Integrated Investment Appraisal of Waste Water Facility Project: The Case of a Proposed Waste Water Treatment Plant in South Africa

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ABSTRACT

This analysis is an evaluation study of a Water Conservation and Resource Plan with Infrastructure Execution located in South Africa. The Cost-Benefit Analysis (CBA) in this appraisal study contains a comprehensive analysis of the Wastewater treatment plant project from various perspectives that mainly involves the project's financial, economic, stakeholder and risk analyses. The influences of each main stakeholders are measured to assess the project's potential costs and benefits. The recycling project benefits will be assessed against the option of purchasing water for use by the mining company and its large resident community of workers and their families.

Keywords: Water, Wastewater, South Africa, Water treatment, Infrastructure, Cost-Benefit Analysis, Integrated Investment Appraisal.

ÖZ

Bu analiz, Güney Afrika'da bulunan Altyapı Yürütmeli Su Koruma ve Kaynak Planının bir değerlendirme çalışmasıdır. Bu değerlendirme çalışmasındaki Maliyet-Fayda Analizi (CBA), temel olarak projenin finansal, ekonomik, paydaş ve risk analizlerini içeren çeşitli perspektiflerden Atıksu arıtma tesisi projesinin kapsamlı bir analizini içerir. Her ana paydaşın etkileri, projenin potansiyel maliyetlerini ve faydalarını değerlendirmek için ölçülür. Geri dönüşüm projesinin faydaları, maden şirketi ve büyük yerleşik işçi topluluğu ve aileleri tarafından kullanılmak üzere su satın alma seçeneğine göre değerlendirilecektir.

Anahtar Kelimeler: Su, Atıksu, Güney Afrika, Su arıtma, Altyapı, Maliyet-Fayda Analizi, Entegre Yatırım Değerlendirmesi.

DEDICATION

"اللَّهُمَّ انْفَعَنَا بِمَا عَلَّمْتَنا وَعَلِّمْنا مَا يَنْفَعُنا وَزِدْنَا عِلْمَا"

O Allah! Benefit us through what you teach us, and teach us what is beneficial for us, and increase us in knowledge.

This study is wholeheartedly dedicated to my beloved *family*, my brother *Ali,* my uncles & aunts *Mohamed, Jamal, Maha, Hussein* ,& *Suha* who have been my source of inspiration and gave me strength and continually provide their moral, spiritual, emotional, and financial support.

To my mother, *Nadia*, Thank you for supporting me and for always being there for me. All my success and achievements will always be dedicated to you, for being the reason behind the person I became to.

The biggest thanks go to my darling aunt *Faten* for pushing me to start this journey, I would not have made it without you. Thank you for all the guidance and support that you have given me, helping me to succeed and instilling in me the confidence that I am capable of doing anything I put my mind to. I am always thankful for the blessing of being not only my aunt but also my go to person and will always look up to you.

To my friend *Lu'ai* whose words of encouragement and push for tenacity ring in my ears. My neighbors *Mohammed, Mohyi, Rukiya,* and *Kemal Bitirim* have supported and took care of me throughout the process. To my classmates and assistants *Walaa, Augustine, David, Gezim,* and *Mehdi.* I cannot list all of the names here, but you are always on my mind, and I will always appreciate all they have done.

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This Thesis is only the beginning of my journey.

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INTRODUCTION

1.1 Background

South Africa is a semi-desert country with a population of approximately 59 million, growing at 1.33%. This population density in South Africa is 49 per Km^2 (127 people per mi^2), with about 66.7 per cent of the population living in the country's urban areas. It has high water stress due to the low amount of rainfall (average of 500 mm per annum) and high water evaporation (average of 1700 mm per annum) (Eberhard & Robinson, 2003). Water has become increasingly scarce due to population growth, economic growth, increased development, and shifting climatic patterns. Many South African communities struggle to access reliable and sufficient water to meet their various nutritional and sanitation needs.

The median age in South Africa is 27.6 years**.** Although South Africa is considered one of Africa's largest economies, it experiences high unemployment levels. According to the latest conference, researchers from the HSRC (Human Science Research Council) and World Bank statistics indicated that the official unemployment rate in South Africa reached 29% in the second quarter of 2019, which could be the highest in a decade (Lavee, 2011). The primary sources of employment for the country's working population are the agricultural, industrial, and service sectors. Quantitatively, the service sector accounts for 72 per cent of total employees in South Africa, while the industrial and agricultural sectors account for 22.91 per cent and 5.09 per cent, respectively. (H. Pletcher, Jul 13, 2020). With a largely South

African workforce living around mines, clean water connectivity is necessary around the mining companies (Lavee, 2011).

This thesis is a feasibility study of constructing a wastewater treatment facility in South Africa to satisfy a nearby platinum mine; the study will discuss the proposed project's details from various perspectives. It aims to quantify the facility's feasibility financially to the project owner and its attractiveness from a bank's perspective. Given that project's water output will be sold strictly to a mine that produces platinum in South Africa for extraction processes, the economic analysis quantifies the cost savings incurred by supplying water via this wastewater treatment project compared to buying the water from an alternative source. It is the concept of water management and reuse. Water reuse is an important topic and finding solutions for the scarcity of water would help saving cost and the environment through handling the discharged water streams from the mine, making sure it meets all of the compliance requirements and minimizing the environmental impact as it is believed that the work of mines could harm the sanitation of water around the area of mines. The mining industry must implement technologies that will reduce water treatments' operational cost and meet the required environmental targets.

1.2 Significance and Objectives

As water scarcity increases, the need to manage water as a national asset and overall social benefit becomes imperative. In South Africa, the local government is constitutionally obligated to provide all domestic water and sewage disposal services. Unfortunately, many people in developing countries like South Africa have to cope with deficient wastewater treatment plants coverage. The main explanation for this low coverage is the required high investment costs of wastewater treatment plants. Therefore, it is vital to progressively assess how South Africa people can achieve their right to an environment that is not harmful to human health or well-being and sufficient water as entranced in their constitutional rights. Besides, it sheds light on the mining industry and how it could affect the current water resources and, hence, impact water quality and sanitation and propose solving the problem through wastewater reuse. Therefore, this study presents an opportunity to assess the possibility of undertaking the proposed wastewater treatment plant that could benefit a large section of the population in a mining facility and set an example for future cost-saving investments in the country.

1.3 Study Methodology

To make sense of the financial and economic viability, it is necessary for projects to be measured, considering that resources are limited to be invested on projects that are technically viable and improve the welfare of members of the population. Integrated Cost-Benefit Analysis goes a long way in achieving this (Jenkins, Kuo, & Harberger, 2019).

The proposed investment feasibility study was performed through integrating the financial, economic, stakeholder and risk analyses. The Cost-Benefit Analysis (CBA) approach analyses the costs and benefits of the project being employed to achieve this. Traditional investment appraisal approaches usually involve a separate investment analysis from a financial perspective and an economic analysis that further stands all on its own.

The proposed project's financial and social feasibility is decided using the Net Present Value (NPV), calculated using the analyses' financial data. Furthermore, applying the equivalent analysis model, a sensitivity analysis was taken to analyse the alternative scenarios by inspecting the impact of their shifts in the general benefit or unless of the proposed investment plan. Besides, it involves conducting an economic analysis using the same model to analyse the economic value and determine the project's feasibility from an economic point of view using Economic Net Present Value (ENPV) concept to present if the proposed project is a gain or loss to the society.

1.4 Study Structure

In this study, Chapter 1 is introductory. It presents the country's background and economic situation, besides providing an overview to present this proposed project's aim. The next chapter serves to provide an understanding of the overall idea of the study by presenting the general image on the state of affairs in South Africa's mining industry, Waste Water Treatment Plants (WWTP) and the efforts being undertaken by both the national government and local governments to improve the lives of people in terms of access to clean water and sanitation. Chapter three discusses the proposed project in particular, while Chapter four reports the methods used to conduct the analysis. The 5th chapter presents the financial analysis, while the emphasis is on economic analysis in Chapter six. Finally, the last chapters seven, eight and nine, incorporate stakeholder analysis, risk analysis, and the study's summary correspondingly.

Chapter 2

STUDY OVERVIEW

2.1 The Mining Industry in South Africa

The world's richest reserves of precious minerals and base metals are located in South Africa, where the largest reserves of Platinum-group metals (PGMs; 88%), Manganese (80%), Chromite (72%) and Gold (13%) known reserves in the world. Mining has helped form South Africa to a greater extent than any other industry by giving more employment opportunity and decreasing unemployment at certain periods. It played a great role in turning a largely rural economy into an industrial one with its high export level and its significant contribution to South Africa's GDP.

Figure 1: Mining Industry

South Africa on the other hand, is a water-limited country with mining activities often located in areas with limited water resources, in which made it challenging for the mining sectors to maintain production without harming the surrounding environment, such impacts have also affected the safety, health and well-being of communities, by its nature, mining can have a deleterious effect on land, water and communities surrounding a mine (Chamber of Mines of South Africa 2004). Historic environmental pollution and degradation from mining and mining-related activities have harmed the success of mining organizations. The mining industry needs water for production purposes, whereas it is used for extraction and things like equipment maintenance, and consumption by the mining communities themselves. As different mining companies have different process depending on their field, platinum has their own process stages. As an instance, the figure explains how water would be needed during the platinum extraction process.

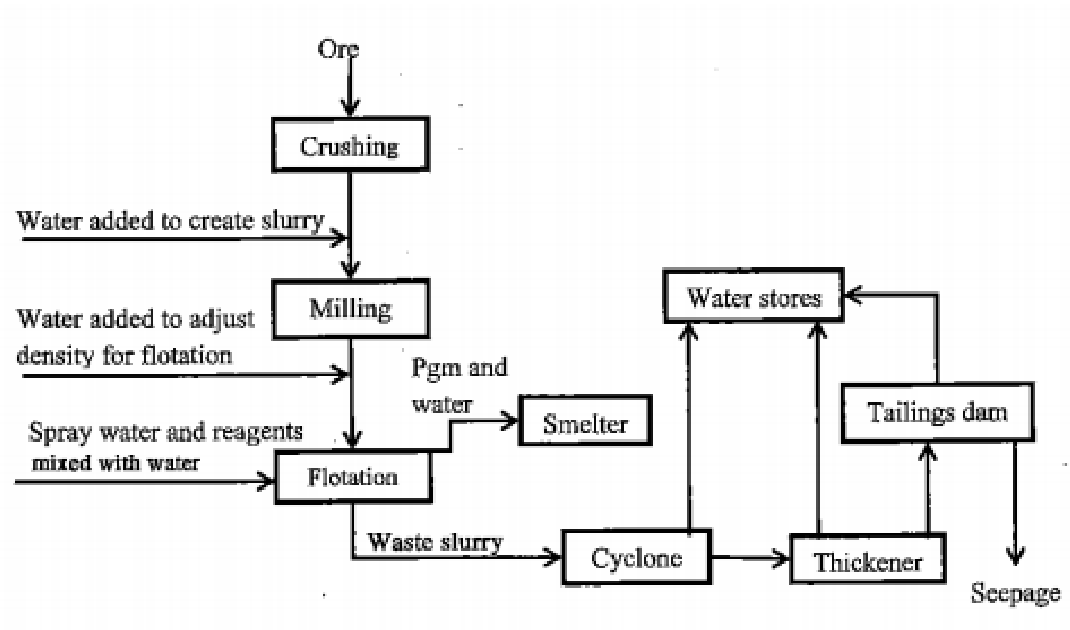


Figure 2: Simplified Water Flow Sheet

Figure 3: The Mine in South Africa

2.2 Sanitation and Waste Water Treatment in Africa

The water shortage has gained worldwide attention throughout the last decade as it threatens food security in arid and semi-arid regions, mostly in Africa. Over 70% of the water used in rural and urban areas in South Africa is surface water drawn from rivers, streams, lakes, ponds and springs (DWAF, 2004). The challenges relating to an adequate supply of clean water in the African continent have been a continuous research subject. According to Wang et al. (2014), 75% of people living in Africa use groundwater for drinking, and other household needs. Once used, the largest portion of the wastewater is discharged into drainage systems without the option of recycling for further usage. This is the problem identified by this study.

The World Health Organization (WHO) documents that the wastewater discharged from households accounts for water pollution's biggest cause. Besides, the need to have a sustainable supply of clean water and reduce water pollution calls for more water treatment plants' investment. Many African governments have embraced this idea, but the challenge has been to proceed to the implementation stage. Wang et al. (2014) assert that conventional water treatment, such as biofilms and activated sludge, is used within Africa due to existential challenges with the supply of power and financial funding availability.

For example, the National Water and Sewerage Corporation of Uganda operates standard wastewater treatment facility solely at Bugolobi wastewater Treatment jobs for Kampala City and one facility in Masaka Sewage Treatment Works. At the same time, it implements stabilization artificial lakes for the other wastewater treatment facilities (Molobela & Sinha, 2011). Nevertheless, in some parts of Africa, significant strides have been made to build the required capacity to come up with reliable wastewater management systems.

The overall situation in terms of wastewater management in Africa is compounded by several characteristic challenges: insufficient infrastructure. Inadequacies in infrastructure related to the existing infrastructural installations' inability to serve the population release wastewater into the system. For instance, in Addis Ababa, Ethiopia, the Kaliti wastewater treatment plant was designed in 1982 to serve 50,000 people, but its infrastructure has enabled it to serve only 13,000 people. Besides infrastructural challenges, poor operation and maintenance is also another major challenge.

To improve the continent's ability to manage water sustainability, Wang et al. (2014) recommend archetypal technologies for wastewater treatment. Such include cost-effective measures to control algae, affordable on-site sanitation construction, low energy consumption treatment, a combination of artificial lakes system with biological treatment, proper disinfection for wastewater, water reuse and desalination, groundwater purification and rainwater treatment.

2.3 Waste Water Treatment and Sanitation in South Africa

As a country, South Africa has been recognised as one of the African countries that have made remarkable strides towards improving their living conditions. The country's top leadership recognises that effective sanitation services contribute to raising a healthy and productive population besides conserving the environment. Nevertheless, Adewumi, Ilemobade & Van (2010) posits that South Africa's sanitation and wastewater treatment systems are under tremendous strain. This results in the release of untreated wastewater into the environment, hence polluting freshwater sources that further worsen people who rely on water from streams and rivers. For instance, river Vaal has experienced increasing raw sewage spillage, making people and animals rely on direct consumption.

The virtue of sanitation facilities is officially acknowledged and confirmed by the international association as a civil right fundamental to an adequate living standard's complete benefit. This further repeated in South Africa's constitution under the bill of rights. In the mining industry, mining companies also recognise and have all expressly stated that their community of workers have a right to access clean water. As a result, the national government delegates responsible for providing sanitation services, including wastewater treatment to local governments. The local governments also termed municipalities apply cooperative governance principles to ensure people's rights are not compromised in service delivery. Local governments also develop and implement legislation to ensure that mines owners are provided with clean water.

As at 2019, South Africa had 824 wastewater treatment systems across 152 municipalities with a collective design capacity to hold 6.5billion litres of wastewater in a day. A recent review of the treatment plants recommended regulatory action on 248 of them due to their critical condition. It is also notable that only 60 (7%) of the country's total wastewater treatment plants received Green Drop Certification in 2013. This is essential because the infrastructure necessary for water treatment in urban and rural areas is on the verge of failure due to lack of good maintenance and proper utilization.

2.4 Initiatives to Improve Waste Water Treatment in South Africa

Owing to the various identifiable challenges associated with wastewater and sanitation management in South Africa, the national government recognises the need to change the situation for the better. However, efforts to improve wastewater treatment in the country have been fragmented due to different local governments' different strategies. Some municipalities have prioritised the issue of wastewater management and continuously allocated funds to ensure the construction of new facilities and good management of the existing ones. On the other hand, some do not recognise wastewater treatment as a big priority. This imbalance prompted the national government to intervene in 2019 and initiate a project to ensure that all wastewater treatment plants are rehabilitated and brought back to full functionality (Cossio et al., 2020).

As a starting point of the plan to ensure rehabilitation of wastewater treatment plants, the South African government announced the release of $24.3 million to rehabilitate the many wastewater treatment plants located in Mpumalanga province (Minnaar, 2020). This project was meant to impact the larger environmental conservation initiative of cleaning the Vaal River in the eastern part of South Africa.

Given the responsibility to ensure that the rehabilitation is completed accordingly, is the East Rand Water Care Company (ERWAT). The company is responsible for ensuring that all wastewater treatment infrastructure in the province is restored to working condition. According to the South African Government, the project implementation protocol was signed between the Ministry of Water and Sanitation, the Ministry of National Defense, the Department of Corporative Governance and Traditional Affairs in Gauteng, the Municipal Infrastructure Support Agency, the Municipality of Emfuleni and the ERWAT.

Another wastewater treatment project that was recently started and completed is the Sebokeng wastewater treatment plant's rehabilitation. The project was initiated in 2018 and completed in May 2019. The project involved demolishing the existing water tanks and building new ones besides earthworks and excavation work in a plant with a total capacity of 50,000 cubic meters per day (Minnaar, 2020). This plant was also a beneficiary of the Vaal River clean-up initiative.

2.5 Waste Water Treatment in South African Mines

One of the most dangerous and the most common hazard from wastewater mines in South Africa is the acid mine drainage (AMD). This and more pollutants are known to find its way into underground and surface water around mines, making it hazardous. To arrest this problem while also providing a source of clean water for people living around mines, recycling has been identified as the best solution. Unfortunately, efforts to improve wastewater treatment in the country through government institutions and local authorities have not been successful. Several municipalities have expressed commitment to ensure that they partner with mining companies in their jurisdictions to ensure that the water released as wastewater can be recycled. Nevertheless, very little has been achieved as the commitments have not been honoured especially by the government side. This challenge leaves many mining companies with the sole option of setting up their own water recycling facilities.

The AMD is the collective term used for wastewater that may contain high salts, sulphate, iron, aluminium, toxic heavy metals such as cadmium and cobalt, and radioactive elements. Such contaminated water can pollute soil and water supplies as it spreads underground and flows into rivers and streams. In South Africa, Geologists claim the contaminated water reaches up to 350 million litres per day (Wang et al., 2014). For the mining companies that have tried to start their own water recycling facilities, they have contracted Dow Southern Africa, a company that installs systems for extracting, separating and purifying metals while also reducing recycling reagents. Such water has been used for human consumption by the mining communities but always required to be supplemented by more from water selling companies.

2.6 The Proposed Project

The proposed project aims at constructing a WWTP for water reuse purposes for a Platinum mine located in South Africa. The undertaking project involves the procedures involved from the point of acquisition of materials, groundbreaking, the actual construction and maintenance of the facility. The facility is structured to ensure efficient energy utilisation by applying modern technology using reverse osmosis as it is cost-effective.

Chapter 3

PROJECT ILLUSTRATION

3.1 Conceptualisation of the Project

Mining wastewater is the byproduct of extraction processes that discharge water after it has been used productively or otherwise. The pollutants existing in wastewater may vary depending on what it gets to be exposed to. The entire idea of wastewater treatment is based on the need to get the pollutants out of the water and ensure that it is available for reuse in a productive way. Further, getting these pollutants out of wastewater eliminates elements that can be harmful to the environment.

According to Minnaar (2020), wastewater treatment aims to remove as much of the suspended solids and possible before the remaining water, usually called affluent, gets discharged back to the environment. As solid material gets to decay, it consumes oxygen needed by plants and animals living in the water. This leads to the destruction of aquatic life, which serves as a livelihood source to many people who depend on large water bodies.

In South African Mines, the absence of fully functional and efficient WWTPs poses a threat to the people and the general environment even though they rely on freshwater from an external supply. Ideally, large mining companies require constructing their own WWTPs to achieve sustainable water usage and improve environmental conservation. This project focuses on a large mining company located in the North West Province of South Africa.

3.2 Project Segments

The project will be split into three main segments. These include the intake facilities that the main water treatment facility and the treated water distribution facilities. The following is a description of each of the three segments whose construction will sum up as the WWTP construction.

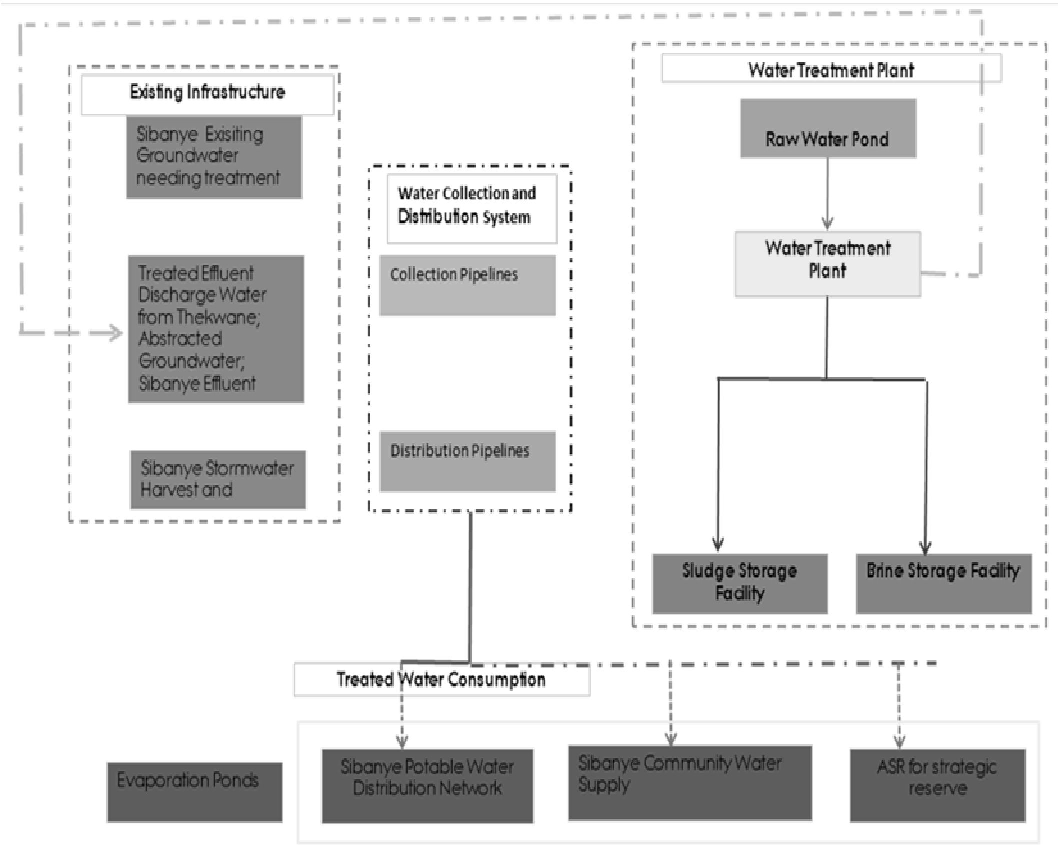


Figure 4: The Wastewater Treatment Plant Distributional System.

3.2.1 Waste Water Intake Network

This is an important component of the project meant to ensure that the targeted wastewater is captured and directed towards the main facility. The wastewater intake will include a network of pipes tapping into all outlets that discharge their wastewater from the mining facility. This part of the project will be made up of numerous interconnected 30 centimetre and 50-centimetre diameter pipes with all direct water to the main plant. The network will terminate at the pre-treatment screening facility which shall involve removing large items from the affluent to prevent damage to the facility's valves, pumps and other sensitive equipment.

3.2.2 Main Waste Water Treatment Facility

Filtered water from the pre-treatment system will be supplied to the membrane system will be dosed with antiscalant and sodium metabisulphite before being pumped into a polishing filter. The chemicals act as fouling and scaling prevention chemical. A five-micron cartridge filter will act as a polishing step to protect the reverse osmosis membranes from any particulate breakaway on the pre-treatment. Polished water will be fed into the reverse osmosis system where total dissolved solids, conductivity and other water constituents will be reduced. The reverse osmosis feed water will be split into 2 streams, permeate and the concentrate. The concentrate will be discharged to the closest drain point. Permeate water will be discharged to the client's treated water tank.

Figure 5: Reverse Osmosis Machines used for Treatment.

A cleaning in place (CIP) procedure will be required to maintain the reverse osmosis in optimal operating condition. This will consist of a tank that has an opening to pour chemicals into. The tank will provide a flooded suction to the reverse osmosis feed pump. The CIP solution will be sent through the reverse osmosis in different cleaning regimes.

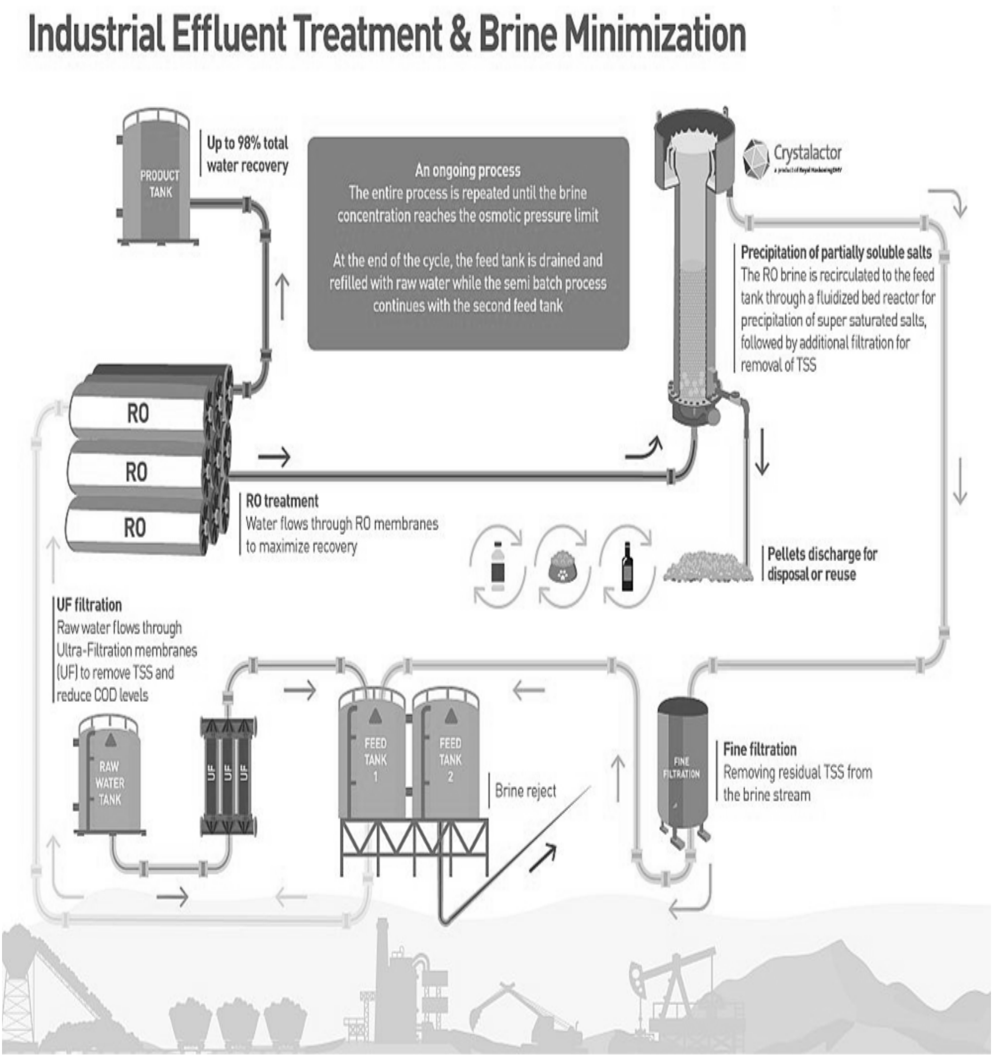


Figure 6: Main Water Treatment Facility

3.2.3 Treated Water Distribution Network

This will entail the infrastructural installations that enable distributing the treated water back into the mine's water needs and neighbouring communities. This section of the plant will include three main subdivisions: the pumping station for the mine's potable water distribution network, the pumping station for the neighbouring potable water distribution network and aquifer storage and recovery for the strategic reserve. The rest shall be supplied to an evaporation pond.

3.3 Area for Project Coverage

The project shall cover one of the largest mines in South Africa located at Rustenburg, Gauteng, South Africa. Below is a map showing the actual location of the proposed project.

Figure 7: The Actual Proposed Site of the WWTP

3.4 Program Cost and Financing

In summary, the entire project is expected to cost ZAR 23,000,000.00 with some allowable margin of error. The following is the planned program cost after analysing all the requirements for constructing the WWTP to completion.

Once the mining company accepts the proposal, the cost of developing the entire facility will be shared between the client and the investor where the investor intends to finance his part using a loan. However, the investor shall recoup the investment cost and profit through periodic payments spread into the future. The calculation of this payment will be dependent on the number of cubic meters of treated water that leaves the facility for productive use.

Chapter 4

METHODOLOGY

This analysis study was conducted applying the Cost-Benefit Analysis method (CBA) to assess the feasibility of the proposed project, including integrating the financial and economic analysis, however, presenting both points of views that help identify and allocate the impacts of the project on the stakeholders. A distinct investment assessment from a financial perspective and economic analysis usually requires conventional investment valuation approaches. The flow of the study will be explained in details in the following sections.

4.1 Financial Analysis

The study is performed to examine the project proposal's financial viability, which will assess whether or not it will be profitable to pursue the project. The financial analysis undergoes the study with different perspectives to understand if the project is financially viable for stakeholders. In contrast, investors will know if they will gain returns if they invest in this project. The Lenders will be allowed To see if enough cash can be produced by the project, to repay them their loan, such study is essential for the banker's perspective to rely on while determining if the project proposed can pay back the loan. It can clarify if the bank and other loan entities to know if the loan is worth the project.

The financial analysis is assessed according to the parameters that follow, starting from the viewpoint of the lender or bank, the review is first conducted without considering the debt. This helps the lenders to see if enough cash flow will be generated by the project to service their debt requirements, From this cash flow, the Annual Debt Service Coverage Ratios (ADSCRs) are determined, and the ratio is what the bank used to determine if the project was worth the loan. Conversely, the financial analysis from the investor's perspective considers the loan as the financing part of the project, making them estimate the profit generated after all the cost is deducted, including the loan repayment. Following the project will be analysed if it is viable using the overall Financial Net Present value (FNPV), which is known if it is positive. That means the project will have positive returns.

4.2 Economic Analysis

The economic analysis is the study that helps to understand and measure the impact of the project on society as a whole. The study aims to determine if society's net benefit would increase or decrease Founded on well-being economics principles. The projects' economic evaluation has its origins in the three postulates (Jenkins, Kuo, & Harberger, 2014).

The principle of Economic analysis that differs from the financial analysis is the availability of distortions. The market and supply values would be evident and the same as the financial price, if there were no distortions. That is hardly ever the case, in fact, nevertheless. The explanation is that in fact, in a normal economy, distortions such as corporate income taxes, import duty, value-added taxes and various forms of subsidies have an ordinary effect on the rate of the foreign exchange and the economical price of the capital patent value of these distortions, The economic largely reflects these distortions into account in order to obtain the actual economic costs and advantages of the project being analysed.

To determine the project's economic aspect, it is important to produce economic cash flow to measure the financial review project's economic gains and costs in parallel. However, using exchange variables, financial values would have to be transformed into economic prices; this is the financial value's economic value ratio. These conversion parameters are measured and used to represent the actual gains and costs of any project inputs and outputs. rThe economic cash flow will be measured in the analysis, which will help measure the Economic Net Present Value (ENPV). Achieving an ENPV that is positive indicates that the planned investment is up-and-coming from different perspective government and individuals in the society, which makes it attractive for all and be willing to invest in such projects.

4.3 Stakeholder Analysis

This section of the study includes analysing who the gainers and losers from undertaking this proposed project. The financial and economic analysis is a base used to build the stakeholder analysis; it measures the amount of loses and benefits. The stakeholder review shall ensure that all participants involved in the project achieve the desired benefits resulting from the project. In most cases, customers, manufacturers, government, and people in society are the project's main stakeholders. For example, in this analysis, the lending institution, which is the necessary funds' source, is a significant stakeholder. The stakeholder analysis will provide for sure if all the required needs are meet.

4.4 Risk Analysis

Risk analysis is the way of understanding all the possible risk available that our proposed project would face. It involves an assessment of the uncertainties existing in the future that can potentially result in losses or undesirable outcomes as a result of either of the parties being part of the project In consideration of the fact that the project will sustain for years to come, some uncertainties need to be taken into account in the planning process. This makes performing a risk analysis a crucial component of the project assessment approach to the Cost-Benefit Analysis (CBA).

For instance, currency exchange rates are some of the key variables that need to be considered because their changes can harm an investment especially where the finances involved are in the form of a foreign currency or key items in the capital investment have to be bought from other countries. Sensitivity analysis helps in the determination of such sensitive variables. Once a sensitivity analysis is completed, the probability should be done to determine the various risk scenarios with their possible influences on the entire project's profit or loss.

Chapter 5

FINANCIAL ANALYSIS

Financial analysis was performed using data obtained from the various research and detailed literature reviews. The Financial analysis Section aims to assess the financial feasibility of the plan. It provides the basis on which more quantitative analyses concerning the project are carried out. It entails the projected amount of revenue to be generated and the expenses incurred by the project. Further, financial analyses involve projections of the capital investment for the project to be fully operational. To ensure consistency, financial analysis requires forecasting revenues and expenditure to be consistent in prices.

Therefore, matters like the rate of inflation and interest rate should be clearly established and stated besides being applied consistently. The other important consideration of the financial analysis is the timing of expenditures and cash receipts. These are required to be adjusted according to variations in accounts receivable and accounts payable, for revenue and expenditure each.

5.1 Parameters and Assumptions

The parameters and assumptions adopted in the financial study of the factory wastewater treatment plant project include;

5.1.1 Quantity of Waste Water Supply

The quantity of wastewater discharged from the Mine is key in determining the amount of treated water generated by the proposed facility. Ideally, this water is the total sum of the cubic meters (M^3) of the wastewater released directly from the mine's activities and mineworkers' residences. Wastewater from the mining facility is mainly the water discharged by the mine's cooling and cleaning sections. Further, the water that pours around the factory, especially during the rainy season will also be part of the aggregate wastewater supply. Therefore, the assumption is that the total M^3 of wastewater that will be cleaned and treated for reuse will be 3,000 M^3.

5.1.2 Price of Water

Water tariffs in South Africa have always been dynamic due to weather seasons changes; that is, from dry to rainy seasons. However, parameters for water pricing for this project are borrowed from the government's estimates. In our proposed project, the water price sold to the mines is set at 7.9 ZAR per M^3.

Apart from the fund set up by the contributors to the investment expenses, sanitation is not being paid for.

5.1.3 Cost of Maintenance and Operating in the Recycling Plant

All costs will be presented in South Africa Rand (ZAR) currency for this project, the main operating costs of labour and energy expenses that are used in pumping wastewater, a charge of 0.134 fuel/m^3 is expected, and the expense of energy shall be held on an annual basis to be R 270,000. Additionally, there are annual maintenance costs of R 1,600,000. The project requires establishing a central recycling plant that will consume all the project's initial capital and require maintenance costs. Besides the cost of maintenance, the wages and salaries for staff are expected to be R 2,160,000.

5.1.4 Taxation and VAT

The Corporate tax rate in South Africa is a flat rate of 28% and a VAT rate of 15%. This project granted an exemption of paying VAT. It is has been added for calculations purposes, although the government will refund it.

5.1.5 Inflation

The South African domestic inflation rate is assumed to be 6% all through the evaluation period.

5.2 Financial Analysis Results

In conducting the financial study, it is possible to determine the project's ability to generate cash flows that are likely to push it through its lifetime. The main costs expected to be met by these cash flows include operational maintenance and periodic repairs. The project's total investment cost is 23 Million ZAR from the financial analysis sheet, which involves both maintenance and running expenses for the planned investment lifetime. The cost included is used in the detailed analysis of the evaluation sheet. The revenues to be generated by the project will solely be in the form of tariff payments by the mine. These tariffs will be compiled daily, and thereafter summarised at the end of each month to aid efficient financial reporting.

Having assessed the cash flows, it is evident that the project shall generate positive cash flows through its life in means it will be able to pay back its loan. By applying the discount rate of 11%, the project yields profits by achieving a positive Financial Net Present Value of approximately R 5.782 Million which indicates that the projected earnings generated exceeds the anticipated costs and a Financial Internal Rate of Return of about 23% and for more accurate results a Modified Internal Rate of Return calculation was conducted of about 17%, the results summary is shown in Table 1 in the following pages.

The financial ratios which include the DSCR and LLC helps the bankers in determining if the project can generate profits while being able to pay back the loan to the lenders, the DSCR ratio calculated in the analysis are presented in Table 7, are 1.5 and above through the years of the project. In contrast, the LLC Ratios indicates a less potential risk for the lender as it is 2.6 and above over the loan's life. This depicts that a loan finance option is a viable option that will help fund the initiation stage and proceed up to a point where the company will generate cash flows to finance the approximated repayments.

Table 1: Summary of the Financial Analysis Results.

Discount Rate	11%
NPV	**5,781,903**
IRR	**23%**
MIRR	**17%**

Table 2: The Cash Flow Statement from Financial Analysis Sheet (Bankers Perspective in Million ZAR)

YEARS			Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11
NOMINAL CASHFLOW														
INFLOWS														
Revenue indexed	ZAR	-	5,806,500	9,169,530	9,719,702	10,302,884	10,950,978	11,576,320	12,270,900	13,007,154	13,825,357	14,614,838	5,093,171	-
Residual value	ZAR	-	-	-	-	-	-	-	-	-	-	-	-	11,502,109
VAT refund by government	ZAR	-	3,000,000	-	-	-	-	-	-	-	-	-	-	-
TOTAL CASH INFLOW			**8,806,500**	**9,169,530**	**9,719,702**	**10,302,884**	**10,950,978**	**11,576,320**	**12,270,900**	**13,007,154**	**13,825,357**	**14,614,838**	**5,093,171**	**11,502,109**
OUTFLOWS														
CAPEX														
Capital expenditure (Net of VAT)	ZAR	-	20,000,000	-	-	-	-	-	-	-	-	-	-	-
VAT payable	ZAR	-	3,000,000	-	-	-	-	-	-	-	-	-	-	-
OPEX														
Control Room operation	ZAR	-	-	-	-	-	-	-	-	-	-	-	-	-
Personnel	ZAR	-	1,445,902	2,289,600	2,426,976	2,572,595	2,726,950	2,890,567	3,064,001	3,247,841	3,442,712	3,649,275	1,271,747	-
Maintenance costs	ZAR	-	1,071,038	1,696,000	1,797,760	1,905,626	2,019,963	2,141,161	2,269,631	2,405,808	2,550,157	2,703,166	942,035	-
Civil	ZAR	-	60,246	95,400	101,124	107,191	113,623	120,440	127,667	135,327	143,446	152,053	52,989	-
Mechanical/E&I	ZAR	-	120,492	190,800	202,248	214,383	227,246	240,881	255,333	270,653	286,893	304,106	105,979	-
Operational Costs	ZAR	-	180,738	286,200	303,372	321,574	340,869	361,321	383,000	405,980	430,339	456,159	158,968	-
TAX PAYABLE														
Tax payable	ZAR	-	809,086	-	386,602	468,724	564,151	1,614,046	1,711,855	1,815,532	1,936,007	2,041,922	711,913	3,220,591
TOTAL CASH OUTFLOW BEFORE FINANCING			**26,687,502**	**4,558,000**	**5,218,082**	**5,590,093**	**5,992,802**	**7,368,416**	**7,811,487**	**8,281,142**	**8,789,554**	**9,306,681**	**3,243,632**	**3,220,591**
NET CASHFLOW (Banker's perspective)			**(17,881,002)**	**4,611,530**	**4,501,620**	**4,712,791**	**4,958,175**	**4,207,904**	**4,459,413**	**4,726,011**	**5,035,803**	**5,308,156**	**1,849,539**	**8,281,519**

Table 3: Financial Ratios (Bankers Perspective in Million ZAR)

YEARS				Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11
FINANCIAL RATIOS															
ADSCR															
Total Debt service		*ZAR*	-	-	3,000,000	2,800,000	2,600,000	2,400,000	2,200,000	-	-	-	-	-	-
Revenue indexed		*ZAR*	-	5,806,500	9,169,530	9,719,702	10,302,884	10,950,978	11,576,320	12,270,900	13,007,154	13,825,357	14,614,838	5,093,171	-
Loan repayment flag		*Flag*	-	-	1	1	1	1	1	-	-	-	-	-	-
Discount Rate	11%	%													
Total Annual operating Cost (NOMINAL)		*ZAR*		2,878,415	4,558,000	4,831,480	5,121,369	5,428,651	5,754,370	6,099,632	6,465,610	6,853,547	7,264,760	2,531,719	-
Net Operating Income		*ZAR*		2,928,085	4,611,530	4,888,222	5,181,515	5,522,327	5,821,950	6,171,267	6,541,543	6,971,810	7,350,078	2,561,452	-
Annual DSCR		*Index*		-	**1.5**	**1.7**	**2.0**	**2.3**	**2.6**	-	-	-	-	-	-
Loan Life Coverage Ratio (LLCR)		*Index*		-	1.9	2.1	2.3	2.5	2.6	-	-	-	-	-	-

5.3 Financial Sensitivity Analysis

The inability to have accurate perdition of the future necessitates a sensitivity analysis for the project. Ideally, sensitivity analysis involves changing the project parameter and displays the effect of the change on the project's eventual outcome.

Variables like fuel prices cannot be dictated in South Africa, making it one of the key reasons for high variability. In the sensitivity analysis, one variable varies simultaneously, while other variables remain constant; thus, the variable has to be separated. To allocate the uncertainty, a financial sensitivity analysis was conducted to identify the variables that were most likely to affect the proposed project's financial performance.

5.3.1 Water Tariff per kℓ

Table 4 demonstrates the sensitivity to shifts in the price of water per kℓ. As shown from the table, a price decrease of 2 ZAR from 8 to 6 ZAR per kℓ results in reducing the FNPV, rendering it negative. However, an increase of 2 ZAR from 8 to 10 ZAR brings about an increase of more than double the project's base rate FNPV.

Table 4: Water Price Per kℓ

Price per M^3 R	**FNPV (Million ZAR)**
6	(4.64)
8	**5.78**
10	16.8

5.3.2 Inflation Rate

As seen in Table 5, a 3% reduction in the inflation rate would increase the project's FNPV from R 5.78 million to R 5.82 million. However, If raised by 3%, the increase would result in a small increase to R 5.84 million.

Table 5: Inflation Rate

PERCENTAGE CHANGE IN INFLATION RATE	FNPV (Million ZAR)
3%	5.82
6%	**5.78**
9%	5.84

5.3.3 Investment Cost Overrun

The following table explicates that a 3 months increase in construction period will bring about approximately 87.5 per cent decrease in the FNPV, and a decrease in the construction period by a 1 month will bring about 75.2 per cent increase in the FNPV.

Table 6: Investment Cost Overrun

INVESTMENT COST OVERRUN	FNPV (ZAR)
3	7,685,279
4	**5,781,903**
7	719,227

5.3.4 Change in CAPEX

An increase of a 4 Million ZAR in CAPEX will decrease approximately 52.4 % of the FNPV to be 2.75 Million ZAR. Similarly, a decrease of the same amount would increase the FNPV by 52.4%. The FNPV's sensitivity to CAPEX fluctuates, as seen in table 7.

Table 7: Change in CAPEX

CAPEX (Million ZAR)	FNPV (Million ZAR)
16	8,811,722
20	**5,781,903**
24	2,752,083

5.4 Financial Analysis Conclusion

The financial feasibility study indicates that the investment produces income, as illustrated in the cash flow sheet using the assumed and collected data. The nominal cash flow was used for Loan purposes, and it must be noted that the real cash flow sheet was calculated in the analysis to reflect the real prices. The financial analysis results prove a positive NPV and acceptable MIRR, which means that the proposed project from the financial perspective is feasible. The financial sensitivity analysis helped determine the risk of changing an important variable such as the inflation of the water price for sale and how these changes might affect the FNPV. The project produces a financial Net Present Value of 5,781 million ZAR and a 17 per cent MIRR shows that the project is financially viable.

Chapter 6

ECONOMIC ANALYSIS

Economic evaluation studies the cost and benefits of the proposed project in order to identify the impact on society. The previous chapters went into details studying the project's financial analysis by considering the cash flows to conduct the Net present value to determine the project feasibility from the project's financial perspective. However, the economic analysis as mentioned looks at the project from the eyes of the society, as such, from economic analysis, we would be able to determine whether the project will increase the net prosperity of society. The study will explain how the variables used to determine the economic feasibility of the project are calculated.

6.1 Economic Assumptions and Parameters

6.1.1 National Variables

The Economic Cost of Capital (ECOK) was estimated to be 11% using the South African Journal. Jenkins, Glenn & Kuo, Chun-Yan & Mphahlele, M. (2003). The economic opportunity cost of capital (EOCK) is the appropriate discount rate to use when estimating the economic net present value.

6.1.2 Commodity-Specific Conversion Factors

In order to convert the financial values into economic values, a conversion factor is needed. To convert our financial feasibility study into an economic study, a multiplication for each value in the financial data-sheet study with the earlier calculated conversion factor has been made. The conversion factor is the ratio of economical prices to financial value. The conversion factors applied for economic analysis are presented in Table 8.

Table 8: Summary of the Conversion Factors.

Items	Conversion Factors
Labor	0.988
Machinery	0.933
Mechanical E&I	0.933
Civil	0.900
maintenance	0.933
operation	0.831
Building and structures	0.900
CAPEX	0.930
Water price	1.51

Financial prices of goods contain distortions, such as import duty and VAT costs, taking into account foreign exchange premiums (FEP). However, the measurement of these products' economic prices is in a manner as to eliminate distortions. To understand the conversion factors, for example, if the CF is less than 1. This implies that the costs financially of the commodity occur higher than the economic value of the item. In this project, the parameters under this classification are Machinery, Mechanical and all the operational inputs and the items used to maintain it. The project labour expenses are the biggest distortion when translating its financial price to an economic value: the income tax also the gap within the investment's fees and alternative fees. A calculation was made for skilled and unskilled labour. However, the project has no identification of the amount of skilled labour to unskilled.

So, an average of both labour's classification was calculated to have the economic analysis's conversion factor. The values that contain financial grants of contributions by the government are not considered economic benefits or cost, as they are mostly transferred within the economy, indicating why the VAT refunded conversion factor value was equal to Zero. Lastly, the loan CF is assumed to be 1, which means that the financial values are similar to the study's economic value.

6.2 Economic Analysis Results

The Economic Viability of the project will be explained in this chapter. The proposed project's economic resource flow statement was conducted to determine whether the project was justified from society's perspective. Table 9 shows the economic valuation of the inflows and outflows of the project. The gross economic benefits and cost of selling water were estimated using the previous chapters' methodology. The Economic Analysis Summary results are listed in Table 10, where the Economic Net Present Value and IRR are shown. The ENPV of 42,005 Million ZAR Moreover, an Economic Internal Rate of Return (EIRR) of nearly 250%, a Modified Internal Rate of Return was calculated for a more accurate study to be 44%. This clearly depicts that the organisation stands to benefit from cost-saving and increased value for the investment made towards installing the treatment facility. This is depicted by the modified internal rate of return at 44%. Compared to the alternative solution of purchasing water for use by the mining community, the economic analysis also provides evidence that the treatment alternative is more sustainable.

Table 9: Resource Flow Statement of the Economic Analysis (In Million ZAR)

ECONOMIC ANALYSIS - REAL														
INFLOW														
Revenue indexed	ZAR	1.52	8,820,000	13,140,000	13,140,000	13,140,000	13,176,000	13,140,000	13,140,000	13,140,000	13,176,000	13,140,000	4,320,000	-
Residual value	ZAR	0.931	-	-	-	-	-	-	-	-	-	-	-	5,638,484
VAT refund by government	ZAR	-	-	-	-	-	-	-	-	-	-	-	-	-
Loan Drawdown	ZAR	1	10,000,000	-	-	-	-	-	-	-	-	-	-	-
ECONOMIC VALUATION OF INFLOW			**18,820,000**	**13,140,000**	**13,140,000**	**13,140,000**	**13,176,000**	**13,140,000**	**13,140,000**	**13,140,000**	**13,176,000**	**13,140,000**	**4,320,000**	**5,638,484**
OUTFLOW														
CAPEX														
Capital expenditure (Net of VAT)	ZAR	0.931	18,611,413	-	-	-	-	-	-	-	-	-	-	-
VAT payable	ZAR	-	-	-	-	-	-	-	-	-	-	-	-	-
OPEX														
Control Room operation	ZAR	0.831	-	-	-	-	-	-	-	-	-	-	-	-
Personnel	ZAR	0.988	1,427,993	2,133,247	2,133,247	2,133,247	2,133,247	2,133,247	2,133,247	2,133,247	2,133,247	2,133,247	701,341	-
Maintenance costs	ZAR	0.933	998,860	1,492,174	1,492,174	1,492,174	1,492,174	1,492,174	1,492,174	1,492,174	1,492,174	1,492,174	490,578	-
Civil	ZAR	0.900	54,221	81,000	81,000	81,000	81,000	81,000	81,000	81,000	81,000	81,000	26,630	-
Mechanical/E&I	ZAR	0.933	112,372	167,870	167,870	167,870	167,870	167,870	167,870	167,870	167,870	167,870	55,190	-
Operational Costs	ZAR	0.831	150,264	224,477	224,477	224,477	224,477	224,477	224,477	224,477	224,477	224,477	73,801	-
TAX PAYABLE														
Tax payable	ZAR	-	-	-	-	-	-	-	-	-	-	-	-	-
LOAN PAYABLE														
Principal repayment	ZAR	1	-	1,886,792	1,779,993	1,679,239	1,584,187	1,494,516	-	-	-	-	-	-
Interest payment	ZAR	1	-	943,396.23	711,997	503,772	316,837	149,452	-	-	-	-	-	-
ECONOMIC VALUATION OF OUTFLOW			**21,355,123**	**6,928,956**	**6,590,757**	**6,281,777**	**5,999,792**	**5,742,735**	**4,098,767**	**4,098,767**	**4,098,767**	**4,098,767**	**1,347,540**	-
ECONOMIC NET CASHFLOW			**(2,535,123)**	**6,211,044**	**6,549,243**	**6,858,223**	**7,176,208**	**7,397,265**	**9,041,233**	**9,041,233**	**9,077,233**	**9,041,233**	**2,972,460**	**5,638,484**

Table 10: Summary of Economic Analysis Results. (In Million ZAR).

EOCK	11%
ENPV	**42,005,449**
EIRR	**250%**
MIRR	**44%**

6.2.1 Inflation Rate

As illustrated in table 11, a 3% contraction in inflation rate produces a raise in the FNPV of the proposed project from R 42,005 million to R 42,029 million If increased by 3%; the change would be a slight increase to about R 42,100 million.

Table 11: Inflation Rate

PERCENTAGE CHANGE IN INFLATION RATE	ENPV (Million ZAR)
3%	42,029
6%	**42,005**
9%	42,100

6.2.2 Investment Cost Overrun

As Table 12 explicates, a 3 months increase during the construction period will bring about approximately 14.39 per cent decrease in the ENPV, and a decrease in the construction period by 1 month will bring about 5.45 per cent increase in the ENPV.

Table 12: Investment Cost Overrun

INVESTMENT COST OVERRUN (Months)	**ENPV (ZAR)**
3	44,294,033
4	**42,005,449**
7	35,960,537

6.2.3 Change in CAPEX

An increase of a 4 Million ZAR in CAPEX will decrease approximately 7.25% of the ENPV to be 38.96 Million ZAR; similarly, a decrease of the same amount would increase the ENPV by 7.25%. The sensitivity of the ENPV to fluctuations in CAPEX is presented in the table below.

Table 13: Change in CAPEX

CAPEX (Million ZAR)	**ENPV (ZAR)**
16	45,049,202
20	**42,005,449**
24	38,961,695

6.3 Conclusion of Economic Analysis

The wastewater treatment facility project's economic analysis shows that the proposed project positively impacts society as its ENPV is 42.005 Million ZAR. Furthermore, the EIRR and EMIRR proved positive feedback about the study. The Economic sensitivity analysis tested the uncertainty in some of the project's inputs and their effect on the project's outcome. The most significant factor was the change in the project's duration more about the uncertainty discussed in the Risk Analysis chapter.

Chapter 7

STAKEHOLDER ANALYSIS

In stakeholder analysis, we try to understand the gainer and losers from undertaking the project. We first need to determine who the stakeholders in the project are It is known as the Distributional analysis aims to analyse how each stakeholder participating in the project is influenced. The stakeholder analysis is determined by understanding that the item's economic cost is the total of the financial value also the aggregate of inputs' externalities. The ENPV of the commodity equals the total PV from each financial value inputs, including all the input's externalities PV, noting that each corresponding discount rate was applied to calculate the Present Values. The formula of the calculation is as follow.

$$\textbf{ENPV= FNPV + PV (}\sum\textbf{Externalities)} \quad (1)$$

A reconciliation of the financial, externalities and economic influences of the investment study calculation was made with a check to confirm whether the above formula was applied to the study's available numbers. The following table 14 will be a summary of the reconciliation test. The financial outcome is found in the first column, the externalities are represented in the second column, and the economic outcomes are found in the third column. The fourth column is where their previous formula is proved that the economic values are the sum of the financial and the externalities present value.

Table 14: The Financial, Externalities and the Economic Reconciliation Statement (Million ZAR)

RECONCILIATION OF FINANCIAL, ECONOMIC AND STAKEHOLDER STATEMENTS							
EOCK	11%	%	Financial	Externality	Economic	Fin. + Ext.	[Check]
INFLOW							
Revenue indexed		ZAR	54,732,238	28,405,339	83,137,577	83,137,577	True
Residual value		ZAR	1,922,473	(133,476)	1,788,997	1,788,997	True
VAT refund by government		ZAR	3,000,000	(3,000,000)	-	-	True
Loan Drawdown		ZAR	10,000,000	-	10,000,000	10,000,000	True
TOTAL INFLOW			**69,654,711**	**25,271,863**	**94,926,574**	**94,926,574**	
OUTFLOW							
CAPEX							
Capital expenditure (Net of VAT)		ZAR	20,000,000	(1,388,587)	18,611,413	18,611,413	True
VAT payable		ZAR	3,000,000	(3,000,000)	-	-	True
OPEX							
Control Room operation		ZAR	-	-	-	-	True
Personnel		ZAR	13,656,024	(169,140)	13,486,883	13,486,883	True
Maintenance costs		ZAR	10,115,573	(681,702)	9,433,871	9,433,871	True
Civil		ZAR	569,001	(56,900)	512,101	512,101	True
Mechanical/E&I		ZAR	1,138,002	(76,691)	1,061,311	1,061,311	True
Operational Costs		ZAR	1,707,003	(287,809)	1,419,194	1,419,194	True
TAX PAYABLE							
Tax payable		ZAR	5,290,854	(5,290,854)	-	-	True
LOAN PAYABLE							
Principal repayment		ZAR	6,302,816	-	6,302,816	6,302,816	True
Interest payment		ZAR	2,093,536	-	2,093,536	2,093,536	True
TOTAL OUTFLOW		ZAR	**63,872,808**	**(10,951,683)**	**52,921,125**	**52,921,125**	True
Net Externality Impacts		ZAR	**5,781,903**	**36,223,546**	**42,005,449**	**42,005,449**	True

7.1 Distributive Impact Analysis

In this section of the study, a distributive impact study of the externalities produced will determine the losers and gainers and how this happens due to the project. Table 15 will be showing a summary of the test.

Table 15: Distributive Analysis (Million ZAR)

DISTRIBUTIVE ANALYSIS OF EXTERNALITIES	Externality	Government	Consumers	Labour
Revenue indexed	28,405,339	-	28,405,339	-
Residual value	(133,476)	(133,476)	-	-
VAT refund by government	(3,000,000)	(3,000,000)	-	-
Loan Drawdown	-	-	-	-
Inflows	25,271,863	(3,133,476)	28,405,339	-
Capital expenditure (Net of VAT)	(1,388,587)	(1,388,587)	-	-
VAT payable	(3,000,000)	(3,000,000)	-	-
Control Room operation	-	-	-	-
Personnel	(169,140)	(169,140)	-	-
Maintenance costs	(681,702)	(681,702)	-	-
Civil	(56,900)	(56,900)	-	-
Mechanical/E&I	(76,691)	(76,691)	-	-
Operational Costs	(287,809)	(287,809)	-	-
Tax payable	(5,290,854)	(5,290,854)	-	-
Principal repayment	-	-	-	-
Interest payment	-	-	-	-
Outflows	(10,951,683)	(10,951,683)	-	-
NET EXTERNALITIES	**36,223,546**	**7,818,207**	**28,405,339**	-

The net externalities represent the total of all the positive and negative impact every stakeholder participating within the proposed investment. The Consumers (water user) are the gainers from this project as their net benefit is about 28,405 Million

ZAR, mainly generated from the economic value of water recycled. The government receives a positive externality due to undertaking this project of about 7,818 Million ZAR due to the project. These profits are from the tariffs received and the tax commitments of the commodities applied in the analysis study, the tax of income imposed on workers, also the residual value from those inputs that the government stands obliged to substitute in the scheduled period. In contrast, the government's contribution to our project's expenditure expense may be the product of the government's debt.

7.2 Conclusion of Stakeholder Analysis

The study reveals that customers are the top winners due to undertaking the planned investment by a net externality benefit of 28,405 million ZAR, and the negatively impacted are the other project that did not have the potential to be subsidised from financing the wastewater treatment plant for this project. Labours did not receive any net benefits. However, it is known that they are benefited from employment and the new vacancies opportunities due to constructing the new plant.

Chapter 8

RISK ANALYSIS

In any study or appraisal, there is uncertainty. To eliminate any major problems in our analysis study, a risk simulation is undertaken to guarantee no changes in the project's variables, especially that the proposed project is assumed to be continued. The risk analysis is applied to the financial and economic outcome we had in our previous chapters in this project to analyse the variations that could be obtained.

8.1 Risk Simulation

The simulation approach to analyse the uncertainties associated in this investment plan is Riskease software. It is by expressing the uncertainty in the critical variables related to the study in terms of probability distributions, using it to reflect the impact of uncertainty on the project results, from the financial and economic analysis a repeated simulation of about five thousand (5,000) times, the simulation uses the distribution for the values of the uncertain and sensitive variables in order to obtain a distribution of probabilities of occurrence and possible outcomes of the project. The difference between sensitivity analysis and risk analysis is that in sensitivity analysis only change in one variable keeps other variables constant how it would affect the study results. In contrast, in Risk estimation enables several factors to be modified simultaneously, allowing us to see a cumulative impact on the results of the project. Furthermore, the risk analysis allows in knowing the possibility of occurrence, which is not available in sensitivity analysis, which helps allocate the factors that influence the project's results.

8.2 Risk Variable

The sensitivity analysis provided us with the factors that possess the greatest influence on the project's result. They were tested separately; however, in the risk analysis, another approach was used. In this section will be discussing each variable that was tested.

8.2.1 Investment Cost Overrun

As seen in our previous chapter of sensitivity analysis, this parameter Impacts our financial and economic outcomes of the project. Investment cost overruns could be due to more than one factor, including lack of proper project management during construction and inadequate planning for implementation. Therefore, the management is supposed to be more cautious by controlling this to a large extent.

8.2.2 Inflation

Inflation is a variable that is determined from an exterior resource out of the management's control. The real prices of the project's inflows and outflows get affected by the fluctuation of the inflation rate, which could directly affect the project's operating cost and affect the project's financial outcome.

8.2.3 Change in CAPEX

This variable directly impacts the project's financial outcome and, by addition, the project's economic feasibility. It could be the insufficient project formulation, lack of proper planning and management. Such variables could be controlled up to a certain extent; however, it will still have uncertainty and its risks affecting the project has to be tested and identified.

As the variables related to the risk study have been identified, a simulation of the variable's probability distribution will be conducted. The likely range of variables, mostly these simulations, is based on an expert or historical data on the variables.

8.3 Risk Analysis

A 5,000 prediction test through the Risk ease program has been undertaken by utilising the risk variables previously found from the sensitivity study. The following table displays the risk report, which involves the potential set of risk variable values and their respective distributional probability.

8.4 Financial Risk Simulation

The outcome obtained previously in the financial analysis, and we concluded an FNPV of 5,781,903 Million ZAR. A probability study was made to analyse the changes in FNPV in probability using the risky variables and assumptions. Figure 8 shows the probability study graph, which indicates that 30% chance the FNPV would be negative and an expected value of -1,935,760 whereas 70% chance the FNPV will be positive with an expected value of 6,551,968.

8.5 Economic Sensitivity Analysis

The Economic Sensitivity Analysis will study the parameters that would affect the project's outcome on society's welfare, as in the financial sensitivity analysis. As discussed before, there is uncertainty in the project's inputs that would affect the feasibility study results. This test of the study will be discussed in the following section.

8.6 Economic Risk Simulation

The probability distribution of the economic outcomes is illustrated in Figure 9, and it presents that the ENPV has no percentage chance of becoming negative. The graph shows a probability range of 50% below would have a positive ENPV of about 16,761,296 which is considered the lowest ENPV that would occur and a 50% probability above with an expected value 23,530,610 ZAR.

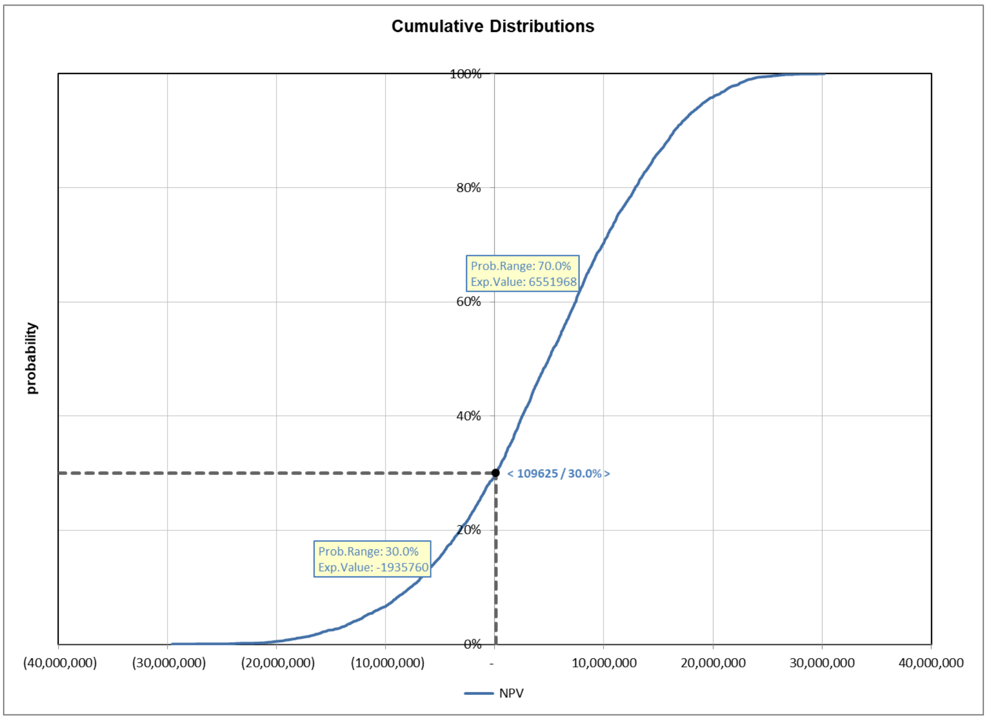


Figure 8: Financial Probability Graph.

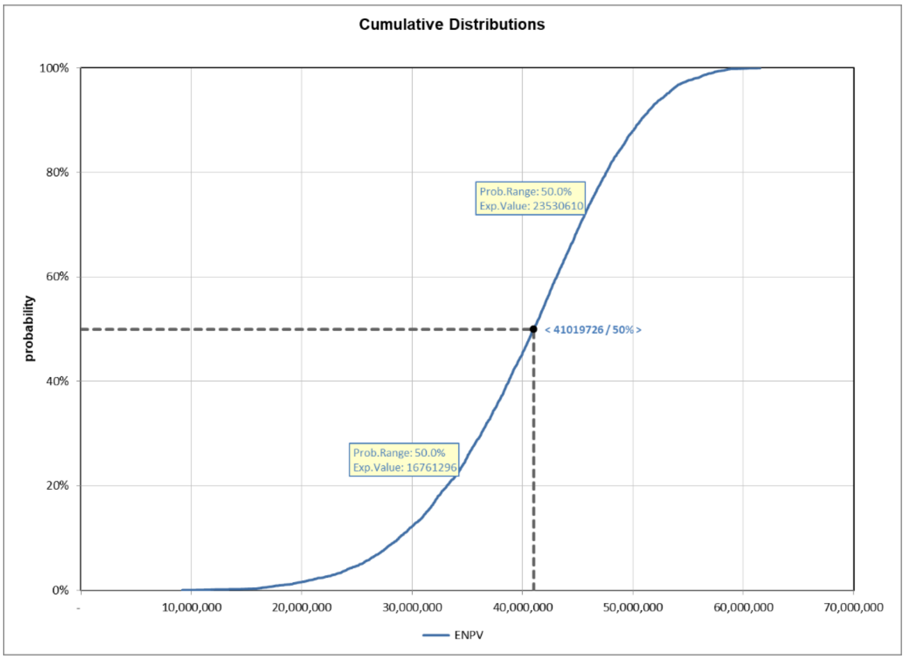
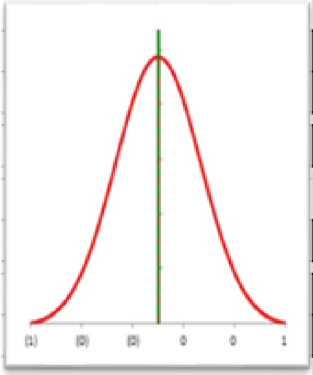


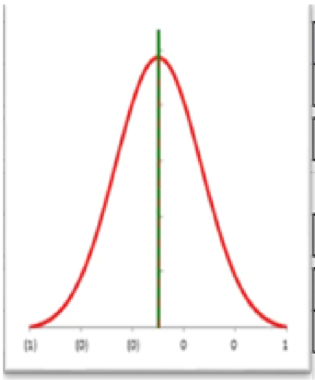
Figure 9: Economic Probability Graph.

Table 16: Risk Variables Report

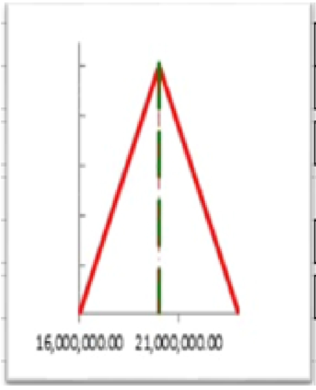
Risk Variables profile report



Risk Variable 1			Construction duration
Base Value			4
Probability distribution:			NORMAL
	MIN	MEAN	MAX
Range:	3	5	7
Standard deviation:			0.67
Degree of skewness:			LOG



Risk Variable 2			Inflation Rate
Base Value			6%
Probability distribution:			NORMAL
	MIN	MEAN	MAX
Range:	3%	6%	9%
Standard deviation:			0.01
Degree of skewness:			0%



Risk Variable 3		Base CAPEX
Base Value		20,000,000.00
Probability distribution:		TRIANGULAR
	MIN	MAX
Range:	16,000,000.00	24,000,000.00
Degree of skewness:		0%

8.7 Conclusion of Risk Analysis

The Risk analysis proved that the study's financial outcomes would have a probability of being negative of about 30%, which lower than the probability of having a positive value. However, the project's economic viability proved that the economic outcome would always have a positive value that indicates that the project positively impacts society. The reason is that the consumers are benefited from the proposed project more than being negatively impacted. The study outcomes have many probabilities to check the possible o achieve as follows a table with the summary of the outcomes' statistics. The probability of incurring loss rather than profit is quite less. The summary of the project's outcomes is shown in Table 17 below.

Table 17: Summary of the Project Outcomes Probability Statistics.

	FNPV	**FMIRR**	**ENPV**	**EMIRR**
Mean	4,616,185	14%	40,283,701	43%
Median	4,945,933	16%	41,021,324	41%
Std. Deviation	9,296,307	9%	8,453,849	11%
Minimum	(29,577,852)	-15%	9,171,256	19%
Maximum	30,207,041	32%	61,516,252	205%
Probability <0	29.6%	8.3%	`0.0%	0.0%

Chapter 9

CONCLUSION

Access to clean water is one of the main determinants of the quality of life lived by humans. Depending on the proximity to freshwater bodies, infrastructural development, technological advancement and availability of finances, different world regions differ inaccessibility to clean water. Therefore, it remains a responsibility of governing authorities and well-endowed private entities to ensure that areas with the human settlement can access clean water.

As stated in the introductory chapter, it is the mining company's responsibility to ensure that the mine residents have access to clean water and sanitation. The idea of conducting a CBA analysis to establish whether the company opt for water recycling instead of buying water is informed by the large volumes of wastewater discharged from the mine. With an estimated total cost of ZAR 23,000,000, the wastewater treatment plant proves to be a highly capital intensive project. Nevertheless, the sharing formula between the investor and mining company proves to be favourable since the investor is expected to fund it using a loan.

In order to appraise the suitability of the water recycling option, the Cost-Benefit Analysis approach was applied, including the integration of financial and economic analysis. The financial feasibility study explicates that the project will have profitable cash flows that will last its lifetime and repay the debt facility. The assumed and also collected data presented in the cash flow projection indicates that the nominal cash flow translates to a positive NPV of ZAR 5.781 million and a MIRR of 17% that can be embraced. This leads to the conclusion that the feasible from a financial perspective.

Further, the project's economic viability as per the resource flow presentation and analysis indicates that the wastewater treatment facility will positively impact society with an ENPV of ZAR 42.005 million. The stakeholder analysis conducted through distributional analysis established that the treated water consumers are the project's main gainers. Simultaneously, the government also recorded positive externalities as a result of the taxes emerging from the project's expenditure. The risk analysis for the economic outcomes proved that the proposed project would mostly have a 0% probability of harming society. In other words, the project's economic viability has 0% probability statistics of having a negative outcome. However, it is also evident that the project proves to be feasible, the management should be keen to mitigate the risks associated with lack of proper project management during construction and inadequate planning in implementation.

Overall, the extent of the economic outcome relies heavily on the successful implementation of the project resources. The people living around mine stand to benefit more from a water treatment plant than the alternative solution of purchased freshwater. This is mainly because the wastewater treatment plant assures them of constant water supply instead of purchased water whose fulltime availability cannot be guaranteed. The general environment shall also flourish since the high volumes of polluted water will no longer be discharged to the detriment of the surrounding flora and fauna.

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