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Water Quality and Supply in Metro Roxas Water District towards Sustainable Operations

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ABSTRACT

The Metro Roxas Water District (MRWD) is a public water utility that covers more than 40,000 active service connections for Roxas City, Panay, Ivisan, and some portions of Sigma, Capiz. This study assessed the operational status of MRWD in terms of water supply and quality, identified key factors that affect water supply and quality, and analyzed water supply trend using historical data of its water production from 2019 to 2023. The 396 respondents were selected out of 41,805 concessionaires to answer a researcher-made questionnaire about their perception on MRWD's water supply, water quality, and level of impact of identified key factors that affect the supply and quality of water. Data gathered were analyzed using frequency, percentage, mean, standard deviation, and regression. Findings showed that waste management and water leakages had significant impact on operational status of MRWD, while natural hazards, pollution, population growth, source of water, urbanization, and water temperature had considerable impact. Results also revealed that MRWD's operational status was operational for both water quality and water supply. Natural hazards and waste management were key factors that act as significant predictors of MRWD's operational status, while pollution, population growth, source of water, urbanization, water leakages, and water temperature did not act as significant predictors. The SWOT analysis and matrix was utilized to evaluate secondary data and correlate with quantitative data results. The insights in SWOT analysis and matrix served as awareness for MRWD about its internal factors that can take advantage to battle the challenges and grab opportunities for the sustainability of its operations in the future.

Keywords: MRWD, Operational status, Water quality, Water supply, Metro Roxas, and Sustainability.

INTRODUCTION:

Water is one of the most vital elements on earth. An individual cannot survive without water and an individual cannot live healthily without access to safe and clean quality of water. Water shortages and degradation of water quality pose serious challenges to the sustainability of water resources and threaten

human health and ecosystem integrity. The United Nations Educational, Scientific, and Cultural Organization (UNESCO) (2019) states that securing adequate water of sufficient quality to meet human, environmental, social, and economic demands and support sustainable development of nations is a major

concern. The United Nations has established 17 Sustainable Development Goals (SDG) and one of these focuses on clean water and sanitation. Sustainable development, through its mechanism and content, seeks to achieve a set of goals that anchors the life that human beings ought to preserve for the next generation. The SDG's sixth goal, Clean Water and Sanitation, emphasizes the vital role that proper hygiene, sanitation, and access to clean water play in both preventing and controlling disease. The vision of this goal, if attained, will ensure that every individual has access to enough clean water to satisfy their basic necessities, and reliable, inexpensive water supply and sanitation services, which was supported by equitably extended and efficiently maintained infrastructure, making it simple to maintain healthy lifestyles and behaviors (United Nations, 2018). The goal of Metro Roxas Water District (MRWD) is to be one the leading water providers in the Philippines through delivering exceptional customer service, utilizing sustainable water resources, and taking an active part in environmental preservation and conservation in the next years to come and as well as providing quality services to its concessionaires in Roxas City, Ivisan, Panitan, Panay, and selected parts of Sigma.

Each year, MRWD faces increasing demands of new installations for its water services as the population in Roxas City and other parts of Capiz continue to rise. This study sought to fill in the gaps by assessing and evaluating MRWD's operational status and to identify the major factors, which also pose as risks that affect the supply and quality of water to focus on developing strategies and enhancing the resilience of MRWD's water systems. This study made an effort to close the quality gaps between services, products, and processes by incorporating sustainability. This also addressed the existing and anticipated organizational issues, such as the capacity to deliver services efficiently and promptly but struggles to meet customer demand effectively; disparities between the resources allocated to service delivery and what is actually required to meet customers' expectations; breakdowns, system failures, prolonged service disruptions; inconsistent service quality and customer dissatisfaction; and other underlying problems that are yet to be addressed. Moreover, the standard Non-Revenue Water (NRW)

percentage rate should be maintained at 25 percent or lower of the total water produced as recommended by World Bank (Kingdom *et al.*, 2006). A number of factors contribute to the NRW, including pipe leaks, illegal connections, theft, and misuse of fire hydrants (JICA, 2019; Fuerte AB., 2023). If a water service provider exceeds beyond that rate, it is already critical and can result to too much losses and may affect financial viability and may lead to privatization for government-owned water districts and bankruptcy for private water service providers. Metro Roxas Water District (MRWD) is experiencing a fluctuation of these percentages, and according to the data provided, the average NRW of the organization is already near the ceiling of the recommended percentage.

The question arises whether the operational status of the organization has the means to sustain its supply and quality water services to the public in the next years to come, considering the factors that could affect the quality and quantity of water and meet the demands of the increasing population. The operational status assessment and analysis on its influencing factors are critical to MRWD's operations, as they can provide useful information for improving the sustainable utilization of water resources. The results of this research can be used as a guide and a point of reference by the government and regulatory bodies for assessing the operational status of the water service provider or gauging the quality of their services. This study revealed the key factors to provide action plans to mitigate the negative effects of the risks associated with the water quality and supply and develop strategies to address the problems and sustain the service operations of Metro Roxas Water District (MRWD) in the succeeding years. The gap between the world's supply and demand for water continued to grow. Some areas are already experiencing water stress and water scarcity. Closing these gaps in this research on water sustainability would contribute to more effective and holistic water management practices to guarantee that both the present and future generations have access to clean and safe water.

The study was anchored on the Water Quality - Science, Assessment and Policy of Summers, (2020) and the Socio-Ecological Systems Framework (SESF) by Leslie *et al.* (2015). According to Summers',

(2020) “Water Quality - Science, Assessments and Policy”, there are seven water quality parameters that are used to measure and assess the quality of water. The physical parameters include color, taste, odor, temperature, turbidity, solids, and electrical conductivity. The standards for water quality are significant since different applications may have varying needs. Color, taste, and odor are the organoleptic properties that can be determined using the human being senses. Therefore, safe and potable water must be clear and transparent and does not have any faulty odor or smell. Social-Ecological Systems Framework (SESF) offers guidelines for evaluating the social and ecological aspects that affect the management and use of resources in a sustainable way (Leslie *et al.*, 2015). The SESF was created in order to perform institutional evaluations on natural resource systems and identify relevant problems with collective action. The foundation of the system provides a decomposable list of variables positioned around an "action situation" in which players make decisions and take actions based on the information available to them from their locations. This allows researchers to undertake diagnostic inquiry and compare findings (Nagel & Partelow, 2022).

The primary purpose of this study was to assess the operational status of MRWD and to identify the key factors that contribute to the supply and quality of water in MRWD as perceived by the concessionaires. The results were compared with its water supply volume data for the last five years to yield a thorough understanding of the organization’s operational status.

METHODOLOGY:

The descriptive research design was the most suited as utilized in this study. Descriptive research targets to describe a population, situation or phenomenon in an accurate and systematic way where it can answer the what, where, when and how questions (McCombes, 2022). A mix of qualitative and quantitative data was used in the study. For the quantitative data, the researcher provided a validated and reliability tested researcher-made questionnaire to the respondents to evaluate the operational status of Metro Roxas Water District (MRWD) in terms of water quality and water supply and the level of impact of the key factors that

contribute to the supply and quality of water. The results were analyzed and interpreted using the descriptive statistical tools such frequency, percentage, mean, standard deviation, and regression. On the other hand, the time series method of trend analysis was utilized to analyze the secondary data of MRWD’s water supply volume from years 2019-2023. Additionally, the Strengths, Weaknesses, Opportunities, Threats (SWOT) analysis and matrix were used to provide insights into the conditions of the study's variables and yielded a thorough understanding of the organization’s operational status and evaluate its capacity to be sustainable. The study aimed to obtain data from 396 out of 41,805 concessionaires of Metro Roxas Water District (MRWD) with active service connections as respondents through stratified sampling method using Cochran’s formula. The respondents were provided with a researcher-made questionnaire to answer all the necessary data and information needed for the study. The respondents’ profile consisted of their classification, divided into five (5) categories: residential, government, commercial, industrial, and bulk sales, their geographical area whether they live in an urban or rural area, the number of household members (if residential) or company employees (if government, commercial, industrial, or bulk sales), and their latest water consumption. This study was conducted at Roxas City and selected parts of Ivisan, Panitan, Panay, and Sigma in the province of Capiz.

RESULTS AND DISCUSSION:

The secondary data showed that annual average total water supply volume produced by Metro Roxas Water District (MRWD) from 2019 to 2023 was 12,550,270.80 cu.m. The annual total water production was below average in 2019, 2020, and 2021, while it was above average in 2022 and 2023. The composition of the total water produced in 2019 was 72.13 percent for the total billed water and 27.87 percent for the Non-Revenue Water (NRW). In 2020, the billed water composed of 74.86 percent, and 25.14 percent NRW. In 2021, the total billed water was 72.97 percent and 27.03 percent NRW. Year 2022 showed a significant decrease in the billed water and increase in NRW with 69.69 percent and 30.31 percent, respectively. In 2023, the total billed water was increased to 77.04 percent and lowered the NRW to 22.96 percent. The results

can be compared to the study of Bernas (2019), wherein MRWD also previously experienced a large increase in the water volume of 798,970.61 cu.m. in 2018 when two sets of pumping equipment were procured and utilized. It also resulted to an increase of the total water volume capacity from 27,000 cu.m. per day to 28,400 cu.m. per day. Moreover, it was also noticed that the lowest water production volume within five years was in 2020 in which it may attributed to the COVID-19 pandemic when there was a decrease in commercial and industrial activity, and perhaps even in the amount of water used by municipalities as a result of restrictions, lockdowns, and poor economic growth. Disruptions in the global supply chain may also be a reason due to lockdowns and travel restrictions that may affect the availability of chemicals, equipment, and spare parts needed for water treatment and production processes. The Supply and Demand Theory supported this study in which the theory in the context of water supply could result in a leftward shift of the supply curve, indicating lower quantities supplied at each price level. In 2023, a notable decrease in water production volume was experienced by Metro Roxas Water District (MRWD), which was linked to the after effects of Typhoon Agaton and drought warnings during the year as discussed earlier. The results adhered to the study of Bernas (2019), which showed the history of MRWD, experiencing the great Typhoon Yolanda that resulted to adverse effects in the water supply volume whereas, continuous repairs of damaged facilities and rehabilitation was performed in the water treatment plant. Power outages were also a factor in decrease and limitations in MRWD's pumping capacity. The Centers for Disease Control and Prevention also conformed to this study that widespread power outages brought on by natural disasters may interfere with the distribution and treatment process.

The Dublin-Rio Principles can be applied in this analysis about MRWD's attempt to implement sustainable water use and equitable and effective management, specifically in principle number two, the Participatory Approach, in which water resource creation and management should involve planners, policymakers, and managers, and principle number four, Social and Economic Value of Water, in which

all of its conflicting applications, water has social and economic importance and is a public good. The Supply and Demand Theory can also be linked to the water billed analysis in which MRWD continues to pursue accessible and safe water supply to its concessionaires by conducting interconnection projects and expansion works to meet the demand and provide stronger water pressure in households, government, business, and other sectors in the society. The key factors that affect the supply and quality of water in MRWD as perceived by the concessionaires that had considerable impact were natural hazards, pollution, population growth, source of water, urbanization, and water temperature, while key factors that had significant impact were waste management and water leakages. The operational status of MRWD on water quality and water supply as a whole was operational for both water quality and water supply. Moreover, the operational status of MRWD on water supply was operational and the result on the operational status of MRWD on water quality was also operational. Furthermore, findings revealed that there were two (2) key factors, namely: natural hazards; and waste management, that affect the supply and water quality of Metro Roxas Water District (MRWD) and act as significant predictors of its operational status as perceived by the concessionaires, while the key factors such as pollution, population growth, source of water, urbanization, water leakages, and water temperature did not act as significant predictors of the operational status of MRWD.

The study of Kamani *et al.* (2012) conformed to the result of this study that high percentage of water loss in distribution networks due to huge leakages is one of the biggest issues water utilities must deal with. As observed, the major factor that contributed to the increase in Metro Roxas Water District's (MRWD's) Non-Revenue Water (NRW) in 2022 was due to a number of significant physical losses, specifically in water losses/leakages from broken pipes, ground-breaking and underground leaks in the transmission and distribution lines. El-Zahab and Zayed, (2019) adhered to the results where their study also showed concerning leaks in resource transmission pipelines, which led them to investigate leak detection systems thoroughly to lower the possibility of leaks and the

harm they cause. Similarly, the study of Bernas, (2019) showed that MRWD had also previously NRW mitigation efforts, specifically in 2016 and 2018, when there were continuous repairs of damaged facilities and rehabilitation performed in the MRWD water treatment plant when it was affected by the massive Typhoon Yolanda. While the NRW in 2014, 2015, 2016, 2017, and 2018 resulted to favorable annual decreases for the district.

Moreover, Ustaoglu *et al.* (2020) found that incorrect disposal of gravel, sand, and solid debris was one of the factors leading to the decline in water quality. In the study of Gebremichael *et al.* (2020) it stated two reasons for the decline in water quality were due to indoor practices involving water-containing materials and water constraints, and due to animal and human waste. Villar-Navascués and Fragkou's, (2021) study found that organoleptic water qualities, such as odor and taste, are some of the key elements that influence how people perceive the quality of their water and go about their everyday lives. It was also shown in their results that some households had to boil their water to avoid dangers associated with water quality and use it for their daily consumption. Likewise, the study of Delpla *et al.* (2020) found that water quality satisfaction depended on the taste, odor, and color of tap water for the consumers in Quebec to be confident in utilizing tap water for drinking.

It was recommended in their study that targeted education programs are important for reducing the number of people who only consume bottled water. Victory *et al.* (2022) averred that 98 percent of the respondents were afraid that drinking the tap water in their area would make them sick, 79 percent refrained from drinking it because of concern about chemical and micro-biological pollution, and 73 percent said they would drink it regardless of taste if they knew it was safe. The findings in the study of Halder and Islam, (2015) and Dwivedi *et al.* (2018) also concluded that water quality will be directly impacted by human activities like urbanization, population growth, industrial production, climate change, and religious beliefs. The results of this study can also be compared to the study conducted by Gebremichael *et al.* (2020) that the factors that contributed to the

quality and supply of water in Debre Tabor town, north-west Ethiopia were drought, limited source of water, water sources in rural and urban regions, both improved and unimproved, lack of facilities and water contamination. Additionally, the findings of this study also adhered to the Environmental Determinism Theory, which states that the features and evolution of communities and ecosystems are mostly determined by environmental elements, including topography, climate, and geography.

In the Philippine setting, the Philippine Water Supply and Sanitation Master Plan (PWSSMP) 2019-2030 confirmed the result of this study that several natural, environmental, and human-related factors can have an impact on the availability and quality of water that include pollution, population, climate change, temperature, lack of technology/equipment, waste water management, water conservation and more, which can differ by region to attain a clean, affordable, safe, and sustainable water supply, as well as good sanitation, by 2030.

Moreover, the plan was developed by the Philippine government as a National Action Plan to increase everyone's access to a sustainable and safe supply of water and sanitation services in the Philippines, with a focus on achieving the targets set forth in the Sustainable Development Goals (SDGs), particularly Goal 6: Clean Water and Sanitation. The factors pose as threats and causes that may lead to degrading water supply if not addressed. The SWOT analysis and matrix identified strengths, weaknesses, opportunities, and threats of MRWD and analyzed their relationships with each other. Strengths identified were pumping equipment investments, Non-Revenue Water (NRW) mitigation, operational water supply, and operational water quality. Weaknesses recognized were vulnerability to natural hazards, water leakages, and rapid change in water supply. Opportunities foreseen were expansion of service areas, enhanced customer service and engagement, and innovation and technology adoption. Threats determined were the key factors that affect the water supply and quality, increasing total water billed, and commercial bottled water.

Strengths, Weaknesses, Opportunities, and Threats (SWOT) Analysis

Internal Factors	
<p>Strengths</p> <ol style="list-style-type: none"> 1. Pumping Equipment Investments 2. Non-revenue Water (NRW) Mitigation 3. Operational Water Supply 4. Operational Water Quality 	<p>Weaknesses</p> <ol style="list-style-type: none"> 1. Vulnerability to Natural Hazards 2. Water Leakages 3. Rapid Change in Water Supply
External Factors	
<p>Opportunities</p> <ol style="list-style-type: none"> 1. Expansion of Service Areas 2. Enhanced Customer Service and Engagement 3. Innovation and Technology Adoption 	<p>Threats</p> <ol style="list-style-type: none"> 1. Key Factors that Affect the Water Supply and Quality 2. Increasing Water Demand 3. Commercial Bottled Water

Strengths, Weaknesses, Opportunities, and Threats (SWOT) Matching Matrix

Swot Matching Matrix		Internal Factors	
		Strengths	Weaknesses
External Factors	Opportunities	<p>Matching Strategy</p> <ol style="list-style-type: none"> 1. S1-O1: Leverage pumping equipment investments to support the expansion of service areas. 2. S2-O2: Apply NRW mitigation initiatives in enhancing customer service and engagement. 3. S2-O3: Implement NRW mitigation activities through innovation and technology adoption. 4. S3, S4-O3: Utilize operational advantages in water supply and quality to foster technological adoption and innovation. 	<p>Change Strategy</p> <ol style="list-style-type: none"> 1. W1-O1: Strengthen resilience to natural hazards to support the expansion of service areas 2. W2-O2: Implement proactive leak detection and repair strategies to enhance customer service and engagement. 3. W3-O1, O3: Consider innovation and technology adoption to adapt to rapid changes in water supply and support service expansion.
	Threats	<p>Neutralization Strategy</p> <ol style="list-style-type: none"> 1. S1-T1: Utilize pumping equipment investments to mitigate the impact of key factors affecting water supply and quality. 2. S3,S4-T3: Promote operational water supply and water quality strengths to counter competition from commercial bottled water. 3. S1-T2: Use pumping equipment investments to adapt to increasing water demand. 	<p>Defensive Strategy</p> <ol style="list-style-type: none"> 1. W1-T1: Enhance adaptability to natural hazards to mitigate threats to water supply and quality. 2. W2-T1: Implement proactive leak detection and repair strategies to reduce water losses and mitigate threats to water supply and quality. 3. W3-T2: Enhance water supply management to adapt to rapid changes in water supply and manage increasing water demand.

CONCLUSION:

The Metro Roxas Water District (MRWD) experiences fluctuations in total water production over the years, with an overall increasing trend in the latter part of the period. Additionally, the composition of billed water and Non-Revenue Water (NRW) also vary, indicating changes in factors such as water distribution efficiency and infrastructure management. The water production volume increases, whenever Metro Roxas Water District (MRWD) invests in new pumping equipment UniversePG | www.universepg.com

and expansion projects but decreases due to the effects of natural hazards. Interconnection and expansion projects help increase the water pressure and extend MRWD’s water services to elevated and far areas, increasing their water consumption; therefore, contributed to the stable increase in the water billed. The Non-Revenue Water (NRW) reduction programs and leak detection activities minimize water losses and maximize the amount of water available for consumption and contribute to sustainable water

management and ensure the availability of water for future generations. The NRW mitigation can increase the water billed and make MRWD more reliable to the consumers. The result on the water quality and water supply of MRWD as a whole indicates that the organization has earned positive feedback from its concessionaires, demonstrating effective operations in delivering safe, adequate, and affordable water. This positive perception enhances the organization's reputation and suggests that it is successfully fulfilling its mission of providing quality water services to the community and proves its sustainability. The MRWD's operational status on water quality shows that the district is capable of providing safe and potable water quality to its concessionaires, thereby deemed as operational on average. The identified key factors could pose threats to MRWD's water supply and quality in the future because of their impact in the operations and can be a hindrance in the delivery of quality services to the consumers. The presence of natural hazards, pollution, population growth, urbanization, and changes in water temperature can directly affect the availability and quality of water resources.

Moreover, issues related to waste management and water leakages can worsen these challenges by contributing to water contamination, and increase Non-Revenue Water (NRW). This result can guide Metro Roxas Water District (MRWD) in prioritizing efforts and resources towards addressing these factors to ensure the continued delivery of quality water services to its concessionaires. The insights in the SWOT analysis give strategic planning and decision-making an organized method that helps MRWD develop actionable strategies to capitalize on opportunities, address weaknesses, maximize strengths, and mitigate threats, thereby enhancing their chances of achieving long-term sustainability and meeting their goals. Matching the internal factors and external factors in the SWOT analysis gave a thorough explanation of the relationships of these internal factors and how it impacts the external factors in both positive and negative approaches to analyze problems and potentials of MRWD in different views.

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CONFLICTS OF INTEREST:

There is no conflict of interest disclosed by the author.

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