8%), drought (60.8%), water crisis (38%), food crisis 44.8%, and disease (72, 8%). People with a limited understanding of environmental conditions and climate change predict various possibilities for disasters due to climate change. The various disasters presented in the table above are predicted to threaten the life of the people of Makassar City with quite significant possibilities, except for the relatively small number of food availability.

This condition shows that the community is still optimistic that they will remain and can survive conditions of extreme climatic threats, but the productivity and availability of food production can still be used as life support. The clean water crisis is quite worrying because of the increasingly limited access to clean water both in quality and quantity, water consumption patterns that are not environmentally friendly, waste in water utilization, and the discontinuity of public policies regarding the protection and restoration of raw water sources will continue to be threats in the future.

BBWS-PJ Adaptation Strategy

BBWS-PJ plans three types of scenarios to choose from for the adaptation strategy to the Jeneberang river problem (See Tables 3). The scenario for determining operational policies for natural resources management is influenced by the conditions of the economic growth scenario, whether it is low, medium, or high, as well as political conditions and climate change factors. The operational policy for implementing the natural resource management strategy is the main direction for implementing the

Table 3. Water Balance Projection in Jeneberang WS in 2013 to 2033, with a low economic scenario

Information	**(m³/dt)**				
	2013	**2018**	**2023**	**2028**	**2033**
Water Requirement:					
- Irrigation	122,89	126,82	126,82	126,82	126,82
- Household and Urban	7,84	9,26	10,93	13,71	16,99
- Industry	0,50	0,69	0,87	0,80	1,26
- Pond	17,32	17,35	17,39	17,43	17,47
The amount of water needed	148,55	154,12	156,00	158,76	162,54
Availability	139,79	150,72	155,49	161,84	166,51
Q Mainstay 80%	741,26	741,26	741,26	741,26	741,26

Source: Primary Data Analysis, 2018

predetermined natural resource management strategy.

Each scenario matrix contains 5 aspects, namely 1) Conservation of Natural Resources, 2) Utilization of Natural Resources, 3) Control of Water Damage, 4) Information Systems of Natural Resources, and Roles, 5) Participation of Community and Business World. The summary of the scenario of adaptation strategy options that have been, are being, or will be implemented by BBWS-PJ is arranged in the form of a matrix with the following contents Low Economic Scenario Adaptation Strategy (Scenario 1), Adaptation Strategy for Medium Economic Scenarios (Scenario 2), and High Economic Scenario Adaptation Strategy (Scenario 3).

CONCLUSIONS, RECOMMENDATION, AND LIMITATION

Based on the results and discussion, conclusions can be drawn from the dissertation research on the RDM Model for drinking water management in Makassar City as follows;

1. Climate scenarios are representations of future climate conditions that are compiled based on the output of climate models that are built to study the consequences of anthropogenic effects on climate change and are often used as input for climate change impact models. Exogenous uncertainty elements are divided into, uncertainty related to hazard, uncertainty related to exposure, and uncertainty related to vulnerability.
2. Future climate change has the potential to exacerbate threats to the PDAM's built infrastructure, particularly the risk of flooding in the lower topographical catchment area and the danger of landslides in the upstream catchment area. Climate change is expected to increase the threat of landslides in several assets. Regarding the PDAM plan for development plans, especially infrastructure construction, planning the location of transmission pipelines, and tapping buildings, both primary and secondary or tertiary channels, it is necessary to consider the threat of landslides.
3. Climate change adaptation is a process of adjustment to real or actual or predicted climate and its impacts which aim to reduce hazards or take advantage of every opportunity. Adaptation actions can take the form of modification of plans, rehabilitation, or construction and reconstruction of buildings. Besides, PDAM management uses 'no-regret' adaptation options or which provide benefits until the future climate and its impacts occur.
4. Short-term adaptation strategy plans are very important to be implemented as the initial basis for long-term climate change adaptation planning and are integrated into planning mechanisms or management in the form of a Business Development Plan (Business Plan) or

PDAM RKAP as well as the annual and medium-term plans of city governments. Implementation of the intended action plan, especially the preparation of programs for maintenance or exploration of new raw water sources, integrating the results of the Vulnerability Assessment and Adaptation Plan into the revised Business Plan for the next 5 years, and the city government formulates a budget program for improving natural resource management in the next annual APBD budget plan.

5. Long-term planning activities, BBWS-PJ and PDAM Makassar City must be able to monitor and control river flow and increase in demand in line with population growth rates and then assess whether this condition will be in a stable, vulnerable, or very vulnerable condition.

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