

Judul : **Integration of Green Ergonomics in Robust Decision Making Approach in Water Resources Management in Makassar City**

Jurnal : **International Journal of Technology (IJ-Tech)**

Reputasi : **Terindeks Scopus Q2, SJR 0.43, EBSCO, Impact Factor 1.395**

No	Item	Tanggal	Halaman
1	Submission Letter (Cover Letter)	2 September 2021	2
	First Manuscript Submitted	2 September 2021	4
2	First Decision of Manuscript	12 January 2022	17
3	1 st Submission Paper Revised and Response Letter to Reviewer	17 January 2022	20 34
	Reduce Pages of Manuscript	1 March 2022	38
5	2 nd Submission of Revised Version of Manuscript	1 March 2022	40
	Result of Line-editing of Manuscript	9 March 2022	52
6	Final Paper Proofreading and Copyright Form	22 March 2022	55
7	LoA Issued	31 March 2022	71
7	Paper Published	1 April 2022	74

Submission Letter



Universitas Muslim Indonesia

Cover Letter

September 2, 2021

Dr. Mohammed Ali Berawi

Editor in-Chief

International Journal of Techonology (IJ-Tech)

Dear Editor:

I wish to submit a research article for publication in IJ-Tech titled “Integration of Green Ergonomics in Robust Decision Making (RDM) Approach in Water Resources Management in Makassar City.” The paper was coauthored by Zakir Sabara, Irma Nur Afiah, Rofiqul Umam.

This study integrated the concept of Green Ergonomics research on water resource management and expected that decision making and strategy identification can lead to efficiency and effectiveness the work system of water resource management. We believe that our study makes a significant contribution to the literature because, to our knowledge, there has been no investigation of the integration of green ergonomics and RDM. Therefore, we believe that this paper will be of interest to the readership of your journal.

This manuscript has not under consideration by another journal. We have read and understood your journal’s policies, and we believe that neither the manuscript nor the study violates any of these. There are no conflicts of interest to declare.

Thank you for your consideration. I look forward to hearing from you.

Sincerely,

Assoc. Prof. Dr. Ir. Zakir Sabara, ST., MT., IPM., ASEAN Eng
Faculty of Technology Industry, Universitas Muslim Indonesia, Indonesia

Integration of Green Ergonomics in Robust Decision Making (RDM) Approach in Water Resources Management in Makassar City

Abstract. In water resources management, a planning strategy is required in order to be able to minimize the perpetually encountered problems. Water resources for drinking water in Makassar City and other regions in Indonesia are managed by the respective vertical agencies and regional governments. The Regional Drinking Water Company (PDAM) of Makassar City as a company that manages the fulfillment of clean water needs for the residents of Makassar City has operational activities, i.e., managing the distribution and service of drinking water that meets health requirements to the society in an equitable, orderly and regular manner, and carrying out urban development and services. Green Ergonomics becomes a guideline for proposing the basis of interventions, social responsibility, and environmental or ecospheric responsibility. Green Ergonomics is also necessitated for the evaluation and sustainable development, and for a good reciprocal relationship of human and natural systems. Green ergonomics develops an understanding of how variety of resources such as energy, biological entities, and minerals flow through work systems and integrate with ecosystems.

Keywords: Water Resource, RDM, Green Ergonomics, Environment

1. Introduction

Generally, the expansion of flood areas in Makassar City is induced by a decrease in the water catchment areas due to an increase of residential areas as a result of an increase in the city population on account of both births and urbanization trends. At the same time, there is a decrease in the quantity and quality of water due to a decrease in the supply of clean water from two rivers that passed through Makassar City, which are the Jeneberang River and the Lekopancing River. The two rivers originate in different regional government areas and create their own problems in their management that have the potential to cause conflict.

Global climate change has an impact on water resources, especially on the water cycle, water demand, water supply, and water quality standards. According to (Emanuel, 2005) there are two causes of global climate change, i.e.; population growth in coastal areas and natural events. This is in harmony with (Nelson et al., 2010) who stated that global climate change can trigger an increase in the need for clean water supplies, and (Karl et al., 2009a; Lange-Morales et al., 2014) who concluded that an increase in temperature results in changes in river water discharge which causes humans to need more water to grow and maintain health.

In water resources management, a planning strategy is required to be able to minimize the perpetually encountered problems. Water resources for drinking water in Makassar City and other regions in Indonesia are managed by the respective vertical agencies and regional governments. Regulatory clauses on water resources management rules are distinct although the policy implementation is not optimal when the water resources pass through territorial areas that are administratively under different regional governments.

Green ergonomics includes several principles, including *eco-efficiency*, *eco-effectivity* and *eco-productivity* (Thatcher et al., 2013). The green ergonomics approach can be applied in evaluating and developing industries for sustainable development. Green ergonomics ensures that human and natural systems are in a good reciprocal relationship. Green

ergonomics in which there are factors of efficiency, effectiveness, and productivity move beyond the specific reference of a work system. Green ergonomics develops an understanding of how variety of resources such as energy, nutrients, biological entities and minerals flow through work systems and integrate with ecosystems. This involves understanding something about flows of life cycle transformation and their integration, and understanding what happens to the 'waste' generated by the system (Lange-Morales et al., 2014).

The Regional Drinking Water Company (PDAM) of Makassar City as a company that manages the fulfillment of clean water needs for the residents of Makassar City has operational activities, i.e., managing the distribution and service of drinking water that meets health requirements to the society in an equitable, orderly and regular manner, and carrying out urban development and services. The last 10 years, the government and PDAM of Makassar City tend to face the same problems related to the management and utilization of water resources, which are; (1) drought in the dry season and flood in the rainy season, (2) competition for water use between the upstream and downstream areas or conflicts in various sectors, (3) excessive and inefficient use of water or leakage, (4) narrowing and silting of rivers and lakes due to pressure on land for settlement and industry, (5) pollution of surface water and ground water, and (6) erosion due to deforestation. These increasingly complex problems require PDAM Makassar City to manage water resources optimally so that it can support people's lives well.

With various encountered problems related to the imbalance in the amount of water availability, it is necessary to manage the amount of water availability and the amount of water demand. Therefore, the water utilization is able to meet the criteria of integration is space functional, sustainable, and environmentally friendly. One method that can be employed to analyze environmental problems is the Robust Decision Making (RDM) method. RDM can be relied on in strategic decision making for strategic water resources planning policies. (Karl et al., 2009b), (Matrosov et al., 2013), and (Casal-Campos et al., 2015) studied environmental problems and water resources management, but did not involve decision making as a key strategy for solving water management problems.

In addition, this study aimed to integrate the concept of Green Ergonomics as a guide to propose the basis of interventions, social responsibility, and environmental or ecospheric responsibility on water resources management. Green Ergonomics is also required for evaluation and sustainable development, and for a good reciprocal relationship of human and natural systems. Green ergonomics develops an understanding on how variety of resources such as energy, biological entities, and minerals flow through work systems and integrate with ecosystems. This involves understanding the flow of the transformation life cycle and its integration (Lange-Morales et al., 2014). Consequently, it is considered necessary to combine ecological or environmental aspects with ergonomic aspects, which in this case is the water resources management in a work system.

Furthermore, there are several recent studies that discussed water resources (Knox et al., 2018; Odume and Wet, 2016; Xie et al., 2017) but did not examine the decision making in the water resources management system and the previous research did not use an approach that focuses on global environmental and climate issues that are full of uncertainty. Moreover, this is the first research that integrates the concept of Green Ergonomics research on water resources management; hence, it is expected that decision making and strategy

identification can lead to efficiency and effectiveness in the work system of water resources management.

2. Methods

This study used the RDM approach for strategic decision making on water resources management planning for drinking water in Makassar City. Robust in this study is considered as the ability of the system to face decision-making constraints on water resources planning for drinking water. The concept to develop is the concept of ecosystem elasticity which can be improved by upgrading the scale of resistance. This is measured by the magnitude of the disturbance and the maximum threat required to determine the resilience or flexibility of the system with the decisions taken (De Bruijn, 2005). Furthermore, the resilience of the economic system and social system is also developed as an integrated material in the interdisciplinary studies, which in this case are the study of Green Ergonomics and Environmental Management.

2.1. Data Resources

The data collected in this study are primary data and secondary data. The primary data was obtained directly through observation, FGD, and interviews with resource persons in regards to the questionnaire guide. Meanwhile, the secondary data in this study were regional and national planning documents, Strategic Planning (Renstra) of Makassar City PDAM, Strategic Planning of Water River Central Region-Pompengan Jeneberang (BBWS-PJ), State Electricity Company (PLN), Central Statistics Agency (BPS) of Makassar City, and relevant related research. In addition, the secondary data were used as a Focus Group Discussion (FGD) material by discussing the 2011-2036 Corporate Plan of Makassar City PDAM, long-term plan documents, management of challenges and opportunities, and the BBWS-PJ master plan.

2.2. Data Collection

The data were collected through structured interviews, consumer surveys through questionnaire distribution which also involved all aspects of humans and work systems, and in-depth observation methods on various objects related to water resources planning and management activities. 125 respondents (61 men and 64 women) from 14 sub-districts in Makassar City were participated in this study. They were representation from 10 various professions with range of age was 18 to 65 years old and that is expected to represent the water user community in Makassar City.

The results of the observations were then combined with the primary and secondary data to conduct a Focus Group Discussion with the entire components involved. In short, there were four steps in data collection in order to obtain quality data, which were; (1) *Participatory Scoping*, (2) *Case Generation and Exploration Models*, (3) *Discovery Scenarios*, and (4) *Trade-off Analysis*. In data collection, FGD was also conducted with environmental and ergonomics experts as one of the integrations of Green Ergonomics in RDM to obtain scenarios for solving water resources problems in Makassar City.

2.3 Data Analysis Techniques

The analytical technique that will be applied in this study comply with the 4-step key RDM process and procedure which are iterative. The four key steps were used to adhere to

the research objectives, i.e.: (1) Participatory Scoping; (2) Case Generation and Exploration; (3) Scenario Discovery; and, (4) Tradeoff Analysis. Participatory scoping is basically a form of focusing attention on issues or problems that will be studied or resolved through Focused-Group Discussions (FGD).

The participants who are expected to attend the event are stakeholders, policy makers, resource persons, environmental ergonomics experts and water user communities according to their respective capacities. This activity aims to define or limit the scope of objectives and measurements, the scope of strategies that can be employed to achieve the objectives, the scope of uncertainty that will affect the successful use of the strategy, and the scope of relationships that will help demonstrate the process of using the measurement. Thus, the conceptual model of problem solving is shown in Figure 1.

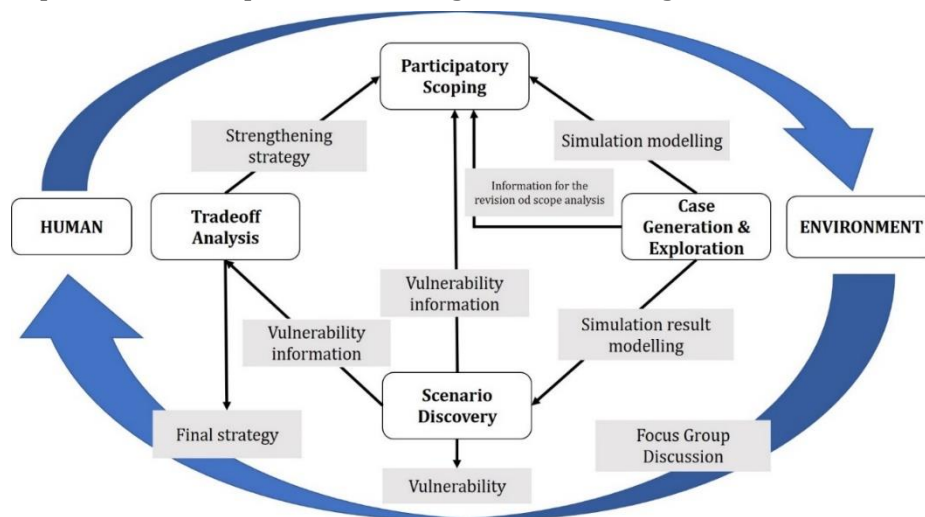


Figure 1 Green Ergonomics- RDM Conceptual Model

In order to implement the conceptual model above, the following steps are implemented:

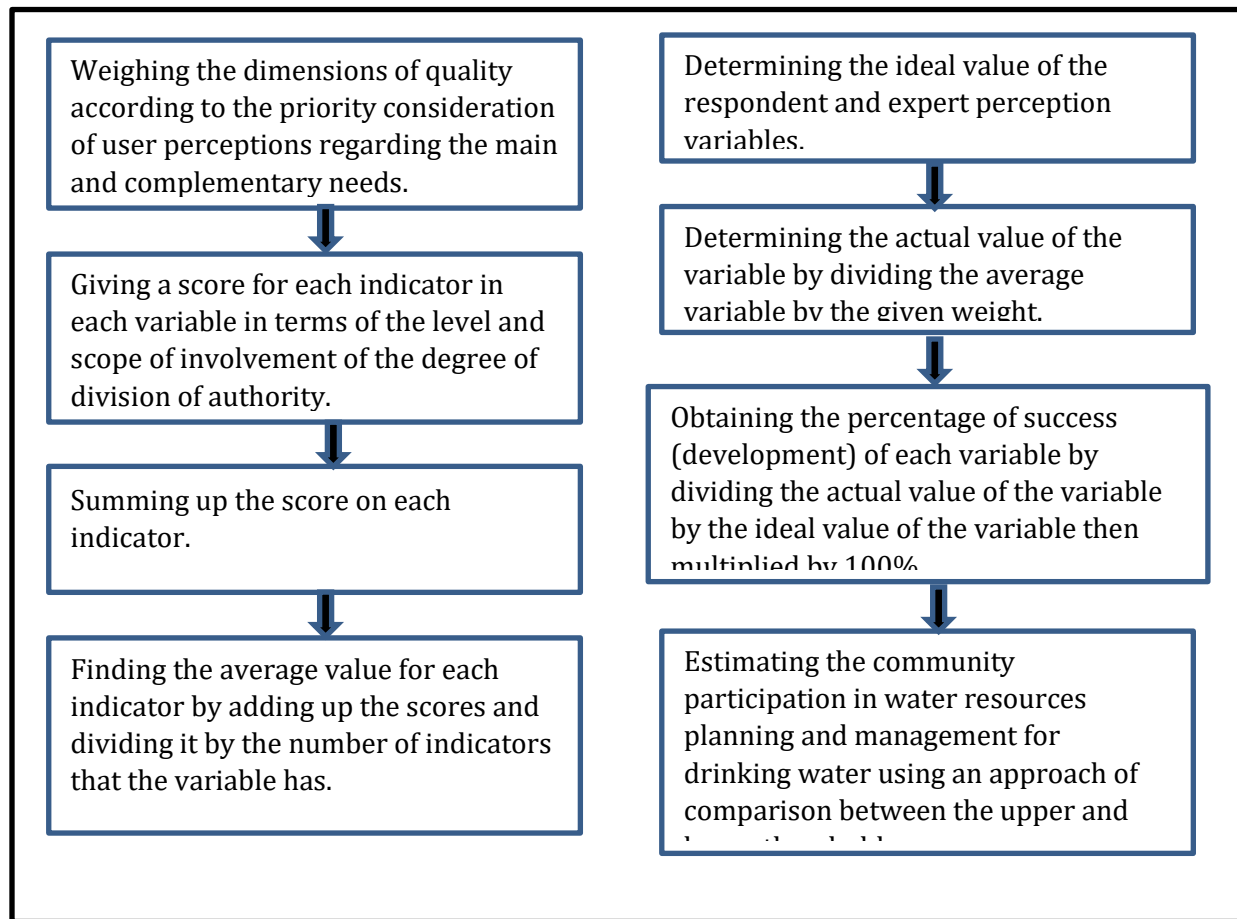


Figure 2. Data Analysis Stage

3. RESULTS AND DISCUSSION

Five main data components were obtained: (1) Data on future climate change vulnerability and adaptation strategies; (2) Data for Jeneberang River management system planning; (3) Data for drinking water management planning of Makassar City PDAM; (4) Socio-economic data of PDAM Makassar City customers; and (5) Green Ergonomics concept in water resources management in Makassar City. The five data were obtained from vulnerability assessment documents, focus group discussions, interviews, and socio-economic surveys of the people using PDAM water services.

The data were analyzed descriptively and the results were used to answer 4 key research questions that lead to the achievement of research objectives. In this study, vulnerability data were used as the baseline data in Exogenous Factors or Exogenous Uncertainty (Xs) while adaptation strategies were used as Policy Levers data (Ls). Exogenous uncertainty (Xs) is a factor that is difficult for decision makers to control but is important in determining the success of the strategy. Meanwhile, Policy Levers (Ls) are the diversity of

combinations of short-term adaptation actions consisting of alternative strategies that will be implemented.

3.1 Climate Vulnerability Data

The data obtained from BMKG (Meteorological, Climatological, and Geophysical Agency), both in publications and in focused group discussions, confirms this condition by presenting data on rainfall patterns (precipitation) and Makassar City temperature per 10 years. Based on Makassar City BMKG data, the average rainfall pattern in Makassar is fixed but the rainy season or period will be shorter. The temperature of Makassar City is constantly increasing and has an impact on increasing evaporation and sea level rise which causes tidal flooding. The lowest temperature occurs in July – September (20°C) and the highest (31°C) is in August – October with an average temperature of 26°C per month. The highest rainfall happens in January and February, while the lowest or driest occurs in August – October.

Historically, floods and strong winds that occur almost every year cause losses and damage to Makassar City. According to (BBWS-PJ, 2014), between 1999 – 2013, there were 26 cases of flooding that damaged 324 houses and impacted 6,476 people. The flood in January 2013 caused 5,763 people as the victims and was declared the worst flood in the history of Makassar City. The worst impacted areas were located in the lowlands with poor drainage and sanitation systems. New housings on the suburb of a former agricultural area became the main flood site in January 2013. Strong winds occurred with an average of 2 cases per year. Reports on cases of strong winds that damaged around 300 houses and killed around 200 people occurred between 2003 – 2012. Droughts, fires, large sea waves, and endemic diseases also became the problems that occurred in Makassar City. All take place due to climate change which is uncertain or difficult to predict and will have different impacts according to the geographical location of the region.

3.2 Jeneberang River System Planning Data

Floods in agricultural and residential areas occur due to the inability of river bodies to accommodate the passing water discharge. The floods occur in Maros River, Sinjai River, Bialo River, Pappa River, Allo River, Tamanroya River, Calendu River, Pampang River and Tallo River. Increased erosion and sedimentation in rivers that cause siltation and reduced water storage capacity especially take place in Maros watershed, Jeneberang watershed (mainly due to the landslide of Mount Bawakaraeng), Pappa watershed and Tamanroya watershed. Especially in the Jeneberang watershed, due to the collapse of the slopes of Mount Bawakaraeng, sedimentation into the Jeneberang River was 167.2 million m³ and sedimentation in the Bilibili Reservoir was 75.2 million m³. High sedimentation reaches 3,862 tons/year (Tamanroya watershed 342 tons/year, Jeneberang watershed 1,280 tons/year, Kelara-Karaloe watershed 219 tons/year, Maros watershed 233 tons/year, and Pappa watershed 247 tons/year). Abrasion and critical beaches are spread in almost all regencies/cities in Jeneberang river area, i.e., Takalar Regency, Bantaeng Regency, Bulukumba Regency, Sinjai Regency, Selayar Regency, Makassar City, Jeneponto Regency, and Maros Regency. The total length of the abraded and critical beach is 237 km.

3.3 Makassar City PDAM Drinking Water Management Planning Data

Makassar City PDAM revealed that the biggest problem faced by PDAM Makassar City is the supply of clean water for drinking water. The most important service is the clean water

supply network. This network is threatened by the increasing demand for water as the urban population grows and it is difficult to keep up with the increase in supply. In Makassar city, the urban clean water system relies heavily on water supply from surrounding districts such as Gowa and Maros. In addition, Urbanization and lack of proper management of clean water sources puts these sources at risk. Accordingly, the clean water system also requires additional network to meet the increasing demand and regular maintenance. It is in line with

Details of the problems faced by PDAM Makassar City in water resources management for drinking water for Makassar City residents are:

1. Limited supply of raw water; In regard to raw water constraints, it is proposed to add or build reservoirs that are prioritized for drinking water, SPAM (drinking water supply system) regionalization, and proposals regarding PP (government regulations) that regulate Water Use Rights.
2. Unfavorable regulations; In terms of regulation, Law Number 23 of 2014 regarding Regional Government states that BUMD (Regional Owned Enterprises) is in the form of Perumda or Perusda.
3. Long-term debt; Even though Makassar City PDAM is in the healthy category or has paid off its debt, there are other 175 PDAMs that have debts to the Ministry of Finance with a total debt of IDR 4.7 trillion. The current status is that 76 PDAMs have been restructured (Rp3,297 trillion or 70%), 9 PDAMs do not participate in restructuring (Rp55 billion or 1%), 29 are in the restructuring process (Rp359 billion or 8%), and 6 are restructured (Rp988 billion or 21 %).
4. The electricity tariffs (TTL); In order to run the production and distribution of water to the society, almost all PDAMs use PLN electricity. The average electricity load reaches 40% of the production cost. The condition or national electricity capacity for PDAM is 250 Mega Watt (relatively small for PLN).

3.4 PDAM Customer Condition Data

The survey results show that most of the water sources utilized to meet the needs of clean water already use PDAM service water (84%) but for drinking water needs, people use refilled water (45.6%) more than PDAM services (42.4%). The trend of urban people choosing refilled water is for the reasons of convenience and practicality since they do not need to boil the water for drinking anymore. However, there are still 11.2% of respondents who use well/artesian well water for bathing and washing needs and 5.6% who use it as a source of drinking water.

The types of PDAM customers that were successfully captured in this study were household customers (88.8%) and the rest were public and business facilities. There were 6.4% of respondents who chose not to answer on the grounds that they were not PDAM customers or used other water sources.

The survey results show that some respondents stated that it was easy (61.6%), very easy (29.6%), moderately difficult (6.4%) and difficult (2.4%) to meet their daily clean water needs. This shows that the people of Makassar City are generally still easy to get clean water services for their daily needs.

The survey results show that more than 60% of respondents stated that the quality of clean water for drinking water provided by PDAM Makassar City is odorless, tasteless, and colorless both in the dry season and in the rainy season, while 26% stated that it still smells,

tastes, and is colored both in the dry season and in the rainy season. The rest chose not to respond.

Table 1. Dry Season and Rainy Season Water Quality

NO.	RESPONSE	CLIMATE	ODOR	%	TASTE	%	COLOR	%
1	Yes	Dry	14	13.3	9	8.6	14	13.3
		Rainy	20	19.0	9	8.6	27	25.7
2	Not	Dry	89	84.8	88	83.8	82	78.1
		Rainy	83	79.0	87	82.9	69	65.7
3	No Response	Dry	2	1.9	8	7.6	9	8.6
		Rainy	2	1.9	9	8.6	9	8.6
		Dry	105	100	105	100	105	100
		Rainy	105	100	105	100	105	100

3.5 Green Ergonomics Concept in Water Resources Management in Makassar City

One approach that can be employed to examine this problem is green ergonomics. A study on green ergonomics is necessitated to ensure that PDAM as a water resource administrator in Makassar city must be able to carry out its production process ergonomically, cleanly and efficiently.

In this study, the concept of Green Ergonomics is used to balance the water resources management with the role of humans as managers themselves. Ergonomics currently does not only study the state of a micro work system, but more broadly, it also discusses environmental problems. For almost two decades, (Helander et al., 1996) proposed that ergonomics should address the problems of water and food shortages, inefficient use of energy, pollution and waste, and rapid urbanization. Ergonomics experts are deemed necessary to collaborate in environmental management in one area and must be able to overcome global environmental and social problems such as pollution from big cities. Therefore, this study incorporates the concept of Green Ergonomics as a complement in the water resources management.

3.6 Goal Setting, Achievement Strategies, Forms of Uncertainty, and Measurement Results Models

The RDM process begins with focus group discussion activities that bring together the parties and decision makers to set goals and consider the severity of the problems found in decisions, strategies that can be used to achieve goals, uncertainties that will affect the strategies, and the relationships that govern strategic performance related to decision-making considerations (Patterson et al., 2009)

XLRM refers to four factors: (1) Policy levers (Ls) which means the diversity of combinations of short-term adaptation actions consisting of alternative strategies that will be used, which in this study refer to the Strategic Planning documents of PDAM and BBWS-PJ as the buffer institutions; (2) Exogenous Factors or Exogenous Uncertainty (Xs) which are factors that are difficult to control by decision makers but are important in determining the success of the strategy which in this research refers to the Makassar City Vulnerability Study Document; (3) Risk and Impact Measurement (Ms) which refers to the calculation and evaluation of hazards and risks combined with aspects of vulnerability, exposure, and

sensitivity of city system components caused by unpredictable exogenous factors, which in this study refers to the results of the analysis of the level of vulnerability, exposure, sensitivity, and adaptability; and (4) Relationships and Models (Rs) which represent simulation models that describe the success or failure of adaptation strategies as measured by the impact of risk or the impact of exposure hazard due to exogenous uncertainty (Table 6).

Table 6. Main Elements of XLRM

Exogenous Uncertainty (Xs)	Policy Lever (Ls)
Hazard related uncertainty: <i>Increasing rainfall/flood, Sedimentation, Drought, Environmental damage, Sea level rise, Beach abrasion, Strong wind, Tidal wave.</i> Exposure related uncertainty: <i>Residential area, Total population, Population density, Poverty, Economic growth and equity.</i> Vulnerability related uncertainty: <i>City expansion, Population growth, Clean water supply, Soil erosion, Floods and puddles, Long dry season, Disease outbreak</i>	BBWS-PJ 1. Integrated upstream-downstream Water Resources Management implementation. 2. Construction/upgrade, operation and maintenance: • Water source capacity, • Water discharge for raw water facilities/infrastructure services to meet domestic/household, urban and industrial needs (RKI), • Coverage of irrigation and swamp network services, • Coverage of area protected from the danger of flooding. PDAM 1. Production optimization and capacity building for WTP (Water Treatment Plant) IV and V. 2. Construction of New WTP (Tallo River raw water). 3. Development of the main and tertiary distribution of pipeline network in the Eastern Region (II and III). 4. Rehabilitation of old Dutch pipelines for gradual water loss rates of at least 1 - 2% per year. 5. Plans for adding raw water to support the raw water crisis of WTP II Panaikang by utilizing raw water from the Tallo River during the dry season. 6. Service plan in bulk for PDAM Maros Regency customers which is directly adjacent to the Makassar City PDAM service area.
Relations and Models (Rs)	Impact Measurement (Ms)
ArcGIS Model: calculating the impact of the risk and impact damage SWMM Model Integrated Analytical Risk Model	Availability of raw water supply: balance and effectiveness of available budget related to various impacts of natural resource management planning for drinking water.

3.7 Adaptive and Robust Strategic Decisions in Water Resources Planning for Drinking Water in Makassar City

Based on the results of this study, the key elements of a robust adaptive strategy are identified as follows:

- a) Implementing clear and measurable short-term projects/programs, which, in spite of the risks, still provide minimal benefits until the occurrence of future climate change and its impacts (near-term no-regret projects);
- b) Observing visible signs or indicators of exogenous uncertainty that requires PDAM and BBWS-PJ to prepare additional investments;
- c) Considering and deciding which projects or program activities should be postponed, which in this case are the additional investment to be carried out in the uncertain future conditions;
- d) Monitoring and preparing a pessimistic budget for the remaining vulnerabilities, which in this context are the project sequence or program activities in the master plan that are projected to fail to achieve the objectives of natural resource management for drinking water in Makassar City.

The program activities in the master plan document that have been analyzed, owned by both BBWS-PJ and Makassar City PDAM, can apply smaller and less expensive activity plans in their efforts to achieve water reliability in various climatic conditions and water demands. In the planning analysis, it was found that in various cases, BBWS-PJ project and Makassar City PDAM could implement smaller and less expensive project activities to achieve water reliability across climatic conditions and demand. The results of the study show that the range of river flow conditions and future demand can achieve water reliability. The performance of raw water sources in each region has an identical tendency and has the possibility to achieve water reliability. It is certain, however, that among the planned projects, there will be raw water sources or other types of projects that fail to achieve water reliability.

3.8 Sustainable Water Resources Management with Green Ergonomics Approach

In the water resources management, the Green Ergonomics approach can be employed to support the efficiency of water resources management from raw water to clean water which will be distributed to the residents in Makassar City. The application of this concept is a combination of ergonomic and environmental aspects by developing an understanding of how water resources are in line with the work systems and integrate with the larger ecosystems. This involves the understanding of life cycle flows, their transformation and integration, and understanding how the waste generated by the system is utilized (Véronneau and Cimon, 2007)

In Ergonomics, humans play an important role in the implementation of a system. The success of a work system also depends on the ability of workers to implement the system. In the water resources management, in the face of uncertainty that becomes a risk, Ergonomics can be involved in its activities. The involvement of the Ergonomics approach can strengthen the values of management (Holden, 2012).

In other words, there is a necessity for a reconceptualization of the water resources management system which previously only focused on the uncertainty of raw water discharge and its management, but now requires the integration of humans and the environment in its management. Workers in each production line must be competent in carrying out their work. Workers must know the scope of their work well and create an ergonomic work environment by taking adjustments and flexibility in work into account (Lange-Morales et al., 2014). By paying more attention to this, it is possible to demonstrate a more sustainable approach to water resources management as shown in figure 2.

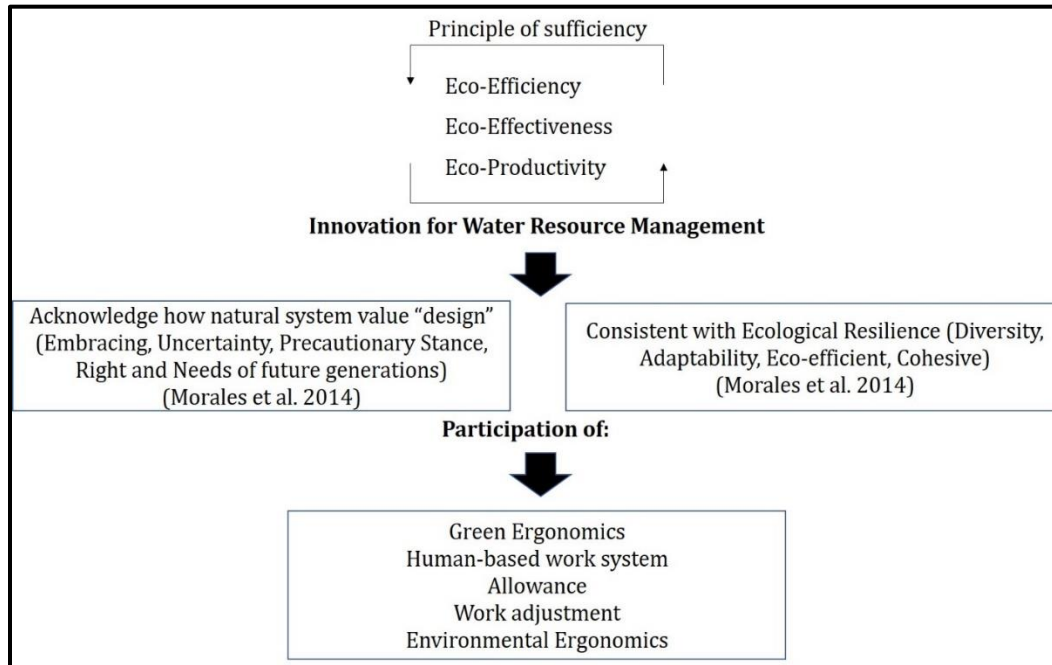


Figure 3. Green Ergonomics Concept for Water Resources Management

4. Conclusions

It can be concluded that:

1. The scenario for determining operational policies for natural resource management is influenced by conditions of low, medium, and high economic growth scenarios, and political conditions, as well as climate change. Each scenario matrix contains 5 aspects, which are (1) Natural Resources Conservation, (2) Natural Resources Utilization, (3) Water Damage Control, (4) Natural Resources Information System, and (5) Society and Business Participation. These are the summary of scenarios for the choice of adaptation strategies that have been, are being, or will be implemented by BBWS-PJ.
2. It is very important to implement a short-term adaptation strategy plan as the initial basis for long-term climate change adaptation planning and to integrate it into the planning mechanism or management in the form of the PDAM Business Development Plan or RKAP and the city government's annual and medium-term plans.
3. Participatory Ergonomics and Environmental Ergonomics can be taken into account in the development of Water Resources Management in Makassar City by involving environmental factors, adjustments, and leniency.

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First Decision of Manuscript

[IJTech] Decision for manuscript #IE-5113: Need to be Revised

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Decision Result : Revise

Dear **Dr. Zakir Sabara**

We have finished the review and made decision on your manuscript entitled [**Integration of Green Ergonomics in Robust Decision Making (RDM) Approach in Water Resources Management in Makassar City**] which was submitted to International Journal of Technology.

We have decided that your manuscript **Need to be Revised**

We also send you the review result from the reviewers. Here is the detail review result:

Notes from Editor:

1. Please revise according to the reviewer's comment, and highlights the revised in different color 2. It is suggested to include at least 3 relevant IJTech articles as references

Reviewer (1)

Introduction:

The author has discussed the introduction and problem statement clearly. The objective of the paper has also been introduced in this section.

Methodology:

The methodology of the study has been thoroughly explained in this section taking into account the stages required.

Results and Discussion:

The author has analysed, discussed and reviewed the results critically. As a whole, the author successfully integrates the concept of Green Ergonomics research on water resources management in Water Resources Management in Makassar City.

References:

The author has included all relevant references in the paper and cited these papers correctly.

Other:

Not available.

This research presents a new idea on Integration of Green Ergonomics in Robust Decision Making (RDM) Approach in Water Resources Management in Makassar City.

Originality	4 (<i>above average</i>)
Technical	4 (<i>above average</i>)
Methodology	5 (<i>excellent</i>)
Readability	4 (<i>above average</i>)
Practicability	5 (<i>excellent</i>)

Organization 5 (*excellent*)
Importance 5 (*excellent*)

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-

Reviewer (2)

Introduction:

1) You did not define green ergonomics. you mentioned in result and section discussion which is not suitable.

2) I could not see the objectives of your study.

Methodology:

Please inform how many respondents answer the survey/questionnaire and who are the respondents represent group (eg: local people/law enforcer/district office staff etc)

Results and Discussion:

1) section 3.3, please discuss in detail the finding of PDAM data (why they rated as per result)..any similar pattern of data in maybe other country.

2) some results (3.1, 3.2) can be presented in table for better data visualization.

3) you did not define what is XLRM.

References:

only 3 from 17 references are most recent (2016-2021). please include more updated literature.

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Please check the margins and format. The margin is not consistent between the pages.

Originality 4 (*above average*)
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To: zakir.sabara@umi.ac.id, afiah.irma@umi.ac.id, rofiqulumam.geoscience@gmail.com

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1st Submission of Revised Manuscript

Integration of Green Ergonomics in Robust Decision Making (RDM) Approach in Water Resources Management in Makassar City

Abstract. In water resources management, a planning strategy is required in order to be able to minimize the perpetually encountered problems. Water resources for drinking water in Makassar City and other regions in Indonesia are managed by the respective vertical agencies and regional governments. The Regional Drinking Water Company (PDAM) of Makassar City as a company that manages the fulfillment of clean water needs for the residents of Makassar City has operational activities, i.e., managing the distribution and service of drinking water that meets health requirements to the society in an equitable, orderly and regular manner, and carrying out urban development and services. Green Ergonomics becomes a guideline for proposing the basis of interventions, social responsibility, and environmental or ecospheric responsibility. Green Ergonomics is also necessitated for the evaluation and sustainable development, and for a good reciprocal relationship of human and natural systems. Green ergonomics develops an understanding of how variety of resources such as energy, biological entities, and minerals flow through work systems and integrate with ecosystems.

Keywords: Water Resource, RDM, Green Ergonomics, Environment

1. Introduction

Generally, the expansion of flood areas in Makassar City is induced by a decrease in the water catchment areas due to an increase of residential areas as a result of an increase in the city population on account of both births and urbanization trends. At the same time, there is a decrease in the quantity and quality of water due to a decrease in the supply of clean water from two rivers that passed through Makassar City, which are the Jeneberang River and the Lekopancing River. The two rivers originate in different regional government areas and create their own problems in their management that have the potential to cause conflict.

Global climate change has an impact on water resources, especially on the water cycle, water demand, water supply, and water quality standards. According to (Emanuel, 2005) there are two causes of global climate change, i.e.; population growth in coastal areas and natural events. This is in harmony with (Nelson et al., 2010) who stated that global climate change can trigger an increase in the need for clean water supplies, and (Karl et al., 2009a; Lange-Morales et al., 2014) who concluded that an increase in temperature results in changes in river water discharge which causes humans to need more water to grow and maintain health. Additionally, **in line with Hartono et al. (2010)** that water quality should be improved to meet clean water standards.

In water resources management, a planning strategy is required to be able to minimize the perpetually encountered problems. Water resources for drinking water in Makassar City and other regions in Indonesia are managed by the respective vertical agencies and regional governments. Regulatory clauses on water resources management rules are distinct although the policy implementation is not optimal when the water resources pass through territorial areas that are administratively under different regional governments.

Green ergonomics includes several principles, including *eco-efficiency*, *eco-effectivity* and *eco-productivity* (Thatcher et al., 2013). The green ergonomics approach can be applied in evaluating and developing industries for sustainable development. Green ergonomics ensures that human and natural systems are in a good reciprocal relationship. Green ergonomics in which there are factors of efficiency, effectiveness, and productivity move beyond the specific reference of a work system. Green ergonomics develops an understanding of how variety of resources such as energy, nutrients, biological entities and minerals flow through work systems and integrate with ecosystems. This involves understanding something about flows of life cycle transformation and their integration, and understanding what happens to the 'waste' generated by the system (Lange-Morales et al., 2014).

The Regional Drinking Water Company (PDAM) of Makassar City as a company that manages the fulfillment of clean water needs for the residents of Makassar City has operational activities, i.e., managing the distribution and service of drinking water that meets health requirements to the society in an equitable, orderly and regular manner, and carrying out urban development and services. The last 10 years, the government and PDAM of Makassar City tend to face the same problems related to the management and utilization of water resources, which are; (1) drought in the dry season and flood in the rainy season, (2) competition for water use between the upstream and downstream areas or conflicts in various sectors, (3) excessive and inefficient use of water or leakage, (4) narrowing and silting of rivers and lakes due to pressure on land for settlement and industry, (5) pollution of surface water and ground water, and (6) erosion due to deforestation. These increasingly complex problems require PDAM Makassar City to manage water resources optimally so that it can support people's lives well.

With various encountered problems related to the imbalance in the amount of water availability, it is necessary to manage the amount of water availability and the amount of water demand. Therefore, the water utilization is able to meet the criteria of integration is space functional, sustainable, and environmentally friendly. One method that can be employed to analyze environmental problems is the Robust Decision Making (RDM) method. RDM can be relied on in strategic decision making for strategic water resources planning policies. (Karl et al., 2009b), (Matrosov et al., 2013), (Hidayatno et al., 2015), and (Casal-Campos et al., 2015) studied environmental problems and water resources management, but did not involve decision making as a key strategy for solving water management problems.

In addition, this study aimed to integrate the concept of Green Ergonomics as a guide to propose the basis of interventions, social responsibility, and environmental or ecospheric responsibility on water resources management. Green Ergonomics is also required for evaluation and sustainable development, and for a good reciprocal relationship of human and natural systems. Green ergonomics develops an understanding on how variety of resources such as energy, biological entities, and minerals flow through work systems and integrate with ecosystems. This involves understanding the flow of the transformation life cycle and its integration (Lange-Morales et al., 2014). Consequently, it is

considered necessary to combine ecological or environmental aspects with ergonomic aspects, which in this case is the water resources management in a work system.

Furthermore, there are several recent studies that discussed water resources (Hidayatno et al., 2015; Juniati et al., 2019; Knox et al., 2018; Octavia et al., 2020; Odume and Wet, 2016; Xie et al., 2017) but did not examine the decision making in the water resources management system and the previous research did not use an approach that focuses on global environmental and climate issues that are full of uncertainty. Moreover, this is the first research that integrates the concept of Green Ergonomics research on water resources management; hence, it is expected that decision making and strategy identification can lead to efficiency and effectiveness in the work system of water resources management.

2. Methods

This study used the RDM approach for strategic decision making on water resources management planning for drinking water in Makassar City. Robust in this study is considered as the ability of the system to face decision-making constraints on water resources planning for drinking water. The concept to develop is the concept of ecosystem elasticity which can be improved by upgrading the scale of resistance. This is measured by the magnitude of the disturbance and the maximum threat required to determine the resilience or flexibility of the system with the decisions taken (De Bruijn, 2005). Furthermore, the resilience of the economic system and social system is also developed as an integrated material in the interdisciplinary studies, which in this case are the study of Green Ergonomics and Environmental Management.

2.1. Data Resources

The data collected in this study are primary data and secondary data. The primary data was obtained directly through observation, FGD, and interviews with resource persons in regards to the questionnaire guide. Meanwhile, the secondary data in this study were regional and national planning documents, Strategic Planning (Renstra) of Makassar City PDAM, Strategic Planning of Water River Central Region-Pompengan Jeneberang (BBWS-PJ), State Electricity Company (PLN), Central Statistics Agency (BPS) of Makassar City, and relevant related research. In addition, the secondary data were used as a Focus Group Discussion (FGD) material by discussing the 2011-2036 Corporate Plan of Makassar City PDAM, long-term plan documents, management of challenges and opportunities, and the BBWS-PJ master plan.

2.2. Data Collection

The data were collected through structured interviews, consumer surveys through questionnaire distribution which also involved all aspects of humans and work systems, and in-depth observation methods on various objects related to water resources planning and management activities. 125 respondents (61 men and 64 women) from 14 sub-districts in Makassar City were participated in this study. They were representation from

10 various professions with range of age was 18 to 65 years old and that is expected to represent the water user community in Makassar City.

The results of the observations were then combined with the primary and secondary data to conduct a Focus Group Discussion with the entire components involved. In short, there were four steps in data collection in order to obtain quality data, which were; (1) *Participatory Scoping*, (2) *Case Generation and Exploration Models*, (3) *Discovery Scenarios*, and (4) *Trade-off Analysis*. In data collection, FGD was also conducted with environmental and ergonomics experts as one of the integrations of Green Ergonomics in RDM to obtain scenarios for solving water resources problems in Makassar City.

2.3 Data Analysis Techniques

The analytical technique that will be applied in this study comply with the 4-step key RDM process and procedure which are iterative. The four key steps were used to adhere to the research objectives, i.e.: (1) Participatory Scoping; (2) Case Generation and Exploration; (3) Scenario Discovery; and, (4) Tradeoff Analysis. Participatory scoping is basically a form of focusing attention on issues or problems that will be studied or resolved through Focused-Group Discussions (FGD).

The participants who are expected to attend the event are stakeholders, policy makers, resource persons, environmental ergonomics experts and water user communities according to their respective capacities. This activity aims to define or limit the scope of objectives and measurements, the scope of strategies that can be employed to achieve the objectives, the scope of uncertainty that will affect the successful use of the strategy, and the scope of relationships that will help demonstrate the process of using the measurement. Thus, the conceptual model of problem solving is shown in Figure 1.

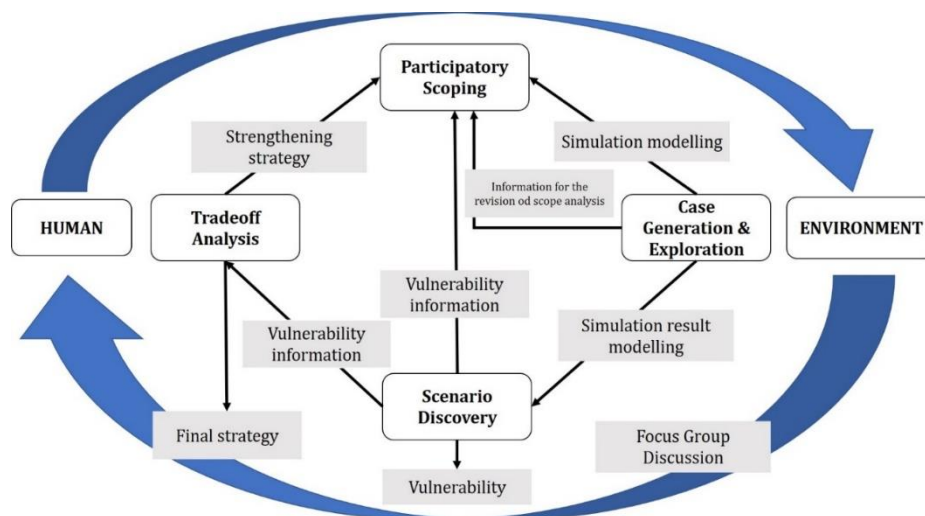


Figure 1 Green Ergonomics- RDM Conceptual Model

In order to implement the conceptual model above, the following steps are implemented:

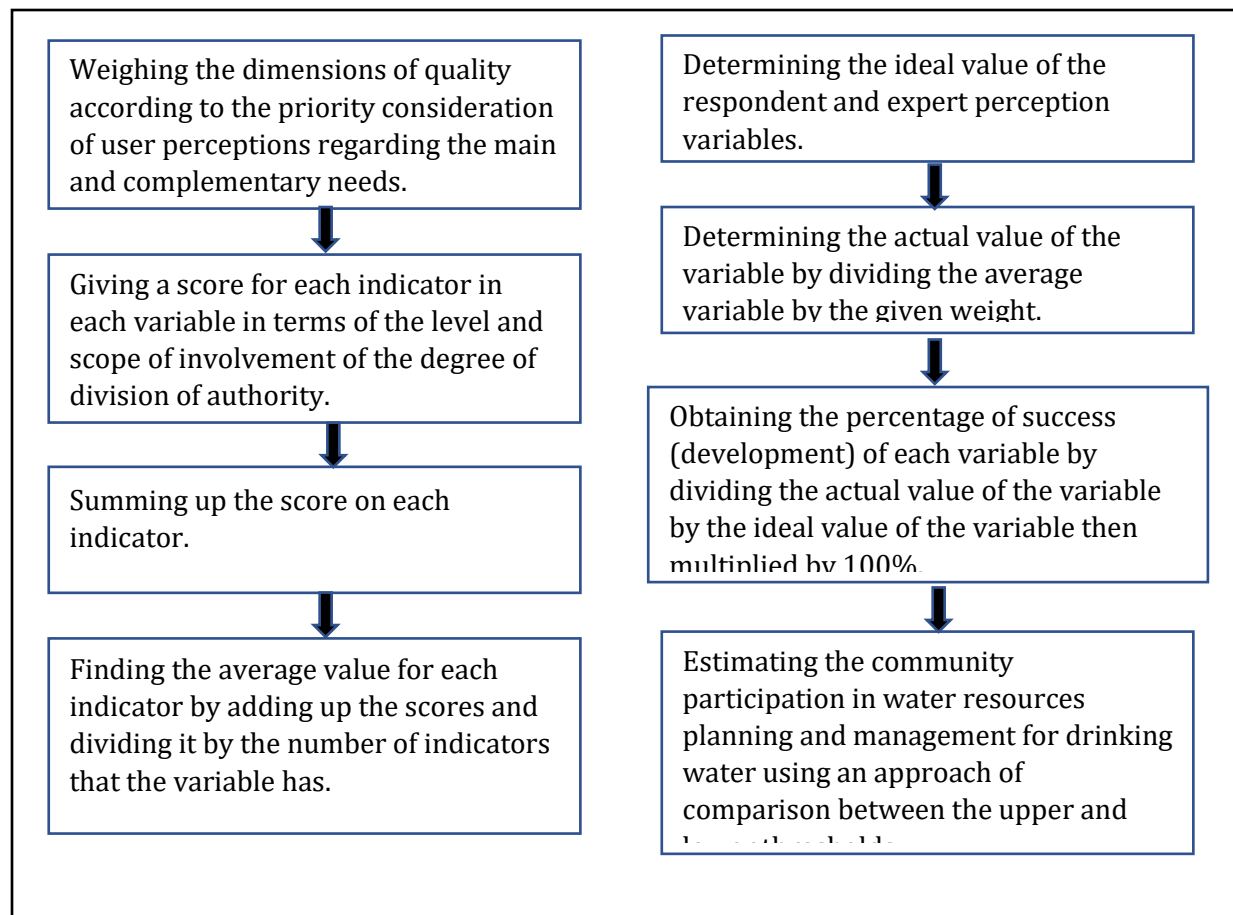


Figure 2. Data Analysis Stage

3. RESULTS AND DISCUSSION

Five main data components were obtained: (1) Data on future climate change vulnerability and adaptation strategies; (2) Data for Jeneberang River management system planning; (3) Data for drinking water management planning of Makassar City PDAM; (4) Socio-economic data of PDAM Makassar City customers; and (5) Green Ergonomics concept in water resources management in Makassar City. The five data were obtained from vulnerability assessment documents, focus group discussions, interviews, and socio-economic surveys of the people using PDAM water services.

The data were analyzed descriptively and the results were used to answer 4 key research questions that lead to the achievement of research objectives. In this study, vulnerability data were used as the baseline data in Exogenous Factors or Exogenous Uncertainty (Xs) while adaptation strategies were used as Policy Levers data (Ls). Exogenous uncertainty (Xs) is a factor that is difficult for decision makers to control but is important in determining the success of the strategy. Meanwhile, Policy Levers (Ls) are the

diversity of combinations of short-term adaptation actions consisting of alternative strategies that will be implemented.

3.1 Climate Vulnerability Data

The data obtained from BMKG (Meteorological, Climatological, and Geophysical Agency), both in publications and in focused group discussions, confirms this condition by presenting data on rainfall patterns (precipitation) and Makassar City temperature per 10 years. Based on Makassar City BMKG data, the average rainfall pattern in Makassar is fixed but the rainy season or period will be shorter.

Table 1. Average Temperature and Rainfall of Makassar City

MONTH	TEMPERATURE °C			PRECIPITATION (mm)
	LOWEST	AVERAGE	HIGHEST	
January	23.0	26.0	29.1	671
February	23.4	26.3	29.3	556
March	23.0	26.4	29.8	408
April	22.8	26.6	30.5	175
May	22.8	26.9	31.0	101
June	21.7	26.0	30.4	67
July	20.9	25.6	30.4	37
August	20.4	25.7	31.0	14
September	20.9	26.0	31.1	25
October	21.8	26.5	31.2	56
November	22.9	26.7	30.5	213
December	23.0	26.1	29.3	552

Historically, floods and strong winds that occur almost every year cause losses and damage to Makassar City. According to (BBWS-PJ, 2014), between 1999 – 2013, there were 26 cases of flooding that damaged 324 houses and impacted 6,476 people. The flood in January 2013 caused 5,763 people as the victims and was declared the worst flood in the history of Makassar City. The worst impacted areas were located in the lowlands with poor drainage and sanitation systems. New housings on the suburb of a former agricultural area became the main flood site in January 2013. Strong winds occurred with an average of 2 cases per year. Reports on cases of strong winds that damaged around 300 houses and killed around 200 people occurred between 2003 – 2012. Droughts, fires, large sea waves, and endemic diseases also became the problems that occurred in Makassar City. All take place due to climate change which is uncertain or difficult to predict and will have different impacts according to the geographical location of the region.

3.2 Jeneberang River System Planning Data

Floods in agricultural and residential areas occur due to the inability of river bodies to accommodate the passing water discharge. The floods occur in Maros River, Sinjai River, Bialo River, Pappa River, Allo River, Tamanroya River, Calendu River, Pampang River and

Tallo River. Increased erosion and sedimentation in rivers that cause siltation and reduced water storage capacity especially take place in Maros watershed, Jeneberang watershed (mainly due to the landslide of Mount Bawakaraeng), Pappa watershed and Tamanroya watershed. Especially in the Jeneberang watershed, due to the collapse of the slopes of Mount Bawakaraeng, sedimentation into the Jeneberang River was 167.2 million m³ and sedimentation in the Bilibili Reservoir was 75.2 million m³. High sedimentation reaches 3,862 tons/year (Tamanroya watershed 342 tons/year, Jeneberang watershed 1,280 tons/year, Kelara-Karaloe watershed 219 tons/year, Maros watershed 233 tons/year, and Pappa watershed 247 tons/year). Abrasion and critical beaches are spread in almost all regencies/cities in Jeneberang river area, i.e., Takalar Regency, Bantaeng Regency, Bulukumba Regency, Sinjai Regency, Selayar Regency, Makassar City, Jeneponto Regency, and Maros Regency. The total length of the abraded and critical beach is 237 km.

3.3 Makassar City PDAM Drinking Water Management Planning Data

Makassar City PDAM revealed that the biggest problem faced by PDAM Makassar City is the supply of clean water for drinking water. The most important service is the clean water supply network. This network is threatened by the increasing demand for water as the urban population grows and it is difficult to keep up with the increase in supply. In Makassar city, the urban clean water system relies heavily on water supply from surrounding districts such as Gowa and Maros. In addition, Urbanization and lack of proper management of clean water sources puts these sources at risk. Accordingly, the clean water system also requires additional network to meet the increasing demand and regular maintenance. It is in line with a study from Tadesse et al., (2013) that one major issue of water source distribution is lack of proper management is waiting time or queuing of water supply.

Details of the problems faced by PDAM Makassar City in water resources management for drinking water for Makassar City residents are:

5. Limited supply of raw water; In regard to raw water constraints, it is proposed to add or build reservoirs that are prioritized for drinking water, SPAM (drinking water supply system) regionalization, and proposals regarding PP (government regulations) that regulate Water Use Rights.
6. Unfavorable regulations; In terms of regulation, Law Number 23 of 2014 regarding Regional Government states that BUMD (Regional Owned Enterprises) is in the form of Perumda or Perusda.
7. Long-term debt; Even though Makassar City PDAM is in the healthy category or has paid off its debt, there are other 175 PDAMs that have debts to the Ministry of Finance with a total debt of IDR 4.7 trillion. The current status is that 76 PDAMs have been restructured (Rp3,297 trillion or 70%), 9 PDAMs do not participate in restructuring (Rp55 billion or 1%), 29 are in the restructuring process (Rp359 billion or 8%), and 6 are restructured (Rp988 billion or 21 %).
8. The electricity tariffs (TTL); In order to run the production and distribution of water to the society, almost all PDAMs use PLN electricity. The average electricity load reaches 40% of the production cost. The condition or national electricity capacity for PDAM is 250 Mega Watt (relatively small for PLN).

3.4 PDAM Customer Condition Data

The survey results show that most of the water sources utilized to meet the needs of clean water already use PDAM service water (84%) but for drinking water needs, people use refilled water (45.6%) more than PDAM services (42.4%). The trend of urban people choosing refilled water is for the reasons of convenience and practicality since they do not need to boil the water for drinking anymore. However, there are still 11.2% of respondents who use well/artesian well water for bathing and washing needs and 5.6% who use it as a source of drinking water.

The types of PDAM customers that were successfully captured in this study were household customers (88.8%) and the rest were public and business facilities. There were 6.4% of respondents who chose not to answer on the grounds that they were not PDAM customers or used other water sources.

The survey results show that some respondents stated that it was easy (61.6%), very easy (29.6%), moderately difficult (6.4%) and difficult (2.4%) to meet their daily clean water needs. This shows that the people of Makassar City are generally still easy to get clean water services for their daily needs.

The survey results show that more than 60% of respondents stated that the quality of clean water for drinking water provided by PDAM Makassar City is odorless, tasteless, and colorless both in the dry season and in the rainy season, while 26% stated that it still smells, tastes, and is colored both in the dry season and in the rainy season. The rest chose not to respond.

Table 2. Dry Season and Rainy Season Water Quality

NO.	RESPONSE	CLIMATE	ODOR	%	TASTE	%	COLOR	%
1	Yes	Dry	14	13.3	9	8.6	14	13.3
		Rainy	20	19.0	9	8.6	27	25.7
2	Not	Dry	89	84.8	88	83.8	82	78.1
		Rainy	83	79.0	87	82.9	69	65.7
3	No Response	Dry	2	1.9	8	7.6	9	8.6
		Rainy	2	1.9	9	8.6	9	8.6
		Dry	105	100	105	100	105	100
		Rainy	105	100	105	100	105	100

3.5 Green Ergonomics Concept in Water Resources Management in Makassar City

One approach that can be employed to examine this problem is green ergonomics. A study on green ergonomics is necessitated to ensure that PDAM as a water resource administrator in Makassar city must be able to carry out its production process ergonomically, cleanly and efficiently.

In this study, the concept of Green Ergonomics is used to balance the water resources management with the role of humans as managers themselves. Ergonomics currently does not only study the state of a micro work system, but more broadly, it also discusses

environmental problems. For almost two decades, (Helander et al., 1996) proposed that ergonomics should address the problems of water and food shortages, inefficient use of energy, pollution and waste, and rapid urbanization. Ergonomics experts are deemed necessary to collaborate in environmental management in one area and must be able to overcome global environmental and social problems such as pollution from big cities. Therefore, this study incorporates the concept of Green Ergonomics as a complement in the water resources management.

3.6 Goal Setting, Achievement Strategies, Forms of Uncertainty, and Measurement Results Models

The RDM process begins with focus group discussion activities that bring together the parties and decision makers to set goals and consider the severity of the problems found in decisions, strategies that can be used to achieve goals, uncertainties that will affect the strategies, and the relationships that govern strategic performance related to decision-making considerations (Patterson et al., 2009). This activity used XLRM framework which is used to set up the simulation model. XLRM refers to four factors; (1) Exogenous Uncertainty (X) which are factors that are difficult to control by decision makers but are important in determining the success of the strategy which in this research refers to the Makassar City Vulnerability Study Document, (2) Policy Levers (L) which means the diversity of combinations of short-term adaptation actions consisting of alternative strategies that will be used, which in this study refer to the Strategic Planning documents of PDAM and BBWS-PJ as the buffer institutions, (3) Risk and Impact Measurements (M) means the calculation and evaluation of hazards and risks combined with aspects of vulnerability, exposure, and sensitivity of city system components caused by unpredictable exogenous factors, which in this study refers to the results of the analysis of the level of vulnerability, exposure, sensitivity, and adaptability, and (4) Relationships and Models (Rs) which represent simulation models that describe the success or failure of adaptation strategies as measured by the impact of risk or the impact of exposure hazard due to exogenous uncertainty (Table 3).

Table 3. Main Elements of XLRM

Exogenous Uncertainty (Xs)	Policy Lever (Ls)
Hazard related uncertainty: Increasing rainfall/flood, Sedimentation, Drought, Environmental damage, Sea level rise, Beach abrasion, Strong wind, Tidal wave.	BBWS-PJ 3. Integrated upstream-downstream Water Resources Management implementation. 4. Construction/upgrade, operation and maintenance: • Water source capacity, • Water discharge for raw water facilities/infrastructure services to meet domestic/household, urban and industrial needs (RKI), • Coverage of irrigation and swamp network services, • Coverage of area protected from the danger of flooding.
Exposure related uncertainty: Residential area,	

<i>Total population, Population density, Poverty, Economic growth and equity.</i> Vulnerability related uncertainty: <i>City expansion, Population growth, Clean water supply, Soil erosion, Floods and puddles, Long dry season, Disease outbreak</i>	PDAM 7. Production optimization and capacity building for WTP (Water Treatment Plant) IV and V. 8. Construction of New WTP (Tallo River raw water). 9. Development of the main and tertiary distribution of pipeline network in the Eastern Region (II and III). 10. Rehabilitation of old Dutch pipelines for gradual water loss rates of at least 1 - 2% per year. 11. Plans for adding raw water to support the raw water crisis of WTP II Panaikang by utilizing raw water from the Tallo River during the dry season. 12. Service plan in bulk for PDAM Maros Regency customers which is directly adjacent to the Makassar City PDAM service area.
Relations and Models (Rs)	Impact Measurement (Ms)
ArcGIS Model: calculating the impact of the risk and impact damage SWMM Model Integrated Analytical Risk Model	Availability of raw water supply: balance and effectiveness of available budget related to various impacts of natural resource management planning for drinking water.

3.7 Adaptive and Robust Strategic Decisions in Water Resources Planning for Drinking Water in Makassar City

Based on the results of this study, the key elements of a robust adaptive strategy are identified as follows:

- e) Implementing clear and measurable short-term projects/programs, which, in spite of the risks, still provide minimal benefits until the occurrence of future climate change and its impacts (near-term no-regret projects);
- f) Observing visible signs or indicators of exogenous uncertainty that requires PDAM and BBWS-PJ to prepare additional investments;
- g) Considering and deciding which projects or program activities should be postponed, which in this case are the additional investment to be carried out in the uncertain future conditions;
- h) Monitoring and preparing a pessimistic budget for the remaining vulnerabilities, which in this context are the project sequence or program activities in the master plan that are projected to fail to achieve the objectives of natural resource management for drinking water in Makassar City.

The program activities in the master plan document that have been analyzed, owned by both BBWS-PJ and Makassar City PDAM, can apply smaller and less expensive activity plans in their efforts to achieve water reliability in various climatic conditions and water demands. In the planning analysis, it was found that in various cases, BBWS-PJ project and Makassar City PDAM could implement smaller and less expensive project activities to achieve water reliability across climatic conditions and demand. The results of the study show that the range of river flow conditions and future demand can achieve water reliability. The performance of raw water sources in each region has an identical tendency and has the possibility to achieve water reliability. It is certain, however, that among the

planned projects, there will be raw water sources or other types of projects that fail to achieve water reliability.

3.8 Sustainable Water Resources Management with Green Ergonomics Approach

In the water resources management, the Green Ergonomics approach can be employed to support the efficiency of water resources management from raw water to clean water which will be distributed to the residents in Makassar City. The application of this concept is a combination of ergonomic and environmental aspects by developing an understanding of how water resources are in line with the work systems and integrate with the larger ecosystems. This involves the understanding of life cycle flows, their transformation and integration, and understanding how the waste generated by the system is utilized (Véronneau and Cimon, 2007)

In Ergonomics, humans play an important role in the implementation of a system. The success of a work system also depends on the ability of workers to implement the system. In the water resources management, in the face of uncertainty that becomes a risk, Ergonomics can be involved in its activities. The involvement of the Ergonomics approach can strengthen the values of management (Holden, 2012).

In other words, there is a necessity for a reconceptualization of the water resources management system which previously only focused on the uncertainty of raw water discharge and its management, but now requires the integration of humans and the environment in its management. Workers in each production line must be competent in carrying out their work. Workers must know the scope of their work well and create an ergonomic work environment by taking adjustments and flexibility in work into account (Lange-Morales et al., 2014). It is in line with (Bharti et al., 2020) that there is the need for a paradigmatic in water management to be more integrated and adaptive management approaches and innovations are key to enhancing urban water management systems. By paying more attention to this, it is possible to demonstrate a more sustainable approach to water resources management as shown in figure 3.

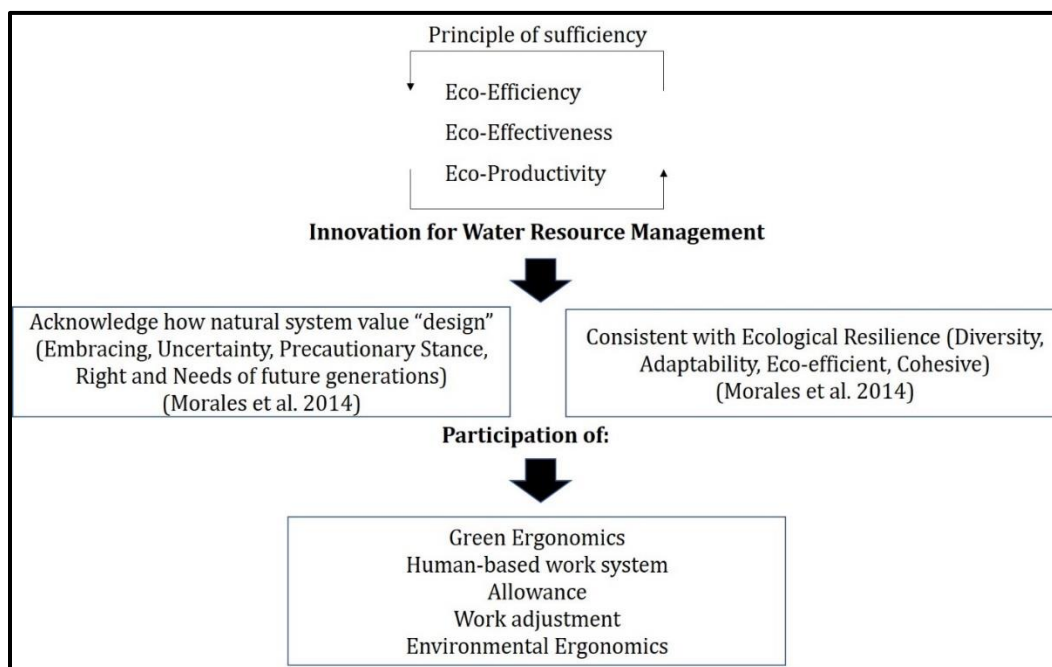


Figure 3. Green Ergonomics Concept for Water Resources Management

4. Conclusions

It can be concluded that:

4. The scenario for determining operational policies for natural resource management is influenced by conditions of low, medium, and high economic growth scenarios, and political conditions, as well as climate change. Each scenario matrix contains 5 aspects, which are (1) Natural Resources Conservation, (2) Natural Resources Utilization, (3) Water Damage Control, (4) Natural Resources Information System, and (5) Society and Business Participation. These are the summary of scenarios for the choice of adaptation strategies that have been, are being, or will be implemented by BBWS-PJ.
5. It is very important to implement a short-term adaptation strategy plan as the initial basis for long-term climate change adaptation planning and to integrate it into the planning mechanism or management in the form of the PDAM Business Development Plan or RKAP and the city government's annual and medium-term plans.
6. Participatory Ergonomics and Environmental Ergonomics can be taken into account in the development of Water Resources Management in Makassar City by involving environmental factors, adjustments, and leniency.

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Response Letter to Reviewers

List of Changes

Manuscript:

Integration of Green Ergonomics in Robust Decision Making (RDM) Approach in Water Resources Management in Makassar City

Response and Revision made by Author(s)

Reviewer #1:

No	Comments	Revision/Changes
1	The author has discussed the introduction and problem statement clearly. The objective of the paper has also been introduced in this section	Thank you very much.
2	The methodology of the study has been thoroughly explained in this section taking into account the stages required.	We appreciated your comment for our manuscript.
3	The author has analysed, discussed and reviewed the results critically. As a whole, the author successfully integrates the concept of Green Ergonomics research on water resources management in Water Resources Management in Makassar City.	Thank you for pointing this out. We really appreciated it.
4	The author has included all relevant references in the paper and cited these papers correctly.	Thank you very much. We also added new articles as references.
5	This research presents a new idea on Integration of Green Ergonomics in Robust Decision Making (RDM) Approach in Water Resources Management in Makassar City.	We really appreciated the time and effort that you have dedicated to providing your valuable feedback on our manuscript.

Reviewer #2:

No	Comments	Revision/Changes
1	You did not define green ergonomics. You mentioned in result and section discussion which is not suitable.	Thank you for your comment. We moved the explanation of Green Ergonomics from page 6 (Results and Discussion) to page 1 (Introduction; paragraph 4).
2	I could not see the objectives of your study.	We have added the detail information regarding the objective of this study (Introduction; paragraph 7). <i>"In addition, this study aimed to integrate the concept of Green Ergonomics as a guide to propose the basis of interventions, social responsibility, and environmental or ecospheric responsibility on water resources management."</i>
3	Please inform how many respondents answer the survey/questionnaire and who are the respondents represent group (e.g.: local people/law enforcer/district office	We have added the information regarding number of respondents and respondent group (Methods; paragraph 3). <i>"125 respondents (61 men and 64 women)"</i>

	staff etc)	<i>from 14 sub-districts in Makassar City were participated in this study. They were representation from 10 various professions with range of age was 18 to 65 years old and that is expected to represent the water user community in Makassar City"</i>
4	Section 3.3, please discuss in detail the finding of PDAM data (why they rated as per result). Any similar pattern of data in maybe other country.	<i>Thank you for pointing this out. We have added detail discussion and one reference (Results; Paragraph 6) "The most important service is the clean water supply network. This network is threatened by the increasing demand for water as the urban population grows and it is difficult to keep up with the increase in supply. In Makassar city, the urban clean water system relies heavily on water supply from surrounding districts such as Gowa and Maros. In addition, Urbanization and lack of proper management of clean water sources puts these sources at risk. Accordingly, the clean water system also requires additional network to meet the increasing demand and regular maintenance. It is in line with a study from Tadesse et al., (2013) that one major issue of water source distribution is lack of proper management is waiting time or queuing of water supply."</i>
5	Some results (3.1, 3.2) can be presented in table for better data visualization.	We have added Table 3.1 for data visualization of Section 3.1.
6	You did not define what is XLRM.	We have modified this part. <i>"This activity used XLRM framework which is used to set up the simulation model. XLRM refers to four factors; (1) Exogenous Uncertainty (X) which are factors that are difficult to control by decision makers but are important in determining the success of the strategy which in this research refers to the Makassar City Vulnerability Study Document, (2) Policy Levers (L) which means the diversity of combinations of short-term adaptation actions consisting of alternative strategies that will be used, which in this study refer to the Strategic Planning documents of PDAM and BBWS-PJ as the buffer institutions, (3) Risk and Impact Measurements (M) means the calculation and evaluation of hazards and risks combined with aspects of vulnerability, exposure, and sensitivity of city system components caused by unpredictable exogenous factors, which in this study refers to the results of the analysis of the level of vulnerability, exposure, sensitivity, and adaptability, and (4) Relationships and Models</i>

		<i>(Rs) which represent simulation models that describe the success or failure of adaptation strategies as measured by the impact of risk or the impact of exposure hazard due to exogenous uncertainty."</i>
7	Only 3 from 17 references are most recent (2016-2021). Please include more updated literature.	We have added 4 latest articles as our references.
8	Please check the margins and format. The margin is not consistent between the pages	We revised the margin.

Reduce Pages of Manuscript

[IJTech-IE-5113] Please reduce your pages

1 message

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Tue, Mar 1, 2022 at 3:27 PM

Dear Dr. Zakir Sabara,

The editorial board is delighted to inform you that your paper entitled "**Integration of Green Ergonomics in Robust Decision Making (RDM) Approach in Water Resources Management in Makassar City**" has been accepted to be published on IJTech.

Congratulation!

However, please noted you have to reduce the pages, the maximum paper length is 10 pages.

Please resend your latest manuscript by replying to this email no later than **March 04, 2022**,

We will use your latest manuscript to continue the publication process,

We look forward to receiving your revised paper at your earliest convenience.

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2nd Submission of Revised Manuscript

Integration of Green Ergonomics in Robust Decision Making (RDM) Approach in Water Resources Management in Makassar City

Abstract. In water resources management, a planning strategy is required in order to be able to minimize the perpetually encountered problems. Water resources for drinking water in Makassar City and other regions in Indonesia are managed by the respective vertical agencies and regional governments. The Regional Drinking Water Company (PDAM) of Makassar City as a company that manages the fulfillment of clean water needs for the residents of Makassar City has operational activities, i.e., managing the distribution and service of drinking water that meets health requirements to the society in an equitable, orderly and regular manner, and carrying out urban development and services. Green Ergonomics becomes a guideline for proposing the basis of interventions, social responsibility, and environmental or ecospheric responsibility. Green Ergonomics is also necessitated for the evaluation and sustainable development, and for a good reciprocal relationship of human and natural systems. Green ergonomics develops an understanding of how variety of resources such as energy, biological entities, and minerals flow through work systems and integrate with ecosystems.

Keywords: Water Resource, RDM, Green Ergonomics, Environment

1. Introduction

Generally, the expansion of flood areas in Makassar City is induced by a decrease in the water catchment areas due to an increase of residential areas as a result of an increase in the city population on account of both births and urbanization trends. At the same time, there is a decrease in the quantity and quality of water due to a decrease in the supply of clean water from two rivers that passed through Makassar City, which are the Jeneberang River and the Lekopancing River. The two rivers originate in different regional government areas and create their own problems in their management that have the potential to cause conflict.

Global climate change has an impact on water resources, especially on the water cycle, water demand, water supply, and water quality standards. According to (Emanuel, 2005) there are two causes of global climate change, i.e.; population growth in coastal areas and natural events. This is in harmony with (Nelson et al., 2010) who stated that global climate change can trigger an increase in the need for clean water supplies, and (Karl et al., 2009a; Lange-Morales et al., 2014) who concluded that an increase in temperature results in changes in river water discharge which causes humans to need more water to grow and maintain health. Additionally, **in line with Hartono et al. (2010)** that water quality should be improved to meet clean water standards.

In water resources management, a planning strategy is required to be able to minimize the perpetually encountered problems. Water resources for drinking water in Makassar City and other regions in Indonesia are managed by the respective vertical agencies and regional governments. Regulatory clauses on water resources management rules are distinct although the policy implementation is not optimal when the water resources pass through territorial areas that are administratively under different regional governments.

Green ergonomics includes several principles, including *eco-efficiency*, *eco-effectivity* and *eco-productivity* (Thatcher et al., 2013). The green ergonomics approach can be applied in evaluating and developing industries for sustainable development. Green ergonomics ensures that human and natural systems are in a good reciprocal relationship. Green ergonomics in which there are factors of efficiency, effectiveness, and productivity move

beyond the specific reference of a work system. Green ergonomics develops an understanding of how variety of resources such as energy, nutrients, biological entities and minerals flow through work systems and integrate with ecosystems. This involves understanding something about flows of life cycle transformation and their integration, and understanding what happens to the 'waste' generated by the system (Lange-Morales et al., 2014).

The Regional Drinking Water Company (PDAM) of Makassar City as a company that manages the fulfillment of clean water needs for the residents of Makassar City has operational activities, i.e., managing the distribution and service of drinking water that meets health requirements to the society in an equitable, orderly and regular manner, and carrying out urban development and services. The last 10 years, the government and PDAM of Makassar City tend to face the same problems related to the management and utilization of water resources, which are; (1) drought in the dry season and flood in the rainy season, (2) competition for water use between the upstream and downstream areas or conflicts in various sectors, (3) excessive and inefficient use of water or leakage, (4) narrowing and silting of rivers and lakes due to pressure on land for settlement and industry, (5) pollution of surface water and ground water, and (6) erosion due to deforestation. These increasingly complex problems require PDAM Makassar City to manage water resources optimally so that it can support people's lives well.

With various encountered problems related to the imbalance in the amount of water availability, it is necessary to manage the amount of water availability and the amount of water demand. Therefore, the water utilization is able to meet the criteria of integration is space functional, sustainable, and environmentally friendly. One method that can be employed to analyze environmental problems is the Robust Decision Making (RDM) method. RDM can be relied on in strategic decision making for strategic water resources planning policies. (Karl et al., 2009b), (Matrosov et al., 2013), (Hidayatno et al., 2015), and (Casal-Campos et al., 2015) studied environmental problems and water resources management, but did not involve decision making as a key strategy for solving water management problems.

In addition, this study aimed to integrate the concept of Green Ergonomics as a guide to propose the basis of interventions, social responsibility, and environmental or ecospheric responsibility on water resources management. Green Ergonomics is also required for evaluation and sustainable development, and for a good reciprocal relationship of human and natural systems. Green ergonomics develops an understanding on how variety of resources such as energy, biological entities, and minerals flow through work systems and integrate with ecosystems. This involves understanding the flow of the transformation life cycle and its integration (Lange-Morales et al., 2014). Consequently, it is considered necessary to combine ecological or environmental aspects with ergonomic aspects, which in this case is the water resources management in a work system.

Furthermore, there are several recent studies that discussed water resources (Hidayatno et al., 2015; Juniati et al., 2019; Knox et al., 2018; Octavia et al., 2020; Odume and Wet, 2016; Xie et al., 2017) but did not examine the decision making in the water resources management system and the previous research did not use an approach that focuses on global environmental and climate issues that are full of uncertainty. Moreover, this is the first research that integrates the concept of Green Ergonomics research on water resources management; hence, it is expected that decision making and strategy identification can lead to efficiency and effectiveness in the work system of water resources management.

2. Methods

This study used the RDM approach for strategic decision making on water resources management planning for drinking water in Makassar City. Robust in this study is considered as the ability of the system to face decision-making constraints on water resources planning for drinking water. The concept to develop is the concept of ecosystem elasticity which can be improved by upgrading the scale of resistance. This is measured by the magnitude of the disturbance and the maximum threat required to determine the resilience or flexibility of the system with the decisions taken (De Bruijn, 2005). Furthermore, the resilience of the economic system and social system is also developed as an integrated material in the interdisciplinary studies, which in this case are the study of Green Ergonomics and Environmental Management.

2.1. Data Resources

The data collected in this study are primary data and secondary data. The primary data was obtained directly through observation, FGD, and interviews with resource persons in regards to the questionnaire guide. Meanwhile, the secondary data in this study were regional and national planning documents, Strategic Planning (Renstra) of Makassar City PDAM, Strategic Planning of Water River Central Region-Pompengan Jeneberang (BBWS-PJ), State Electricity Company (PLN), Central Statistics Agency (BPS) of Makassar City, and relevant related research. In addition, the secondary data were used as a Focus Group Discussion (FGD) material by discussing the 2011-2036 Corporate Plan of Makassar City PDAM, long-term plan documents, management of challenges and opportunities, and the BBWS-PJ master plan.

2.2. Data Collection

The data were collected through structured interviews, consumer surveys through questionnaire distribution which also involved all aspects of humans and work systems, and in-depth observation methods on various objects related to water resources planning and management activities. 125 respondents (61 men and 64 women) from 14 sub-districts in Makassar City were participated in this study. They were representation from 10 various professions with range of age was 18 to 65 years old and that is expected to represent the water user community in Makassar City.

The results of the observations were then combined with the primary and secondary data to conduct a Focus Group Discussion with the entire components involved. In short, there were four steps in data collection in order to obtain quality data, which were; (1) *Participatory Scoping*, (2) *Case Generation and Exploration Models*, (3) *Discovery Scenarios*, and (4) *Trade-off Analysis*. In data collection, FGD was also conducted with environmental and ergonomics experts as one of the integrations of Green Ergonomics in RDM to obtain scenarios for solving water resources problems in Makassar City.

2.3 Data Analysis Techniques

The analytical technique that will be applied in this study comply with the 4-step key RDM process and procedure which are iterative. The four key steps were used to adhere to the research objectives, i.e.: (1) *Participatory Scoping*; (2) *Case Generation and Exploration*; (3) *Scenario Discovery*; and, (4) *Tradeoff Analysis*. Participatory scoping is basically a form of focusing attention on issues or problems that will be studied or resolved through Focused-Group Discussions (FGD).

The participants who are expected to attend the event are stakeholders, policy makers, resource persons, environmental ergonomics experts and water user communities according to their respective capacities. This activity aims to define or limit the scope of

objectives and measurements, the scope of strategies that can be employed to achieve the objectives, the scope of uncertainty that will affect the successful use of the strategy, and the scope of relationships that will help demonstrate the process of using the measurement. Thus, the conceptual model of problem solving is shown in Figure 1.

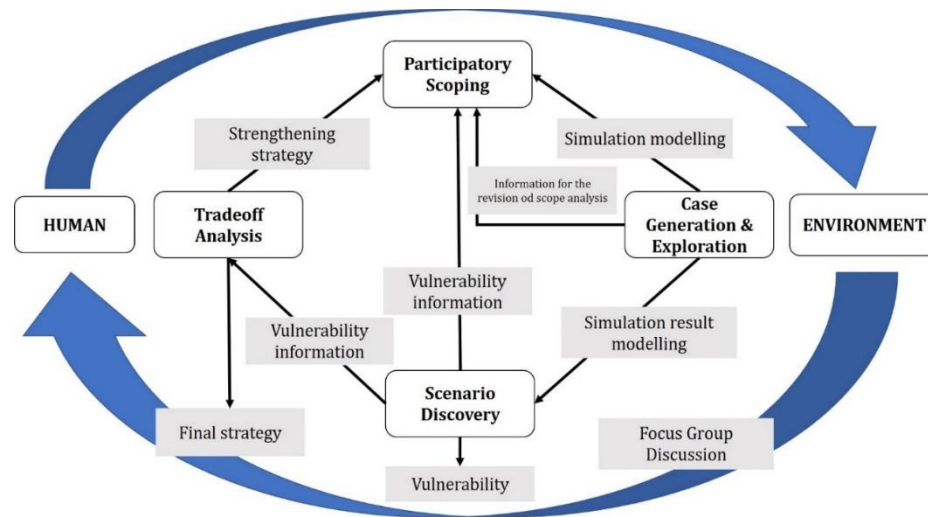


Figure 1 Green Ergonomics- RDM Conceptual Model

In order to implement the conceptual model above, the following steps are implemented:

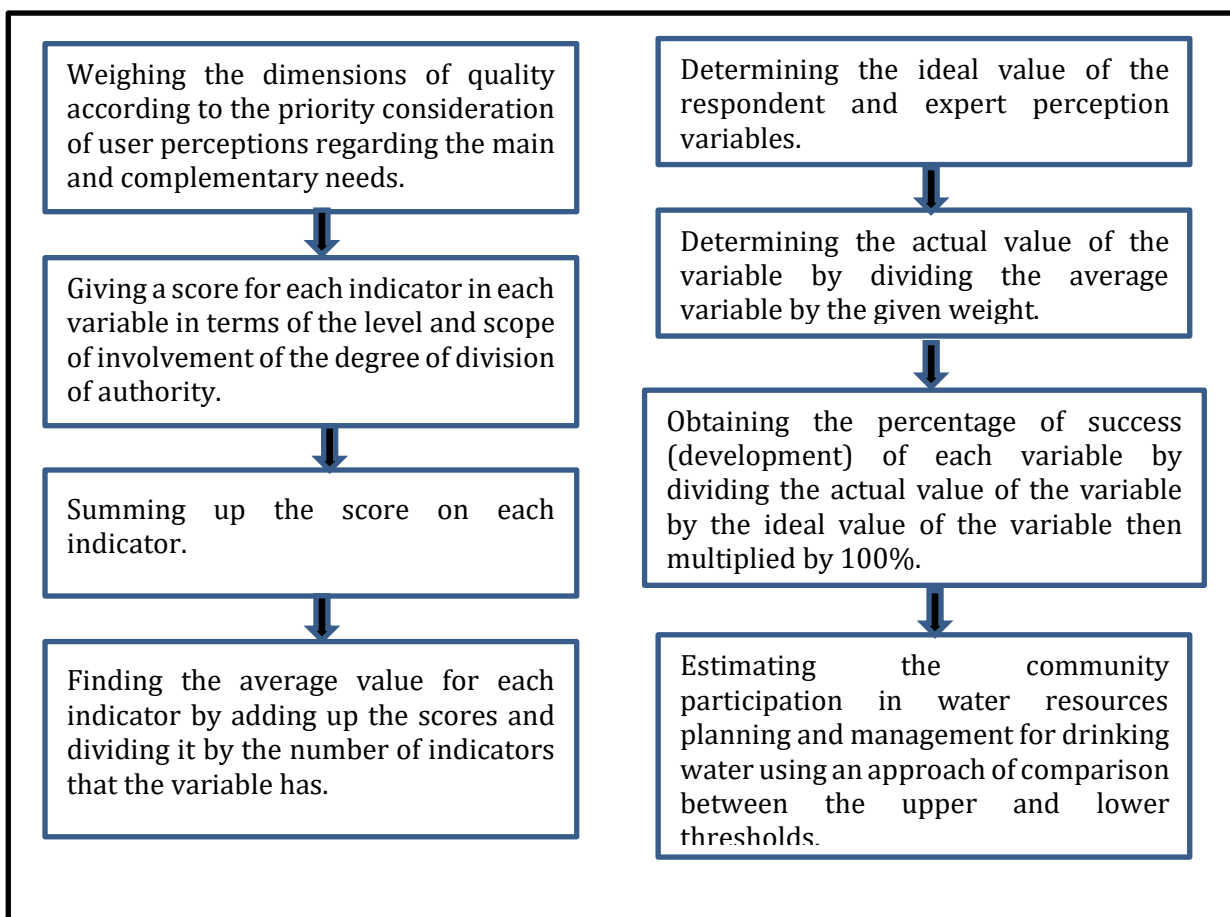


Figure 2. Data Analysis Stage

3. RESULTS AND DISCUSSION

Five main data components were obtained: (1) Data on future climate change vulnerability and adaptation strategies; (2) Data for Jeneberang River management system planning; (3) Data for drinking water management planning of Makassar City PDAM; (4) Socio-economic data of PDAM Makassar City customers; and (5) Green Ergonomics concept in water resources management in Makassar City. The five data were obtained from vulnerability assessment documents, focus group discussions, interviews, and socio-economic surveys of the people using PDAM water services.

The data were analyzed descriptively and the results were used to answer 4 key research questions that lead to the achievement of research objectives. In this study, vulnerability data were used as the baseline data in Exogenous Factors or Exogenous Uncertainty (Xs) while adaptation strategies were used as Policy Levers data (Ls). Exogenous uncertainty (Xs) is a factor that is difficult for decision makers to control but is important in determining the success of the strategy. Meanwhile, Policy Levers (Ls) are the diversity of combinations of short-term adaptation actions consisting of alternative strategies that will be implemented.

3.1 Climate Vulnerability Data

The data obtained from BMKG (Meteorological, Climatological, and Geophysical Agency), both in publications and in focused group discussions, confirms this condition by **presenting** data on rainfall patterns (precipitation) and Makassar City temperature per 10 years. Based on Makassar City BMKG data, the average rainfall pattern in Makassar is fixed but the rainy season or period will be shorter.

Table 1. Average Temperature and Rainfall of Makassar City

MONTH	TEMPERATURE °C			PRECIPITATION (mm)
	LOWEST	AVERAGE	HIGHEST	
January	23.0	26.0	29.1	671
February	23.4	26.3	29.3	556
March	23.0	26.4	29.8	408
April	22.8	26.6	30.5	175
May	22.8	26.9	31.0	101
June	21.7	26.0	30.4	67
July	20.9	25.6	30.4	37
August	20.4	25.7	31.0	14
September	20.9	26.0	31.1	25
October	21.8	26.5	31.2	56
November	22.9	26.7	30.5	213
December	23.0	26.1	29.3	552

Historically, floods and strong winds that occur almost every year cause losses and damage to Makassar City. According to (BBWS-PJ, 2014), between 1999 – 2013, there were 26 cases of flooding that damaged 324 houses and impacted 6,476 people. The flood in January 2013 caused 5,763 people as the victims and was declared the worst flood in the history of Makassar City. The worst impacted areas were located in the lowlands with poor

drainage and sanitation systems. New housings on the suburb of a former agricultural area became the main flood site in January 2013. Strong winds occurred with an average of 2 cases per year. Reports on cases of strong winds that damaged around 300 houses and killed around 200 people occurred between 2003 – 2012. Droughts, fires, large sea waves, and endemic diseases also became the problems that occurred in Makassar City. All take place due to climate change which is uncertain or difficult to predict and will have different impacts according to the geographical location of the region.

3.2 Jeneberang River System Planning Data

Floods in agricultural and residential areas occur due to the inability of river bodies to accommodate the passing water discharge. The floods occur in Maros River, Sinjai River, Bialo River, Pappa River, Allo River, Tamanroya River, Calendu River, Pampang River and Tallo River. Increased erosion and sedimentation in rivers that cause siltation and reduced water storage capacity especially take place in Maros watershed, Jeneberang watershed (mainly due to the landslide of Mount Bawakaraeng), Pappa watershed and Tamanroya watershed. Especially in the Jeneberang watershed, due to the collapse of the slopes of Mount Bawakaraeng, sedimentation into the Jeneberang River was 167.2 million m³ and sedimentation in the Bilibili Reservoir was 75.2 million m³. High sedimentation reaches 3,862 tons/year (Tamanroya watershed 342 tons/year, Jeneberang watershed 1,280 tons/year, Kelara-Karaloe watershed 219 tons/year, Maros watershed 233 tons/year, and Pappa watershed 247 tons/year). Abrasion and critical beaches are spread in almost all regencies/cities in Jeneberang river area, i.e., Takalar Regency, Bantaeng Regency, Bulukumba Regency, Sinjai Regency, Selayar Regency, Makassar City, Jeneponto Regency, and Maros Regency. The total length of the abraded and critical beach is 237 km.

3.3 Makassar City PDAM Drinking Water Management Planning Data

Makassar City PDAM revealed that the biggest problem faced by PDAM Makassar City is the supply of clean water for drinking water. The most important service is the clean water supply network. This network is threatened by the increasing demand for water as the urban population grows and it is difficult to keep up with the increase in supply. In Makassar city, the urban clean water system relies heavily on water supply from surrounding districts such as Gowa and Maros. In addition, Urbanization and lack of proper management of clean water sources puts these sources at risk. Accordingly, the clean water system also requires additional network to meet the increasing demand and regular maintenance. It is in line with a study from Tadesse et al., (2013) that one major issue of water source distribution is lack of proper management is waiting time or queuing of water supply.

Details of the problems faced by PDAM Makassar City in water resources management for drinking water for Makassar City residents are:

1. Limited supply of raw water; In regard to raw water constraints, it is proposed to add or build reservoirs that are prioritized for drinking water, SPAM (drinking water supply system) regionalization, and proposals regarding PP (government regulations) that regulate Water Use Rights.
2. Unfavorable regulations; In terms of regulation, Law Number 23 of 2014 regarding Regional Government states that BUMD (Regional Owned Enterprises) is in the form of Perumda or Perusda.
3. Long-term debt; Even though Makassar City PDAM is in the healthy category or has paid off its debt, there are other 175 PDAMs that have debts to the Ministry of Finance with a total debt of IDR 4.7 trillion. The current status is that 76 PDAMs have been restructured (Rp3,297 trillion or 70%), 9 PDAMs do not participate in restructuring

(Rp55 billion or 1%), 29 are in the restructuring process (Rp359 billion or 8%), and 6 are restructured (Rp988 billion or 21 %).

4. The electricity tariffs (TTL); In order to run the production and distribution of water to the society, almost all PDAMs use PLN electricity. The average electricity load reaches 40% of the production cost. The condition or national electricity capacity for PDAM is 250 Mega Watt (relatively small for PLN).

3.4 PDAM Customer Condition Data

The survey results show that most of the water sources utilized to meet the needs of clean water already use PDAM service water (84%) but for drinking water needs, people use refilled water (45.6%) more than PDAM services (42.4%). The trend of urban people choosing refilled water is for the reasons of convenience and practicality since they do not need to boil the water for drinking anymore. However, there are still 11.2% of respondents who use well/artesian well water for bathing and washing needs and 5.6% who use it as a source of drinking water.

The types of PDAM customers that were successfully captured in this study were household customers (88.8%) and the rest were public and business facilities. There were 6.4% of respondents who chose not to answer on the grounds that they were not PDAM customers or used other water sources.

The survey results show that some respondents stated that it was easy (61.6%), very easy (29.6%), moderately difficult (6.4%) and difficult (2.4%) to meet their daily clean water needs. This shows that the people of Makassar City are generally still easy to get clean water services for their daily needs.

The survey results show that more than 60% of respondents stated that the quality of clean water for drinking water provided by PDAM Makassar City is odorless, tasteless, and colorless both in the dry season and in the rainy season, while 26% stated that it still smells, tastes, and is colored both in the dry season and in the rainy season. The rest chose not to respond.

Table 2. Dry Season and Rainy Season Water Quality

NO.	RESPONSE	CLIMATE	ODOR	%	TASTE	%	COLOR	%
1	Yes	Dry	14	13.3	9	8.6	14	13.3
		Rainy	20	19.0	9	8.6	27	25.7
2	Not	Dry	89	84.8	88	83.8	82	78.1
		Rainy	83	79.0	87	82.9	69	65.7
3	No Response	Dry	2	1.9	8	7.6	9	8.6
		Rainy	2	1.9	9	8.6	9	8.6
		Dry	105	100	105	100	105	100
		Rainy	105	100	105	100	105	100

3.5 Green Ergonomics Concept in Water Resources Management in Makassar City

One approach that can be employed to examine this problem is green ergonomics. A study on green ergonomics is necessitated to ensure that PDAM as a water resource administrator in Makassar city must be able to carry out its production process ergonomically, cleanly and efficiently.

In this study, the concept of Green Ergonomics is used to balance the water resources management with the role of humans as managers themselves. Ergonomics currently does not only study the state of a micro work system, but more broadly, it also discusses

environmental problems. For almost two decades, (Helander et al., 1996) proposed that ergonomics should address the problems of water and food shortages, inefficient use of energy, pollution and waste, and rapid urbanization. Ergonomics experts are deemed necessary to collaborate in environmental management in one area and must be able to overcome global environmental and social problems such as pollution from big cities. Therefore, this study incorporates the concept of Green Ergonomics as a complement in the water resources management.

3.6 Goal Setting, Achievement Strategies, Forms of Uncertainty, and Measurement Results Models

The RDM process begins with focus group discussion activities that bring together the parties and decision makers to set goals and consider the severity of the problems found in decisions, strategies that can be used to achieve goals, uncertainties that will affect the strategies, and the relationships that govern strategic performance related to decision-making considerations (Patterson et al., 2009). This activity used XLRM framework which is used to set up the simulation model. XLRM refers to four factors; (1) Exogenous Uncertainty (X) which are factors that are difficult to control by decision makers but are important in determining the success of the strategy which in this research refers to the Makassar City Vulnerability Study Document, (2) Policy Levers (L) which means the diversity of combinations of short-term adaptation actions consisting of alternative strategies that will be used, which in this study refer to the Strategic Planning documents of PDAM and BBWS-PJ as the buffer institutions, (3) Risk and Impact Measurements (M) means the calculation and evaluation of hazards and risks combined with aspects of vulnerability, exposure, and sensitivity of city system components caused by unpredictable exogenous factors, which in this study refers to the results of the analysis of the level of vulnerability, exposure, sensitivity, and adaptability, and (4) Relationships and Models (Rs) which represent simulation models that describe the success or failure of adaptation strategies as measured by the impact of risk or the impact of exposure hazard due to exogenous uncertainty (Table 3).

Table 3. Main Elements of XLRM

Exogenous Uncertainty (Xs)	Policy Lever (Ls)
Hazard related uncertainty: <i>Increasing rainfall/flood,</i> <i>Sedimentation,</i> <i>Drought,</i> <i>Environmental damage,</i> <i>Sea level rise,</i> <i>Beach abrasion,</i> <i>Strong wind,</i> <i>Tidal wave.</i>	BBWS-PJ 1. Integrated upstream-downstream Water Resources Management implementation. 2. Construction/upgrade, operation and maintenance: • Water source capacity, • Water discharge for raw water facilities/infrastructure services to meet domestic/household, urban and industrial needs (RKI), • Coverage of irrigation and swamp network services, • Coverage of area protected from the danger of flooding.
Exposure related uncertainty: <i>Residential area,</i> <i>Total population,</i> <i>Population density,</i> <i>Poverty,</i> <i>Economic growth and equity.</i>	PDAM 1. Production optimization and capacity building for WTP (Water Treatment Plant) IV and V. 2. Construction of New WTP (Tallo River raw water).

Vulnerability related uncertainty: <i>City expansion,</i> <i>Population growth,</i> <i>Clean water supply,</i> <i>Soil erosion,</i> <i>Floods and puddles,</i> <i>Long dry season,</i> <i>Disease outbreak</i>	3. Development of the main and tertiary distribution of pipeline network in the Eastern Region (II and III). 4. Rehabilitation of old Dutch pipelines for gradual water loss rates of at least 1 - 2% per year. 5. Plans for adding raw water to support the raw water crisis of WTP II Panaikang by utilizing raw water from the Tallo River during the dry season. 6. Service plan in bulk for PDAM Maros Regency customers which is directly adjacent to the Makassar City PDAM service area.
Relations and Models (Rs)	Impact Measurement (Ms)
ArcGIS Model: calculating the impact of the risk and impact damage SWMM Model Integrated Analytical Risk Model	Availability of raw water supply: balance and effectiveness of available budget related to various impacts of natural resource management planning for drinking water.

3.7 Adaptive and Robust Strategic Decisions in Water Resources Planning for Drinking Water in Makassar City

Based on the results of this study, the key elements of a robust adaptive strategy are identified as follows:

- a) Implementing clear and measurable short-term projects/programs, which, in spite of the risks, still provide minimal benefits until the occurrence of future climate change and its impacts (near-term no-regret projects);
- b) Observing visible signs or indicators of exogenous uncertainty that requires PDAM and BBWS-PJ to prepare additional investments;
- c) Considering and deciding which projects or program activities should be postponed, which in this case are the additional investment to be carried out in the uncertain future conditions;
- d) Monitoring and preparing a pessimistic budget for the remaining vulnerabilities, which in this context are the project sequence or program activities in the master plan that are projected to fail to achieve the objectives of natural resource management for drinking water in Makassar City.

The program activities in the master plan document that have been analyzed, owned by both BBWS-PJ and Makassar City PDAM, can apply smaller and less expensive activity plans in their efforts to achieve water reliability in various climatic conditions and water demands. In the planning analysis, it was found that in various cases, BBWS-PJ project and Makassar City PDAM could implement smaller and less expensive project activities to achieve water reliability across climatic conditions and demand. The results of the study show that the range of river flow conditions and future demand can achieve water reliability. The performance of raw water sources in each region has an identical tendency and has the possibility to achieve water reliability. It is certain, however, that among the planned projects, there will be raw water sources or other types of projects that fail to achieve water reliability.

3.8 Sustainable Water Resources Management with Green Ergonomics Approach

In the water resources management, the Green Ergonomics approach can be employed to support the efficiency of water resources management from raw water to clean water which will be distributed to the residents in Makassar City. The application of this concept is a combination of ergonomic and environmental aspects by developing an understanding of how water resources are in line with the work systems and integrate with

the larger ecosystems. This involves the understanding of life cycle flows, their transformation and integration, and understanding how the waste generated by the system is utilized (Véronneau and Cimon, 2007)

In Ergonomics, humans play an important role in the implementation of a system. The success of a work system also depends on the ability of workers to implement the system. In the water resources management, in the face of uncertainty that becomes a risk, Ergonomics can be involved in its activities. The involvement of the Ergonomics approach can strengthen the values of management (Holden, 2012).

In other words, there is a necessity for a reconceptualization of the water resources management system which previously only focused on the uncertainty of raw water discharge and its management, but now requires the integration of humans and the environment in its management. Workers in each production line must be competent in carrying out their work. Workers must know the scope of their work well and create an ergonomic work environment by taking adjustments and flexibility in work into account (Lange-Morales et al., 2014). It is in line with (Bharti et al., 2020) that there is the need for a paradigmatic in water management to be more integrated and adaptive management approaches and innovations are key to enhancing urban water management systems. By paying more attention to this, it is possible to demonstrate a more sustainable approach to water resources management as shown in figure 3.

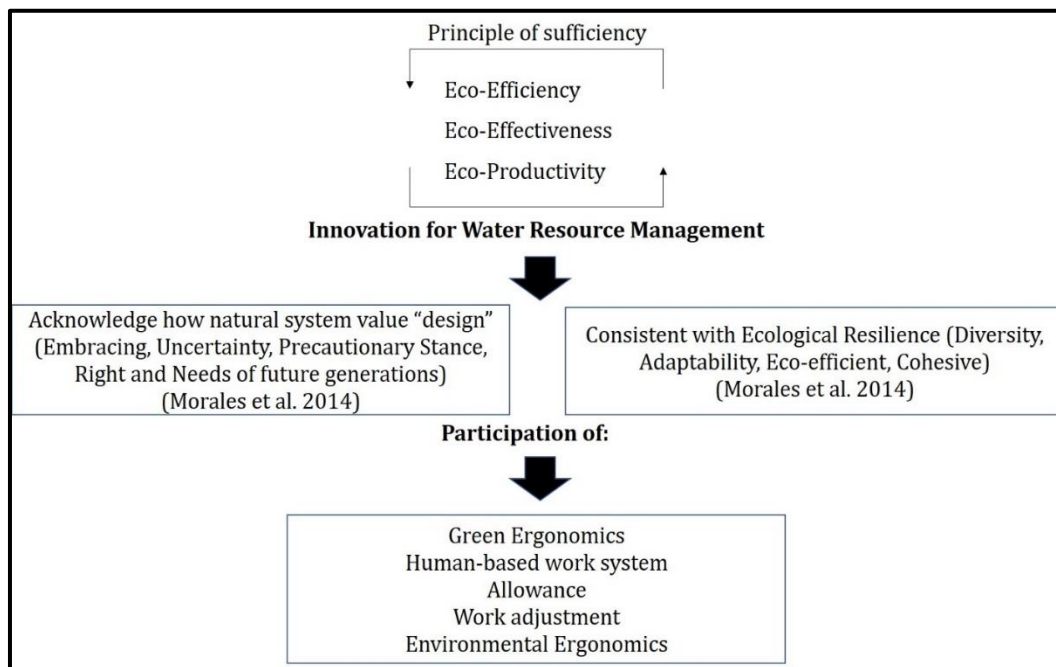


Figure 3. Green Ergonomics Concept for Water Resources Management

4. Conclusions

It can be concluded that:

1. The scenario for determining operational policies for natural resource management is influenced by conditions of low, medium, and high economic growth scenarios, and political conditions, as well as climate change. Each scenario matrix contains 5 aspects, which are (1) Natural Resources Conservation, (2) Natural Resources Utilization, (3) Water Damage Control, (4) Natural Resources Information System, and (5) Society and Business

- Participation. These are the summary of scenarios for the choice of adaptation strategies that have been, are being, or will be implemented by BBWS-PJ.
2. It is very important to implement a short-term adaptation strategy plan as the initial basis for long-term climate change adaptation planning and to integrate it into the planning mechanism or management in the form of the PDAM Business Development Plan or RKAP and the city government's annual and medium-term plans.
 3. Participatory Ergonomics and Environmental Ergonomics can be taken into account in the development of Water Resources Management in Makassar City by involving environmental factors, adjustments, and leniency.

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Integration of Green Ergonomics in Robust Decision Making (RDM) Approach in Water Resources Management in Makassar City

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Abstract. Water resources management has several challenges such as water stress, droughts, human contamination, increasing population, and natural calamities. Therefore, effective strategic planning in water resources management, a planning strategy is required in order critical to be able to minimize these perpetually encountered problems challenges. Water resources for drinking water in Makassar City and other regions in Indonesia are managed by the respective vertical agencies and regional governments. The Regional Drinking Water Company (PDAM) of Makassar City as a company that manages the fulfillment of clean water needs for the residents of Makassar City and has performs operational activities. In this study, we aimed to integrate the concept of green ergonomics as a guide to propose the basis of interventions, social responsibility, and environmental or ecospheric responsibility in water resources management Green Ergonomics becomes a guideline for proposing the basis of interventions, social responsibility, and environmental or ecospheric responsibility. Green ergonomics is also necessitated for the evaluation and sustainable development, and for a good reciprocal relationship of between human and natural systems. In addition, green ergonomics develops an understanding of how a variety of resources such as energy, biological entities, and minerals flow through work systems and integrate with the ecosystems.

Keywords: Environment; Green ergonomics; Robust decision making; Water Resource; RDM, Green Ergonomics, Environment

1. Introduction

Generally, the expansion of flood areas in Makassar City is induced by a decrease in the water catchment areas as a result of due to an increased of residential areas. This is as a result of and due to the increasing in the city population on account of both births and urbanization trends. At the same time Simultaneously, due to the lack of clean water supply from two rivers, the Jeneberang River and the Lekopancing River, passing through Makassar City, there is a decrease in the quantity and quality of water due to a decrease in the supply of clean water from two rivers that passed through Makassar City, which are the Jeneberang River and the Lekopancing River. The two rivers originate in from different regional government areas and create their own problems in their terms of management that have the could potentially lead to cause conflicts.

Global climate change has an significantly impacted on water resources, especially on the water cycle, water demand, water supply, and water quality standards. According to Emanuel; (2005), there are two causes of global climate change; i.e., population growth in coastal areas and natural events. This finding is in harmony-line with studies conducted by Nelson et al.; (2010), who stated that global climate change can trigger an increase in the need for clean water supplies, and Karl et al.; (2009a); Kasayanond et al.; (2019); and Lange-Morales et al.; (2014), who concluded that an increase in temperature results in changes in river water discharge, which causes humans to need more water

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to grow and maintain health. Furthermore, ~~Additionally, in line with~~ Hartono et al. (2010) ~~stated~~ that water quality should be improved to meet clean water standards. ~~To counter these challenges, an in-water resources management, effective a strategic planning strategy is required imperative to be able to minimize the perpetually encountered problems.~~ Water resources for drinking water in Makassar City and other regions in Indonesia are managed by the respective vertical agencies and regional governments. Regulatory clauses on water resources management rules are distinct, although ~~the~~ policy implementation is not optimal when the water resources pass through territorial areas that are administratively under different regional governments.

Green ergonomics includes several principles, ~~including such as~~ *eco-efficiency, eco-effectivity*, and *eco-productivity* (Thatcher et al., 2013). The green ergonomics approach can be applied in evaluating and developing industries ~~for to promote~~ sustainable development. ~~Green ergonomics~~ *In addition, it* ensures that human and natural systems ~~are in maintain~~ a good reciprocal relationship. ~~Green ergonomics~~ *Green ergonomics in which there are* *with* factors of efficiency, effectiveness, and productivity move beyond the specific reference of a work system. Green ergonomics ~~helps~~ *develops* an understanding of how ~~a~~ variety of resources such as energy, nutrients, biological entities, and minerals flow through work systems and integrate with ~~the~~ ecosystems. This involves understanding ~~something about the~~ flows of life cycle transformation and their integration, and understanding what happens to the “waste” generated by the system (Lange-Morales et al., 2014).

The Regional Drinking Water Company (PDAM) of Makassar City ~~as a company that~~ manages the fulfillment of clean water needs for the residents of Makassar City. ~~It also has performs~~ operational activities, ~~i.e., such as~~ managing the distribution and service of drinking water that meets ~~the~~ health requirements ~~to of~~ the society in an equitable, orderly, and regular manner, and ~~carriesing~~ out *sustainable and environmentally friendly* urban development and services, ~~sustainable, and environmentally friendly~~. One method that can be employed to analyze environmental problems is the Robust Decision Making (RDM) method. ~~RDM can be relied on which is reliable in the strategic decision-making for strategic~~ water resources planning policies. ~~Some studies have investigated~~ (Karl et al., 2009b), (Matrosov et al., 2013), (Hidayatno et al., 2015), and (Casal Campos et al., 2015) ~~studied~~ environmental ~~problems challenges~~ and water resources management, ~~but however, they~~ did not involve decision-making as a key strategy for solving water management ~~problems challenges~~ (Karl et al., 2009b; Matrosov et al., 2013; Hidayatno et al., 2015; Casal-Campos et al., 2015).

~~In addition,~~ *This study* aimed to integrate the concept of ~~Green-green~~ *Ergonomics* as a guide to propose the basis of interventions, social responsibility, and environmental or ecospheric responsibility ~~on~~ water resources management. Green ~~Ergonomics~~ is also ~~required important~~ for ~~the~~ evaluation and sustainable development, and ~~for maintaining~~ a good reciprocal relationship ~~of between~~ human and natural systems. ~~In addition, Green ergonomics it helps~~ *develops* an understanding ~~of a~~ how ~~a~~ variety of resources such as energy, biological entities, and minerals flow through work systems and integrate with ~~the~~ ecosystems. This involves understanding the flow of the transformation life cycle and its integration (Lange-Morales et al., 2014). Consequently, it is considered necessary to combine ecological or environmental aspects with ergonomic aspects, which, in this case, is the water resources management in a work system.

Furthermore, ~~although there are~~ several recent studies ~~that discussed~~ *investigated* water resources (Hidayatno et al., 2015; Odume and Wet, 2016; Xie et al., 2017; Juniati et

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A comma used before “and/or” in a series of three or more items, usually used in American English.

al., 2019; Knox et al., 2018; Juniati et al., 2019; Octavia et al., 2020; Odume and Wet, 2016; Sabara et al., 2020; Xie et al., 2017), but they did not examine the decision making in the water resources management system and the previous research did not use an approach that focuses on global environmental and climate issues that are fulfilled with of uncertainty. Moreover, To our knowledge, this is the first research that integrates the concept of Green Ergonomics research on water resources management; hence, it is expected that decision-making and strategy identification can lead to efficiency and effectiveness in the work system of water resources management.

2. Methods

This study used the RDM approach for strategic decision-making on water resources management planning for drinking water in Makassar City. In this study, Robust in this study is considered as the ability of the system to face decision-making constraints on water resources planning for drinking water. The concept to develop is the concept of ecosystem elasticity which that can be improved by upgrading the scale of resistance. This is measured by the magnitude of the disturbance and the maximum threat required to determine the resilience or flexibility of the system with the decisions taken (De Bruijn, 2005). Furthermore, the resilience of the economic system and social system is also developed as an integrated material in the interdisciplinary studies, which, in this case, are the study of Green-green Ergonomics and Environmental Management studies.

2.1. Data Resources

The data collected in this study are primary data and secondary data. The primary data was obtained directly through observation, focus group discussions (FGDs), and interviews with resource persons in regards to the questionnaire guide. Meanwhile, the secondary data in this study were regional and national planning documents, Strategic Planning (Renstra) of Makassar City PDAM, Strategic Planning of Water River Central Region-Pompengan Jeneberang (BBWS-PJ), State Electricity Company (PLN), Central Statistics Agency (BPS) of Makassar City, and relevant related research. In addition, the secondary data were used as a Focus Group Discussion (FGD) material by discussing the 2011-2036 Corporate Plan of Makassar City PDAM, long-term plan documents, management of challenges and opportunities, and the BBWS-PJ master plan.

2.2. Data Collection

The data were collected through structured interviews, consumer surveys through using questionnaire distribution, which also involved all aspects of humans and work systems, and in-depth observation methods on various objects related to water resources planning and management activities. Overall, 125 respondents (61 men and 64 women) from 14 sub-districts in Makassar City were participated in this study. They were participants represent were from 10 various professions with an age range of age was between 18 to and 65 years old and that is expected to represent the water user community in Makassar City. The results of the observations were then combined with the primary and secondary data to conduct an Focus Group Discussion FGD with the entire components involved. In short, brief, there were four steps were adopted in data collection in order to obtain quality data, which were; (1) Participatory participatory Scoping, (2) Case Generation and Exploration Models, (3) Discovery Scenarios, and (4) Trade-off Analysis. In data collection, FGD was also conducted with environmental

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and ergonomics experts as one of the integrations of ~~Green-green~~ Ergonomics in RDM to obtain scenarios for solving water resources problems in Makassar City.

2.3 Data Analysis Techniques

The analytical technique ~~that will be~~ applied in this study complies with the ~~4four~~-step key RDM process and procedure, ~~which are iterative as mentioned above. The four key steps were used to adhere to the research objectives, i.e.:~~ (1) Participatory Scoping; (2) Case Generation and Exploration; (3) Scenario Discovery; and, (4) Tradeoff Analysis. Participatory scoping is ~~basically~~ a form of focusing attention on issues or ~~problems~~ challenges that will be studied or resolved through ~~Focused Group Discussions (FGDs)~~.

The participants who are expected to attend the event are stakeholders, policy makers, resource persons, environmental ergonomics experts, and water user communities according to their respective capacities. This activity aims to define or limit the scope of objectives and measurements, ~~the~~ scope of strategies that can be employed to achieve the objectives, ~~the~~ scope of uncertainty that will affect the successful use of the strategy, and ~~the~~ scope of relationships that will help demonstrate the process of using the measurement. Thus, the conceptual model of problem-solving is shown in Figure 1.

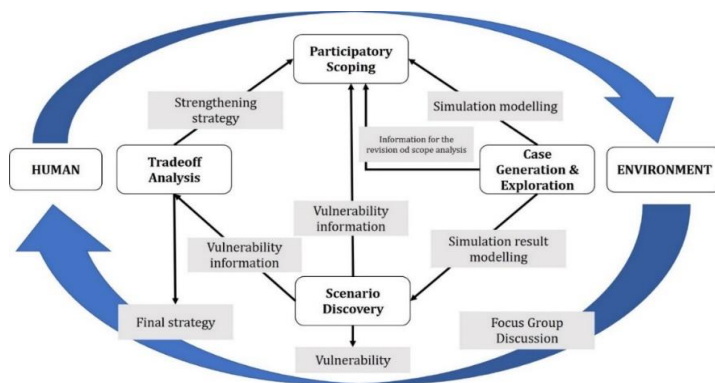


Figure 1 Green eErgonomics - RDM Conceptual Model

~~In order to~~ To implement the conceptual model ~~shown~~ above, the following steps are implemented:

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All text in the Figures is readable - font size ≥ 8pt.

Per guidelines, all figures should be embedded correctly positioned within your Word files, and should also be supplied as separate graphics files in their original formats. EPS, TIFF or PSD formats are preferred. Use a minimum of 300 dpi.

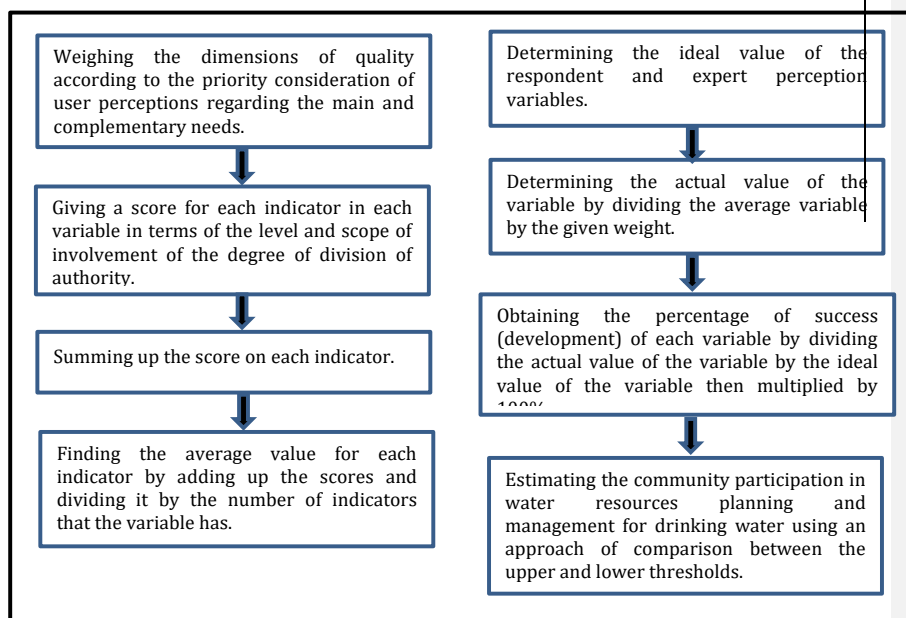


Figure 2. Data Analysis Stage

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Note that figures should be cited in order.

3. Results and Discussion

Five main data components were obtained: (1) data on future climate change vulnerability and adaptation strategies, (2) data for Jeneberang River management system planning, (3) data for drinking water management planning of Makassar City PDAM, (4) socio-economic data of PDAM Makassar City customers, and (5) Green Ergonomics concept in water resources management in Makassar City. The five data were obtained from vulnerability assessment documents, focus group discussions FGDs, interviews, and socio-economic surveys of the people using PDAM water services. The data were analyzed descriptively, and the results were used to answer 4-four key research questions that lead to the achievement of research objectives. In this study, vulnerability data were used as the baseline data in exogenous factors or exogenous uncertainty (Xs) while adaptation strategies were used as Policy-policy levers data (Ls) data. Exogenous uncertainty (Xs) is are factors that is difficult for decision-makers to control; but however, they are important in determining the success of the strategy. Meanwhile, Policy Levers (Ls) are the diversity of combinations of short-term adaptation actions consisting of alternative strategies that will be implemented.

3.1. Climate Vulnerability Data

Historically, floods and strong winds that occur almost every year cause losses and damage to Makassar City. According to BBWS-PJ, (2014), between 1999 and 2013, there were 26 cases of flooding that damaged 324 houses and impacted 6,476 people. The flood in January 2013 caused-affected 5,763 people as the victims and was declared the worst flood in the history of Makassar City. The worst impacted areas were located in the lowlands, with poor drainage and sanitation systems. New housings in the suburb of a former agricultural area became the main flood site in January 2013. Strong winds

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occurred with an average of ~~2~~^{two} cases per year. Reports on cases of strong winds that damaged around 300 houses and killed around 200 people occurred between 2003 ~~—and~~ 2012. ~~In addition, D~~^{addition}roughts, fires, large sea waves, and endemic diseases ~~also became the problems~~^{are also} ~~were other events~~^{became the problems} that occurred in Makassar City. All ~~take place due~~^{are attributed} ~~these events~~^{to climate change}, which is uncertain or difficult to predict and will have different impacts according to the geographical location of the region.

3.2. Jeneberang River System Planning Data

Floods in agricultural and residential areas occur due to the inability of river bodies to accommodate the passing water discharge. ~~The f~~^Floods occur in ~~the~~^{the} Maros River, Sinjai River, Bialo River, Pappa River, Allo River, Tamanroya River, Calendu River, Pampang River, and Tallo River. Increased erosion and sedimentation in rivers that cause siltation and reduced water storage capacity especially take place in ~~the Maros watershed~~^{the Maros watershed}, Jeneberang ~~watershed~~^{watershed} (mainly due to ~~the large-scale~~^{the large-scale} landslide ~~of at~~^{at} Mount Bawakaraeng), Pappa ~~watershed~~^{watershed}, and Tamanroya watersheds. Especially in the Jeneberang watershed, due to the collapse of the slopes of Mount Bawakaraeng, sedimentation into the Jeneberang River was 167.2 million m³ and sedimentation in the Bilibili Reservoir was 75.2 million m³. High sedimentation reaches 3,862 tons/year (Tamanroya watershed 342 tons/year, Jeneberang watershed 1,280 tons/year, Kelara-Karaloe watershed 219 tons/year, Maros watershed 233 tons/year, and Pappa watershed 247 tons/year).

3.3. Makassar City PDAM Drinking Water Management Planning Data

Makassar City PDAM revealed that the biggest ~~problem~~^{challenge} faced by PDAM Makassar City is the supply of clean ~~water for~~^{water for} drinking water. ~~The most important and the service is the of a~~^{is the of a} clean water supply network. ~~In addition, T~~^{In addition}his network is threatened by ~~the increasing demand for water as due to the increasing the urban population grows and it is difficult to keep up with the increase in supply~~^{the increasing demand for water as due to the increasing the urban population grows and it is difficult to keep up with the increase in supply}. In Makassar city, the urban clean water system relies heavily on water supply from surrounding districts such as Gowa and Maros. ~~In addition~~^{Moreover}, ~~u~~^urbanization and ~~the~~^{the} lack of proper management of clean water sources puts these sources at risk. ~~Accordingly~~^{As a result}, the clean water system ~~also~~^{also} requires ~~an~~^{an} additional network to meet the increasing demand and regular maintenance. ~~It~~^{This} ~~finding~~^{finding} is in line with ~~a study from by~~^{a study from by} Tadesse et al., (2013), ~~indicating~~^{indicating} that one ~~of the~~^{of the} major issues of ~~the~~^{the} water source distribution is ~~the~~^{the} lack of proper management ~~is in~~^{is in} waiting time or queuing of water supply.

3.4. PDAM Customer Condition Data

The survey results show that most of the water sources utilized to meet the needs of clean water ~~already~~^{already} use PDAM service water (84%); ~~but however~~^{but however} for drinking water ~~needs~~^{needs}, people ~~use prefer~~^{use prefer} refilled water (45.6%) ~~more than to~~^{more than to} PDAM services (42.4%). The trend of urban people choosing refilled water is for the reasons of convenience and practicality since they ~~do not no longer~~^{do not no longer} need to boil the water for drinking ~~anymore~~^{anymore}. However, ~~there are still~~^{there are still} 11.2% of ~~the~~^{the} respondents ~~still who~~^{still who} use well/artesian well water for bathing and washing needs, and 5.6% who use it as a source of drinking water. The types of PDAM customers that were successfully captured in this study were household customers (88.8%) and the rest were public and business facilities. There were 6.4% of respondents who chose not to answer ~~on the grounds that~~^{because} they were not PDAM customers or used other water sources.

The survey results show that ~~61.6% of the some~~^{61.6% of the some} respondents ~~stated that it was found~~^{stated that it was found} ~~it easy~~^{it easy} ~~to meet their daily clean water needs~~^{to meet their daily clean water needs} (~~61.6%~~^{61.6%}), ~~very easy~~^{very easy} (~~29.6%~~^{29.6%}), ~~very easy~~^{very easy} (~~29.6%~~^{29.6%}), ~~very easy~~^{very easy} (~~29.6%~~^{29.6%}).

moderately difficult (6.4% moderately difficult), and difficult (2.4% difficult) to meet their daily clean water needs. This shows indicates that the majority of the people of Makassar City are generally still easy to get easy access to clean water services for their daily needs. In addition, The survey results show that more than 60% of respondents stated that the quality of clean water for drinking water provided by PDAM Makassar City is odorless, tasteless, and colorless, both in the dry season and in the rainy seasons, while 26% stated that it still smells, tastes, and is colored both in the dry season and in the rainy season. The rest chose not to respond, as shown in Table 1.

Table 1. Dry Season and Rainy Season Water Quality

No	Response	Climate	Odor	%	Taste	%	Color	%
1	Yes	Dry	14	13.3	9	8.6	14	13.3
		Rainy	20	19.0	9	8.6	27	25.7
2	Not	Dry	89	84.8	88	83.8	82	78.1
		Rainy	83	79.0	87	82.9	69	65.7
3	No Response	Dry	2	1.9	8	7.6	9	8.6
		Rainy	2	1.9	9	8.6	9	8.6
		Dry	105	100	105	100	105	100
		Rainy	105	100	105	100	105	100

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3.5. Green Ergonomics Concept in Water Resources Management in Makassar City

One approach that can be employed to examine this problem is green ergonomics. A study on green ergonomics is necessitated to ensure that PDAM as a water resource administrator in Makassar city must be able to carry out its production process ergonomically, cleanly, and efficiently. In this study, the concept of Green ergonomics is used to balance the water resources management with the role of humans as managers themselves. Green Ergonomics currently does not only study the state of a micro work system, but more broadly, it also discusses environmental problems more broadly. For almost two decades, (Helander et al., (1996) proposed that ergonomics should address the problems of water and food shortages, inefficient use of energy, pollution and waste, and rapid urbanization. Green Ergonomics experts are deemed necessary to collaborate in environmental management in one area and must be able to overcome global environmental and social problems such as pollution from big cities. Therefore, this study incorporates the concept of Green Ergonomics as a complement in the water resources management.

3.6 Goal Setting, Achievement Strategies, Forms of Uncertainty, and Measurement Results Models

The RDM process begins with focus group discussion (FGD) activities that bring together the parties and decision-makers to set the goals and consider the severity of the problems found in the decisions, strategies that can be used to achieve goals, uncertainties that will affect the strategies, and the relationships that govern strategic performance related to decision-making considerations (Patterson et al., 2009). This activity uses the XLRM framework, which is used to set up the simulation model. XLRM refers to four factors: (1) Exogenous Uncertainty (Xs) which are factors that are difficult to

control by decision-makers but are important in determining the success of the strategy, which in this research refers to the Makassar City Vulnerability Study Document; (2) **Policy Levers (Ls)** which means are the diversity of combinations of short-term adaptation actions consisting of alternative strategies that will be used, which, in this study, refer to the Strategic Planning documents of PDAM and BBWS-PJ as the buffer institutions; (3) **Risk-risk** and **Impact M** measurements (M) means or the calculation and evaluation of hazards and risks combined with aspects of vulnerability, exposure, and sensitivity of city system components caused by unpredictable exogenous factors, which in this study refers to the results of the analysis of the level of vulnerability, exposure, sensitivity, and adaptability; and (4) **Relationships—relationships** and **Models—models** (Rs), which represent simulation models that describe the success or failure of adaptation strategies as measured by the impact of risk or the impact of exposure hazard due to **exogenous uncertainty** (Table 2).

Table 2. Main Elements of XLRM

Exogenous Uncertainties (Xs)	Policy Levers (Ls)
	BBWS-PJ
Hazard related uncertainty: <u>Increasing rainfall/flood;</u> <u>Sedimentation;</u> <u>Drought;</u> <u>Environmental damage;</u> <u>Sea level rise;</u> <u>Beach abrasion;</u> <u>Strong wind;</u> <u>Tidal wave;</u>	1. Integrated upstream-downstream Water Resources Management implementation. 2. Construction/upgrade, operation, and maintenance: • Water source capacity, • Water discharge for raw water facilities/infrastructure services to meet domestic/household, urban and industrial needs (RKI), • Coverage of irrigation and swamp network services, • Coverage of areas protected from the danger of flooding.
Exposure related uncertainty: <u>Residential area;</u> <u>Total population;</u> <u>Population density;</u> <u>Poverty;</u> <u>Economic growth and equity;</u>	PDAM
Vulnerability related uncertainty: <u>City expansion;</u> <u>Population growth;</u> <u>Clean water supply;</u> <u>Soil erosion;</u> <u>Floods and puddles;</u> <u>Long dry season;</u> <u>Disease outbreak</u>	1. Production optimization and capacity building for WTP (Water Treatment Plant) IV and V; 2. Construction of New WTP (Tallo River raw water); 3. Development of the main and tertiary distribution of pipeline network in the Eastern Region (II and III); 4. Rehabilitation of old Dutch pipelines for gradual water loss rates of at least 1%—2% per year; 5. Plans for adding raw water to support the raw water crisis of WTP II Panaikang by utilizing raw water from the Tallo River during the dry season; 6. Service plan in bulk for PDAM Maros Regency customers, which is directly adjacent to the Makassar City PDAM service area;
Relations and Models (Rs)	Impact Measurement (Ms)
ArcGIS m Model: Calculating the impact of the risk and impact damage	Availability of raw water supply: Balance and effectiveness of available budget related to various impacts of natural resource management planning for drinking water;
SWMM Model	
Integrated a Analytical R risk M model	

3.7 Adaptive and Robust Strategic Decisions in Water Resources Planning for Drinking Water in Makassar City

Based on the results of this study, the key elements of a robust adaptive strategy are identified as follows:

- Implementing clear and measurable short-term projects/programs, which, ~~in spite of~~ despite the risks, still provide minimal benefits until the occurrence of future climate change and its impacts (near-term no-regret projects);
- Observing visible signs or indicators of ~~exogenous uncertainty~~ that requires PDAM and BBWS-PJ to prepare additional investments;
- Considering and deciding which projects or program activities should be postponed, which in this case are the additional investment to be carried out in the uncertain future conditions;
- Monitoring and preparing a pessimistic budget for the remaining vulnerabilities, which, in this context, are the project sequence or program activities in the master plan that are projected to fail to achieve the objectives of natural resource management for drinking water in Makassar City.

The results of the study show that the range of river flow conditions and future demand can achieve water reliability. The performance of raw water sources in each region has an identical tendency and has the possibility to achieve water reliability. It is certain, however, that among the planned projects, there will be raw water sources or other types of projects that fail to achieve water reliability.

3.8 Sustainable Water Resources Management with Green Ergonomics Approach

In ~~the~~ water resources management, the ~~Green-green~~ Ergonomics approach can be employed to support the efficiency of water resources management from raw water to clean water ~~which will be distributed to the residents in Makassar City~~. The application of this concept is a combination of ergonomic and environmental aspects by developing an understanding of how water resources are in line with the work systems and integrating ~~them~~ with the larger ecosystems. This involves ~~the understanding the~~ of life cycle flows, their transformation and integration, and ~~understanding~~ how the waste generated by these systems ~~is-are~~ utilized (Véronneau and Cimon, 2007). In ~~green~~ Ergonomics, humans play an important role in the implementation of a system. The success of a work system also depends on the ability of workers to implement the system. In ~~the~~ water resources management, in the face of uncertainty that becomes a ~~potential~~ risk, ~~e~~Ergonomics can be involved in its activities. The involvement of the ~~green Ergonomics ergonomics~~ approach can strengthen the values of ~~the~~ management (Holden, 2012).

In other words, there is a necessity for a reconceptualization of the water resources management system, which ~~otherwise~~ previously ~~only~~ focused ~~only~~ on the uncertainty of raw water discharge and its management, ~~but~~ ~~Now, however, it~~ requires the integration of humans and the environment in its management. Workers in each production line must be competent in carrying out their work. Workers must know the scope of their work well and create an ergonomic work environment by ~~taking-considering~~ adjustments and flexibility in work ~~into account~~ (Lange-Morales et al., 2014). It is in line with (Bharti et al., 2020) that there is the need for a paradigmatic in water management to be more integrated and ~~that~~ adaptive management approaches and innovations are key to enhancing urban water management systems. By paying more attention to this, it is possible to demonstrate a more sustainable approach to water resources management as shown in Figure 3.

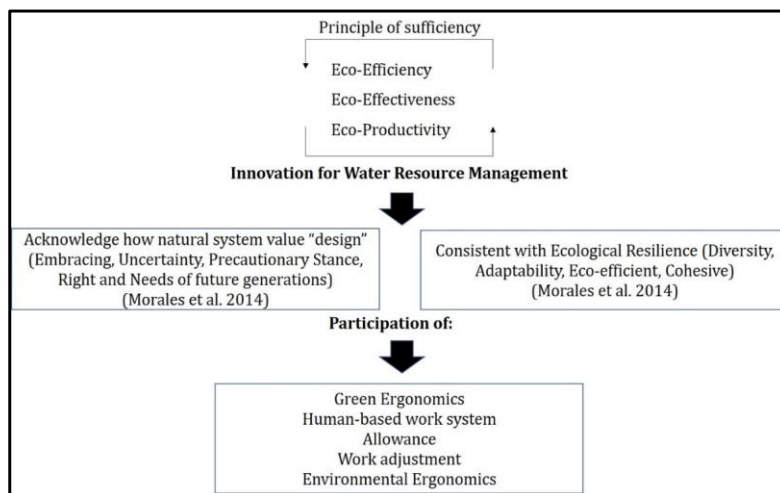


Figure 3. Green Ergonomics concept for water resources management

4. Conclusions

In conclusion, can be concluded that:

The scenario for determining operational policies for natural resource management is influenced by conditions of low, medium, and high economic growth scenarios, and political conditions, as well as climate change.

It is very important to implement a short-term adaptation strategy plan as the initial basis for long-term climate change adaptation planning and to integrate it into the planning mechanism or management in the form of the PDAM Business Development Plan or RKAP and the city government's annual and medium-term plans.

Participatory Ergonomics and Environmental Ergonomics can be taken into account considered in the development of Water Resources Management in Makassar City by involving environmental factors, adjustments, and leniency.

Acknowledgements

Provide acknowledgements accordingly. List here those individuals or institutions who gave help, assistance during the research (e.g., providing grants, laboratory facility, writing assistance or proof reading the article, etc.). In case of the grants, please provide the number and year of the grant received.

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ⁱCorresponding author's email: name@ai.ue.oa, Tel.: +00-00-000000; Fax: +00-00-000000
doi: [10.14716/ijtech.v0i0.0000](https://doi.org/10.14716/ijtech.v0i0.0000)

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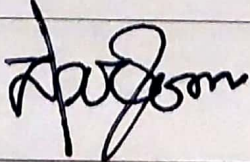
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Thu, Mar 31, 2022 at 3:59 PM

Dear Dr. Zakir Sabara,

On behalf of the Editorial Board, I am pleased to inform you that your paper entitled: **"Integration of Green Ergonomics in Robust Decision Making (RDM) Approach in Water Resources Management in Makassar City"** has been accepted to be published in International Journal of Technology (IJTech). You can find the Letter of Acceptance on attachment.

Thank you for your cooperation.

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Kind regards,
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February 9, 2022

Acceptance Letter

Dear Dr. Zakir Sabara, Dr. Irma Nur Afiah, and Mr. Rofiqul Umam

Greetings from Depok!

The editorial board is delighted to inform you that your paper entitled “**Integration of Green Ergonomics in Robust Decision Making (RDM) Approach in Water Resources Management in Makassar City**” has been accepted to be published in IJTech. At the present, we are conducting further necessary action to complete the publication process.

On behalf of IJTech, we appreciate your intention and willingness to publish your work with IJTech.

Warmest regards,



Prof. Dr. Mohammed Ali Berawi
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Journal Publishing

Dear

1. Dr. Zakir Sabara
2. Dr. Irma Nur Afiah
3. Mr. Rofiqul Umam

Greetings from Depok!

On behalf of the Editorial Board, I am pleased to inform you that your article entitled **Integration of Green Ergonomics in Robust Decision Making (RDM) Approach in Water Resources Management in Makassar City** has been published online in *Volume 13 Issue 2, Apr 2022*. You can check the online version at: <https://ijtech.eng.ui.ac.id/issue/77>

The articles are available to be accessed and downloaded free of charge. The hardcopy version is being printed and one copy will be delivered to the corresponding author.

Thank you for your contribution to IJTech and we look forward to a good collaboration in the next future.

Yours sincerely,

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afiah irma <afiah.irma@umi.ac.id>

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Integration of Green Ergonomics in Robust Decision Making Approach in Water Resources Management in Makassar City

Zakir Sabara^{1*}, Irma Nur Afiah², Rofiqul Umam³

¹*Department of Chemical Engineering, Faculty of Industrial Technology, Universitas Muslim Indonesia, Makassar, Indonesia*

²*Department of Industrial Engineering, Faculty of Industrial Technology, Universitas Muslim Indonesia, Makassar, Indonesia*

³*Department of Applied Chemistry for Environment, Faculty of Science and Technology, Kwansei Gakuin University, Sanda, Japan*

Abstract. Water resources management has several challenges such as water stress, droughts, human contamination, increasing population, and natural calamities. Therefore, effective strategic planning is critical to minimize these challenges. Water resources for drinking water in Makassar City and other regions in Indonesia are managed by the respective vertical agencies and regional governments. The Regional Drinking Water Company of Makassar City manages the fulfillment of clean water needs for the residents of Makassar City and performs operational activities. In this study, we aimed to integrate the concept of green ergonomics as a guide to propose the basis of interventions, social responsibility, and environmental or ecospheric responsibility in water resources management. Green ergonomics is necessitated for the evaluation and sustainable development and good reciprocal relationship between human and natural systems. In addition, green ergonomics develops an understanding of how a variety of resources such as energy, biological entities, and minerals flow through work systems and integrate with the ecosystems.

Keywords: Environment; Green ergonomics; Robust decision making; Water resource

1. Introduction

Generally, the expansion of flood areas in Makassar City is induced by a decrease in water catchment areas as a result of increased residential areas. This is due to the increasing city population on account of both births and urbanization trends. Simultaneously, due to the lack of clean water supply from two rivers, the Jeneberang River and the Lekopancing River, passing through Makassar City, there is a decrease in the quantity and quality of water. The two rivers originate from different regional government areas and create their own problems in terms of management that could potentially lead to conflicts.

Global climate change has significantly impacted water resources, especially on the water cycle, demand, supply, and quality standards. Furthermore, the availability of clean water sources has been declining over time (Ali et al., 2018). According to (Emanuel, 2005), there are two causes of global climate change: population growth in coastal areas

*Corresponding author's email: zakir.sabara@umi.ac.id, Tel.: +62811-446-284; Fax: +62411 455695
doi: [10.14716/ijtech.v13i2.5113](https://doi.org/10.14716/ijtech.v13i2.5113)

and natural events. This finding is in line with studies conducted by (Nelson et al., 2010), who stated that global climate change can trigger an increase in the need for clean water supplies, and (Karl, Melillo, et al., 2009; Kasayanond et al., 2019; Lange-Morales et al., 2014), who concluded that an increase in temperature results in changes in river water discharge, causing humans to need more water to grow and maintain health. Furthermore, Hartono et al. (2010) stated that water quality should be improved to meet clean water standards. To counter these challenges, an effective strategic planning is imperative. Water resources for drinking water in Makassar City and other regions in Indonesia are managed by the respective vertical agencies and regional governments. Regulatory clauses on water resources management rules are distinct, although policy implementation is not optimal when the water resources pass through territorial areas that are administratively under different regional governments.

Green ergonomics includes several principles such as *eco-efficiency*, *eco-effectivity*, and *eco-productivity* (Thatcher et al., 2013). The green ergonomics approach can be applied in evaluating and developing industries to promote sustainable development. In addition, it ensures that human and natural systems maintain a good reciprocal relationship. Green ergonomics with factors of efficiency, effectiveness, and productivity move beyond the specific reference of a work system. Green ergonomics helps develop an understanding of how a variety of resources such as energy, nutrients, biological entities, and minerals flow through work systems and integrate with the ecosystems. This involves understanding the flows of life cycle transformation and their integration and understanding what happens to the “waste” generated by the system (Lange-Morales et al., 2014).

The Regional Drinking Water Company (PDAM) of Makassar City manages the fulfillment of clean water needs for the residents of Makassar City. It also performs operational activities such as managing the distribution and service of drinking water that meets the health requirements of the society in an equitable, orderly, and regular manner and carries out sustainable and environmentally friendly urban development and services. One method that can be employed to analyze environmental problems is the Robust Decision Making (RDM) method, which is reliable in the strategic decision-making for water resources planning policies. Some studies have investigated environmental challenges and water resources management; however, they did not involve decision-making as a key strategy for solving water management challenges (Karl, Melilo, et al., 2009); (Matrosov et al., 2013); (Hidayatno et al., 2015); (Casal-Campos et al., 2015).

This study aimed to integrate the concept of green ergonomics as a guide to propose the basis of interventions, social responsibility, and environmental or ecospheric responsibility in water resources management. Green ergonomics is also important for the evaluation and sustainable development and maintaining a good reciprocal relationship between human and natural systems. In addition, it helps develop an understanding of how a variety of resources such as energy, biological entities, and minerals flow through work systems and integrate with the ecosystems. This involves understanding the flow of the transformation life cycle and its integration (Lange-Morales et al., 2014). Consequently, it is considered necessary to combine ecological or environmental aspects with ergonomic aspects, which, in this case, is the water resources management in a work system.

Furthermore, although several recent studies investigated water resources (Hidayatno et al., 2015; Odume & Wet, 2016; Xie et al., 2017; Knox et al., 2018; Juniati et al., 2019; Sabara et al., 2020), they did not examine the decision making in the water resources management system and did not use an approach that focuses on global environmental and climate issues filled with uncertainty. To our knowledge, this is the first research that integrates the concept of green ergonomics research on water resources management; hence, it is

expected that decision-making and strategy identification can lead to efficiency and effectiveness in the work system of water resources management.

2. Methods

This study used the RDM approach for strategic decision-making on water resources management planning for drinking water in Makassar City. In this study, robust is considered as the ability of the system to face decision-making constraints on water resources planning for drinking water. The concept to develop is the concept of ecosystem elasticity that can be improved by upgrading the scale of resistance. This is measured by the magnitude of the disturbance and maximum threat required to determine the resilience or flexibility of the system with the decisions taken (De Bruijn, 2005). Furthermore, the resilience of the economic system and social system is also developed as an integrated material in the interdisciplinary studies, which, in this case, are the green ergonomics and environmental management studies.

2.1. Data Resources

Data collected in this study are primary and secondary data. The primary data was obtained directly through observation, focus group discussions (FGDs), and interviews with resource persons in regards to the questionnaire guide. Meanwhile, the secondary data were regional and national planning documents, Strategic Planning (Renstra) of Makassar City PDAM, Strategic Planning of Water River Central Region-Pompengan Jeneberang (BBWS-PJ), State Electricity Company (PLN), Central Statistics Agency (BPS) of Makassar City, and relevant related research. In addition, the secondary data were used as FGD material by discussing the 2011–2036 Corporate Plan of Makassar City PDAM, long-term plan documents, management of challenges and opportunities, and the BBWS-PJ master plan.

2.2. Data Collection

Data were collected through structured interviews, consumer surveys using questionnaire distribution, which also involved all aspects of human and work systems, and in-depth observation methods on various objects related to water resources planning and management activities. Overall, 125 respondents (61 men and 64 women) from 14 sub-districts in Makassar City participated in this study. The participants were from 10 various professions with an age range between 18 and 65 years. The results of the observations were then combined with the primary and secondary data to conduct an FGD with the entire components involved. In brief, four steps were adopted in data collection to obtain quality data; (1) *participatory scoping*, (2) *case generation and exploration models*, (3) *discovery scenarios*, and (4) *trade-off analysis*. In data collection, FGD was also conducted with environmental and ergonomics experts as one of the integrations of green ergonomics in RDM to obtain scenarios for solving water resources problems in Makassar City.

2.3. Data Analysis Techniques

The analytical technique applied in this study complies with the four-step key RDM process and procedure, as mentioned above. Participatory scoping is a form of focusing attention on issues or challenges that will be studied or resolved through FGDs.

The participants who are expected to attend the event are stakeholders, policymakers, resource persons, environmental ergonomics experts, and water user communities according to their respective capacities. This activity aims to define or limit the scope of objectives and measurements, scope of strategies that can be employed to achieve the objectives, scope of uncertainty that will affect the successful use of the strategy, and scope

of relationships that will help demonstrate the process of using the measurement. Thus, the conceptual model of problem-solving is shown in Figure 1.

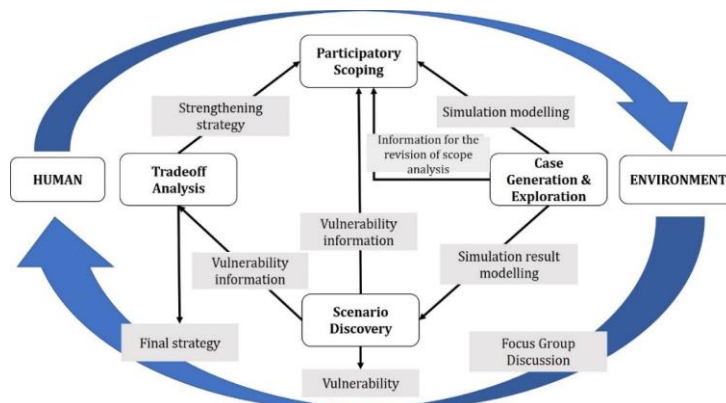


Figure 1 Green ergonomics - RDM conceptual model

To implement the conceptual model shown above, the following steps are implemented as shown in Figure 2.

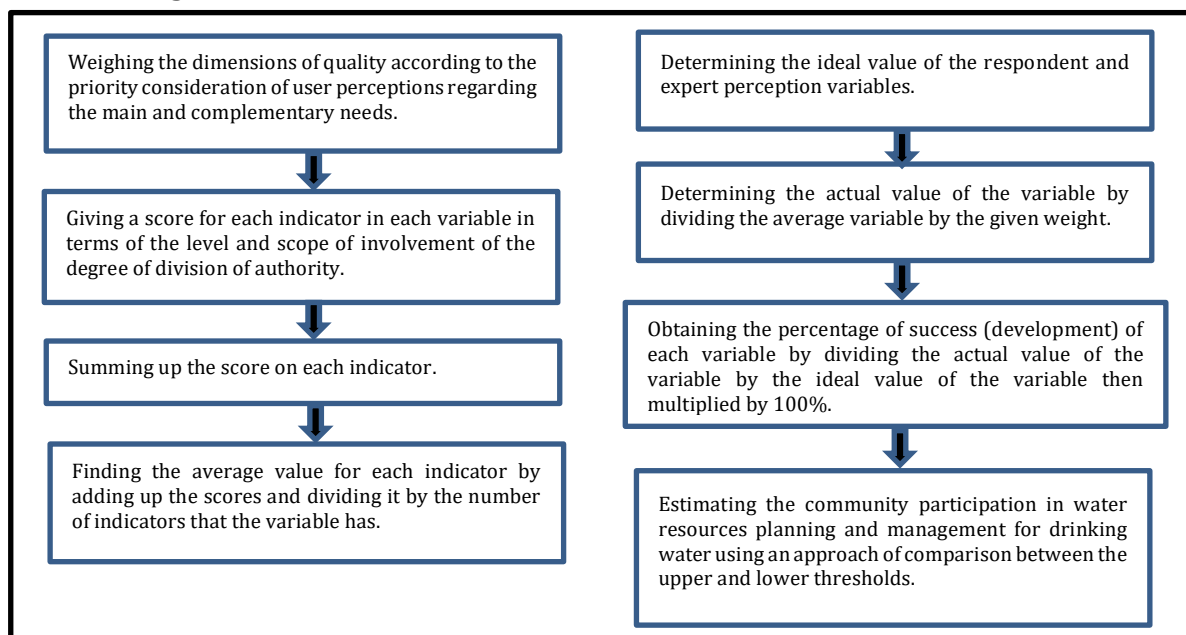


Figure 2 Data analysis stage

3. Results and Discussion

Five main data components were obtained: (1) data on future climate change vulnerability and adaptation strategies, (2) data for Jeneberang River management system planning, (3) data for drinking water management planning of Makassar City PDAM, (4) socio-economic data of PDAM Makassar City customers, and (5) green ergonomics concept in water resources management in Makassar City. The five data were obtained from vulnerability assessment documents, FGDs, interviews, and socio-economic surveys of the people using PDAM water services. The data were analyzed descriptively, and the results were used to answer four key research questions that led to the achievement of research objectives. In this study, vulnerability data were used as the baseline data in exogenous factors or exogenous uncertainties (Xs) while adaptation strategies were used as policy levers (Ls) data. Xs are factors difficult for decision-makers to control; however, they are

important in determining the success of the strategy. Meanwhile, *Ls* are the diversity of combinations of short-term adaptation actions consisting of alternative strategies that will be implemented.

3.1. *Climate Vulnerability Data*

Historically, floods and strong winds that occur almost every year cause losses and damage to Makassar City. According to [BBWS-JP \(2014\)](#), between 1999 and 2013, there were 26 cases of flooding that damaged 324 houses and impacted 6,476 people. The flood in January 2013 affected 5,763 people and was declared the worst flood in the history of Makassar City. The worst impacted areas were located in the lowlands, with poor drainage and sanitation systems. New housings in the suburb of a former agricultural area became the main flood site in January 2013. Strong winds occurred with an average of two cases per year. Reports on cases of strong winds that damaged around 300 houses and killed around 200 people occurred between 2003 and 2012. In addition, droughts, fires, large sea waves, and endemic diseases were other events that occurred in Makassar City. All these events are attributed to climate change, which is uncertain or difficult to predict and will have different impacts according to the geographical location of the region.

3.2. *Jeneberang River System Planning Data*

Floods in agricultural and residential areas occur due to the inability of river bodies to accommodate the passing water discharge. Floods occur in the Maros River, Sinjai River, Bialo River, Pappa River, Allo River, Tamanroya River, Calendu River, Pampang River, and Tallo River. Increased erosion and sedimentation in rivers that cause siltation and reduced water storage capacity especially take place in the Maros, Jeneberang (mainly due to large-scale landslide at Mount Bawakaraeng), Pappa, and Tamanroya watersheds. Especially in the Jeneberang watershed, due to the collapse of the slopes of Mount Bawakaraeng, sedimentation into the Jeneberang River was 167.2 million m³ and sedimentation in the Bilibili Reservoir was 75.2 million m³. High sedimentation reaches 3,862 tons/year (Tamanroya watershed 342 tons/year, Jeneberang watershed 1,280 tons/year, Kelara-Karaloe watershed 219 tons/year, Maros watershed 233 tons/year, and Pappa watershed 247 tons/year).

3.3. *Makassar City PDAM Drinking Water Management Planning Data*

Makassar City PDAM revealed that the biggest challenge faced by PDAM Makassar City is the supply of clean drinking water and the service of a clean water supply network. In addition, this network is threatened by increasing demand for water due to the increasing urban population. In Makassar city, the urban clean water system relies heavily on water supply from surrounding districts such as Gowa and Maros. Moreover, urbanization and the lack of proper management of clean water sources put these sources at risk. As a result, the clean water system requires an additional network to meet the increasing demand and regular maintenance. This finding is in line with a study by [Tadesse et al. \(2013\)](#), indicating that one of the major issues of the water source distribution is the lack of proper management in waiting time or queuing of water supply.

3.4. *PDAM Customer Condition Data*

The survey results show that most of the water sources utilized to meet the needs of clean water use PDAM service water (84%); however, for drinking water, people prefer refilled water (45.6%) to PDAM services (42.4%). The trend of urban people choosing refilled water is for the reasons of convenience and practicality since they no longer need to boil the water for drinking. However, 11.2% of the respondents still use well/artesian well water for bathing and washing needs, and 5.6% who use it as a source of drinking water. The types of PDAM customers that were successfully captured in this study were

household customers (88.8%) and the rest were public and business facilities. There were 6.4% of respondents who chose not to answer because they were not PDAM customers or used other water sources.

The survey results show that 61.6% of the respondents found it easy to meet their daily clean water needs, 29.6% very easy, 6.4% moderately difficult, and 2.4% difficult. This indicates that the majority of the people of Makassar City still get easy access to clean water services for their daily needs. In addition, the survey results show that more than 60% of respondents stated that the quality of clean water for drinking water provided by PDAM Makassar City is odorless, tasteless, and colorless, both in the dry and rainy seasons, while 26% stated that it still smells, tastes, and is colored both in the dry season and in the rainy season. The rest chose not to respond, as shown in Table 1.

Table 1. Dry season and rainy season water quality

No.	Response	Climate	Odor	%	Taste	%	Color	%
1	Yes	Dry	14	13.3	9	8.6	14	13.3
		Rainy	20	19.0	9	8.6	27	25.7
2	Not	Dry	89	84.8	88	83.8	82	78.1
		Rainy	83	79.0	87	82.9	69	65.7
3	No Response	Dry	2	1.9	8	7.6	9	8.6
		Rainy	2	1.9	9	8.6	9	8.6
		Dry	105	100	105	100	105	100
		Rainy	105	100	105	100	105	100

3.5. Green Ergonomics Concept in Water Resources Management in Makassar City

An approach that can be employed to examine this problem is green ergonomics. A study on green ergonomics is necessitated to ensure that PDAM as a water resource administrator in Makassar city must be able to carry out its production process ergonomically, cleanly, and efficiently. In this study, the concept of green ergonomics is used to balance water resources management with the role of humans as managers themselves. Green ergonomics currently does not only study the state of a micro work system but also discusses environmental problems more broadly. It is in line with a study by [Sarker et al., \(2018\)](#) that green ergonomics could enhance the sustainable relationship between human well-being and natural resource systems. Green ergonomics experts are deemed necessary to collaborate in environmental management in one area and must be able to overcome global environmental and social problems such as pollution from big cities. Therefore, this study incorporates the concept of green ergonomics as a complement in water resources management.

3.6. Goal Setting, Achievement Strategies, Forms of Uncertainty, and Measurement Results Models

The RDM process begins with FGD activities that bring together the parties and decision-makers to set the goals and consider the severity of the problems found in the decisions, strategies that can be used to achieve goals, uncertainties that will affect the strategies, and the relationships that govern strategic performance related to decision-making considerations ([Patterson et al., 2009](#)). This activity uses the XLRM framework, which is used to set up the simulation model. XLRM refers to four factors: (1) Xs, which are factors difficult to control by decision-makers but are important in determining the success of the strategy, which in this research refers to the Makassar City Vulnerability Study Document; (2) Ls are the diversity of combinations of short-term adaptation actions consisting of alternative strategies that will be used, which, in this study, refer to the Strategic Planning documents of PDAM and BBWS-PJ as the buffer institutions; (3) risk and

impact measurements (M) or the calculation and evaluation of hazards and risks combined with aspects of vulnerability, exposure, and sensitivity of city system components caused by unpredictable exogenous factors, which in this study refers to the results of the analysis of the level of vulnerability, exposure, sensitivity, and adaptability; and (4) relationships and models (Rs), which represent simulation models that describe the success or failure of adaptation strategies as measured by the impact of risk or the impact of exposure hazard due to X (Table 2).

Table 2. Main Elements of XLRM

Exogenous Uncertainties (Xs)	Policy Levers (Ls)
Hazard related uncertainty: <i>Increasing rainfall/flood</i> <i>Sedimentation</i> <i>Drought</i> <i>Environmental damage</i> <i>Sea level rise</i> <i>Beach abrasion</i> <i>Strong wind</i> <i>Tidal wave</i>	BBWS-PJ 1. Integrated upstream-downstream Water Resources Management implementation. 2. Construction/upgrade, operation, and maintenance: • Water source capacity, • Water discharge for raw water facilities/infrastructure services to meet domestic/household, urban and industrial needs (RKI), • Coverage of irrigation and swamp network services, • Coverage of areas protected from the danger of flooding.
Exposure related uncertainty: <i>Residential area</i> <i>Total population</i> <i>Population density</i> <i>Poverty</i> <i>Economic growth and equity</i>	PDAM 1. Production optimization and capacity building for WTP (Water Treatment Plant) IV and V 2. Construction of New WTP (Tallo River raw water) 3. Development of the main and tertiary distribution of pipeline network in the Eastern Region (II and III)
Vulnerability related uncertainty: <i>City expansion</i> <i>Population growth</i> <i>Clean water supply</i> <i>Soil erosion</i> <i>Floods and puddles</i> <i>Long dry season</i> <i>Disease outbreak</i>	4. Rehabilitation of old Dutch pipelines for gradual water loss rates of at least 1%–2% per year 5. Plans for adding raw water to support the raw water crisis of WTP II Panaikang by utilizing raw water from the Tallo River during the dry season 6. Service plan in bulk for PDAM Maros Regency customers, which is directly adjacent to the Makassar City PDAM service area
Relations and Models (Rs)	Impact Measurement (Ms)
• ArcGIS model: Calculating the impact of the risk and impact damage • SWMM Model • Integrated analytical risk model	Availability of raw water supply: Balance and effectiveness of available budget related to various impacts of natural resource management planning for drinking water

3.7. Adaptive and Robust Strategic Decisions in Water Resources Planning for Drinking Water in Makassar City

Based on the results of this study, the key elements of a robust adaptive strategy are identified as follows:

- Implementing clear and measurable short-term projects/programs, which, despite the risks, still provide minimal benefits until the occurrence of future climate change and its impacts (near-term no-regret projects);
- Observing visible signs or indicators of X that requires PDAM and BBWS-PJ to prepare additional investments;
- Considering and deciding which projects or program activities should be postponed, which in this case are the additional investment to be carried out in the uncertain future conditions;
- Monitoring and preparing a pessimistic budget for the remaining vulnerabilities, which, in this context, are the project sequence or program activities in the master plan that are projected to fail to achieve the objectives of natural resource management for drinking water in Makassar City.

The results of the study show that the range of river flow conditions and future demand can achieve water reliability. The performance of raw water sources in each region has an identical tendency and has the possibility to achieve water reliability. It is certain, however, that among the planned projects, there will be raw water sources or other types of projects that fail to achieve water reliability.

3.8. Sustainable Water Resources Management with Green Ergonomics Approach

In water resources management, the green ergonomics approach can be employed to support the efficiency of water resources management from raw water to clean water. The application of this concept is a combination of ergonomic and environmental aspects by developing an understanding of how water resources are in line with the work systems and integrating them with the larger ecosystems. This involves understanding the life cycle flows, their transformation and integration, and how the waste generated by these systems are utilized (Véronneau & Cimon, 2007). In green ergonomics, humans play an important role in the implementation of a system. The success of a work system also depends on the ability of workers to implement the system. In water resources management, in the face of uncertainty that becomes a potential risk, ergonomics can be involved in its activities. The involvement of the green ergonomics approach can strengthen the values of the management (Holden, 2012).

In other words, there is a necessity for a reconceptualization of the water resources management system, which otherwise previously focused only on the uncertainty of raw water discharge and its management. Now, however, it requires the integration of humans and the environment in its management. Workers in each production line must be competent in carrying out their work. Workers must know the scope of their work well and create an ergonomic work environment by considering adjustments and flexibility in work (Lange-Morales et al., 2014). It is in line with (Bharti et al., 2020) that there is the need for a paradigmatic in water management to be more integrated and that adaptive management approaches and innovations are key to enhancing urban water management systems. By paying more attention to this, it is possible to demonstrate a more sustainable approach to water resources management as shown in Figure 3.

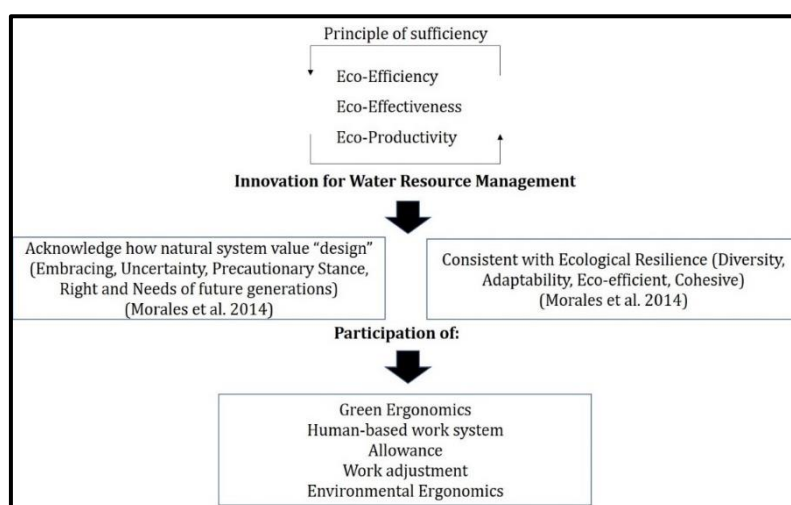


Figure 3 Green ergonomics concept for water resources management

4. Conclusions

In conclusion, the scenario for determining operational policies for natural resource management is influenced by conditions of low, medium, and high economic growth

scenarios and political conditions, as well as climate change. It is very important to implement a short-term adaptation strategy plan as the initial basis for long-term climate change adaptation planning and to integrate it into the planning mechanism or management in the form of the PDAM Business Development Plan or RKAP and the city government's annual and medium-term plans. Participatory Ergonomics and Environmental Ergonomics can be considered in the development of Water Resources Management in Makassar City by involving environmental factors, adjustments, and leniency.

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