# SUSTAINABILITY, TECHNOLOGY, INNOVATION, ECONOMY AND GOVERNANCE: MULTIDISCIPLINARY PERSPECTIVES ON CONTEMPORARY CHALLENGES

Editor

*Dr. Teena Singh*

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# Sustainability, Technology, Innovation, Economy and Governance: Multidisciplinary Perspectives on Contemporary Challenges


## Editor

**Dr. Teena Singh**

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# PREFACE

In the ever-evolving landscape of global challenges, interdisciplinary research has become essential to address the complex issues we face in urban planning, sustainability, technology, economics, and social governance. This book brings together a diverse collection of scholarly articles that explore these interconnected fields, with a particular focus on their implications for Indonesia. Drawing on rigorous research and practical case studies, the chapters within this volume provide valuable insights into the ways in which we can approach problems ranging from urban development and climate change to financial performance and green marketing.

The contributors to this book represent a cross-section of experts from various disciplines, each offering their unique perspective on contemporary issues. From the implementation of Transit Oriented Development (TOD) in urban spaces to the evaluation of financial strategies during the Covid-19 era, the chapters reflect both the local challenges and global trends shaping our world. The studies also delve into emerging fields such as the management of hazardous waste in onshore oil fields, the use of interpretive structural modeling in educational institutions, and the integration of green marketing strategies in corporate governance.

One of the key themes that runs through this book is the idea of sustainability—whether through environmental protection, economic resilience, or technological innovation. Many of the chapters explore how industries, governments, and organizations can adapt and thrive in a world marked by uncertainty and rapid change. The contributions are not only theoretical but also practical, offering strategies and methodologies that can be applied to real-world challenges.

We hope that this book will serve as both a reference and a source of inspiration for scholars, practitioners, and policymakers. It aims to foster greater collaboration and knowledge exchange across disciplines, as the solutions to our most pressing issues require a holistic approach. By combining the insights from urban planning, climate science, business analysis, and social studies, we believe this volume can contribute to the advancement of sustainable practices and innovative solutions in Indonesia and beyond.

We would like to express our sincere gratitude to all the authors, whose work forms the foundation of this book, and to the readers for their interest in this critical area of research. It is our hope that this collection of studies will spark new conversations and drive meaningful change in the fields explored.

**Dr. Teena Singh**
**Bursa – December 2024**

# CONTENTS

# CHAPTER 1

# Impelementation of Transit Oriented Development (TOD) Concept in Area Arrangement on Plaza Indonesia Area

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## ABSTRACT

The phenomenon of urban sprawl results in the emergence of a lifestyle of using private vehicles with the main preference in modes of transportation which will have an impact on increasing the problem of congestion, pollution and energy waste in the transportation sector in urban areas. However, urban areas as center of economic growth have problems with high economic costs due to poor spatial planning and transportation. One alternative solution to solve this problem is Transit Oriented Development (TOD). TOD's role is to put forward the concept of urban spatial planning by maximizing the use of mass transportation modes. This research was conducted with the aim of analysing the application of the TOD concept in the Plaza Indonesia area, as one of the pioneers of mixed-use buildings in the capital city of Jakarta which is the most populous city in Indonesia. The Plaza Indonesia area is a very strategic area and is the face of the city of Jakarta. The application of a good TOD concept at Plaza Indonesia really needs to be maximized so that it can become an inspiration for other areas in Jakarta. The TOD concept approach has 3 assessment categories namely Gold Standard, Silver Standard and Bronze Standard. In this study, researchers will analyze the application of the TOD concept that has been implemented, find the TOD standard category that has been achieved, then relate it to precedents that have been successful abroad, so as to present better solution directions for the Plaza Indonesia area.
**Keywords:** Plaza Indonesia Area; Transit Oriented Development (TOD); Urban Sprawl.

## 1. INTRODUCTION

Urbanization gave rise to large cities that were too densely populated, and a very high increase in activity resulted in the movement of people in them so that urban areas expanded even more. Expansion of urban areas with the development of suburban areas as alternative housing for the community or also known as Urban Sprawl. The phenomenon of urban sprawl is a bad phenomenon for cities, one of the causes of this phenomenon is the lifestyle of using private vehicles as the main mode of transportation, especially for people in suburban areas. (Ibraeva et al., 2020)

In urban development, the area around transit points is a potential development area because areas close to transportation routes provide ease of travel and activities that can result from transit activities in the area. As a result, the problem of private transport is constantly growing and the effects it creates are a problem that the state must solve. This problem is closely related to land use which plays an important role in determining the activities and activities of community movements. (Knowles et al., 2020) In fact, the increasing activity of the community, the utilization and diversity of land use are not accompanied by good accessibility, so that transportation problems arise. (Taki et al., 2017)

Several major cities in Europe and America have already implemented the TOD concept (Transit Oriented Development) as a reference in sustainable urban development. Several city governments in Asia such as China, Taiwan, Japan, and Korea have started implementing the TOD concept to solve problems in these countries. In our own country, namely Indonesia, the application of the TOD concept has also been supported by the issuance of PERMEN ATR/BPN RI No.16 of 2007 concerning Guidelines for the Development of Transit Oriented Areas, which indicates that we will apply the TOD Concept in spatial planning in Indonesia, besides that the government will also implement the BRT system(Bus Rapid Transit) which is the initial stage in the application of the TOD area concept.

With the concept of Transit Oriented Areas, it is hoped that cities in Indonesia can overcome transportation phenomena or existing problems to increase accessibility and mobility and reduce dependence on the use of private vehicles so that a city can achieve a sustainable transportation system and can develop even more. The application of TOD in our country will be examined by looking at the coverage of the Plaza Indonesia area, which is onepionir mixed use building in the capital city of Jakarta, as one of the most populous cities in Indonesia. The Plaza Indonesia area is a very strategic area and is an important face of the city of Jakarta. The application of the concept of a good Transit Oriented Area in the Plaza Indonesia area also really needs to be maximized so that it can become an inspiration for other areas.

## 2. METHODS

### 2.1. Definition of Transit Oriented Development (TOD)

Transit Oriented Development (TOD) is a restructuring of urban development by maximizing mixed and integrated land with a healthy lifestyle (walking and cycling) and focusing on mass-scale city transit facilities. TOD itself can be seen in the concept of integrated development of train stations and bus rapid transit as mass transportation facilities for commuters.

The TOD concept was introduced by Petrus Calthrope in the 1980s, who used a mixed spatial pattern to encourage people to live around transit facilities to reduce dependence on driving private vehicles by becoming commuters.

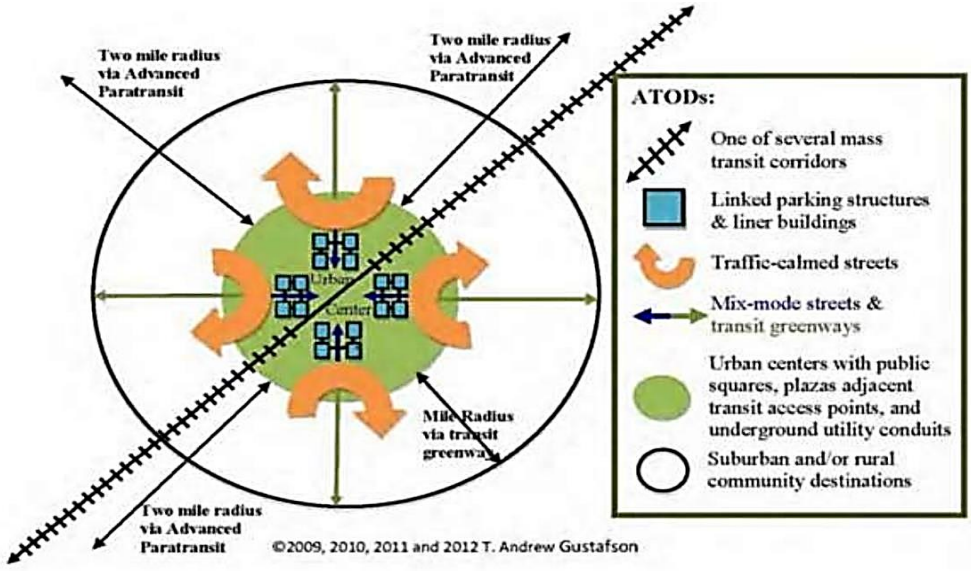


**Figure 1.** TOD policy concept

This concept as shown in Figure 1 is considered as a sustainable urban design concept for the community and improving the quality of life of the community increases, as well as lowering household transportation costs. (Taki et al., 2024)

### 2.2. Components and Characteristics of Development

Transit Oriented Development (TOD) Components in the development of the TOD concept are as follows:

1. There is a circulation network (road);
2. Bus Rapid Transit and its stops;
3. Pedestrian and cyclist facilities to save on the movement of motorized vehicles;
4. Public facilities such as parks, schools, libraries, and others;
5. Dedicated parking area.

### 2.3. Potential, Benefits, and Impacts of Transit Oriented Development (TOD)

With development concentrated on the development of residential and commercial areas in the area around mass transit stations, the TOD concept will reduce the use of private vehicles and encourage intensive use of public transportation. (Taki, Mahmoud, et al., 2018)

The TOD area should have three important aspects, namely density, diversity and design. Density discusses how the intensity of land use is high, then diversity discusses the diversity of land use and types of activity in the area and finally design relates to the design of areas that are friendly to pedestrians and cyclists. (Taki, Maatouk, & Lubis, 2018)

### 2.4. Principle and Keys to the Implementation of Transit Oriented Development (TOD) Targets

The principles and keys to implementing the TOD standard performance targets, reviewed from the TOD Standard 3.0., are as follows. (Taki & Maatouk, 2018)

1. Walk or walk

This principle bears walkability, which is the condition of a road that can be a place for the needs of pedestrians by providing facilities that guarantee safety and comfort for road users. It can be concluded regarding the elements and dimensions in walkability, as follows:

a. Pedestrian (as the main element), where walking activities are prioritized in walkability.
b. Travel time, which according to Jan Gehl, someone will feel tired after walking about 300-400 meters, and the most ideal walking distance is around 100 meters.

2. Cycle or cycling
   This principle prioritizes non-motorized transport networks as one of the basic principles of TOD, because cycling is the healthiest, affordable, and inclusive second mode of mobilization, which will also be able to combines convenience and door-to-door running routes as well as schedule flexibility with the same range and speed as local transportation services.
3. Connect or connect
   This principle emphasizes direct user relations so that it will make it easier for road users to access public transportation facilities and pedestrian paths, in a short time and directly. These connections also include a dense network of road links between small permeable blocks.
   The need for this connection principle is to connect busy pedestrian and cycling paths, to have short, varied, and direct connections, and to increase the availability of goods and public transportation by breaking up large blocks using new adaptive and publicly accessible (pedestrian) lanes. and cyclists).
4. Transit or public transportation
   The location of the placement of the development is close to a network of high quality mass public transport. Public transport services integrate pedestrians with the city beyond walking and cycling distances, to access opportunities and resources. This public transportation is defined as rail-based transportation or bus rapid transit (BRT). Highly efficient and balanced urban mobility and a solid and compact development model will mutually support and strengthen one another.
5. Mix or assimilation
   This principle encourages assimilation or assimilation between residential areas and other areas, such as offices, health facilities, educational facilities, entertainment, and fresh food resources in an area that can be reached by walking or cycling.
6. Density or condense
   This principle maximizes compaction in an area by adjusting the capacity of public transportation. This is due to the high growth in areas that are actually very limited in horizontal growth. Compaction also means using the land as much as possible.
   The aim of this principle is to combine residential and non-residential densities to support high-quality public transportation, local services, and active public space activities.
7. Compact or close up
   This principle focuses on development that has been built, not on the outskirts, so that many public transport routes can be realized. So that residents within the area and outside the area still get adequate public facilities, which of course is also a form of land conservation, and also a way to reduce traffic jams and the number of vehicles on the road, as well as reduce air and noise pollution. This principle guarantees time and energy savings and boosts the economy.

This principle, when applied on an environmental scale, will result in spatial integration with good walking and cycling connectivity, and a focus on public transport stations. On a city scale, a compact city includes and is spatially integrated by the public transportation system.

8. Shift or shift
   This principle aims to increase mobility with regulations regarding parking and road use. With this transitional change to using public transportation, it is hoped that road space and parking areas that are not needed can become productive areas, both socially and economically. So that the reduction of roads and the availability of parking lots will encourage people to switch to using public transportation modes, and in line with other principles. (Taki, Maatouk, Qurnfulah, et al., 2018)

## 3. RESULTS AND DISCUSSIONS

### 3.1. Regional Selection Analysis

The criteria for selecting the location of the TOD Concept Area Arrangement in the Plaza Indonesia Area (Figure 2) require an ideal location and a supportive environment for development. The location criteria include:

1. There is community support to develop and rearrange the environment, so that an organized area is formed.
2. A strategic location with the city center, commercial center and residential areas that underlie the development of this area
3. Availability of supporting transportation access to make it easier for residents to form an organized area.

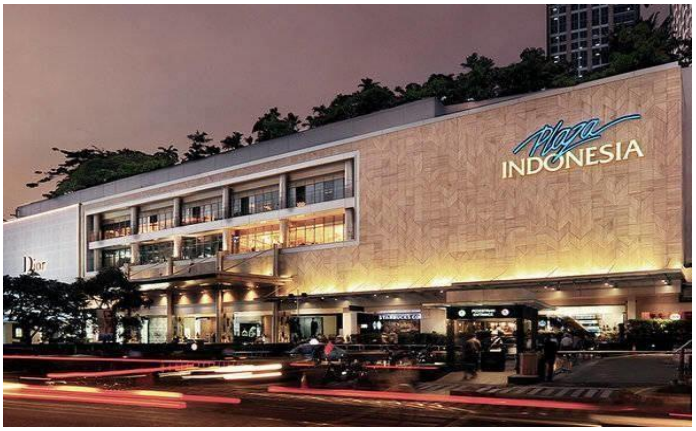


**Figure 2.** Plaza Indonesia Area

Plaza Indonesia itself is a mixed-use building development complex located at M.H. Thamrin, Central Jakarta, which includes hotels, commercial offices, and residential. This complex also has a mall with the same name which was founded in the mid-1990s and is located in a strategic position, namely on one side of the Jakarta landmark, the Selamat Datang Monument at the HI Roundabout. Designed by Hellmuth Obata and Kassabaum (HOK Inc.), this mall measures 42,325 m2 with 6 floors with the theme of a shopping center and a modern lifestyle concept with dining and entertainment facilities.

The Plaza Indonesia complex consists of three mixed-use development towers, namely The Plaza Office Tower, which is an office building, the Keraton at The Plaza and the Grand Hyatt Hotel. Keraton at The Plaza itself is a suite-class hotel and residential tower, with a height

of 225 meters and has 48 floors above the ground. The Plaza Office Tower itself is 200 meters above the ground with 42 floors above ground and 5 floors underground. While the Grand Hyatt Hotel has a height of 122 meters and 30 floors.

### 3.2. TOD Map of Plaza Indonesia Area

It can be seen in the map in Figure 3, that the Plaza Indonesia area is very strategic because it is traversed by public transportation such as the MRT, LRT and electric trains.

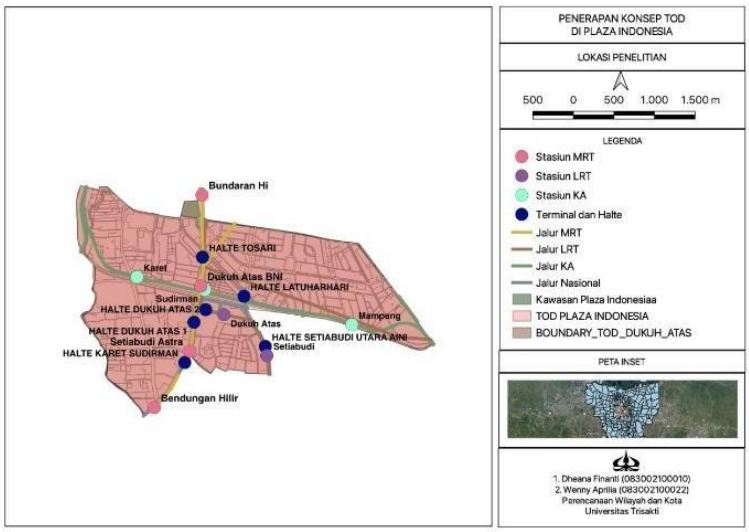


**Figure 3.** Plaza Indonesia TOD Map

With a radius of 400 meters, it can be seen that the Plaza Indonesia area is very strategic because it is close to various activity centers and transportation networks such as malls, hotels, embassies, several MRT, LRT and train stations, terminals/stops, and others. (Taki et al., 2023)

## 4. CONCLUSION

The Plaza Indonesia area is a very strategic area and is the face of the city of Jakarta. The application of a good TOD concept at Plaza Indonesia really needs to be maximized so that it can become an inspiration for other areas in Jakarta. This TOD concept approach has 3 (three) assessment categories namely Gold Standard, Silver Standard and Bronze Standard.

From the discussion conducted by researchers in reference journals, it was found that the Plaza Indonesia complex earned 59 points and received category standards bronze for the successful implementation of the TOD concept at Mall Plaza Indonesia. If some of the design solutions that have been described can be further applied, standard bronze this can be upgraded to standard silver or gold. Planning with adequate facilities and infrastructure with the concept of TOD (Transit Oriented Development) so that users can feel comfortable and easy to carry out various daily activities.

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# CHAPTER 2

# Tax Avoidance Determinants in Consumer Cyclical Companies Listed on The Indonesia Stock Exchange

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## ABSTRACT

In developing economies like Indonesia, tax avoidance is a significant concern for both policymakers and businesses. The Indonesian government has been focused on increasing tax revenue to fund development and infrastructure projects, making tax avoidance a critical issue. The Indonesia Stock Exchange (IDX), which includes a variety of sectors, has seen an increasing interest in how corporate tax behavior affects firm value and overall economic performance. In consumer cyclical industries—such as retail, automotive, and leisure—the volatility of demand and profit cycles may drive companies to explore more flexible financial strategies, including tax avoidance. The impact of variables such as transfer pricing, foreign ownership, capital intensity, firm size, and profitability on tax avoidance practices within these companies warrants examination to understand how firms navigate tax regulations while balancing profitability and compliance.

This study examines the effects of transfer pricing, foreign ownership, capital intensity, company size, and profitability on tax avoidance. The research focuses on consumer cyclical companies listed on the Indonesia Stock Exchange from 2019 to 2023. The results indicate that transfer pricing and capital intensity have a positive effect on tax avoidance. In contrast, company size, foreign ownership, and profitability have a negative effect on tax avoidance. The analysis is conducted using linear regression testing. This study provides the following implications: (1) for companies, non-aggressive tax avoidance practices can enhance firm value, and (2) for tax authorities, it offers insights into tax risks in Indonesia, which may be useful for drafting legislation.

**Keywords**: Tax Avoidance, Foreign Ownership, Transfer Pricing, Capital Intensity, Firm Size, Profitability.

## 1. INTRODUCTION

Taxes play a crucial role in Indonesia's economy. Tax revenue serves as one of the government's primary income sources, funding various development programs, infrastructure projects, public services, and other state functions. However, from 2009 to 2020, the actual tax revenue consistently fell short of its target. This trend began to change in 2021. According to Finance Minister Sri Mulyani Indrawati, state revenues in the 2022 National Budget amounted to IDR 2,626.4 trillion, or 115.9% of the target of IDR 2,266.2 trillion. Of this total, tax revenues reached IDR 1,717.8 trillion, surpassing the target at 115.6% (Ministry of Finance, 2023).

Taxes, as defined in Law Number 28 of 2007 concerning General Provisions on Taxation, Article 1 paragraph 1, are mandatory contributions owed to the state by individuals or entities, enforced by law, without direct compensation. These contributions are utilized to meet the state's needs and maximize public welfare. Based on this legal framework, taxes are clearly a vital source of state revenue.

Indonesia adopts a self-assessment system for tax collection, which places trust in taxpayers to calculate, pay, and report their tax obligations in accordance with the law. However, this system can provide opportunities for taxpayers to minimize taxable income, thereby reducing their tax burden. This behavior contradicts the government's objective of maximizing tax collection.

The divergence of interests between tax authorities and taxpayers—particularly companies—can, according to agency theory, lead to non-compliance or efforts by companies to engage in tax avoidance. Tax avoidance refers to legally reducing tax liabilities by leveraging exemptions, deductions, and deferments allowed under prevailing tax regulations. As Dewinta (2016) noted, tax avoidance is often carried out by companies through strategies such as deferring taxes or utilizing allowable provisions, which ultimately reduce the amount of tax paid and impact state revenues, especially from corporate taxes.

Companies, as significant contributors to tax revenues, play a vital role in bolstering state income. Larger companies are generally expected to contribute more to tax revenues due to their size. As such, company size is one of the variables in this study.

The motivation for this research arises from the increasing incidence of tax avoidance, particularly among companies with foreign affiliations or significant foreign ownership. This study aims to explore the impact of transfer pricing, company size, capital intensity, foreign ownership, and profitability on tax avoidance, focusing on companies within the consumer cyclical sector. This sector was chosen due to evidence suggesting that many companies within it engage in tax avoidance through transfer pricing schemes, often directed by foreign shareholders.

## 2. LITERATURE REVIEW

### Tax Avoidance

Tax avoidance is traditionally defined as the act of transferring wealth from the state to shareholders (Amelia et al., 2014). Hanlon and Heitzman (2010) broadly define tax avoidance as reducing the explicit tax burden, ranging from straightforward actions such as issuing debt instruments with interest deductions to more aggressive practices that may skirt compliance with tax regulations. Their approach aligns with Dyreng et al. (2008) but is broader, as it includes actions within a legal gray area as well as those verging on illegality.

Tax avoidance is a complex and unique issue. On one hand, it is legally permissible; on the other, it is often discouraged. Viewed positively, tax avoidance can be seen as a legitimate strategy for companies to minimize their tax liabilities.

### Transfer Pricing

Transfer pricing, as defined by the OECD (Organization for Economic Cooperation and Development), is the method of determining the prices for transactions conducted between members of a multinational company. In practice, transfer pricing often deviates from standard market prices to align with the internal needs of the company group. While transfer pricing is a normal business activity, it is frequently exploited to shift taxable income to tax havens (low-tax jurisdictions), thereby reducing the overall tax burden on the company group.

### Foreign Ownership

Foreign ownership refers to the proportion of shares owned by individuals, legal entities, or governments based abroad out of a company's total circulating shares (Yoantha, 2015). Foreign-owned companies are often more efficient in addressing internal needs and excel in areas such as training and accounting expertise (Hadi in Adiputri Singal & Wijana Asmara Putra, 2019). Additionally, foreign ownership can serve as a mechanism for enhancing management oversight. Foreign companies tend to prioritize good corporate governance practices, making them a suitable choice for improving transparency (Supradnya et al., 2016).

### Capital Intensity

Capital intensity refers to the amount of capital invested in fixed assets or inventory. It also reflects the ratio of debt to equity, indicating the types of capital a company utilizes, which typically include debt and equity (Ananda, 2020). Depreciation expenses associated with capital investments can lower a company's taxable income by reducing reported profits. Studies often measure capital intensity using the capital intensity ratio, calculated by dividing fixed assets by total assets. High investment in fixed assets leads to higher depreciation costs, which can significantly reduce taxable income.

### Company Size

Company size is a scale used to classify companies based on various criteria, such as total assets or market value (Prasetyorini, 2013). Larger companies tend to have greater access to funding sources, both internal and external, which can enhance their ability to manage risks. Compared to smaller firms, large companies face lower risks due to their stronger financial stability and

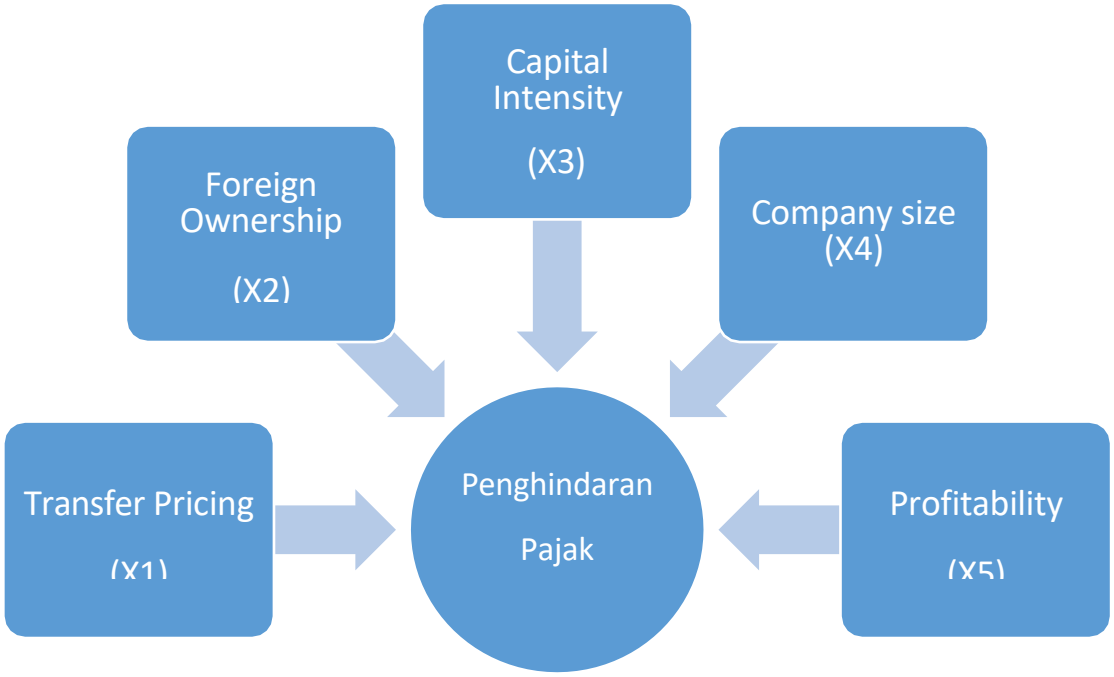
better access to external capital (Ernawati and Widyawati, 2015). Investors are generally more confident in larger companies, which positively impacts their market valuation.

Profitability

Profitability is a key measure of a company's performance. According to Anderson and Reeb (2003) in Prakosa (2014), firms with higher profitability and lower fiscal loss compensation tend to have higher effective tax rates. This highlights the relationship between profitability and a company's tax obligations.

Based on the theoretical framework, the hypotheses for this study are as follows:
H1: Transfer pricing influences tax avoidance.
H2: Foreign ownership affects tax avoidance.
H3: Capital intensity impacts tax avoidance.
H4: Company size influences tax avoidance.
H5: Profitability affects tax avoidance.

Conceptual Framework




## 3. RESEARCH METHOD

Research Type and Approach

This study employs a quantitative descriptive research method. As defined by Sugiyono (2015), quantitative methods involve researching specific populations or samples and analyzing data quantitatively. The research is causal in nature, aiming to examine the effect of independent variables (Xn) on a dependent variable (Yn). The variables include Transfer Pricing (X1), Foreign Ownership (X2), Capital Intensity (X3), Company Size (X4), Profitability (X5), and Tax Avoidance ($\hat{Y}$).

Population and Sample

According to Suryani and Hendryadi (2016), a population is a collection of events, objects, or elements with specific characteristics. In this study, the population consists of financial reports of companies in the consumer cyclicals sector listed on the IDX from 2019 to 2023.

A sample, as defined by Sugiyono (2018), is a subset of a population that possesses certain characteristics. The sample for this study includes financial reports of consumer cyclicals sector companies listed on the IDX that meet specific selection criteria.

Sampling Technique

The sampling technique used is purposive sampling, where samples are chosen based on predetermined criteria. As outlined by Sugiyono (2018), purposive sampling ensures that the samples meet certain considerations. The sample selection criteria for this study are: (1) companies in the consumer cyclicals sector that published annual financial reports consistently between 2019 and 2023; (2) companies that did not incur losses during the 2019–2023 period; (3) companies with complete data on transfer pricing, profitability, company size, capital intensity, and foreign ownership.

Data Collection Technique

Data collection was conducted using documentation methods, which involve reviewing relevant documents to obtain the necessary information (Arikunto, 2019). Based on the hypotheses and research design, the data collected will be analyzed using multivariate analysis techniques to test the effect of independent variables on the dependent variable.

## 4. RESULT AND DISCUSSION

The subjects of this study are companies listed on the Indonesia Stock Exchange within the consumer cyclicals sector during the period from 2019 to 2023. The research sample was selected using a non-probability sampling method with a purposive sampling technique. Based on the criteria applied, a total of 31 companies met the selection requirements, as shown in the following process:

**Table 1 Sample Selection Process**

| No | Information | Amount |
|---|---|---|
| 1 | Companies operating in the consumer cyclical sector from 2019-2023 | 149 |
| 2 | Companies not publishing consecutive financial reports from 2019-2023 | - 5 |
| 3 | Companies in the consumer cyclical sector with losses from 2019-2023 | - 23 |
| 4 | Companies in the consumer cyclical sector without foreign ownership | - 81 |
| 5 | Companies with incomplete financial data reports | - 6 |
| 6 | Outlier data | - 3 |
| Total sample companies | | 31 |
| Total observations for 2019-2023 | | 73 |

Source: Secondary data processed, 2024

The descriptive statistical analysis aims to provide a general overview of the data and trends. Descriptive statistics help summarize data, including the mean, standard deviation, maximum value, and minimum value. The variables used in this study include both dependent and independent variables. The tax avoidance variable (Y) serves as the dependent variable, while the independent variables are transfer pricing (X1), foreign ownership (X2), capital intensity (X3), company size (X4), and profitability (X5). The results of the descriptive statistical analysis for the variables from 2019 to 2023 are presented in Table 2.

**Table 2. Descriptive Statistics**

| | N | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|
| X1_TP | 73 | .0001 | .9365 | .297543 | .3270986 |
| X2_KA | 73 | .0010 | .9964 | .432946 | .3059730 |
| X3_IM | 73 | .0160 | .7472 | .331035 | .1863937 |
| X4_UP | 73 | 25.1348 | 31.7728 | 28.766234 | 1.5884841 |
| X5_PR | 73 | .0018 | .2318 | .071775 | .0616459 |
| Y_ AVOIDANCE TAX | 73 | .0010 | .5976 | .200989 | .1485421 |
| Valid N (listwise) | 73 | | | | |

Source: Output results (SPSS, 2024)

Table 2 shows that the variables influencing tax avoidance have an average value greater than the standard deviation, indicating that the data is heterogeneous or varied.

Based on the results of the classical assumption tests (Normality Test, Multicollinearity Test, Heteroscedasticity Test, and Autocorrelation Test), it is evident that the regression model demonstrates a significant and representative relationship.

**HYPOTHESIS TESTING**

The hypotheses in this study were tested using a multiple regression analysis model. The results of the hypothesis tests are as follows:

Coefficient of Determination Test Results

Table 3 presents the adjusted $R^2$ value of 0.105, meaning that 10% of the variation in tax avoidance can be explained by the variations in the five independent variables: transfer pricing, foreign ownership, capital intensity, company size, and profitability. The remaining 90% is attributed to other factors outside the model. The correlation coefficient ($R^2$) is 0.167, indicating a weak correlation between the independent variables and the dependent variable. Additionally, the Standard Error of Estimate (SEE) is very small at 0.1405267, suggesting that the regression model is highly accurate in predicting the dependent variable.

**Table 3.Coefficient of Determination**

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate | Durbin-Watson |
|---|---|---|---|---|---|
| 1 | .409[a] | .167 | .105 | .1405267 | 2.287 |

a. Predictors: (Constant), X5_PR, X1_TP, X3_IM, X4_UP, X2_KA

b. Dependent Variables: Y_ AVOIDANCE TAX

**Source** : Output results (SPSS, 2024)

The t-test is conducted to evaluate the extent to which each independent variable individually influences the variation of the dependent variable (Imam Ghozali, 2005:84). If the probability value is less than 0.05, the alternative hypothesis (Ha) is accepted, indicating that the independent variable significantly affects the dependent variable on an individual basis. The results of the t-test are presented in Table 4 below:

**Table 4. T-Test Results**

| Model | | Unstandardized Coefficients | | Standardized Coefficients | | |
|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | t | Sig. |
| 1 | (Constant) | .097 | .331 | | .294 | .769 |
| | X1_TP | - .129 | .053 | - .284 | -2.447 | .017 |
| | X2_KA | .098 | .069 | .201 | 1,409 | .163 |
| | X3_IM | - .250 | .118 | - .314 | -2.120 | .038 |
| | X4_UP | .007 | .012 | .079 | .621 | .536 |
| | X5_PR | - .419 | .296 | - .174 | -1.416 | .161 |

a. Dependent Variables: Y_ TAX AVOIDANCE

Source: Ouput results (SPSS, 2024)

Hypothesis Testing Results

Hypothesis 1: Transfer Pricing Influences Tax Avoidance

Transfer pricing has a significant influence on tax avoidance, with a significance level of 0.017 (below 0.05) and a t-value of 2.447 (greater than 1.996). Therefore, Ha is accepted.

Hypothesis 2: Foreign Ownership Does Not Influence Tax Avoidance

Foreign ownership does not significantly affect tax avoidance, as indicated by a significance level of 0.163 (above 0.05) and a t-value of 1.409 (less than 1.996). Hence, Ha is rejected.

Hypothesis 3: Capital Intensity Influences Tax Avoidance

Capital intensity shows a significant influence on tax avoidance, with a significance level of 0.038 (below 0.05) and a t-value of 2.120 (greater than 1.996). Thus, Ha is accepted.

Hypothesis 4: Company Size Does Not Influence Tax Avoidance

Company size does not exhibit a significant influence on tax avoidance, with a significance level of 0.536 (above 0.05) and a t-value of 0.621 (less than 1.996). Therefore, Ha is rejected.

Hypothesis 5: Profitability Does Not Influence Tax Avoidance

Profitability has no significant effect on tax avoidance, as shown by a significance level of 0.161 (above 0.05) and a t-value of 1.416 (less than 1.996). Consequently, Ha is rejected.

F-Test Results

The F-test evaluates whether all independent variables in the model collectively influence the dependent variable. The F-test results are presented in Table 5.

**Table 5. Test F results**

| Model | | Sum of Squares | Df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| 1 | Regression | .266 | 5 | .053 | 2,690 | .028 [b] |
| | Residual | 1,323 | 67 | .020 | | |
| | Total | 1,589 | 72 | | | |

a. Dependent Variables: Y_ AVOIDANCE TAX

b. Predictors: (Constant), X5_PR, X1_TP, X3_IM, X4_UP, X2_KA

Source: Output results (SPSS, 2024)

ANOVA and F-Test Results

Based on the results of the ANOVA and F-tests, the calculated F-value was 2.690, with a probability value of 0.028. Since the probability value is below 0.05, it can be concluded that transfer pricing, foreign ownership, capital intensity, company size, and profitability collectively have a significant influence on tax avoidance.

Discussion

Impact of Transfer Pricing on Tax Avoidance

The first hypothesis examined whether transfer pricing positively impacts tax avoidance. The results indicate a significant influence, with a significance level of 0.017, suggesting that transactions between affiliated companies are linked to tax avoidance practices. This finding contrasts with the study by Hashim and Inayati (2022), which found no relationship between transfer pricing and tax avoidance.

Impact of Foreign Ownership on Tax Avoidance

The second hypothesis tested whether foreign ownership positively affects tax avoidance. The findings reveal that foreign ownership does not significantly influence tax avoidance, with a significance level of 0.163. This result differs from the studies by Alkurdi and Mardini (2020) and Kusbandiyah and Norwani (2018), which found a positive relationship. Companies with foreign ownership may prioritize maintaining a strong corporate image by avoiding tax avoidance and adhering to applicable tax regulations (Suranta et al., 2020).

Impact of Capital Intensity on Tax Avoidance

The third hypothesis investigated whether capital intensity positively impacts tax avoidance. The results show a significant influence, aligning with previous research by Hasyim and Inayati (2022), which also identified a positive relationship. However, this finding contradicts Marta

and Novriyanti (2023), who concluded that capital intensity does not affect tax avoidance.

Impact of Company Size on Tax Avoidance

The fourth hypothesis assessed whether company size positively impacts tax avoidance. The results suggest that company size does not significantly influence tax avoidance. This finding differs from Marta and Novriyanti (2023), who reported a positive relationship. Larger companies may engage in higher tax avoidance activities but still comply with tax regulations to minimize payments.

Impact of Profitability on Tax Avoidance

The fifth hypothesis tested whether profitability affects tax avoidance. The findings indicate no significant relationship between profitability and tax avoidance. This result contrasts with the research of Dewi and Naniek (2017), which reported a positive relationship, where higher profitability led to increased tax avoidance practices. Companies with effective asset management may benefit from tax incentives and breaks, creating the appearance of tax avoidance without engaging in explicit tax evasion (Darmawan, 2014).

## 5. CONCLUSION AND RECOMMENDATIONS

This study aimed to analyze the factors influencing tax avoidance in companies. The independent variables examined include transfer pricing, foreign ownership, capital intensity, company size, and profitability. The research focused on companies listed on the Indonesia Stock Exchange within the consumer cyclicals sector, using a sample of 73 observations over five years (2019–2023).

Based on the results of the data analysis and hypothesis testing, the following conclusions were drawn:

Transfer pricing significantly influences tax avoidance with a significance level of 0.769. This finding differs from the results of Putri & Mulyani (2020). Foreign ownership does not significantly affect tax avoidance, with a significance level of 0.017. This result aligns with the findings of Kusbandiyah & Norwani (2018). Capital intensity has a significant positive effect on tax avoidance, with a significance level of 0.038. These findings are consistent with the research of Marta and Novriyanti (2023). Company size does not significantly influence tax avoidance, with a significance level of 0.536. This result contrasts with the findings of Marta and Novriyanti (2023). Profitability shows no significant effect on tax avoidance, with a significance level of 0.161. This finding differs from the study by Dewi and Naniek (2017).

Recommendations for Future Research

Future studies on similar topics are encouraged to expand the sample size or explore other industry sectors to better capture the dynamics of tax avoidance across diverse sectors. Researchers are advised to include additional variables that may impact tax avoidance, employing alternative proxies to enhance the analysis. Extending the observation period is recommended to account for broader economic conditions, such as the sales challenges faced

by many companies during the 2019–2021 period, which may have influenced variables like transfer pricing and profitability.

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# CHAPTER 3

# The Impacts of Climate Change on the Hydrological Cycle at Semarang

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## ABSTRACT

Climate change affects the hydrological cycle in the form of changes in the intensity and frequency of extreme rainfall. The causes of the increase in extreme rainfall consist of several environmental indicators. The purpose of this study was to determine the conditions of rainfall due to climate change based on land cover conditions. The analytical method in this study is related to hydrology characteristic. The results obtained was based on the analysis of climate characteristics in the Semarang area for 30 years (1990-2023). There is a shift in the rainy and dry months for 1 month, a change in rainfall intensity of ±13%. There is an increase in rainfall during the rainy season, ranging from 12% to 13.3%, and a decrease in rainfall during the dry season of 7% to 9%. This illustrates that in the 2050s, there will be a change in rainfall distribution, where the rainy season will be wetter and the dry season will be drier and last longer as an impact of climate change. Jragung Watershed 73% of the rainwater that falls each year evaporates into the air (evapotranspiration), 6.31% flows on the surface (surface run-off), and 8.01% seeps into groundwater reserves (infiltration).
**Keywords:** Land Cover, Hydrology Cycle, Water Security, Climate Change.

## 1. Introduction

The scientific community around the world has given climatic variability and climate change a great deal of attention. The reason for the global concern about climate change is its impact on every region and all living things. The potential disruptions to the environment, including the delicate balance between biotic and abiotic elements in any ecosystem, highlight the global nature of this issue.

Glaciers are receding (Dyurgerov & Meier 2000), ice is melting more quickly (Gregory et al. 2004; Overpeck et al. 2006; Stroeve et al. 2007), sea levels are increasing (Ramachandran et al. 2017), natural disasters like floods, storms, and cyclones are occurring, and surface temperatures are rising (Kurniyaningrum et al. 2024). Rainfall patterns are changing (Kurniyaningrum et al., 2022). Climate change has an impact on nearly every ecosystem on the planet. Among the world's most fragile ecosystems are rivers. Furthermore, rivers are considered the ecosystems most vulnerable to climate change's direct and indirect effects due to a confluence of other stresses (Durance & Ormerod 2007, 2009). The hydrology and dynamics of rivers will be impacted by impacts on river ecosystems, which also present severe risks to the survival and existence of various aquatic plant and animal species, animals, human populations, etc. Besides sustaining life and offering several ecosystem services, rivers control flooding, sedimentation, erosion, water quality, pollution release, and other factors.

Water resources management (Kundzewicz et al. 2008), water quality (Whitehead et al. 2009), hydro morphological changes (Boon & Raven 2012), changes in catchment land use (Oliver & Morecroft 2014; Kadri et al. 2021), and surface temperature (Putra et al. 2024) are just a few of the many effects of climate change on rivers that have an impact on the dynamics of the entire river. There has also been research on how river systems are affected by climate change (Verghese & Iyer 1993; Gosain et al. 2006, 2011; Boon & Raven 2012; Hosterman et al. 2012). Rivers are essential to Indonesia and are sometimes called the nation's lifeblood. More than 70% of people in rural areas depend on agriculture for their livelihood, and rivers are the primary source of irrigation for this industry. Rivers are also the primary source of electricity, drinking water, transportation, aquaculture, leisure activities, etc. The state of the hydrological cycle is impacted by the growing human activity in the river basin. Therefore, this essay has looked into how climate change affects various aspects of the dynamics of the Jragung River.

## 2. Literature Review

### Hydrological Cycle

The hydrological or water cycle is a continuous water cycle from the atmosphere to the earth and back to the atmosphere. Water circulation occurs through several processes: Evaporation, condensation, precipitation, infiltration, runoff, sublimation, interception, advection, and reservoir storage. The hydrological cycle begins with evaporation, where Water from the sea, lakes, rivers, and soil evaporates into the atmosphere due to sunlight, including evaporation from plants through transpiration. Water vapor then condenses as it cools in the atmosphere, forming clouds of water droplets or ice crystals. When the water droplets in the clouds enlarge, precipitation occurs, where Water falls back to earth as rain, snow, or hail. Some water seeps into the ground through infiltration, while others flow deeper into groundwater through

percolation. Water that is not absorbed flows on the surface as runoff towards rivers and seas. Ice or snow water can turn directly into vapor in cold conditions through sublimation. Rainwater can also be temporarily retained in vegetation during interception before evaporating or falling to the ground. In the atmosphere, water vapor can move horizontally through advection. Before returning to the cycle, Water is stored in various natural reservoirs such as oceans, lakes, rivers, soil, ice, and groundwater.

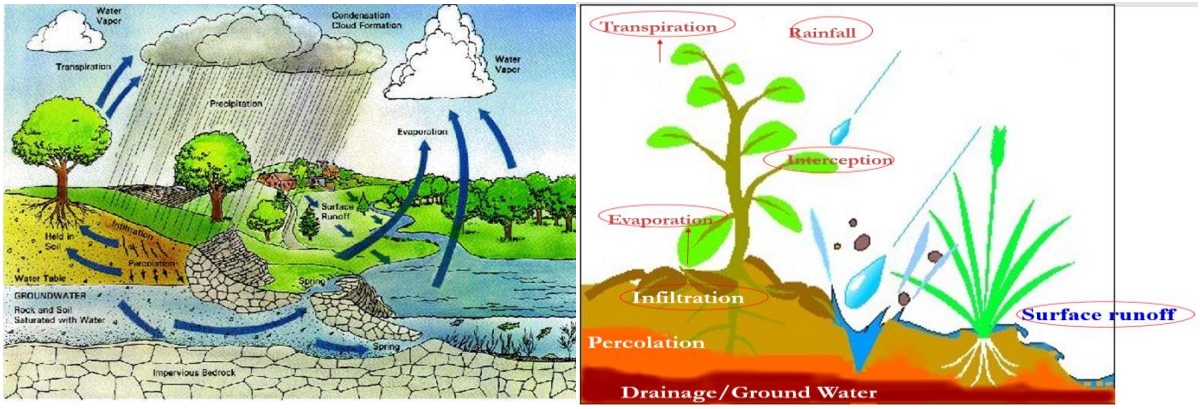


Figure 1. Hydrological Cycle

## Global Climate Change

According to the United Nations, Climate change refers to changes in long-term weather and temperature patterns. When climate change occurs, atmospheric conditions experience increased temperatures, increased greenhouse gases, changes in weather patterns, and more frequent extreme weather phenomena. All of these changes interact with each other, exacerbating the impacts of global warming. Based on BMKG analysis and observations from 116 stations, the average air temperature in September 2023 was 27.0°C, which is 0.4°C higher than the climatological temperature in 1991-2020. This increase shows the difference between the observed and normal temperatures, which is hotter than the long-term average (positive anomaly). Therefore, September 2023 is included in the hottest period. This anomaly is the 4th highest in air temperature observations since 1981.

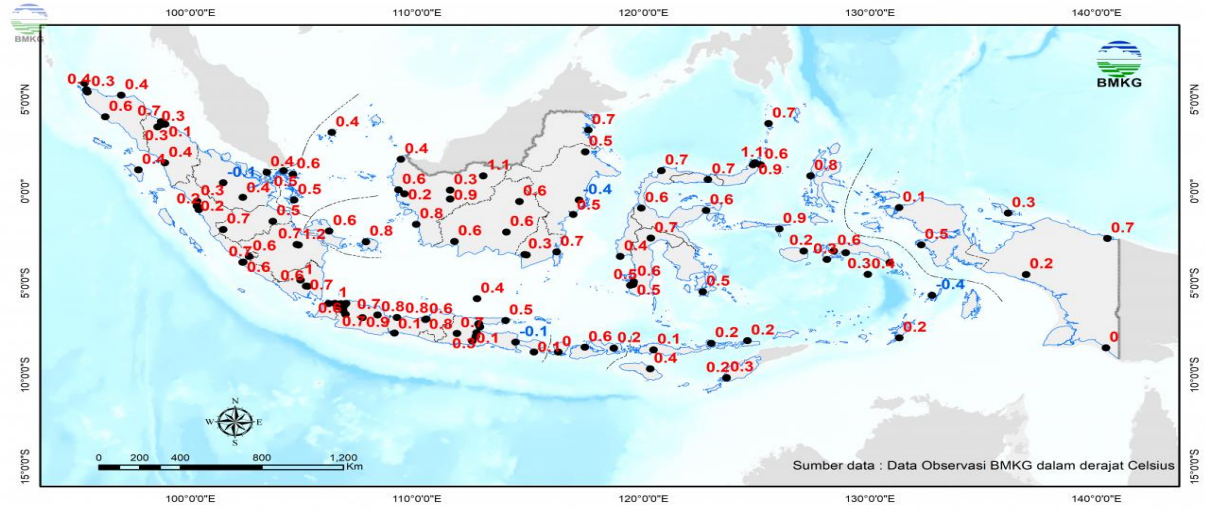


Figure 2. Annual average temperature anomaly 2023 compared to the period 1991-2020 (BMKG, 2023)

Positive air temperature anomalies can have adverse impacts on water resources, including increased evaporation, drought, decreased water quality, changes in rainfall patterns, ecosystem

disruption, and challenges in water management for agriculture. Adaptation in water resource management is essential to mitigate these impacts.

## 3. Material and Method

Based on various climatological correlations and radiation assumptions, this study presents a climate prediction for the future. Models of mathematical representations of interactions between the atmosphere, land surface, oceans, and sea ice are produced using global climate models (GCMs) and regional climate models (RCMs). The state of the research area is impacted by climate change. Below is a description of the methodology.

### 3.1. Study Area

Geographical Location of Jragung Watershed is located in the northern part of Central Java which crosses 4 (four) districts, namely from Demak Regency (65,145.98 ha), Semarang (25,932.55 ha), Grobogan (25,654.64 ha) and Semarang City (1,304.48 ha) with an area of 118,036.64 ha and has a watershed circumference of 135.22 km and a main river length of 72.44 km. The coordinate position of Jragung Watershed is between 1100 21 '57" - 1100 39' 58 " East Longitude and between 60 50' 55 " - 70 13 '59 " South Latitude.


Figure 3. Jragung Watershed

Figure 4. Jragung river condition

### 3.2. Climate Scenario

Rainfall condition prediction is modeled by Coupled Model Intercomparison Project 5 (CMIP). This study uses CMIP 5 models from GFDL and IPSL to project the next 50 years. The model requires fairly long baseline data, namely 30-year baseline data obtained from BMKG data combined with National Oceanic Atmospheric Administration (NOAA) data for the period 1990–2020.

In analyzing annual data, this study uses Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS) from the Climate Hazards Group from 2010 to 2020 as comparative data. In analyzing the effects of climate change on rainfall data, two scenarios were used, namely the Representative Concentration Pathway (RCP) Scenario 4.5 and 8.5 obtained from the Chelsa-Climate website in the form of raster maps. The RCP 4.5 scenario is a scenario that stabilizes radiative forcing at 4.5 Watts per square meter by 2100 without ever exceeding that value, while RCP 8.5 is a scenario that describes a possible future with high risks due to climate change. This scenario is generally used as a basis for worst-case climate change scenarios.

The climate change model describes a watershed's climatological conditions and how they will impact water availability.

## 4. Result and Discussion

### 4.1. Annual rainfall conditions

Rainfall and climate data used are sourced from BBWS Pemali Juana. Around the watershed area are 5 (five) rainfall-observing stations: Ngobo Station, Jatirunggo Station, Bawen Station, Ambarawa Station, and Jragung Station. These rainfall stations have observational data for 1o years (2010-2020). The rainfall data figure 3., shows that the average monthly rainfall reaches the highest value in January at 288 mm and the lowest in August at 22 mm. The highest monthly rainfall in November is 518 mm, and the lowest in August is 116 mm. The lowest monthly rain starts in June and continues until September, with 1 mm of monthly rainfall (Figure 3).

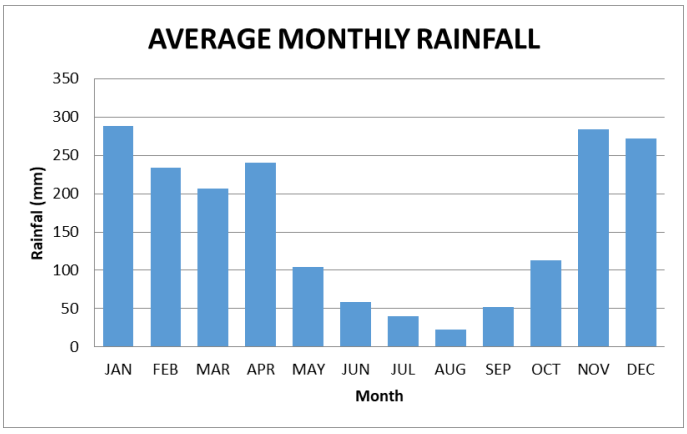


Figure 3. Average monthly rainfall

### 4.2. Climate change impact

Climate Change to Temperature used data by Badan Meteorologi, Klimatologi, Geofisika (BMKG) and Global Historical Climatological Nerwork (GHCN). Used historical data collection from 1990-2020. The projection of rainfall changes is based on climate change data that occurred in the last 10 years, 2010-2020, using the GCM (General Circulation Model) model with the RCP scenario. The projection of rainfall changes is based on climate change data that occurred in the last 10 years, 2010-2020, using the GCM (General Circulation Model) model with the RCP (Representative Concentration Pathway) scenario with a downscaling process. The projection of changes is divided into three stages (representative concentration pathway) with a downscaling process. The projection of changes is divided into three stages, namely short-term (stage 1), medium-term (stage 2), and long-term (stage 3).

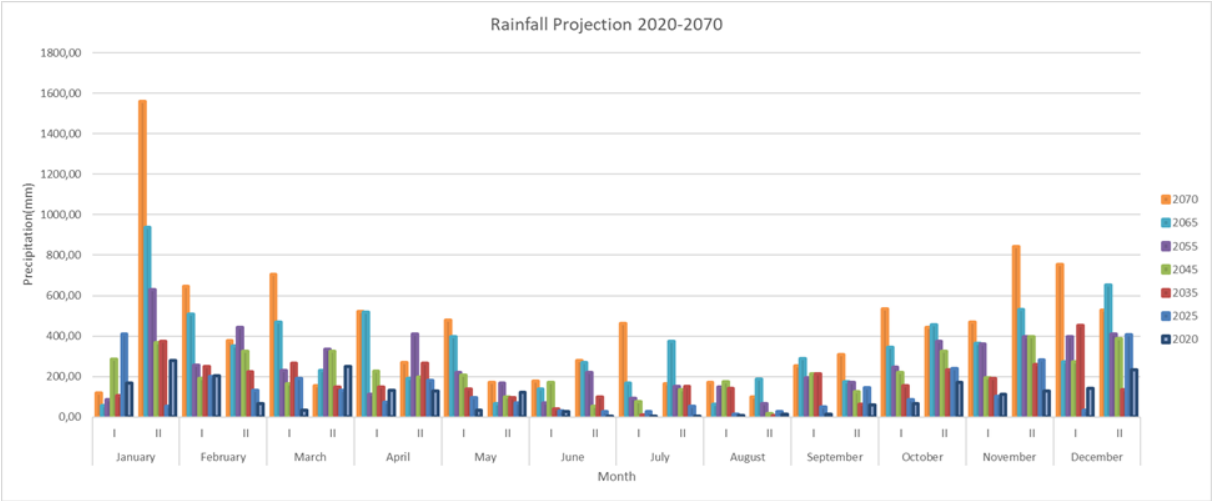


Figure 4 . Rainfall Projection 2020-2070 at Jragung Watershed

Table 1. Precent change of temperature

| Years | 1990-2000 | 2001-2020 | Percentage |
|---|---|---|---|
| Average Temperature ($^0$C) | 27.5 | 27.8 | 1.08 % |

The results of the analysis of temperature trends from 1990 to 2020 show a temperature increase of 1.08% (Table 1). The temperature change is then predicted for the next 40 years in predicting the rainfall patterns that are likely to occur (Table 2).

Table 2. Precent change projection of temperature

| Years | 2021-2040 | 2041-2060 | 2061-2080 |
|---|---|---|---|
| Average Temperature ($^0$C) | 1.08% | 2.16% | 3.21% |

Table 3. Precent Change of Rainfall Data

| | Jan | Feb | Mar | April | May | June | July | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Ave. RR** | 246.6 | 138.5 | 106.0 | 99.0 | 107.6 | 69.4 | 157.5 | 76.0 | 74.0 | 76.0 | 91.2 | 188.6 |
| **Total RR** | 119.2 | 119.2 | 119.2 | 119.2 | 119.2 | 119.2 | 119.2 | 119.2 | 119.2 | 119.2 | 119.2 | 119.2 |
| **Condition** | WET | WET | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | WET |
| **% Change** | 51.7 | 13.9 | -12.5 | -20.4 | -10.8 | -71.8 | 24.3 | -56.8 | -61.1 | -56.8 | -30.7 | 36.8 |
| **SOI (2023)** | 11.8 | 10.5 | −2.0 | 0.3 | −18.5 | 0,2 | −4.3 | −12.7 | −13.6 | −6.8 | −8.6 | −2.4 |

The analysis of rainfall change trends in Semarang from 1990 to 2020 shows that the rainfall patterns that occur experience positive and negative trends. A positive trend indicates an increase in rainfall, while a negative trend indicates a decrease in rainfall. This shows that in the period 1990 to 2020, the rainfall data used as a baseline, which was then compared with the rainfall data in 2023, tended to decrease in intensity and degree of wetness, meaning that Semarang experienced drought conditions caused by heat waves from the effects of increasing surface temperatures. Climate change in Indonesia globally affects local conditions, causing changes in the frequency, area, duration, and time of extreme weather and climate events.

In the study area, there was an anomaly in rainfall. Namely, the impact of the global climate on the study area was seen in April and June. The global conditions experienced increasing rainfall intensity, but in the study area, there was a significant decrease in rainfall intensity; in December, there was an increase in rainfall globally, but the conditions of the study area experienced a reduction in rainfall intensity.

In developing water resources, mitigation is carried out in stages by considering the impact of climate change. Based on the results of this study, the mitigation of water resource conditions is divided into three phases: the short term for 2035, the medium term for 2050, and the long term for 2070. Rainfall predictions for the short term 2035 include shifts in seasonal patterns: rainy season in November, December, January, February, March, and April; dry season in May, June, July, August, September, and October. The maximum rainfall intensity is in December, while the minimum is in July. Increase the average temperature from 0.5°C to 1°C.

The medium-term 2050 includes a rainy season in December, January, February, March, April, and May and a dry season in June, July, August, September, October, and November. The maximum rainfall intensity is in January, while the minimum is in June. The average temperature will increase from 0.8°C to 1.2°C.

The long term 2070 includes rainy seasons in December, January, February, March, April, May, and June and dry seasons in July, August, September, October, and November. The maximum rainfall intensity is in January, while the minimum is in August. The average temperature will increase from 10°C to 1.50°C.

## 5. Conclusion and Recommendation

There is a shift in the rainy and dry months for 1 month, a change in rainfall intensity of ±13%. There is an increase in rainfall during the rainy season, ranging from 12% to 13.3%, and a decrease in rainfall during the dry season of 7% to 9%. This illustrates that in the 2050s, there will be a change in rainfall distribution, where the rainy season will be wetter and the dry season will be drier and last longer as an impact of climate change. Jragung Watershed 73% of the rainwater that falls each year evaporates into the air (evapotranspiration), 6.31% flows on the surface (surface run-off), and 8.01% seeps into groundwater reserves (infiltration).

**Recommendation:** Establish a map of disaster-prone water-related areas as a reference in preparing regional spatial planning and control of spatial utilization.

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# CHAPTER 4

# Sludge Management Technology at Onshore Field X to Mitigate Hazardous and Toxic Waste

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## ABSTRACT

In East Kalimantan, Indonesia, Onshore Field X serves as a terminal for the receiving, processing, and ship-ment of crude oil from several offshore and onshore fields. In addition to the primary products of crude oil and natural gas, hazardous and toxic waste are also produced. Sludge is one of the by-products that necessitates management to ensure that it complies with the regulations of the Ministry of Environment and Forestry of the Republic of Indonesia before it is disposed of. Sludge management encounters numerous obstacles, including the escalating volume of sludge generated from offshore and onshore fields processed by Onshore X field, the restricted capacity of sludge storage ponds, and the rising management expenses annually. The appropriate sludge management technology is needed to address the challenges that arise. This paper explains the changes in sludge management at the Onshore X field from the gravity thickening method in the storage pond, followed by disposal steps by the contractor, by adding stabilization, conditioning, and dewatering methods. The modi-fication of the sludge management system at Onshore X field resulted in additional oil recovery that was still trapped in the sludge due to the previous ineffective process, reducing the volume-mass in the disposal step, and with better sludge management technology, production costs can be lowered.
**Keywords:** Conditioning, Dewatering, Sludge management technology, Stabilization

## 1. INTRODUCTION

In order to ensure that the oil and gas industry adheres to the regulations of the country in which it operates, the refuse products from the production process, which are hazardous waste and toxic waste, must be appropriately managed. According to Table 1, the Mining, Energy, and Oil and Gas (PEM) sub-sector managed 27 million tons of hazardous and toxic waste in 2021, as indicated by the statistical data released by the Indonesian Ministry of Environment and Forestry.

**Table 1.** Statistics data of the Directorate General of PSLB3, hazardous waste management (Ditjen PSLB3, 2022)

| Data Statistik DITJEN PSLB3 \| SIS - KLHK | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| No. | Sub Sektor | JUMLAH LIMBAH B3 YANG DIKELOLA | | | | | | | |
| | | 2015 | | 2017 | | 2019 | | 2021 | |
| | | Unit | Ton | Unit | Ton | Unit | Ton | Unit | Ton |
| 1 | Pertambangan,Energi, dan Migas (PEM) | 34 | 90.417.311,57 | 53 | 55.060.917,97 | 70 | 39.722.274,00 | 57 | 27.363.135,22 |
| 2 | Prasarana dan Jasa | 108 | 31.365.793,62 | 64 | 1.213.303,50 | 120 | 1.391.572,00 | 74 | 365.997,55 |
| 3 | Manufaktur | 91 | 1.827.535,30 | 75 | 392.722,52 | 150 | 1.011.519,00 | 55 | 2.867.570,69 |
| 4 | Agro Industri | 36 | 2.165.722,84 | 70 | 3.638.803,42 | 110 | 2.758.369,00 | 59 | 10.502.671,49 |

The total amount of hazardous waste (B3) in the oil and gas sector from 10 cooperation contract contractors (KKKS) reaches 70,197.35 tons, with a management cost of US$ 12,174,528.50. Of the total hazardous waste amounting to 70,197.35 tons, it consists of 30,987.51 tons of oil-contaminated soil, 6,081.22 tons of operational waste, and 33,128.62 tons of production waste. Meanwhile, the management cost reaching US$ 12,174,528.50 consists of US$ 4,232,551.38 for oil-contaminated soil, US$ 2,785,627.57 for operational waste, and US$ 5,156,349.55 for production waste (Kementerian ESDM, 2019).

In the onshore field X, hazardous and toxic waste from the oil and gas processing are stored in a slurry pit containment pond with an average fluid input of 200 BOPD, and sludge entering the slurry pit is estimated at 115 tons/month. 2022 data shows an average sediment extraction of 100 tons/month, and in 2023, the target for third-party sediment extraction was increased to 175 tons/month. However, the actual extraction in January 2023 only reached 123 tons/month, with an estimated budget of US$50,000/month for managing 150 m3/month of hazardous waste (Soetikno, Anton. 2023).

The persistent rise in sludge waste and management expenses suggests that modifications or enhancements to sludge management techniques would be advantageous. Table 2 on Economic Value for Sludge Handling indicates that effective sludge management yields a favorable economic effect by lowering hazardous waste disposal expenses and minimizing direct waste disposal, hence contributing to environmental sustainability.

This measure can be implemented by people or organizations to mitigate the adverse effects of human activities on the environment using the 3R (Reduce, Reuse, Recycle) approach.

**Table 2.** Economic value for sludge handling estimation (Soetikno, A., 2023)

| Third Party Handling | Sludge Management |
|---|---|
| Total Handling Cost with a volume of 2,490 Tons ≈ 13,053 barrels is Rp. 8,093,978,750 (US$ 540,000). | Total Sludge Management with a volume of 2,490 Tons ≈ 13,053 barrels is Rp. 6,245,860,500 (US$ 417,000). |
| There is no additional oil recovery potential that can be obtained | There is potential oil recovery that can be obtained from selecting this option, assuming 20% oil content from the volume treated, with the following estimated details:<br>20% x 13,053 barrels = 2,611 barrels (US$ 200,000) |
| There are additional costs from the operation of Heavy Equipment (Fuel & Operator) to support this activity. | There are no additional fees for activities (All In). |

The sludge management system currently implemented at the onshore X field consists of only two steps: thickening, which is carried out in the in situ slurry pit or within the company's area, and disposal, which is handled by a third party and managed outside the company's area. As seen in Figure 1, the current sludge management steps and Figure 2, the simplified process plant diagram for sludge management.

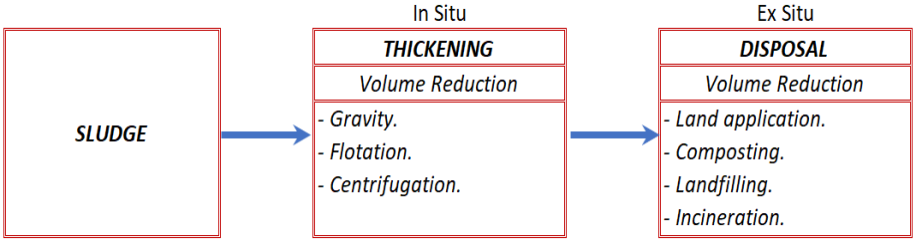



**Figure 1.** Initial sludge management method (Wiratomo, M., 2024)

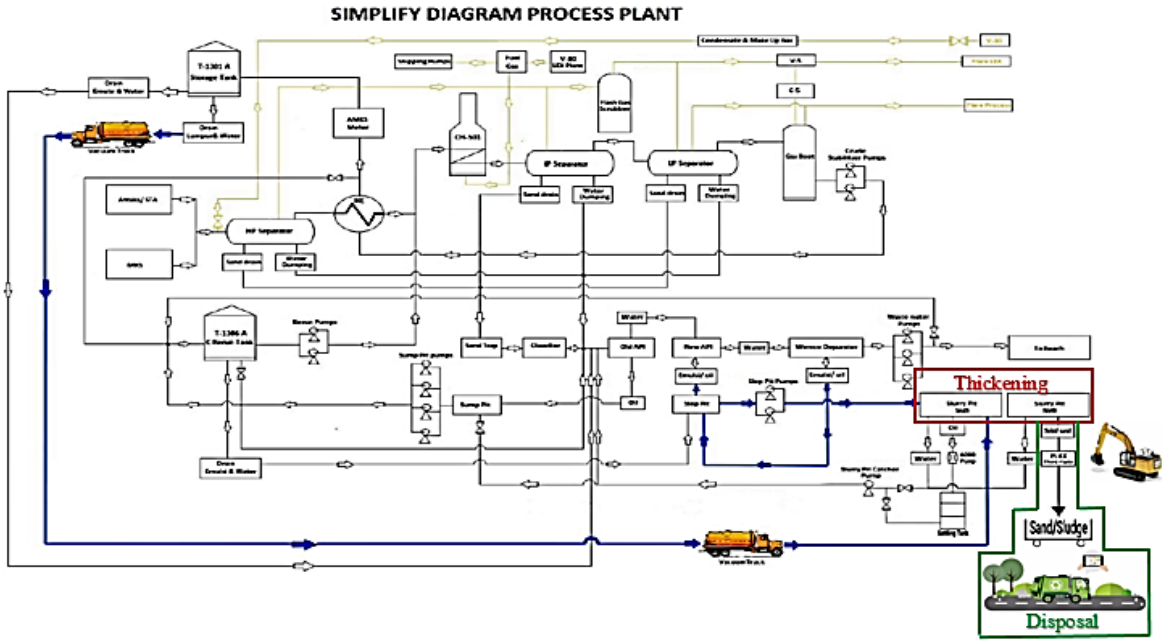



**Figure 2.** A simple diagram of the initial process of sludge management (Soetikno, A., 2023)

Improving the sludge management system requires the addition of several work steps to achieve objective cost-effectiveness and a more comprehensive sludge management, thereby maintaining environmental sustainability as the amount of waste to be disposed of decreases and fulfills the implementation of the responsible waste management hierarchy in Figure 3. Preventing waste generation is a better choice and disposing of waste in landfills should be the last option.


**Figure 3.** Responsible waste management hierarchy (DG Environment, 2023)

## 2. LITERATURE REVIEW

Several methods are frequently employed in industry to manage sludge-type waste in the context of sludge management. The sludge management methods are illustrated in Figure 4.

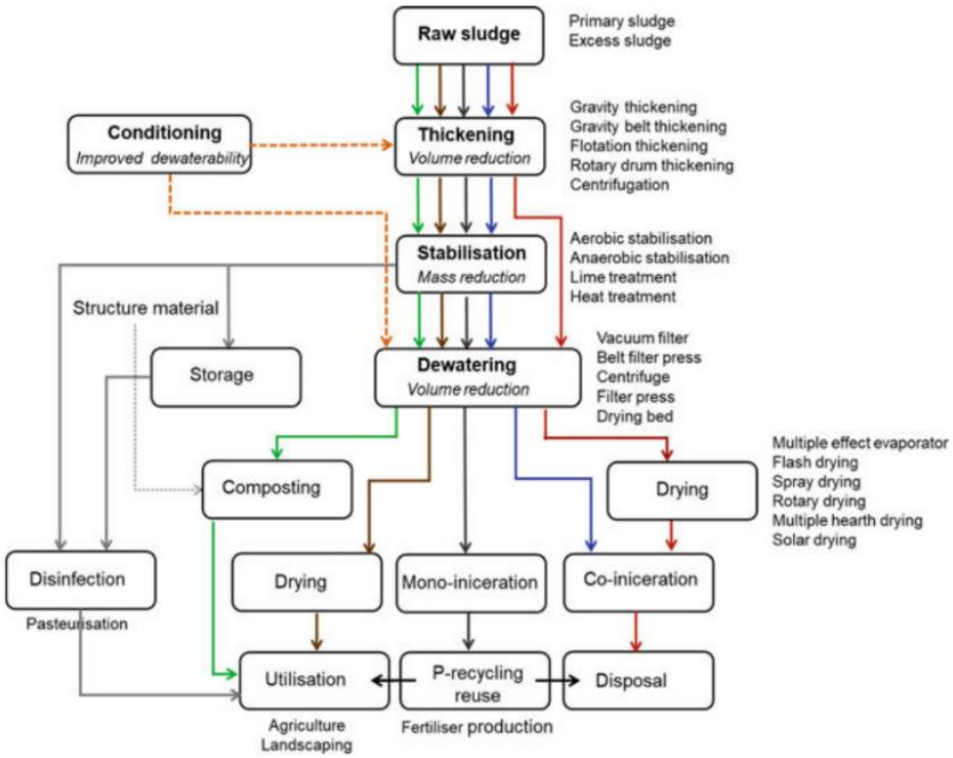



**Figure 4.** Sludge management methods (Radetic, 2019)

The approaches illustrated in Figure 4 can serve as a guide for selecting the suitable approach to enhance initial sludge management, based on the specific features observed in the field. Figure 5 illustrates the incorporation of various technologies, including the application of heat treatment during the stabilization phase, the introduction of a centrifuge process in the dewatering phase, and the implementation of chemical injection in the conditioning phase.

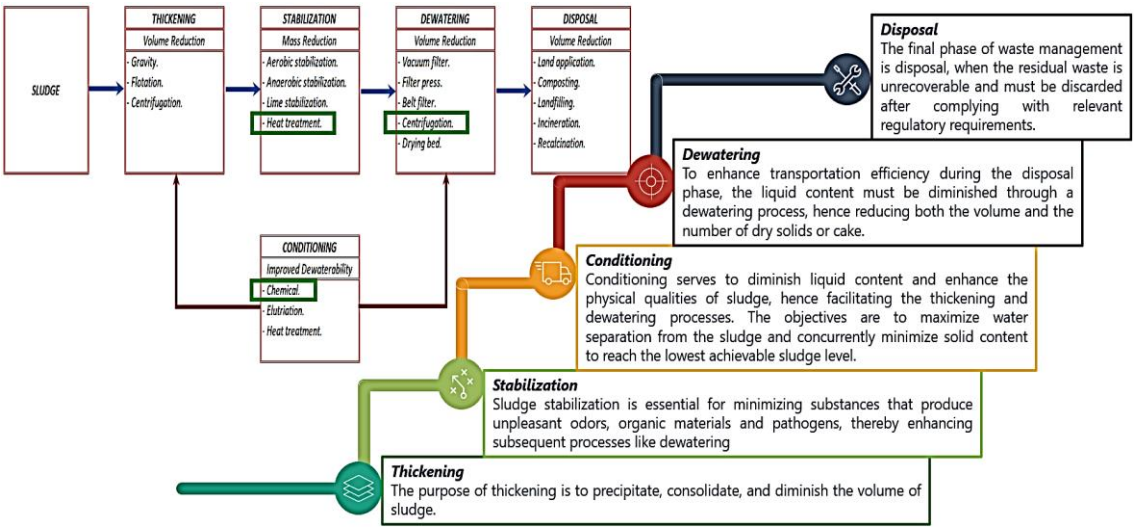



**Figure 5.** Incorporation of sludge management methodologies (Wiratomo, M., 2024)

The addition of stabilization, dewatering and chemical methods from the previous initial sludge management method changes the processing flow diagram to be as shown in Figure 6.

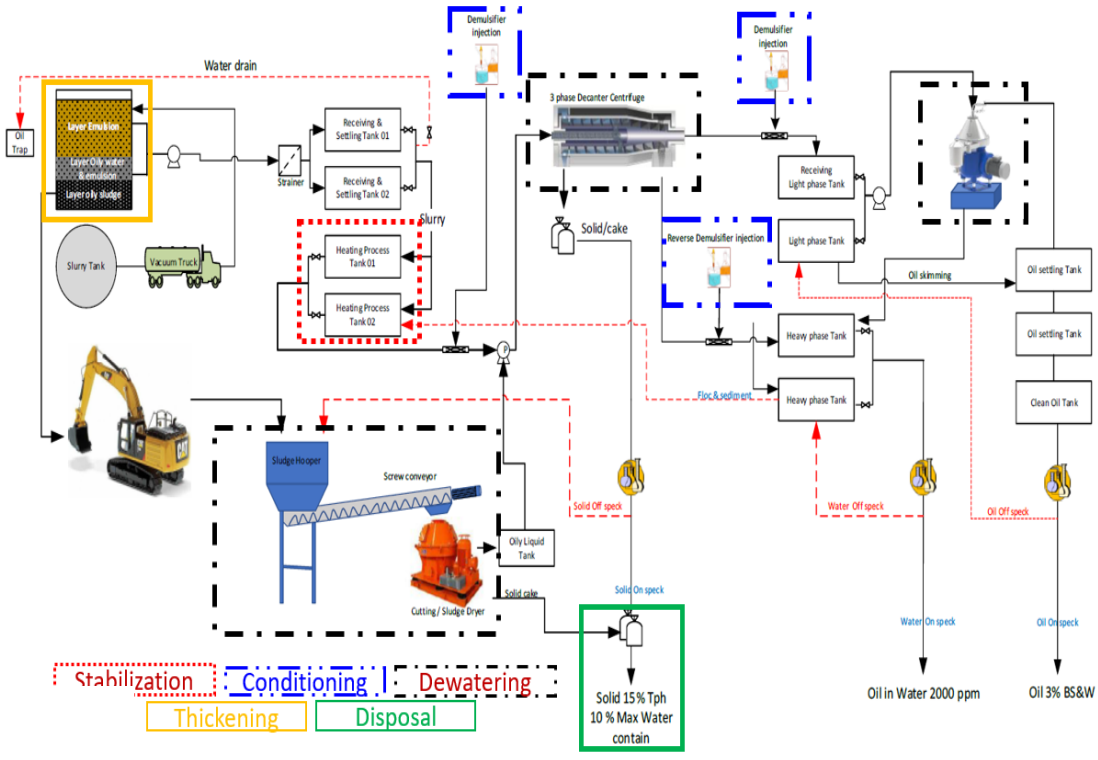



**Figure 6.** Expected flow diagram process (Wiratomo, M., 2024)

## 3. RESEARCH METHOD

The research was conducted using a quantitative method by conducting sludge compatibility experiments through laboratory testing using primary data found in the Onshore X field and reviewing secondary data from previously conducted research literature.

The flow diagram in this study can be seen in Figure 7 which is divided into 5 steps, as follows:

a. Preparation steps, which include the preparation of laboratory apparatus and the provision of laboratory sample tests and chemicals required for the trial, are a critical component of the initial steps.
b. Experimental steps, there are 3 individual testing steps (Thermal, Chemical and Centrifugation) and 1 combined testing step to obtain the best emulsion separation.
c. Analysis of test results, the results of the experimental steps are further analyzed so that they can be applied to sludge processing equipment.
d. Field testing, the results of selected laboratory tests that have been selected are used in the field to obtain the Key Performance Indicators that have been set.
e. The parameters of the equipment used in production should be adjusted, and the parameter settings need to be refined throughout the "trial and error" process.

The final research attempts to decrease sludge management production costs, enhance oil recovery to increase crude oil output, reduce waste disposal, and compliance to hazardous waste management regulations prescribed by the Indonesian Ministry of Environment and Forestry.

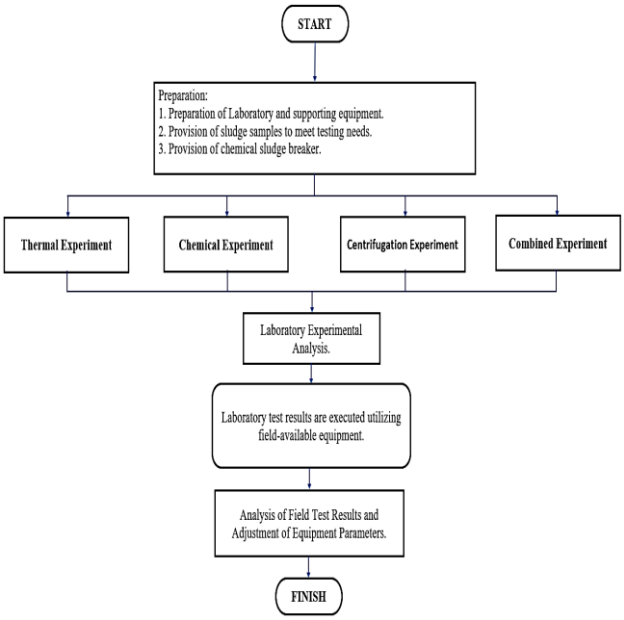



**Figure 7.** Methodology flow chart

## 4. RESULT AND DISCUSSION

Laboratory experiment is required to determine the optimal range of process parameters that should be applied, serving as a reference for the equipment parameters utilized in the field. The laboratory results for thermal, chemical, centrifugation, and combined testing are presented in Figures 8, 9, 10, 11, and 12.

The stabilization steps involving heat treatment of sludge fluid generated by onshore field X are illustrated in Figure 8. Laboratory test results indicate that the separation of sludge into sediment, water, and oil initiates at temperatures exceeding 60 °C.

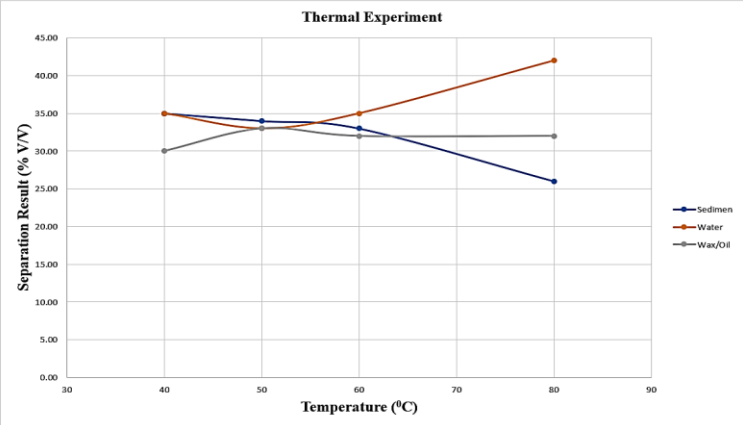



**Figure 8.** Stabilization through heat treatment

The conditioning step involves the addition of chemical injection into the sludge fluid. As illustrated in Table 3 and Figure 9, the laboratory test results indicate that the separation of sludge into sediment, water, and oil demonstrates that the application of chemical product C delivers the most optimal results through the least chemical injection.

**Table 3.** Chemical test data for products A, B and C

| Chemical Product | Temp. | Chemical Dosage | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 500 ppm | | | 3000 ppm | | | 5000 ppm | | |
| | | Sediment (% v/v) | Water (% v/v) | Wax/Oil (% v/v) | Sediment (% v/v) | Water (% v/v) | Wax/Oil (% v/v) | Sediment (% v/v) | Water (% v/v) | Wax/Oil (% v/v) |
| A | 40 $^0$C | 71.00 | 28.00 | 1.00 | 55.00 | 44.00 | 1.00 | 57.00 | 42.00 | 1.00 |
| B | | 74.00 | 25.00 | 1.00 | 70.00 | 29.00 | 1.00 | 57.00 | 42.00 | 1.00 |
| C | | 78.00 | 20.00 | 2.00 | 64.00 | 34.00 | 2.00 | 67.00 | 32.00 | 1.00 |

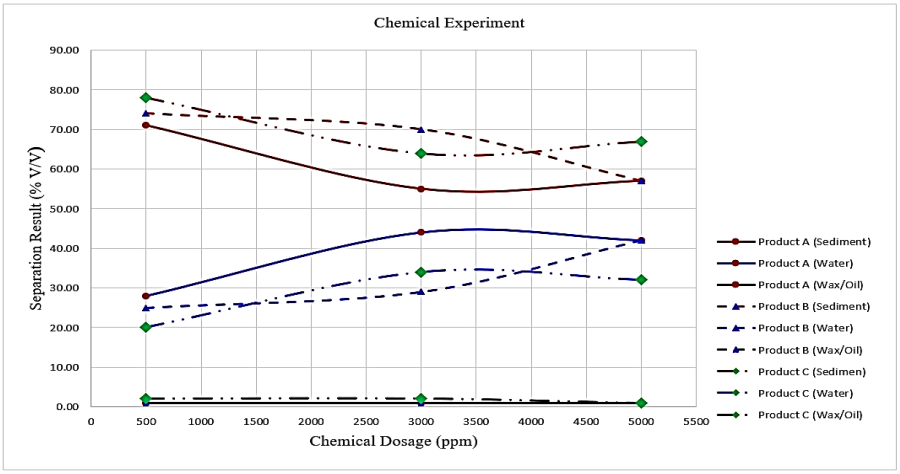



**Figure 9.** Conditioning, adding chemical injection

The dewatering process utilizing a centrifuge on the sludge fluid, as seen in Figure 10 from the laboratory test findings, indicates that optimal separation of sludge into sediment, water, and oil occurs at centrifuge rotations exceeding 1000 RPM.

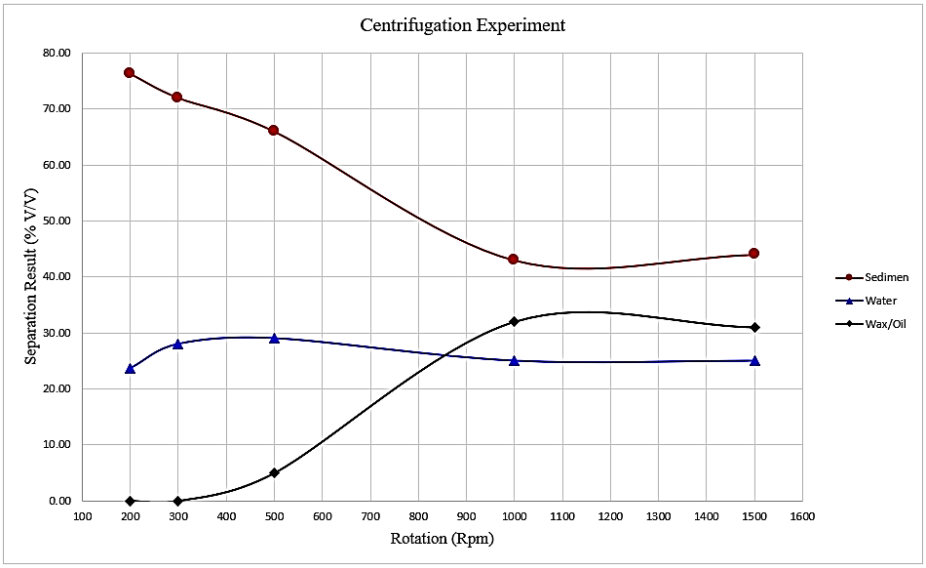



**Figure 10.** Dewatering utilizing a centrifuge

In the combined experiment, which evaluates the operating parameters of the equipment in the field, as illustrated in Figures 11 and 12, it was determined that at a temperature of 80 °C, the application of a chemical dose of 500 ppm at a rotation speed of 1500 RPM achieved the most optimal separation of sediment, water, and oil.

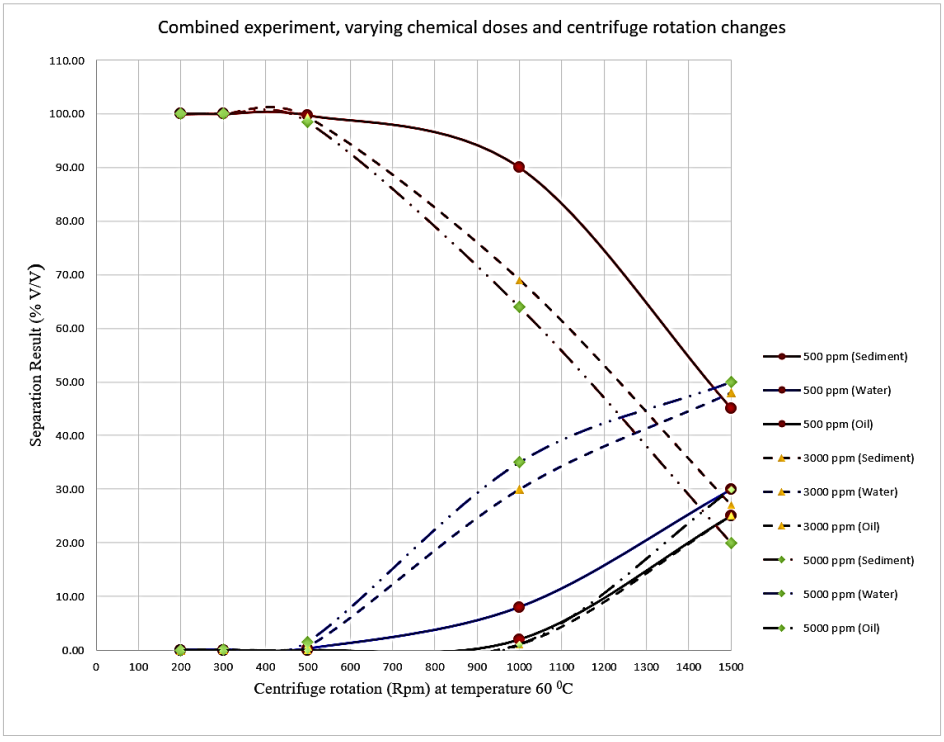



**Figure 11.** Combined experiment, varying chemical doses and centrifuge rotation changes

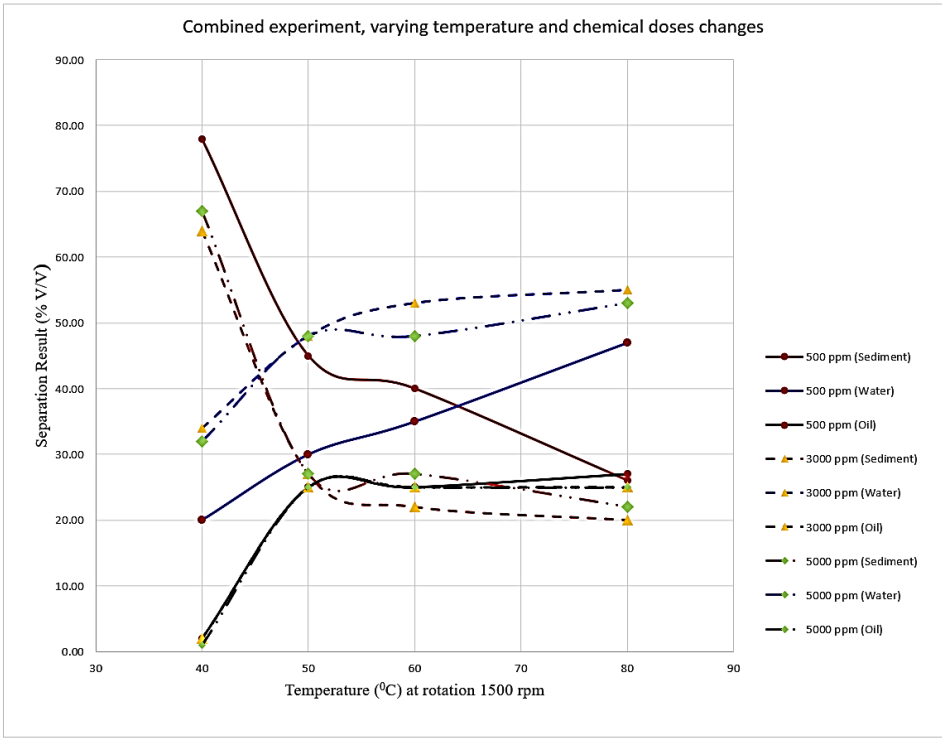



**Figure 12.** Combined experiment, varying temperature and chemical doses changes

Field testing, startup of sludge processing equipment is a trial and error process when applying parameters from laboratory test results to real equipment in the field. The trial process is segmented into three parameters that must align with the Key Performance Indicator, specifically:

a. KPI of Clean Oil Tank.
b. KPI of Clean Water Tank.
c. KPI of Solid/Cake.

The clean oil tank has successfully met the KPI criteria specified in the contract clause during the trial period. The BS&W level is maintained below 3%, with an average of 1.14% BS&W in the oil transferred to the product tank. This data is illustrated in Figure 13, which presents the KPI % BS&W for the clean oil tank.

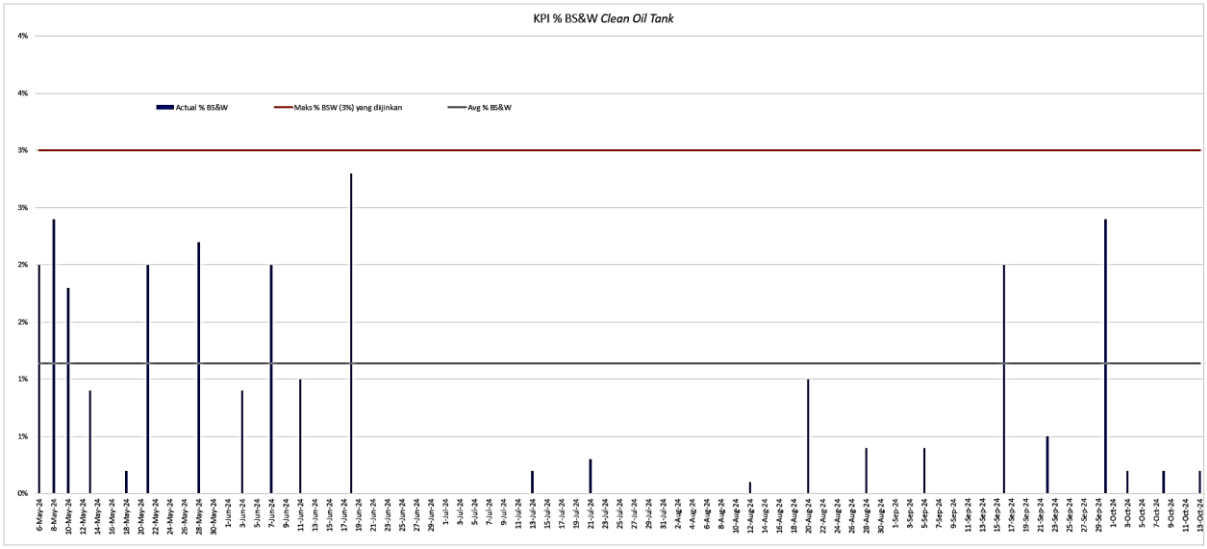



**Figure 13.** KPI % BS&W Clean oil tank

The clean water tank is maintained to achieve key performance indicators, specifically a total petroleum hydrocarbons (TPH) value below 2000 ppm, turbidity below 380 NTU, and a pH range of 6 to 8. The field trial results indicated an average TPH concentration of 461 ppm, turbidity of 204, and a pH average of 6.72. The KPIs for TPH, turbidity, and pH are illustrated in Figures 14, 15, and 16, respectively.

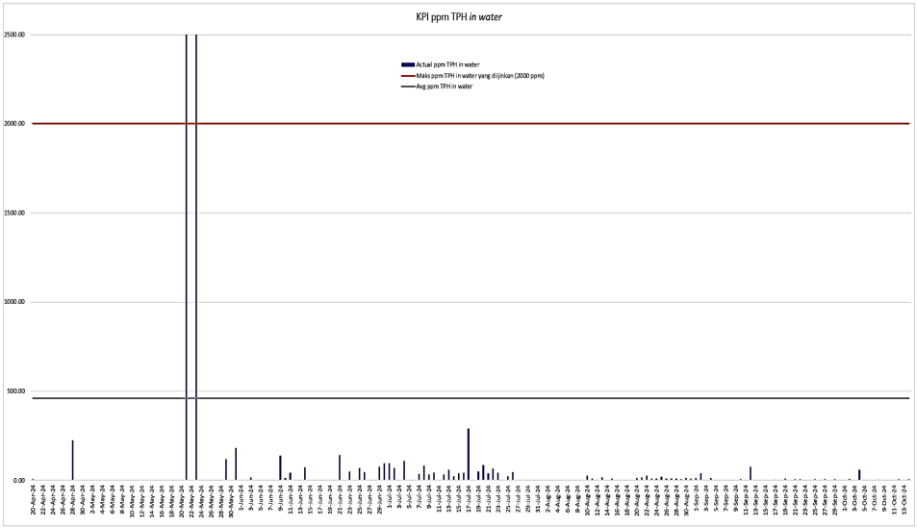



**Figure 14.** KPI ppm TPH in water

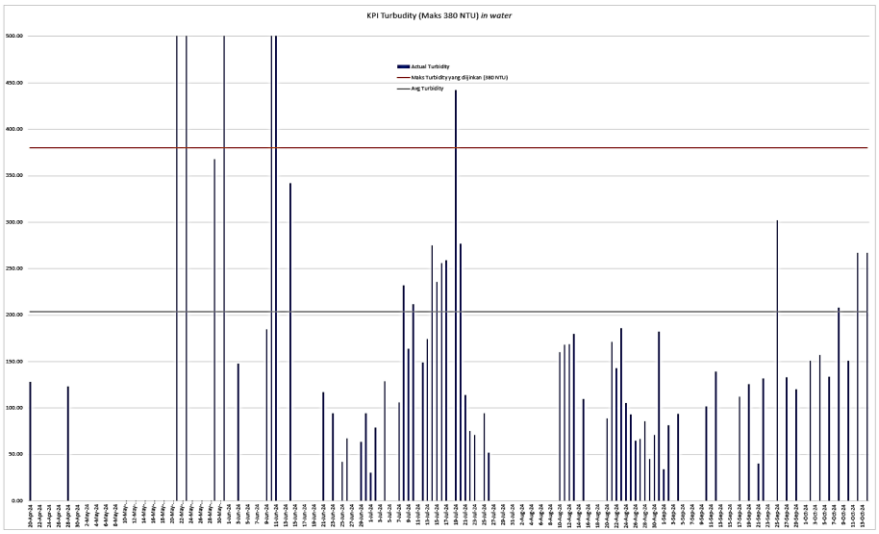



**Figure 15.** KPI Turbidity in water

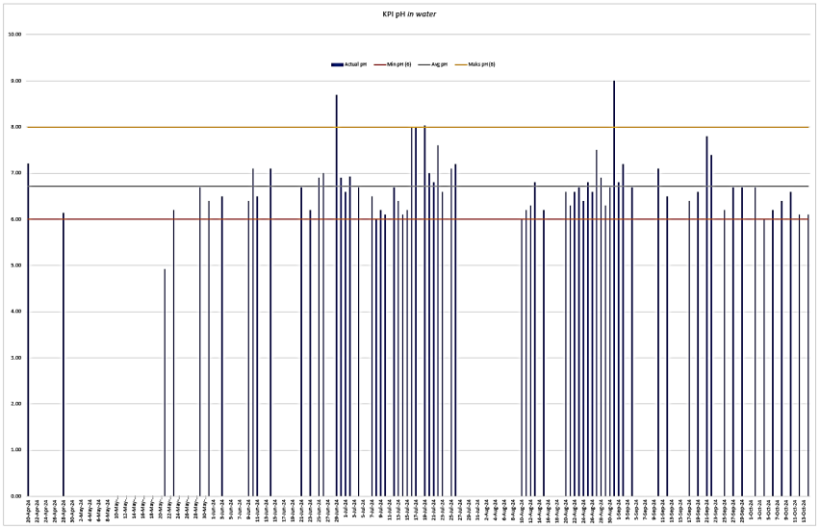



**Figure 16.** KPI pH in water

Solid/cake must comply with TPH <15% and water content in solid <10%. The KPI for TPH has satisfied the allowable threshold of less than 15%, with an average TPH of 8.92%, as illustrated in figure 17 KPI % TPH in Solid.

The maximum allowable water content in solids, as per the KPI, is 10%. However, the dewatering process utilizing tricanter equipment results in an average water content in solids of 22.52%. Figure 18 illustrates the KPI % water content in the solid. The results for the solid/cake are currently not acceptable and necessitate additional dewatering through the drying bed/sludge drying method, as depicted in Figure 16.

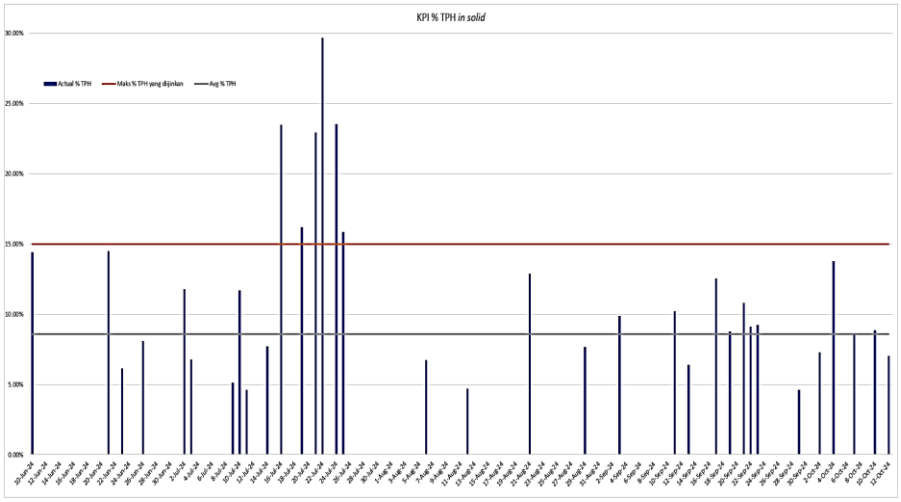



**Figure 17.** KPI % TPH in solid

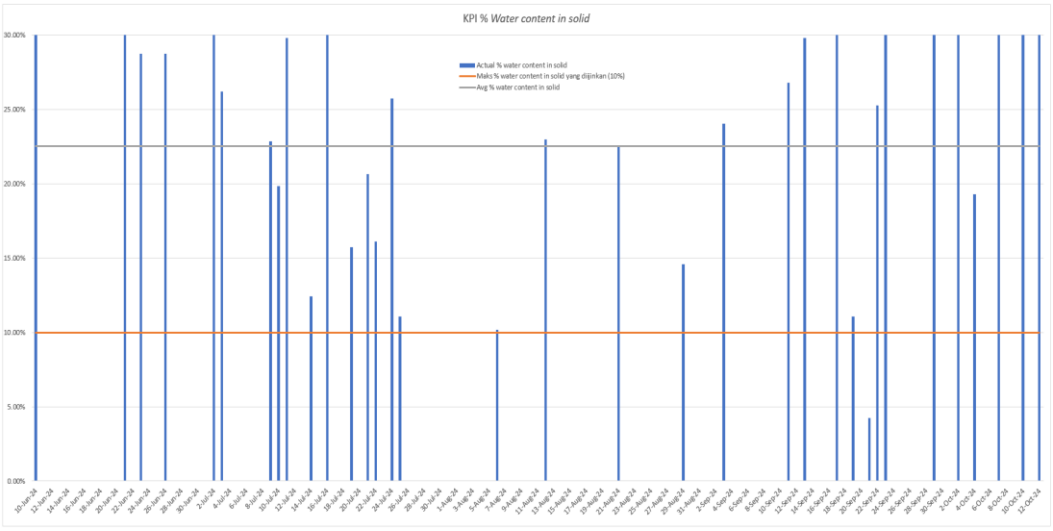
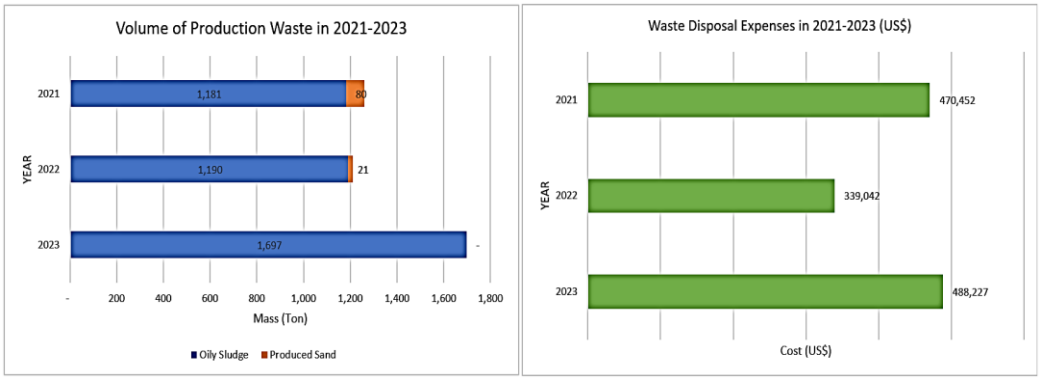



**Figure 18.** KPI % water content in solid

The implementation of sludge management technology over several months has yielded favorable outcomes, specifically in terms of oil recovery, a decrease in the direct disposal of solid waste, and a reduction in costs following the integration of stabilization, conditioning, and dewatering processes, as illustrated in Figures 19 and 20.



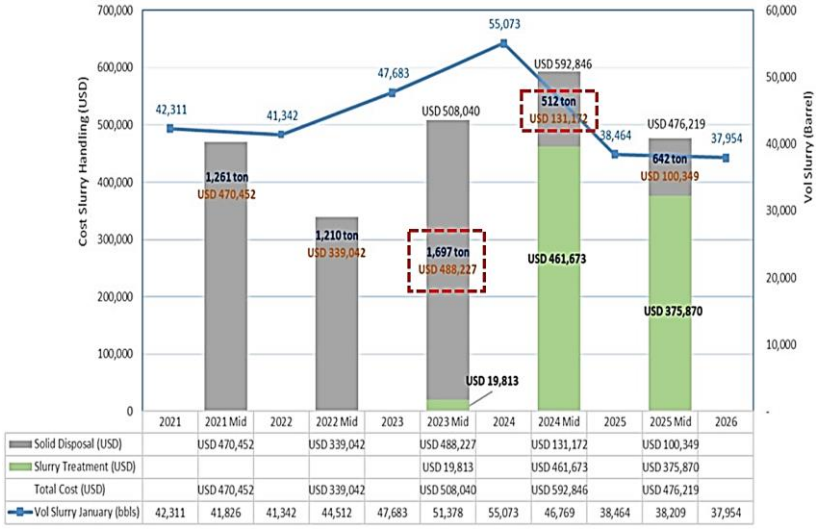



**Figure 19.** Projected cost reductions and lowered waste volume

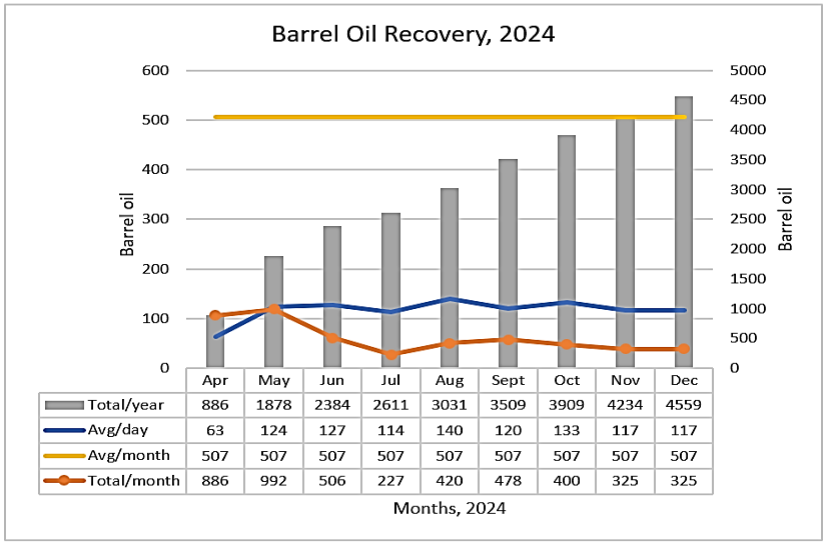



**Figure 20.** Barrel oil recovery

## 5. CONCLUSIONS AND RECOMMENDATIONS

Sludge management utilizing current technology can adhere to the principles of responsible waste management hierarchy where waste prevention is preferable and landfill disposal should be the last choice. The conclusion of this paper is:

a. Through the concept of responsible waste management hierarchy, the onshore X field seeks to perfect the sludge waste management process by adding several methods that are adjusted to the characteristics and conditions of the field, there are 3 methods added, namely stabilization using heat treatment, conditioning with the addition of chemical injection and dewatering.

b. The outcomes of implementing effective sludge management technology are illustrated in Figures 19 and 20, demonstrating that onshore field X can achieve:

- The amount of production waste in the form of oily sludge and produced sand has been successfully reduced from 1697 tons in 2023 to 512 tons (projection until Dec 24) in 2024.
- The expense of waste management for production was successfully reduced from USD 488,000 in 2023 to USD 131,000 (projection until Dec 24) in 2024.
- The amount of oil recovered was successfully achieved from none (0 barrels) in 2023 to 4,500 barrels (projection until Dec 24) in 2024.

c. Based on the results achieved in sludge management, there are several aspects that can be improved, the following are recommendations for improvement:
   - The diverse properties of sludge in each processing batch necessitate the accurate assessment of the appropriate chemical demulsifier dosage, which may differ across batches.
   - Solid output from the tricanter, most of it still does not meet the maximum limit of the requested moisture content specification with an average of 22% (standard KPI < 10%), thus requiring additional dewatering equipment for the solid end product.
   - Productivity in slurry processing is negatively impacted by the tricanter, the main emulsion-breaking equipment, often experiencing blockages due to solid particles.
   - The reliability of the equipment and the availability of spare parts to manage sludge are critical factors to consider, as the process necessitates heating and chemical reactions and fluids contain abrasive particles such as fine sand.

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# CHAPTER 5

# Production Data Analyst and Waterflooding Surveillance Analysis as a Consideration of "X" Field Reactivation

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## ABSTRACT

Field "X" was first produced in 2005, with cumulative production reaching 6.8 MMSTB until 2017, when it was closed, and management ended in 2018. Then in 2021, a tender for field management was held by the Ministry of Energy and Mineral Resources, and company "A" was the winner. With a commitment in the first five years, eight production wells, three injection wells, and surface facility will be managed and produced. With previously existing historical data, it is hoped that field reactivation and development can be carried out appropriately and are expected to optimize recovery and maximize economic return. Water injection into the reservoir was initially intended for the disposal of produced water and pressure maintenance, involving the analysis of production data and monitoring of waterflooding to assess the performance of production wells, water injection in structure A-11, and forecasting production performance. Thus, this research can be considered in the reactivation and development of the field in the future in accordance with operations and economics.
**Keywords:** Economic Limit, Production Forecast, Waterflooding Surveillances.

## 1. INTRODUCTION

The “X” field is located in the southern part of Sumatra with a working area of 267 km2. It has four layers of sandstone with a distribution of porosity values of 7–28%, permeability of 40 mD–58 mD, the thickness of the A-11 layer reaching 22 ft, and an OOIP of 22.1 MMSTB. This field was first produced in 1994 and has not been produced since 2015 with cumulative production of about 6.8MMSTB. The commitment of the operator working area contract to reactivate production wells, injection, and production facilities. The utilization of early production facilities (EPF) in the early production period is a strategic decision by the company's that production can be lifting immediately, in parallel with the refurbishment of existing surface facilities. The rental cost of EPF depends on the capacity of the fluid to be produced, for this reason it is necessary to carry out production forecasting in addition to surveillance waterflooding being important so that operations are conducted efficiently and economically.

Within production analysis, alongside the estimating production performance, production analysis includes channel plot analysis to determine the behavior of generated water in each well. Furthermore, waterflooding surveillance analysis is performed to evaluate the performance of both the reservoir and injection wells during the prior operational phase of field X (Figure 1).

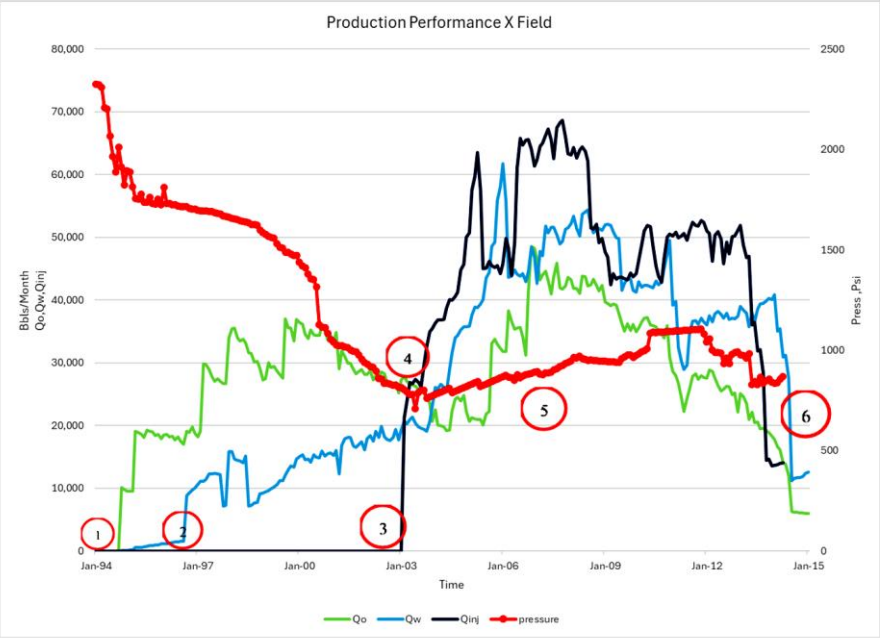


**Figure 1.** Production performance of X field

## 2. LITERATURE REVIEW

The production phase of a field begins when the oil has flowed from the well either by natural flow or through artificial lifting (premiere recovery), secondary recovery by relying on additional driving force from outside the reservoir in the form of water or gas injection and advanced dewatering methods (tertiary recovery) by making physical or chemical changes to the reservoir fluid. Waterflooding is one of the methods of enhanced oil recovery that uses water

as a medium to displace reservoir fluids. In addition to being a displacing medium, water injection also functions as a pressure maintenance mechanism caused by the depletion of the reservoir due to the mobility of the displacing water and also the water that is produced, or for both purposes. (Vishnyakov *et al.*, 2019).

The key to the success of a waterflooding project lies in the planning, execution, and monitoring of surface facilities, wells, and reservoirs. For this reason, collecting accurate, real and continuous data in the form of production data, injection, pressure and injection operation patterns from the field is very important for surveillance programs. There are several types of surveillance that are commonly carried out now, as shown in Table 1.

**Table 1.** Reservoir Surveillance (Arnold, Richart *et al.*, 2020)

| Field Surveillance | Production Well Surveillance | Injection Well surveillance | Facility and Water Injection Quality |
|---|---|---|---|
| Historical field production performance *plot*,<br>Production and injection bubble map,<br>Pressure map,<br>*Watercut* Map,<br>Field decline curve analyses,<br>WOR vs Np *plot*,<br>Rf vs HCPVI *plot*, | Well-by-well production performance *plot*,<br>Well decline curve analysis,<br>SBHP survey,<br>FBHP survey,<br>Salinity measurement,<br>chan *plot*,<br>Production test | Injection rate measurement by panametric survey,<br>Injectivity test,<br>Fall-off test,<br>Hall *plot* | Water injection plant,<br>Injection Pipeline itegrity,<br>Wellhead, cashing, and tubing Integrity,<br>Quality of water injection |

Hall plot is an alternative approach to transient well test analysis, this approach is carried out by measuring variables that can be measured directly on the surface, namely wellhead pressure and injection rate. This plot is generated by plotting the cumulative pressure-time product against the cumulative water injection volume. The slope value indicates the performance of the injection performance.

Voidage Replacement Ratio (Equation 1) is a measure used to assess the effectiveness of water injection in enhancing oil production in a reservoir. VRR is defined as the ratio between the amount of injected water introduced into the reservoir and the amount of fluid that flows to the surface.

$$VRR = \frac{Winj \times Bw}{Np \times [\, Bo \times (\, Rp - Rs \,) \times Bg \,] + Wp \times Bw} \quad (1)$$

The Decline Curve method is a method that can be used to calculate remaining oil or gas reserves from a reservoir that has experienced a decline in production and has not experienced changes in the production method. It can also be used to estimate the amount of production at a certain time, as well as as analysis material for field development. In essence, forecasting of the volume of remaining oil or gas reserves through the application of the decline curve methodology involves the estimation of extrapolated outcomes (the drawing of a linear

representation) derived from a graphical representation (curve) created by plotting the relationship between the production rate and the cumulative production or production time.

Water diagnostic plots or known as Chan plots are a technique used to determine the mechanism of excess water and gas production in oil wells introduced by Chan in 1995. This technique helps identify production problems and improve performance.

## 3. RESEARCH METHOD

This research is a quantitative study conducted in the engineering department of company A using secondary data to predict well production performance and understand the behavior of produced water using the Chan plot method. For waterflooding performance, an analysis of surveillance using the Voidage Replacement Ratio (VRR) method is conducted, as well as identifying injection well problems using the Hall and plot method and analyzing the results for field development after reactivation.

The flow diagram in this study can be seen in Figure 2 which is divided into 6 steps, as follows:

a. Preparation for data collection in the form of pressure data, production data (Np, Gp, Wp), PVT data (Bo, Rs, Bg, Bw, Bwinj), and injection data.
b. Performing calculations of the oil and gas formation volume factor values for several pressure values and determining the gas solubility in oil from PVT data and fluid properties.
c. Calculation of voidage, replacement, and cumulative VRR.
d. Conducting analysis and evaluation of the cumulative VRR results and Hall plot.
e. Analyzing production data to see productivity index and analyzing the Chan plot.
f. Conducting decline curve analysis to illustrate well production after reactivation.

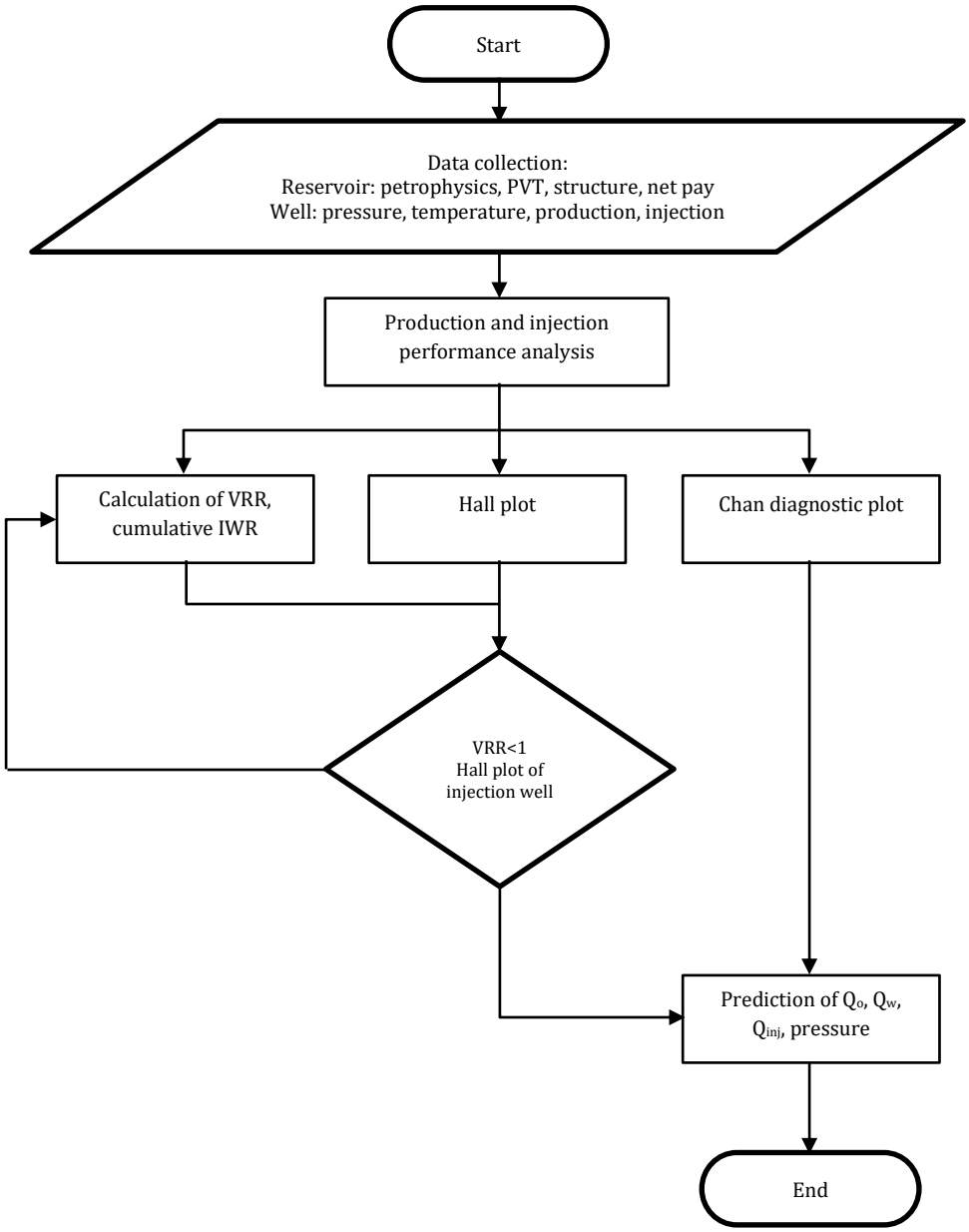


**Figure 2.** Methodology flow chart

## 4. RESULT AND DISCUSSION

Analysis was conducted on the wells produced in field X, specifically in the A-11 layer, with the aim of understanding production performance, productivity index, behavior of produced water in selected wells that will be reactivated, and production forecasting (Figure 4). The data of oil production rate (Qo), water production rate (Qw), and water cut (WC) of 12 wells are given in Table 2. The table shows that the initial production data recorded at different time ranging from October 1994 to November 2006. This indicated the first production of the wells after the wells were drilled and completed. Other information obtained from the table is the final production data of the wells noted from June 2009 to January 2015.

**Table 2.** Layer A-11 production well

| No | Well | Initial Production | | | | Final Production | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Time | Qo (Bbls/d) | Qw (Bbls/d) | WC (%) | Time | Qo (Bbls/d) | Qw (Bbls/d) | WC (%) |
| 1. | AX-01 | Oct-94 | 327 | 1 | 0.35 | Jun-09 | 28 | 285 | 90.9 |
| 2. | AX-02 | Mar-95 | 309 | 13 | 3.9 | Dec-10 | 87 | 259 | 75.0 |
| 3. | AX-03 | Sep-96 | 64 | 240 | 59.3 | Jun-98 | 22 | 263 | 92.0 |
| 4. | AX-05 | Mar-97 | 291 | 20 | 6.5 | Feb-11 | 59 | 277 | 82.5 |
| 5. | AX-07 | Dec-97 | 247 | 118 | 32.3 | Feb-06 | 58 | 357 | 86.0 |
| 6. | AX-08 | Nov-98 | 7 | 40 | 85.0 | Nov-98 | 7 | 40 | 85.0 |
| 7. | AX-08A | Aug-99 | 250 | 21 | 7.7 | Feb-14 | 63 | 216 | 77.4 |
| 8. | AX-09 | Feb-05 | 8 | 45 | 85.0 | Feb-05 | 8 | 45 | 85.0 |
| 9. | AX-10A | Sep-05 | 335 | 70 | 17.4 | Jun-14 | 75 | 319 | 80.9 |
| 10. | AX-11 | Mar-06 | 288 | 40 | 12.4 | Jun-14 | 114 | 227 | 66.5 |
| 11. | AX-12 | Oct-06 | 327 | 96 | 22.8 | Jan-15 | 193 | 407 | 67.8 |
| 12 | AX-12A | Nov-06 | 257 | 98 | 27.5 | Feb-14 | 54 | 113 | 67.4 |

From the candidate wells that will be reactivated, the productivity index calculation is then carried out to determine the optimal production that can be achieved after reactivation. Using the Darc's Law productivity index approach and maximum flow, the calculations for each well were made, as exemplified by the PI and Qo max calculations for well AX-12 below.

$$J = \frac{7.08x^{-3}kh}{\mu oBo\left(\ln\left(\frac{re}{rw}\right) - 0.75 + 5\right)}$$

$$J = \frac{7.08x^{-3}38.2\ 14.2}{0.778\ 1.253\left(\ln\left(\frac{750}{0.28}\right) - 0.75 + 0\right)}$$

J = 0.551 STD/d/Psi

Calculated flow maximum

$Qb = J\ (Ps - Pb)$

$Qb = 0.551\ (2{,}086 - 1{,}965.8)$

$Qb = 66.3$ Bbls

$$Qmax = Qb + \frac{PI\ x\ Pb}{1.8}$$

$$Qmax = 66.3 + \frac{0.0.51\ x\ 1965.8}{1.8}$$

$Qmax = 668$ Bbls

From the production data of well AX-12, the highest liquid gross production reached 639 gross barrels per day. It can be said that the performance of well AX-12 has reached its optimal capacity.

Next, an analysis was conducted using the Chans diagnostic theory, which is a plot graph of WOR, WOR derivative over time. Analysis was conducted on the nine production wells to understand the behavior of produced water. This can serve as a consideration in determining which wells will be reactivated.

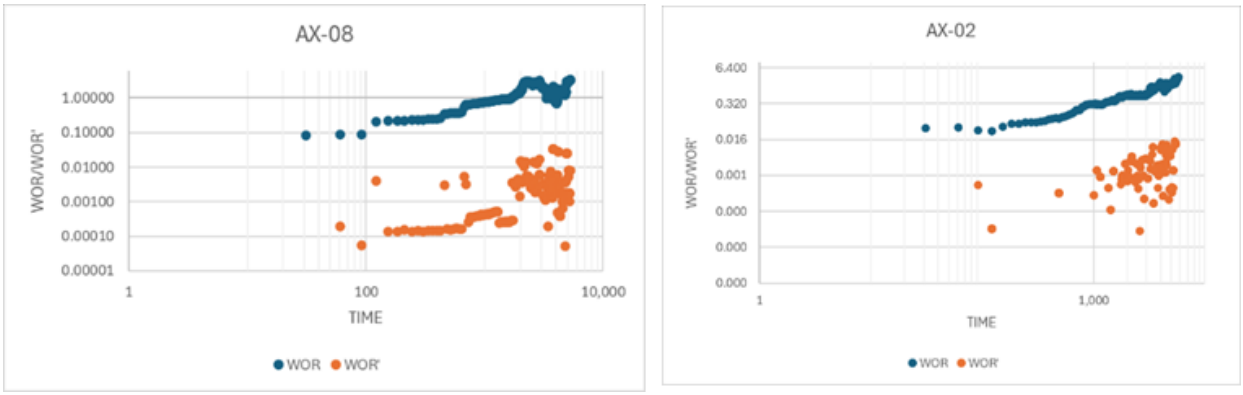


**Figure 4.** Chan plot for wells in layer A-11

The results of Chan diagnostic plot for each well are summarized in Table 3.

**Table 3.** Summary of Chan diagnostic plot

| No | Well | Chan Plot Analysis | WC (%) |
|---|---|---|---|
| 1. | AX-01 | Multilayer channeling | 90.9 |
| 2. | AX-02 | Normal Displacement high WOR | 75.0 |
| 3. | AX-05 | Channeling | 82.5 |
| 4. | AX-07 | Multilayer channeling | 86.0 |
| 5. | AX-08A | Normal Displacement high WOR | 77.4 |
| 6. | AX-10A | Channeling | 80.9 |
| 7. | AX-11 | Normal Displacement high WOR | 66.5 |
| 8. | AX-12 | Normal Displacement high WOR | 67.8 |
| 9. | AX-12A | Near Wellbore Water Channeling. | 67.4 |

The ratio of production to injection fluids becomes important for analysis because if the cumulative value of the production to injection ratio exceeds 1.0-1.2, it can be interpreted as the achievement of equilibrium conditions.

In the early injection period, there was a significant spike in voidage replacement ratio (VRR) values, indicating a water fill-up process in the injected layer. In addition to the potential optimization of injection in the A-11 layer, the injection also resulted in an increase in reservoir pressure as shown in Figure 5. The IWR (Injection Withdrawal Ratio) is the proportion of production to the total production of each injection pattern. In the oil and gas sector, the IWR parameter is frequently employed as a standard for evaluating secondary recovery project performance. Rather of being based on petrophysical or geometrical data, it is used to obtain associated productions. Calculation results of voidage replacement ratio VRR and IWR are given in Table 4.

**Table 3.** Calculation results of VRR and IWR

| Date | P | Bo | Bg | Rs | Bw | Winj (Bbls/M) | Qo Bbls/M | Qg Bbls/M | Qw Bbls/M | Vrr | Iwr |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Oct-94 | 2323.9 | 1.253 | 0.0017 | 680.95 | 1.03 | | 10.148 | 0 | 36 | | |
| Nov-03 | 805.7 | 1.101 | 0.0054 | 169.02 | 1.03 | 20.507 | 23.532 | 109 | 20.625 | 0.004 | 0.004 |
| Feb-13 | 988.0 | 1.120 | 0.0043 | 218.33 | 1.03 | 49.411 | 24.605 | 66 | 38.422 | 0.759 | 0.405 |
| Jan-15 | 869.4 | 869.4 | 0.0050 | 185.87 | 1.03 | 13.656 | 5.988 | 0 | 12.607 | 0.718 | 0.430 |

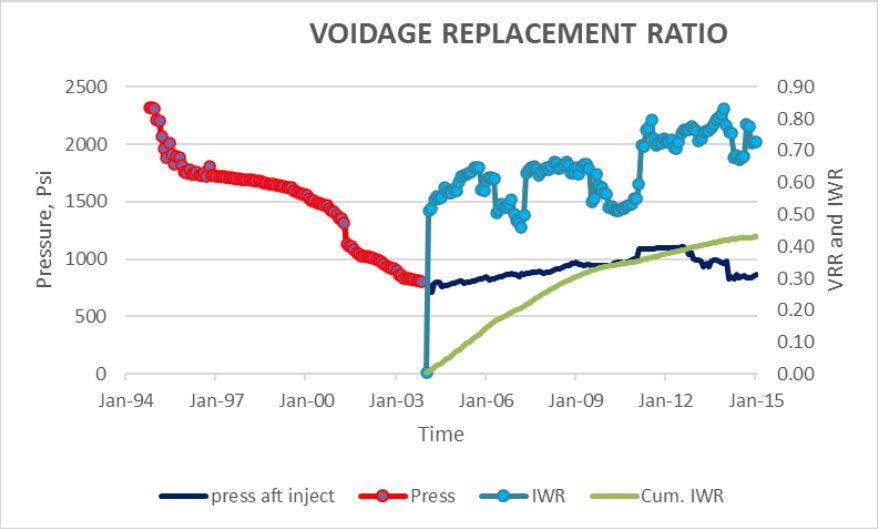


**Figure 5.** VRR Layer A-11

In addition to analyzing and observing injection performance in the reservoir, the performance of the injection wells also needs to be further analyzed. Knowing the reliability of well injection can serve as a basis for optimizing a waterflood operation in the field. The most commonly used method to identify issues with injection wells is the Hall plot method, which involves analyzing the change in slope of the plot between cumulative injection and cumulative pressure at an injection well. Figure 6 shows Hall plot of Well AX-03.

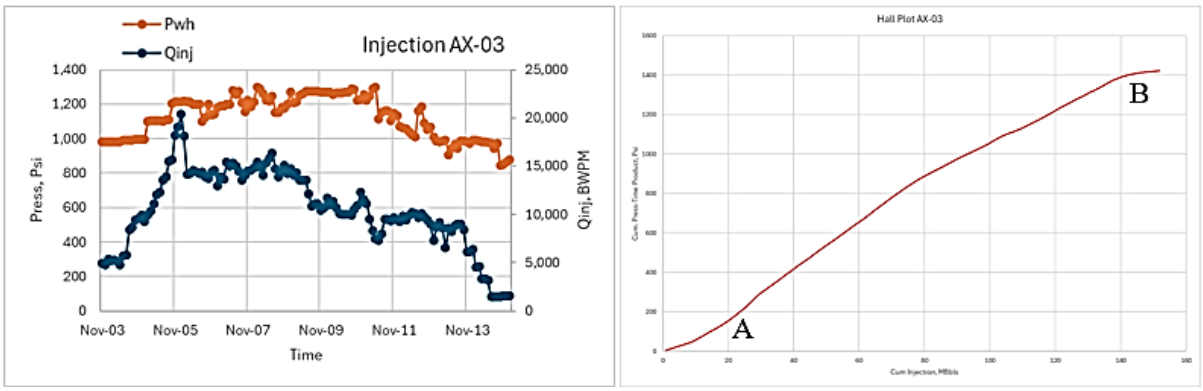


**Figure 6.** Hall Plot of Well AX-03

The injection of field X commenced in October 2003 with a peak injection rate of 2,100 bwpd. Of the three injection wells in operation, one well must be shut in due to indications of blockage (plugging), as evidenced by high pressure at the wellhead. Here is the status of the injection wells**.** From the analysis that has been conducted, several well candidates have been identified for reactivation and production forecasting using decline curve analysis. Well AX-02 is one of the candidates that will be reactivated, with a production forecast using DCA showing a decline of 1.8% per month from the monthly exponential trendline, and subsequently calculated with a harmonic pattern for its production forecasting.

$$q = \frac{qi}{(1 + di t)}$$

$$q = \frac{2{,}686 \text{ bbl/Month}}{(1 + 1.8\%)}$$

$$q = 2{,}638 \text{ bbl/Month}$$

Forecasting is conducted for five years starting from January 2025, following the company's operational targets, with a production forecast of 743 Bbls/m by the end of December 2030 or 24 bbl/d as shown in Figure 7.

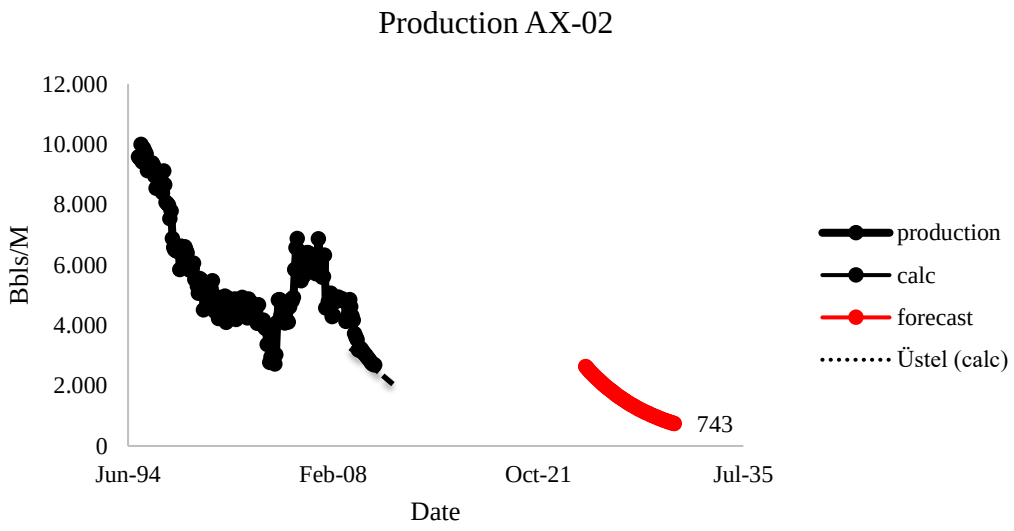


**Figure 7.** Production and forecast production well AX-02

The economic limit set by the company is 20 bbl/d for each well, while still considering the total gross amount produced. Table 4 summarizes the forecasting results of the candidate wells that will be reactivated.

**Table 4.** Result of production forecast from selected wells

| well | Date forecasting | $D_i$, (%/m) | $Q_o$, bbl/d | Cum Prod, bbl |
|---|---|---|---|---|
| AX-02 | Dec-2030 | 1.8 | 24 | 107,904 |
| AX-11 | Dec-2030 | 1.1 | 51 | 170,104 |
| AX-12 | Dec-2030 | 0.8 | 110 | 326,773 |
| AX-12A | Jul-2026 | 7.5 | 21 | 25,117 |

In this study the forecasting of produced water (water cut prediction) is conducted using the dydactic analysis water cut model method on the cumulative production of candidate wells. A plot of water cut values against cumulative production is made to obtain a linear trendline graph. Next, the water cut obtained is inversely calculated against the oil production forecast to determine the water production amount. The water cut prediction of Well AX-02 is shown in Figures 8 and 9. From the linear plot of well AX-02 that has been conducted, the estimated watercut value in January 2025 is 74.12% with an oil production forecast of 2,638 bbl/m.

$$\mathrm{wc} = \frac{\mathrm{Qw}}{(\mathrm{Qw} + \mathrm{Qo})}$$

The value of Qw (water flow rate) can be calculated using the formula above as follows:

$$\mathrm{Qw} = \frac{\mathrm{Qo} - (\mathrm{Qo\ x\ (1 - wc)}}{(1 - \mathrm{wc})}$$

$$\mathrm{Qw} = \frac{2{,}638 - (2{,}638\ \mathrm{x}\ (1 - 74.12\%)}{(1 - 74.12\%)}$$

$$\mathrm{Qw} = 7{,}557\ \mathrm{bbl/m}.$$

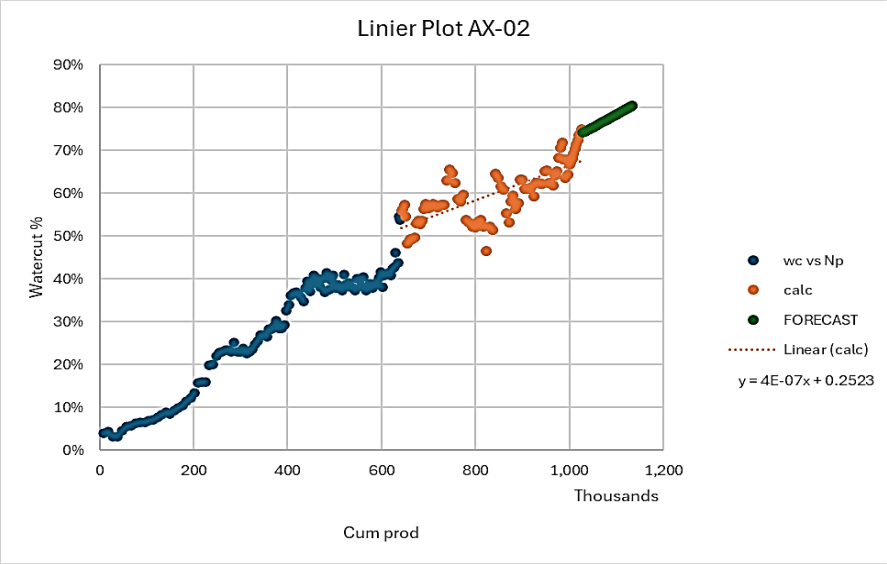


**Figure 8.** Linier plot of water cut (WC) vs cumulative production (Np)

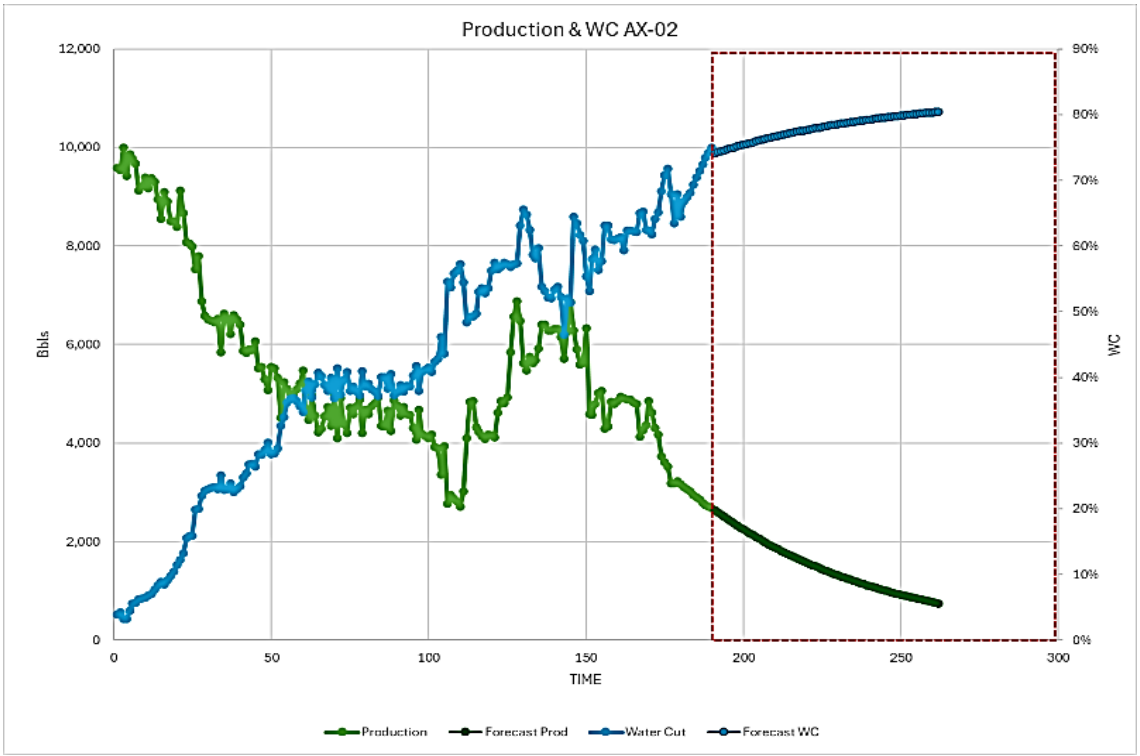


**Figure 9.** Production vs WC of Well AX-02

In a literature, pressure and injection response analysis can be conducted using the Net Voidage Curve (Okoro & Okojie, 2007). In the data processing of this study, the net voidage value for layer A-11 is negative, caused by the voidage value being greater than the replacement. For that reason, the linear trendline value of the pressure plot during direct injection in relation to the cumulative injection amount becomes an approach in forecasting pressure for the next five years (Figure 11). Of the four wells that will be reactivated at the beginning of 2025, field "X" has the potential to obtain a remaining reserve of 629MSTB or 2.8% of OOIP over five years of production (Figure 12).

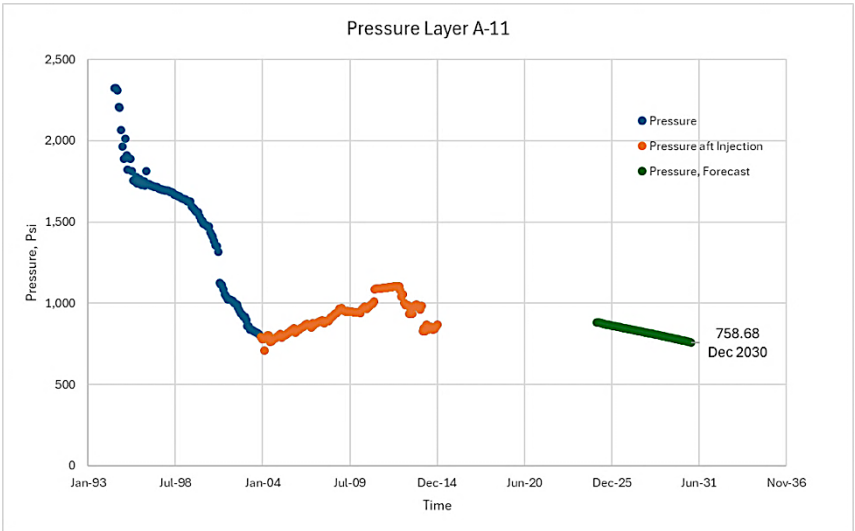


**Figure 10.** Pressure predicting of Well AX-02

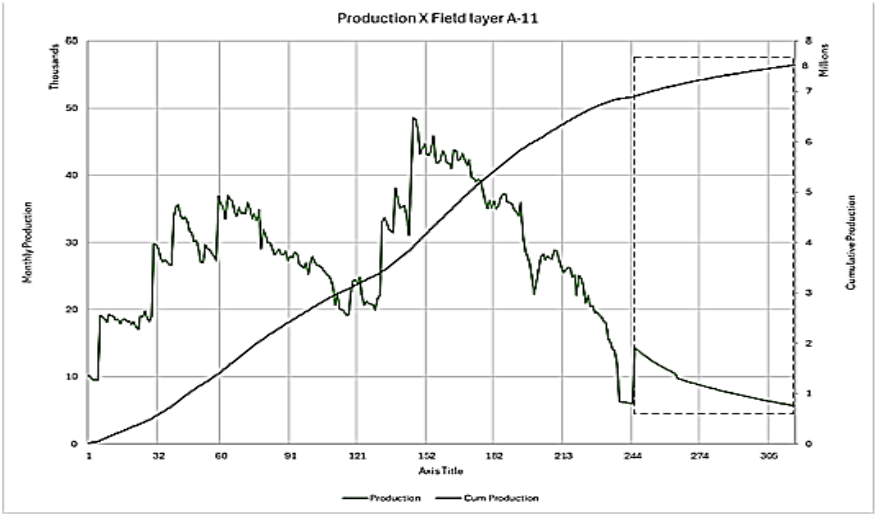


**Figure 11.** Production and cumulative production X field

The forecast for field "X" at the end of 2030 shows oil production at 5,679 bbl/m, water production at 31,541 bbl/m, water injection rate reaching 32,295 bbl/m, and pressure at the end of the forecasting period at 758 Psi.


**Figure 12.** Field Performance "X" until after reactivation

## 5. CONCLUSIONS

Based on the results of the analysis conducted in this study on production data and waterflooding surveillance, it can be concluded that:

a. The selection of reactivated wells based on historical production data is made according to several criteria, including the productivity index of each well, decline rate, gross production, produced water behavior from the results of the chans plot, and other well test results.

b. From the calculation of the VRR value for the A-11 structure until the X field is not operating 0.718 and the cumulative injection withdrawal rate value reaches 0.42, which means that the X field is still able to be injected and increased to increase the recovery factor.

c. The problem of produced water is a consideration in selecting wells to be reactivated in addition to the productivity index of the well and the latest net production from the available data.
d. From the results of the "X" field forecast for five years, the reameaning reserve that can be produced reaches 629MSTB.

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# CHAPTER 6

# Field Development Study of Lgs Field With Sectorization Decline Curve Analysis To Increase Recovery Factor on "H" and "L" Field Structures

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## Abstract

The LGS field consists of 2 structures, namely structures H and L, with a total of 8 wells in them. The current condition of the wells is as follows: 2 wells are abandoned (H-1 & H-2) and 6 wells are suspended (L-1, L-2, L-3, L-4, H-3, and H-4). In the history of well production in structure H, H-4 had a cumulative oil production of 2.3 MMSTB in 2017, while the well that has never been in production (suspended) is H-3. In the history of well production in structure L, L-1 had a cumulative production of 0.43 MMSTB, L-2 had a cumulative production of 0.46 MMSTB, and L-3 had a cumulative production of 2.27 MMSTB. The well that has never been in production (suspended) is L-4. The existing condition has an Original Oil in Place (OOIP) of 28.33 MMSTB, while the cumulative production is 5.46 MMSTB (RF: 19.27%). L and H structure have water drive mechanism. By using J. J. Arps, we can calculate Estimated Ultimate Recovery (EUR) in the L and H structures, the result of the calculation is 10,333 MSTB with cumulative production 5,595 MSTB so remaining oil reserve 4,738 MSTB. The issue at hand is that the recovery factor drainage is still at 19.27%. The next step is to evaluate the production of the wells using Chan Diagnostic plot method and Decline Curve Analysis Sectorization. Both analyses are used to determine if the four wells still have reserves if they were to be reactivated and to determine channelling or water conning. Chan Plot method determines well L1, L3 & H4 indicate Rapid Channelling that cause these wells have short lifetime production. L1 has lifetime running production below 1000 days but L3 dan H4 have lifetime

running production above 1000 days. Chan Plot method also determines well L2 indicates bottom water drive coning, channelling that cause this well short lifetime only 100 days. Decline Curve Analysis Sectorization is performed based on reservoir properties (porosity, permeability and saturation) to get Statistical Calculations on the distribution of property data (porosity, saturation, permeability) and create simplification of tabulation into grouping or sectorization for each property data into three sectors: good sector, moderate sector, and poor sector. Determining the decline curve type using OFM software for each of reservoir L and H and forecasting production until the production rate limit, also determining Ultimate Recovery (UR), Recovery Factor (RF), and Remaining Reserves (RR) to get 2 scenarios which are Base case and workover. In the base case scenario, by producing from the existing wells L-3 and H-4, a production gain of 738 MSTB was achieved. In scenario 2, by conducting workovers (WO) and producing from the existing wells along with the three workover wells, L-1, L-2 and L-4, a production gain of 1,869 MSTB. At the end, the best scenario is going to be used to produce 1,869 MSTB from the 5 idle wells (L3, H4, L1, L2 and L4).

**Keywords:** Recovery Factor, Sectorization Decline Curve Analysis, Channelling, Water Coning, Remaining Reserve

## I. INTRODUCTION

One of the causes of declining production in many oil wells in Indonesia because they are marginal oil field. Therefore, efforts are made to maintain daily oil production by maximizing the output from these aging wells and utilizing abandoned wells through reactivation, drilling, and water injection. One way to optimize production is by predicting the future performance of the reservoir.

L-1 well began production in 2001, but on January 28, 2002, it encountered problems with the Sub Surface Valve, causing the well to be shut in. In 2005, repairs were made to the well, allowing it to resume production. However, on September 23, 2008, issues arose with the Surface Control Sub Surface Safety Valve (the control system at the wellhead was damaged). On September 15, 2014, swabbing was performed, but the well remained non-productive. Then, on December 24, 2016, capillary tube injection (gas source from the annulus of H-4 well) was conducted, which enabled the well to produce but only to the tank. There is no production data from 2014 to 2016.

One of the reasons for the decline in production at L-2 well began with spud-in in 1983. It was put on production in December 2001, but was shut down in 2002 when the FPSO (Floating Production Storage and Offloading) contract expired. In 2004, the well was re-shut in, and there was no production flow. L-3 well was shut in in 2006 due to FPSO issues but resumed production later with a water cut dropping to 50%. In 2007, the well was closed due to a leak in the SCSSV control line. It resumed production again in 2014 until 2016. H-4 well spud in 2004, but production suddenly decreased in 2013, and since then, the well has been opened and closed multiple times. In 2015, the choke was reduced and then increased, continuing until 2017.

The issue at hand is that the recovery factor (RF) remains at 19.27%, with production reported in December 2017 from L-3 and H-4 wells. Afterward, there was a force majeure issue when the FSO (Floating Storage Offloading) LGS malfunctioned, leading to both wells being shut down, and currently, the LGS structure is non-productive. Location of L-1, L-2, L-3, H-4 wells are on Figure 1. Field background can be viewed on Figure 2**.**

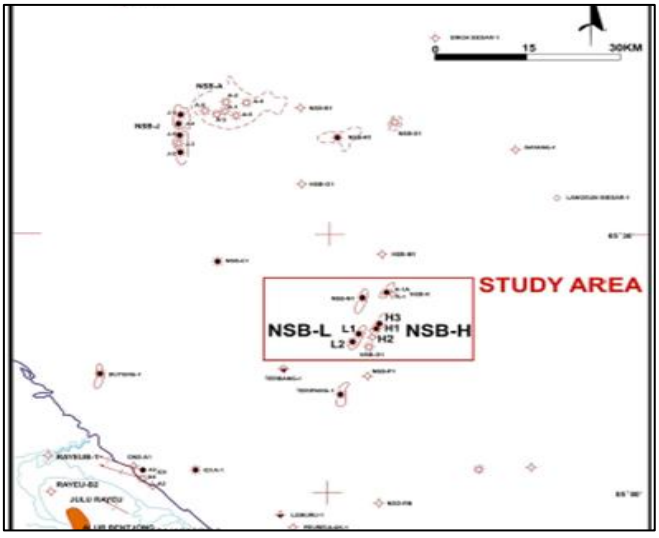


**Figure 1. Location of L-1, L-2, L-3, H-4**

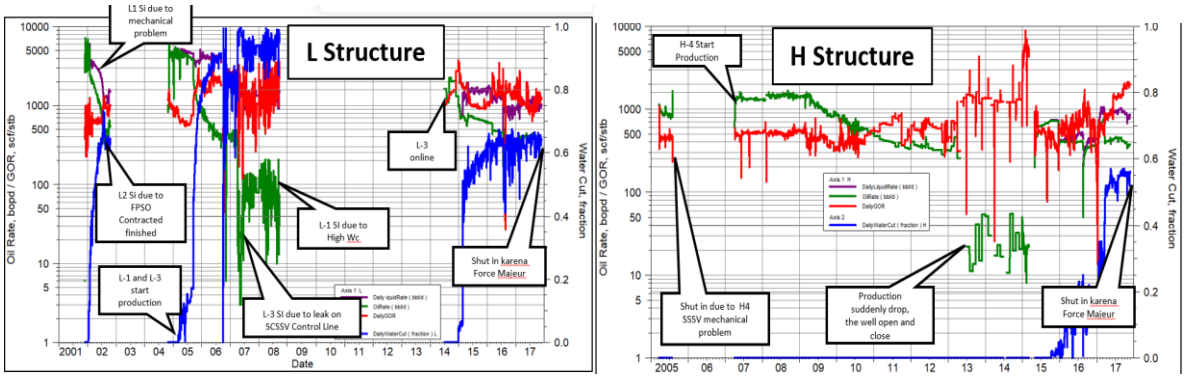


**Figure 2.** Field Background of L and H Structure

## II. PURPOSE AND OBJECTIVE

1. To identify the causes of the non-production of wells L-1, L-2, L-3, and H-4 using the Chan Diagnostic Plot method.
2. To determine the Estimated Ultimate Recovery (EUR) and Remaining Reserves (RR) for the LGS field structure.
3. To conduct a Decline Curve Analysis (DCA) using sectorization on the "L" and "H" structures of the LGS field and obtain the scenario base case and scenario workover for improving the Recovery Factor (RF) in the LGS field.

## III. LITERATURE REVIEW

The issue as mentioned above is that the recovery factor drainage is still at 19.27%. The next step is to evaluate the production of the wells using Diagnostic plot method and Decline Curve Analysis Sectorization. To identify the causes of the non-production of wells L-1, L-2, L-3, and H-4 using the Chan Diagnostic Plot method. By using the Chan Plot method, it can be determined that the causes of the issues in the H and L field structures are short lifetimes well and rapidly increasing water cuts, resulting in non-production in wells L-1, L-2, L-3, and H-4. Chan Diagnostic is a new method developed and verified to determine the mechanisms of excessive water and gas production in oil production wells. Chan's approach involves observing log-log plots of the Water-Oil Ratio (WOR) and the WOR vs. time to understand the water behaviour issues in production wells. Figure 3**.** illustrates the Chan Diagnostic Plot. This plot is used to analyse and diagnose the causes behind the water production in a well, providing valuable insights into the well's performance and helping to predict future production behaviour.

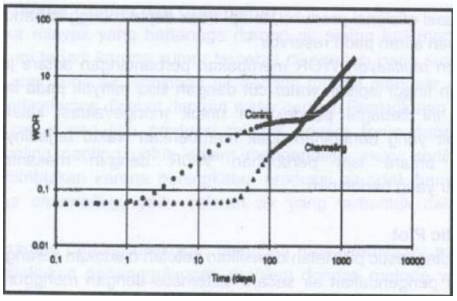


**Figure 3.** Comparison of WOR between Coning and Channeling *(Chan, K.S., 1996)*

This research program to be conducted based on decline curve analysis, a method that can be used to forecast recovery factors from an oil reservoir based on PVT data, rock characteristics, and reservoir fluids is the JJ. Arps method. According to JJ. Arps (1944), there are three types of production decline characteristics: exponential decline (where b = 0), hyperbolic decline (where $0 \leq b \leq 1$), and harmonic decline (where b = 1) (Rukmana, 2012), the plot as shown below Figure 4.

## METHODOLOGY

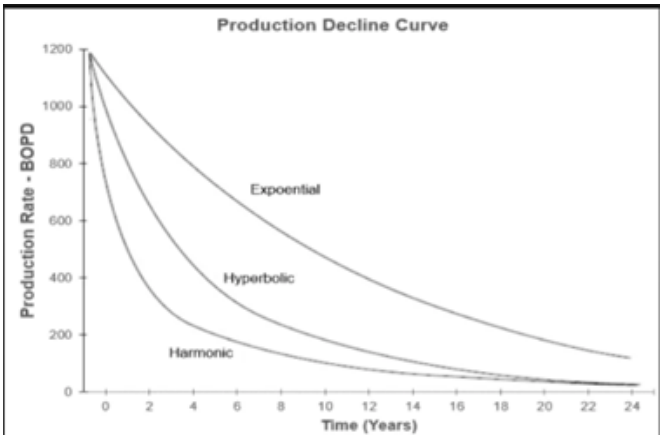


**Figure 4.** Decline Curve Analysis

Sectorization of DCA is performed based on reservoir properties. The combination of 3D property model data with the Decline Curve Analysis (DCA) method can help estimate areas within a field that are not yet optimized. A relatively simple approach is to divide the field into several sectors based on reservoir characteristics, such as:

- Porosity
- Permeability
- Saturation

The data grouped are taken from the saturation and porosity maps. Then, combine the values from the saturation map and the porosity map into a single value by performing calculations to obtain one value that represents both properties. This calculation uses the HCPV equation. Hydrocarbon Pore Volume (HCPV) is defined as the volume of hydrocarbons contained in a reservoir. It represents the portion of the total pore volume that is filled with hydrocarbons, including oil and gas, and is a key parameter for reservoir characterization and resource estimation. The equation for HCPV can be written as:

$$HCPV = 7758 + Vb + \phi + (1 - Swi) \quad (1)$$

Then combine the sectorization of HCPV map with the permeability map. All maps are processed in Petrel software.

## IV. METHODOLOGY

The explanation of the methodology is defined as below:

1. Data Collection includes:
   a. Oil flow rate (qo, bopd)
   b. Fluid flow rate (ql, bfpd)
   c. Cumulative oil production (Np, bopd)
   d. Data on porosity, permeability, and saturation properties

2. Statistical Calculations on the distribution of property data (porosity, saturation, permeability)
3. Simplification of Tabulation into grouping or sectorization for each property data into three sectors: good sector, moderate sector, and poor sector.
4. Creation of overlays for each property data, using red for the good sector, yellow for the moderate sector, and blue for the poor sector.
5. Merging the three overlays into one, incorporating the following transmissibility equation with its sectorization.
6. Reconstruction and production performance analysis, plotting the graphs:
   a. Oil flow rate vs. time
   b. Fluid flow rate vs. time
7. Determining the decline curve type using OFM software and identifying the decline rate.
8. Forecasting production until the production rate limit.
9. Determining Ultimate Recovery (UR), Recovery Factor (RF), and Remaining Reserves (RR).
10. Best development scenario.

## V. DISCUSSION

This research is conducted to analyse the existing conditions with an OOIP of 28.33 MMSTB, while cumulative production is 5.46 MMSTB (RF: 19.27%). The issue is that the recovery factor remains at 19.30%. The causes include low well lifetimes for wells L-1 (high water cut), L-2 (high water cut), and a force majeure situation in well L-3 (shut in), as well as integrity problems in well H-4. All four wells are currently suspended.

This study evaluates the production of these wells using the Chan Diagnostic Plot method and decline curve analysis with sectorization. These analyses aim to determine whether the wells still have reserves if reactivated, as well as to assess channelling and water coning.

This research is expected to be beneficial for the company in obtaining the best scenario for the development of the LGS field, aimed at improving the recovery factor of production. The stages of the analysis and calculations used are as follows:

## VI. EUR Calculation using JJ ARPS method

The calculation is continued by finding Estimated Ultimate Recovery (EUR), Estimated Remaining Reserve (ERR) and Recovery Factor (RF). Estimated Ultimate Recovery (EUR) is an estimation of the amount of oil reserves that can be produced according to the technology, economic conditions, and regulations in place at that time, and produced until its economic limit. Estimated Remaining Reserve (ERR) is an estimation of the remaining reserves in the reservoir that can be produced with the existing technology. The value of EUR, ERR, and RF maximum can be calculated by using equations as below and seen as below Table 1. :

The equation used for a reservoir with water drive as the driving mechanism is typically represented as Equation 2.

$$RE_{Water\ Drive} = 54.898 \times \left(\frac{\phi(1-S_w)}{B_{oi}}\right)^{0.0422} \times \left(\frac{k}{1000} \cdot \frac{\mu_{wi}}{\mu_{oi}}\right)^{0.0770} \times (S_w)^{-0.1903} \times \left(\frac{P_i}{P_a}\right)^{-0.2159} \quad (2)$$

$$EUR = OOIP \times RF \quad (3)$$

$$ERR = EUR - Npt \quad (4)$$

Where:

OOIP = Original Oil in Place, MSTB
EUR = Estimate Ultimate Recovery
ERR = Estimate Remaining Reserve
Npt = Cumulative Production (limit)

Table 1. JJ Arps Method

| Field | Struktur | Lapisan | Drive Mechanism | Recovery Efficiency (%) | ∅ (Fraksi) | $S_w$ (Fraksi) | $B_{oi}$ (Bbl/STB) | k (mD) | $\mu_{wi}$ (cp) | $\mu_{oi}$ (cp) | $P_{Initial}$ (Psi) | $P_{Bubble}$ (Psi) | $P_{Abandon}$ (Psi) | Inplace (MSTB) | EUR (MSTB) | NP Exsisting (MSTB) | Remaining (MSTB) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Langsa | H | Malacca Limestone | Water Drive | 35.84% | 0.12 | 0.25 | 1.231 | 100 | 1 | 0.8 | 2270 | 2017 | 325 | 16275.5 | 5833.6 | 2435 | 3398.6 |
| Langsa | L | Malacca Limestone | Water Drive | 37.45% | 0.1 | 0.17 | 1.61 | 110 | 1 | 0.8 | 2514 | 2773 | 325 | 12014.7 | 4499.8 | 3160 | 1339.8 |

## VII. Chan Plot Diagnostic Analysis

By using the Chan Plot method, it can be determined that the causes of the issues in the H and L field structures are short lifetime wells and rapidly increasing water cuts, resulting in non-production in wells L-1, L-2, L-3, and H-4.

Chan Plot method determines well L-1, L-3 & H-4 indicate Rapid channelling that cause these wells have short lifetime production. L-1 has lifetime running production below 1000 days but L-3 dan H-4 have lifetime running production above 1000 days

Chan Plot method determines well L-2 indicates bottom water drive coning and channelling that caused this well has short lifetime only 100 days.

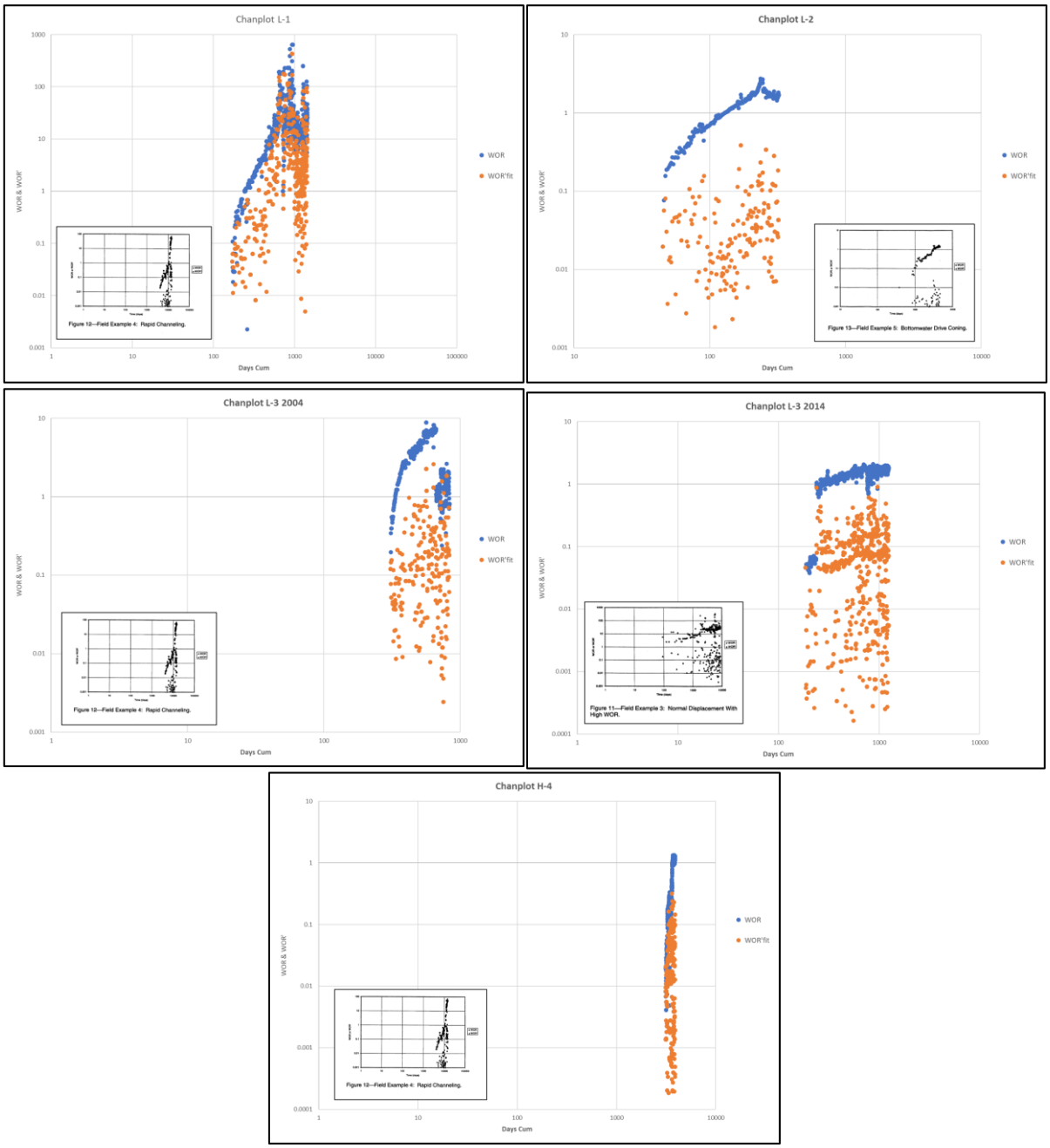


**Figure 5.** Chan Plot of L-1, L-2, L-3, H-4

The Chan Plot diagnostic analysis as in Figure 5**.** indicates the presence of rapid channeling in several wells, as well as coning and normal displacement in some wells. The rapid increase in water makes the wells in the LGS structure uneconomical, despite still having potential. Therefore, a decline curve analysis is conducted to determine the Estimated Ultimate Recovery (EUR) from both reservoirs.

## VIII. Decline Curve Sectorization

As explained on previous page in literature review about Decline Curve Sectorization. All properties data are taken and processed in Petrel software and the appearance shown as below Figure. The LGS Structure, Reservoir L and H. The GnG team has analysed the distribution of HCPV in both reservoirs, as shown below on Figure 6. The distribution of permeability in both reservoirs shown on Figure 7 as below :

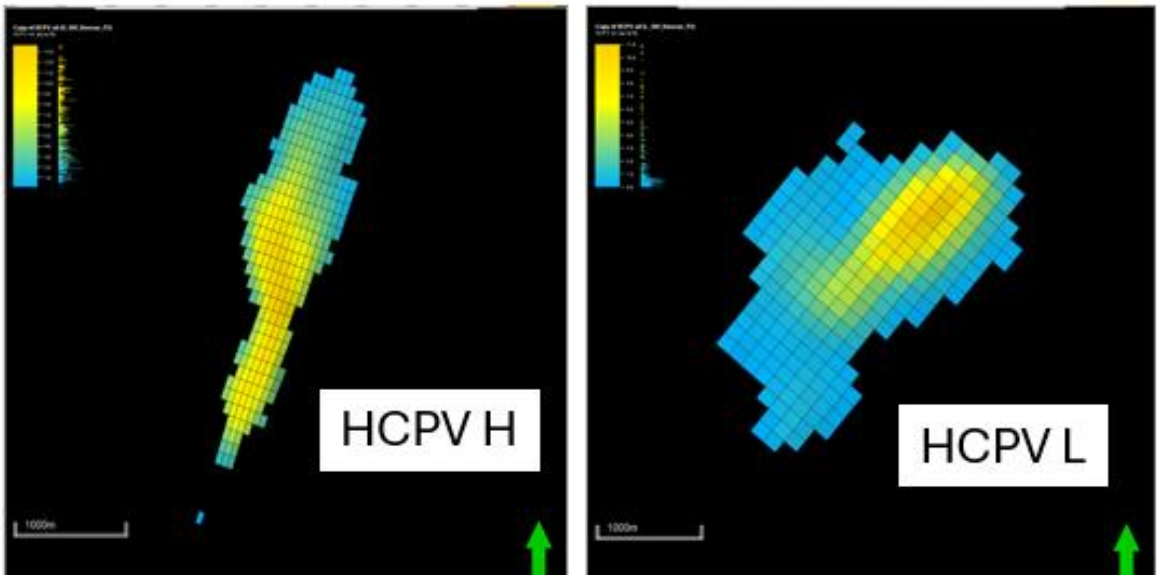


**Figure 6.** Distribution of HCPV in Reservoir H and L

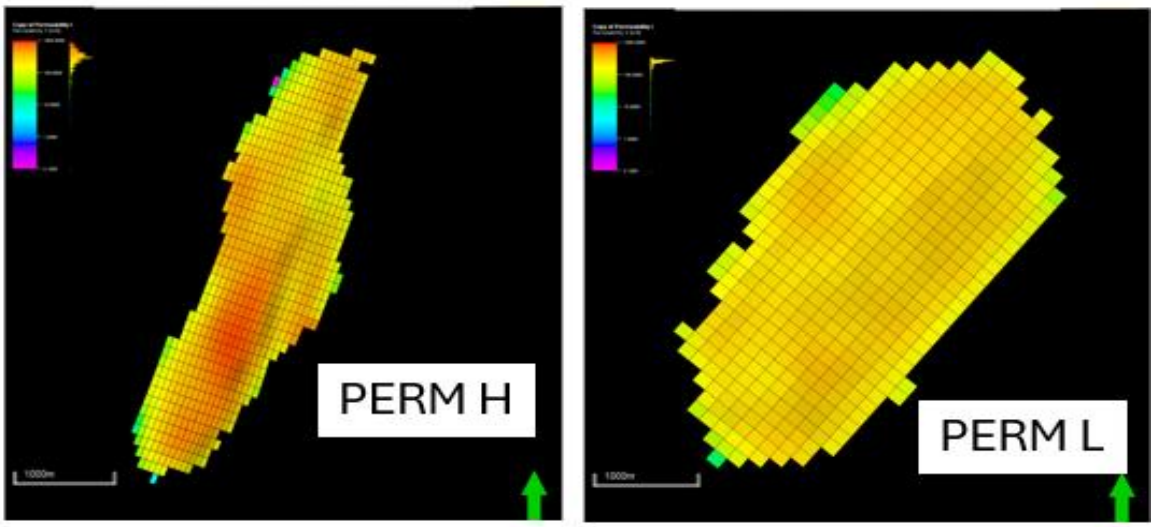


**Figure 7.** Distribution of Permeability in Reservoir H and L

Both properties will be used to conduct sectorization analysis using statistical methods. The grouping of HCPV and permeability sectors is done by first determining the class intervals. After establishing the classes, the two properties will be cross-tabulated to create a sectorization map, as shown in Figure 6 and 7.

The first step is to distribute the property data which are porosity, permeability, and saturation, which are obtained from exporting data from Petrel. This is followed by creating statistical tabulations for each property data, including the highest value, lowest value, number of data classes, class, data range, data interval, median, and frequency. Before creating the statistics for porosity and saturation, both data sets are overlaid first by performing calculations to obtain a single value representing both. This calculation uses the Transmissibility equation, where porosity data is obtained from the field, the layer thickness is considered proportional, meaning the thickness is assumed to be the same, and the oil saturation is from the field data, thus yielding the Hydrocarbon Pore Volume data.

The next step is to determine the type of decline curve using the trial-and-error method and the $X^2$ chi-squared test by creating a tabulation that includes the well number, time (t),

actual production rate (q actual), forecasted production rate (q forecast), and the difference (Di) for various values of b, along with the $X^2$ value (the difference between q actual and q forecast). The value of b is assumed to range from 0 to 1 (b = 0 for exponential, b = 0.1-0.9 for hyperbolic, and b = 1 for harmonic). The procedure is repeated to calculate subsequent data for each well sector. The sector with the smallest $\Sigma X^2$ value indicates the lowest error degree between the actual and forecasted data, and it determines the type of decline curve used, as well as the decline rate. Based on the trial and error and $X^2$ chi-squared test results, all sectors follow an exponential decline curve type.

## IX. RESULT

The calculations are performed in excel software and the result of the sectorization Reservoir H and L are as below :

**Reservoir H**

HCPV Sectorization of Reservoir H can be seen as below Table 2.

**Table 2.** HCPV Sectorization of Reservoir H

| Number of Class | Class Interval | | Middle Interval | Frequency | Frequency | Cumulative Frequency |
|---|---|---|---|---|---|---|
| | Lower | Upper | | | % | % |
| Poor | 0 | 11798 | 5899 | 90 | 24.86 | 24.86 |
| Moderate | 11798 | 74136 | 42967 | 181 | 50.00 | 74.86 |
| Good | 74136 | 150143 | 112139 | 91 | 25.14 | 100.00 |

Permeability Sectorization of Reservoir H can be seen as below Table 3.

**Table 3.** Permeability Sectorization of Reservoir H

| Number of Class | Class Interval | | Middle Interval | Frequency | Frequency | Cumulative Frequency |
|---|---|---|---|---|---|---|
| | Lower | Upper | | | % | % |
| Poor | 2 | 217 | 110 | 186 | 25.10 | 25.10 |
| Moderate | 217 | 412 | 315 | 370 | 49.93 | 75.03 |
| Good | 412 | 857 | 634 | 185 | 24.97 | 100.00 |

The grouping of HCPV and permeability sectors in Reservoir H is conducted by first determining the class intervals. After establishing the classes, the two properties will be cross-tabulated to create a sectorization map, as shown in Figure 8. Next, statistics are created for the HCPV and permeability data, and each data set is simplified into 3 classes. These three classes for each property are then designated as sectors, visualized through an overlay on each data set. The sectors are categorized as good (marked in red), moderate (marked in yellow), and poor (marked in blue). The two data sets are then combined to form 9 HCPV-Permeability sectors (HCPV bad - Poor permeability, HCPV bad - Moderate permeability, HCPV bad - Good permeability, HCPV moderate - Poor permeability, HCPV moderate - Moderate permeability, HCPV moderate - Good permeability, HCPV good - Poor permeability, HCPV good - Moderate permeability, HCPV good - Good permeability) which are simplified into 3 sectors by finding the lower quartile and upper quartile values using linear interpolation. In the end, the good

sector will have good transmissibility and good permeability, the moderate sector will have moderate transmissibility and permeability, and the poor sector will have poor transmissibility and poor permeability. The sector distribution can be validated using well data; if a well has a large cumulative value, it is likely in a sector with good transmissibility and permeability.

After the sectoring is complete, the next step is to plot the positions of the wells based on the obtained data. The result of sectoring the production wells in H Structure is as follows (by class interval):

- **Good Sector**: Permeability range is 412 – 857
  HCPV range is 74136 - 150143

- **Moderate Sector**: Permeability range is 217 - 412
  HCPV range is 11798 - 74136

- **Poor Sector**: Permeability range is 2 - 217
  HCPV range is 0 - 11798

The sectorized wells are then subjected to a Decline Curve Analysis (DCA) for each sector in order to estimate future development plans. From the grid map of reservoir H below, it can be defined:

- Good Sector: H-1, H-4
- Moderate Sector: H-3
- Poor Sector: H-2

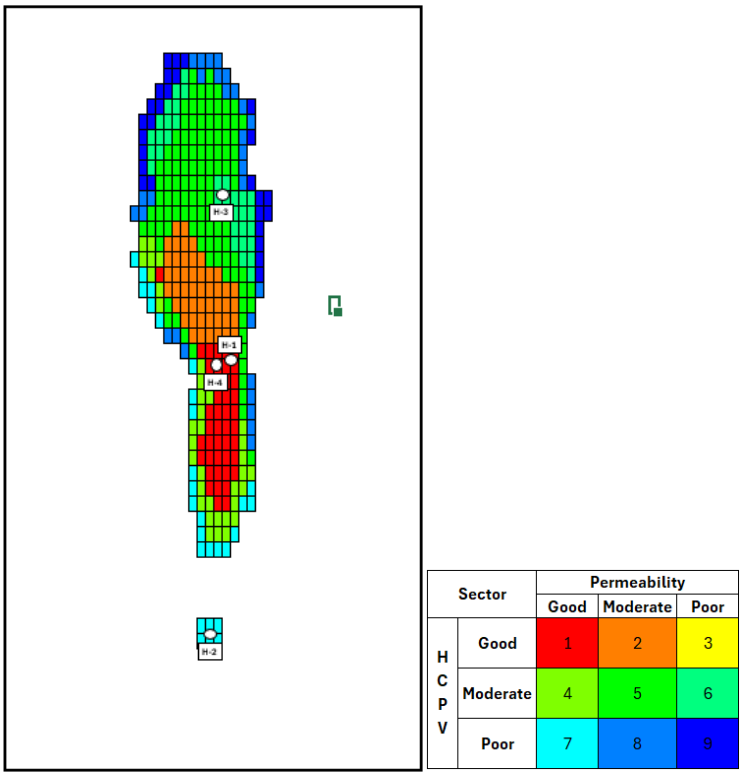


Figure 8. Sectorization Map of Reservoir H

**Reservoir L**

HCPV Sectorization of Reservoir L can be seen as below Table 4.

**Table 4.** HCPV Sectorization of Reservoir L

| Number of Class | Class Interval | | Middle Interval | Frequency | Frequency | Cumulative Frequency |
|---|---|---|---|---|---|---|
| | Lower | Upper | | | % | % |
| Poor | 4 | 3299 | 1651 | 60 | 25.32 | 25.32 |
| Moderate | 3299 | 59021 | 31160 | 118 | 49.79 | 75.11 |
| Good | 59021 | 321607 | 190314 | 59 | 24.89 | 100.00 |

Permeability Sectorization of Reservoir L can be seen as below Table 5.

**Table 5.** Permeability Sectorization of Reservoir L

| Number of Class | Class Interval | | Middle Interval | Frequency | Frequency | Cumulative Frequency |
|---|---|---|---|---|---|---|
| | Lower | Upper | | | % | % |
| Poor | 19 | 218 | 119 | 113 | 25.17 | 25.17 |
| Moderate | 218 | 276 | 247 | 225 | 50.11 | 75.28 |
| Good | 276 | 347 | 312 | 111 | 24.72 | 100.00 |

The grouping of HCPV and permeability sectors is conducted by first determining the class intervals. After establishing the classes, the two properties will be cross-tabulated to create a sectorization map, as shown in the Figure 9 as below. The result of sectoring the production wells in L structure is as follows (by class interval):

- **Good Sector**: Permeability range is 276 - 347
  HCPV range is 59021 - 321607

- **Moderate Sector**: Permeability range is 218 - 276
  HCPV range is 3299 -59021

- **Poor Sector**: Permeability range is 19 - 218
  HCPV range is 4 -3299

From the grid map of Reservoir L below, it can be defined:

- Good Sector: L-1, L-3, L-4
- Moderate Sector: L-2

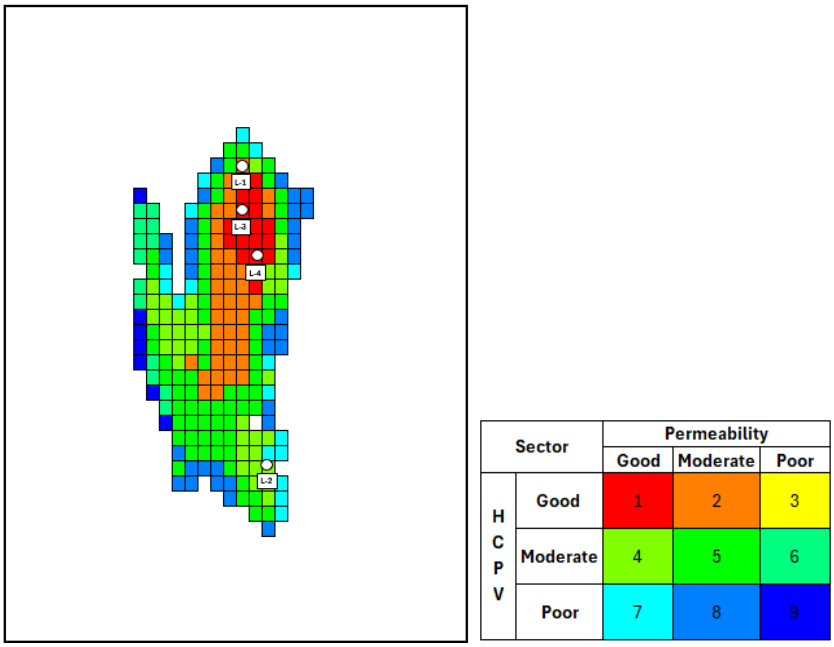


**Figure 9.** Sectorization Map of Reservoir L

## Decline Curve Analysis by Sector

Decline curve analysis can assess the potential of the "L" and "H" structures if there are no issues with channelling or water coning. The results of the DCA sectorization, with lines converging to a single point, indicate that the sector is not suitable for development as it is already mature. However, for DCA with parallel lines, it suggests that there is still potential for development. Here are DCA result on each well in structure L and H which is calculated from OFM (Oil Field Manager) software:

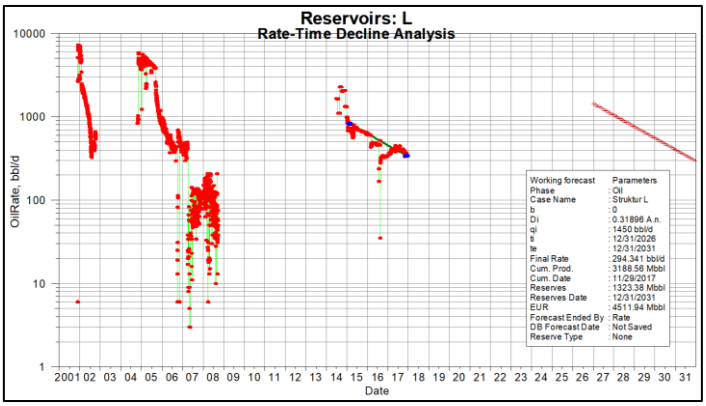


**Figure 10.** Decline Curve Analysis for Reservoir L

Figure 10 shows the decline curve analysis for Reservoir L, where a decline rate of 31.89% was obtained by considering the decline from 2015-2017. The EUR (Estimated Ultimate Recovery) that can be obtained from Reservoir L is 4.5 MMSTB, with current cumulative production at 3.1 MMSTB, this is indicating a remaining reserve of 1.3 MMSTB."

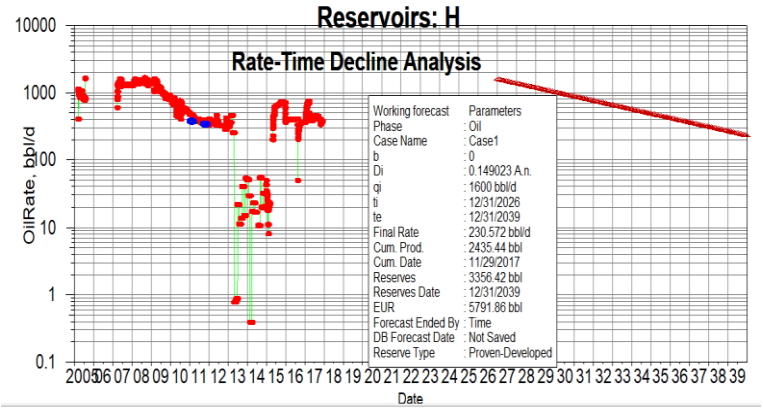


**Figure 11.** Decline Curve Analysis for Reservoir H

Figure 11. shows the decline curve analysis for Reservoir H, where a decline rate of 14.9% was obtained by considering the decline from 2010-2012. The EUR (Estimated Ultimate Recovery) that can be obtained from Reservoir H is 5.79 MMSTB, with current cumulative production at 2.43 MMSTB, this is indicating a remaining reserve of 3.3 MMSTB.

From those two analyses, it can be concluded that the LGS structure, which consists of Reservoir L and Reservoir H, still has potential with remaining reserves of 4.6 MMSTB. This will be discussed in this paper regarding the development of the LGS structure using the sectorization and decline curve methods.

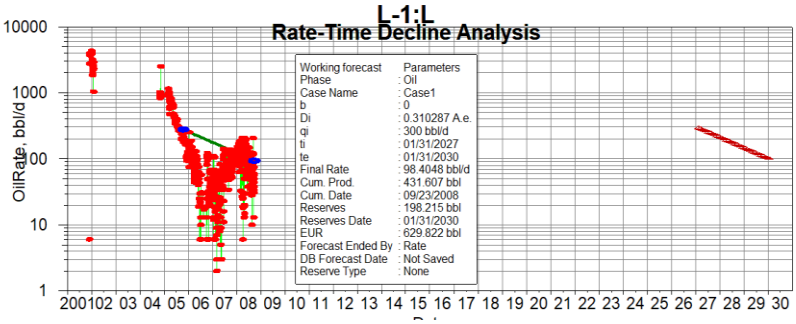


**Figure 12.** Decline Curve Analysis for Reservoir L-1

Figure 12 shows the decline curve analysis for the L-1 Reservoir well, with a decline rate of 31% based on data from 2005 to 2008. The Estimated Ultimate Recovery (EUR) from the L1 Reservoir is 0.629 MMSTB, and the cumulative production to date is 0.43 MMSTB, leaving a remaining reserve of 0.19 MMSTB. The initial rate is 300 bopd.

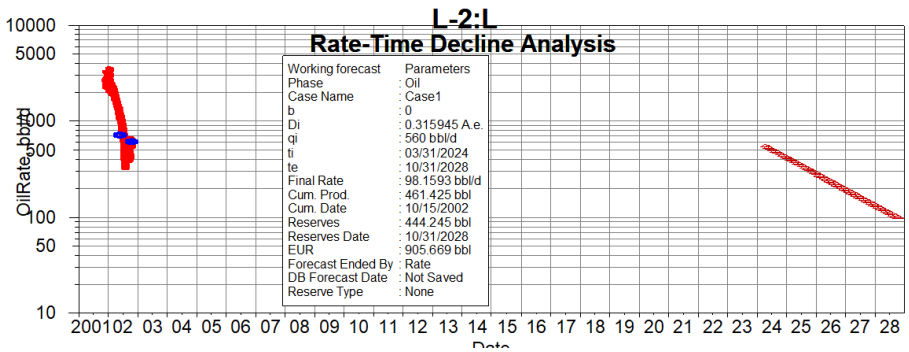


**Figure 13.** Decline Curve Analysis for Reservoir L-2

Figure 13 shows the decline curve analysis for the L-2 Reservoir well, with a decline rate of 31% based on data from 2017. The Estimated Ultimate Recovery (EUR) from the L-2 Reservoir is 0.90 MMSTB, and the cumulative production to date is 0.46 MMSTB, leaving a remaining reserve of 0.44 MMSTB. The initial rate is 560 bopd.

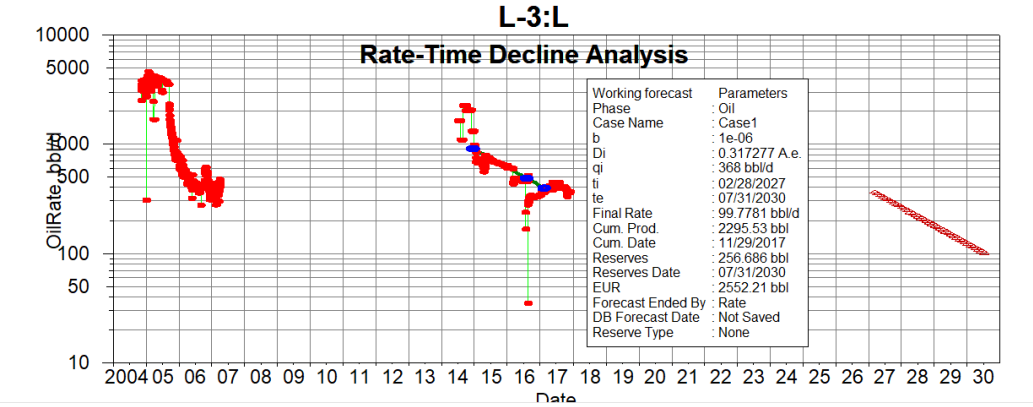


**Figure 14.** Decline Curve Analysis for Reservoir L-3

Figure 14 shows the decline curve analysis for the L-3 Reservoir well, with a decline rate of 31% based on data from 2014 to 2017. The Estimated Ultimate Recovery (EUR) from the L-3 Reservoir is 2.552 MMSTB, and the cumulative production to date is 2.29 MMSTB, leaving a remaining reserve of 0.256 MMSTB. The initial rate (Qoi) is 368 opd.

Note: The DCA results for L-3 are used for workover (WO) of well L-4.

## FORECASTING SCENARIO

There are two development scenarios which will be discussed on this paper:

- Scenario I: Base case
- Scenario II: Base case + workover

**Scenario 1 – Base case**

In Scenario I, optimization is carried out first on the existing wells by screening the wells with high potential and production rates that are still high when the well stops producing. The two proposed wells for re-optimization are L-3 and H-4. Based on the production potential of the wells, forecasting 2 wells is performed. After this, a base rate for each well is obtained, and the wells are reopened.

Scenario wells that we have analyzed are well L-3 and H-4 because this well is the last to produce among the other wells and has been shut in due to a force majeure. This scenario is using the latest oil rate from each well as well as the decline rate from each well, as shown in the Table 6:

**Table 6.** Parameter of Base Case Scenario 1

| Parameter | | | | | |
|---|---|---|---|---|---|
| **Scenario** | **Structure** | **Well** | **Last Rate Production, BOPD** | **Decline Rate, %** | **Oil Rate Limit, BOPD** |
| Base case | L | L-3 | 368 | 31.72 | 100 |
| | H | H-4 | 378 | 19.04 | 100 |

From these parameters, the forecast results are tabulated as follows, Table 7:

**Table 7.** Forecast Result of Scenario 1

| Forecast Result | | | | |
|---|---|---|---|---|
| **Scenario** | **Structure** | **Well** | **Gain Oil, MSTB** | **Total Gain Oil, MSTB** |
| Base case | L | L-3 | 256 | 738 |
| | H | H-4 | 482 | |

The comparison Result of Scenario 1, between Current Cumulative Production and Recovery Factor with Forecast result as seen in Table 8:

**Table 8.** Comparison Result of Scenario 1

| **Scenario** | **Structure** | **OOIP** | **Current NP** | **RF Current** | **Forecast** | | |
|---|---|---|---|---|---|---|---|
| | | | | | **EUR** | **Remaining** | **RF** |
| | | **MMSTB** | **MMSTB** | **%** | **MMSTB** | **MMSTB** | **%** |
| Base case | L | 12.02 | 3.18 | 26.45 | 3.44 | 0.26 | 28.62 |
| | H | 16.31 | 2.43 | 14.89 | 2.91 | 0.48 | 17.84 |

From the Scenario I forecast result, RF value becomes 28.62 % in L-3 and RF 17.84 % in H-4.

**Scenario 2 – Base case + WO**

Scenario II builds on Scenario I by adding two workover wells with the aim of depleting areas not covered by the existing wells. The workover well is placed in an area with a large oil potential unit to maximize extraction. To find the base rate for the workover well. The wells that will be forecasted in scenario 2 are wells L-3 and H-4 as existing wells, and L-1, L-2 and L-4 which will undergo workovers (WO). The forecast will use the latest oil rates from wells L-3 and H-4, applying a more pessimistic decline rate compared to the existing wells, as shown in the table below, Table 9 :

**Table 9.** Parameter of Base case + WO Scenario 2

| **Parameter** | | | | | | |
|---|---|---|---|---|---|---|
| **Scenario** | **Structure** | **Well** | **Category** | **Last Rate Production, BOPD** | **Decline Rate, %** | **Oil Rate Limit, BOPD** |
| Base case + WO | L | L-3 | Existing | 368 | 31.89 | 100 |
| | | L-1 | WO | 300 | 31.02 | 100 |
| | | L-2 | WO | 560 | 31.59 | 100 |
| | | L-4 | WO | 368 | 31.89 | 100 |
| | H | H-4 | Existing | 378 | 19.04 | 100 |

From these parameters, the forecast results are tabulated as follows, Table 10 :

**Table 10.** Forecast Result of Scenario 2

| Forecast Result | | | | | |
|---|---|---|---|---|---|
| **Scenario** | **Structure** | **Well** | **Category** | **Gain Oil, MSTB** | **Total Gain Oil, MSTB** |
| Basecase + WO | L | L-3 | Existing | 256 | 1869 |
| | | L-1 | WO | 431 | |
| | | L-2 | WO | 444 | |
| | | L-4 | WO | 256 | |
| | H | H-4 | Existing | 482 | |

The comparison Result of Scenario 2, between Current Cumulative Production and Recovery Factor with Forecasting result as seen in ha

**Table 11.** Comparison Result of Scenario 2

| **Scenario** | **Structure** | **OOIP** | **Current NP** | **RF Current** | **Forecast** | | |
|---|---|---|---|---|---|---|---|
| | | | | | **EUR** | **Remaining** | **RF** |
| | | **MMSTB** | **MMSTB** | **%** | **MMSTB** | **MMSTB** | **%** |
| Basecase + WO | L | 12.02 | 3.16 | 26.46 | 4.567 | 1.387 | 38.00 |
| | H | 16.31 | 2.43 | 14.90 | 2.912 | 0.482 | 17.85 |

After determining the base rate, a forecast is made, and Scenario II result, RF value is 38% in L-3 and RF 17.85 % in H-4. The Estimated Ultimate Recovery (EUR) is the accumulation of the oil already produced, plus the cumulative oil expected to be produced until the economic limit is reached. Gain oil result of L-3, H-4, L-1, L-2, L-4 are 256 MSTB, 482 MSTB, 431 MSTB, 444 MSTB, 256 MSTB with total 1.869 MMSTB. The current Recovery Factor (RF) of Scenario 2 which is average to be 38.00 % for L Field and 17.85 % for H Field.

## X. CONCLUSIONS

Diagnostic Chan Plot method determines well L-1, L-3 & H-4 indicates Rapid channelling which cause these wells have short lifetime production. L-1 has lifetime running production 100- 1000 days but L-3 dan H-4 have lifetime running production above 1000 days. Chan Plot method also determines well L-2 indicates bottom water drive coning and channelling which caused this well has short lifetime only 100 days.

The Estimated Ultimate Recovery (EUR) that can be obtained from Reservoir H is 2.91 MMSTB, with current cumulative production at 2.43 MMSTB, it is indicating there are still remaining reserves of 0.48 MMSTB. Decline rate H-4 is 19.04. H-4 is in good sector. The Estimated Ultimate Recovery (EUR) that can be obtained from Reservoir L is 4.567 MMSTB, with current cumulative production at 3.18 MMSTB, it's indicating there are still remaining reserves of 1.387 MMSTB. Decline rate L-1 is 31 %, L-2 is 31 %, L-3 is 31 % and L-4 is 31 %. Wells L-1, L-3 and L-4 are in good sector and L-2 is in moderate sector.

Decline Curve Sectorization creates 2 scenarios which are base case and workover. In the base case scenario, by producing the existing wells L-3 and H-4, a production gain of 738 MSTB was achieved, with recovery factors of 28.62% for well L and 17.84% for well H. This indicates that there is still potential for additional production through the workover (WO) scenario. In scenario 2, by conducting workovers (WO) and producing the existing wells along with the three workover wells, L-1, L-2 and L-4, a production gain of 1,869 MSTB was achieved, with recovery factors of 38 % for well L and 17.85% for well H. This suggests there is still potential for additional production through a workover, although further evaluation is needed.

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# CHAPTER 7

# Study Prediction Development Scenario for Selected Layer to Determine Oil Remaining Using JJ ARPS Method and Simulation Reservoir : A Case Study of Field RSL

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## ABSTRACT

The RSL structure is located approximately 57 km northwest of the Berandan Base and is included in the administrative area of Nanggroe Aceh Darussalam Province. The RSL oil field was discovered in 1979 by Pertamina and have produced until 2022. The formation that developed was the Keutapang Formation. This field is a well-developed field with a total of 65 wells with 32 suspended wells and consists of 14 layers. Based on successful well intervention in 2022, This research focus on study case on RSL Field with focus 3 layer (Y, X and

Z) to get best development scenario. Based on calculation of Ganesh thakur Defines 2 type of Drive Mechanism Water Drive and solution Drive. Data type of drive mechanism (Y,X and Z) was used to measure remaining reserve of 3 layers using JJ Arps method. Layer Y is achieved a maximum RF of 43.99% with an estimated incremental reserve of 1620 MSTB, Layer X obtained a maximum RF of 26.58% with an estimated incremental reserve of 184.4 MSTB and Layer Z obtained a maximum RF of 29.86% with an estimated incremental reserve of 381.1 MSTB. Total incremental reserver using JJ Arp method's is 2185 MSTB. To get development scenario data we run reservoir simulation using numerical methods with forecasting 3 layers with detail data ; Layer Y based on scenario existing and additional 2 workover with existing (OOIP = 1,9 MMSTB RF=16.5 %) results incremental 0.07 MMSTB (RF= 20.1 %). Layer X based on scenario existing and additional 9 workover with existing (OOIP = 11,95 MMSTB RF=32 %) results incremental 1.21 MMSTB (RF= 42.1 %). Layer Z based on scenario existing and additional 1 workover with existing (OOIP = 8,81 MMSTB RF=25.5 %) results incremental 0.23 MMSTB (RF= 28.1 %). Total incremental using reservoir simulation is 1510 MSTB. After prognosing program , a scenario will be developed is 12 workover suspended well.

**Keywords:** Suspended, drive mechanism, reserve , water drive, solution gas drive, , Reservoir simulation, Forecasting,Well Intervention, Workover.

## INTRODUCTION

The RSL Field had been produced since 1979 with Peak Production oil is 8689 bopd at 1983. Currently oil production 1 September 2022 is 671 bopd , 6975 bfpd ,wc 93 % with total of well is 65. Cumulative production 32.27 MMSTB (1 Jan 2022), OOIP 183 MMSTB, with only 29 production well and 32 suspended well, 3 abandon well, 1 injection well. Decreasing production showed at 2017 with 200 bopd. To increasing production , some activities had been done such as well intervention / workover well to get selectiver layer from 14 layer. Period 2017-2022 there were successful program well intervention at Layer Y,X and Z ( RSL-44 , RSL-09, RSL-38 and RSL-59 with range production 50 - 100 bopd). Based on this resulted , this study has purpose to study case development scenario on 3 layers.

Overlook this hidden potency of 3 layers, a Study analysis was delivered using method Ganesh takur to determine type of drive Mechanism and pressure analysis.(*Eoremila, Jurnal Petro 2016*) . The Ganesh Thakur method is one of the methods for determining the type of propulsion, by way of a plot between Np/NVsPr/Pinitial. After get data type drive mechanism , calculate remaining oil reserve, recovery factor by using Metode JJ. Arps is a method. It is used to find the value of the recovery factor of 3 layers based on the type of drive mechanism on the reservoir.

To get best scenario, this study also run simulation reservoir of 3 layers, The simulation reservoir begin with data initialization, forecasting data and evaluation of simulation results. The focus is to get scenario for candidate well intervention and workover well of 3 layers.

## RESEARCH METHODOLOGY

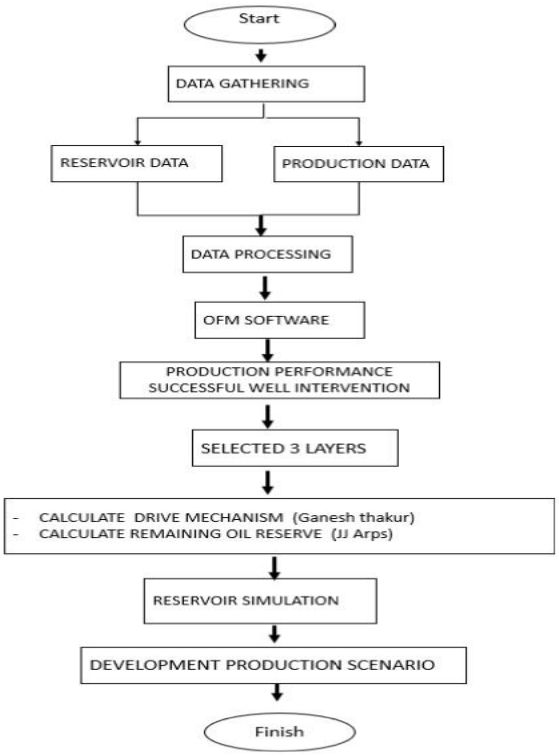


**Figure 1**
Workflow Chart

In order to get development scenario of 3 layers , first step is collecting Subsurface data reservoir and production. . Production data include oil,water, watercut, and GOR production

rate. Next step to select key layer using OFM sosftware for determine increasing production during 2017-2020. It was used to select selective layer Y, X and Z (reference successful well intervention). To calculate type of drive mechanism using Ganesh Takur methods. The reservoir data incluse data on reservoir characteristic and reservoir fluid characteristic (*Ahmed et.al*, 2018). After that , the data to be calculate the intial reserve and recovery factor using JJ Arps Method. After that we got incremental reserve of 3 layers. The simulation reservoir was used to determine development production scenario of 3 layers. Data preparation, data collection, data processing and data validation, Creation and determination of models to be used in simulations based on GGR (Geology Geophysic Reservoir) and petrophysical data, Data input, Initialization and history matching of the reservoir model to be used, Planning of the simulation scenario to be predicted, Implementation of simulations to obtain production performance data, as well as visualization of oil saturation distribution, and Analysis and evaluation of simulation results.
Therefore it conclude to best layer to be choosen based on recovery factor value and incremental reserve oil production.

**Result and Discusion**
The are 3 parts of the analysis and calculations used are as follows:
**Analyses Production Profile using OFM Software**

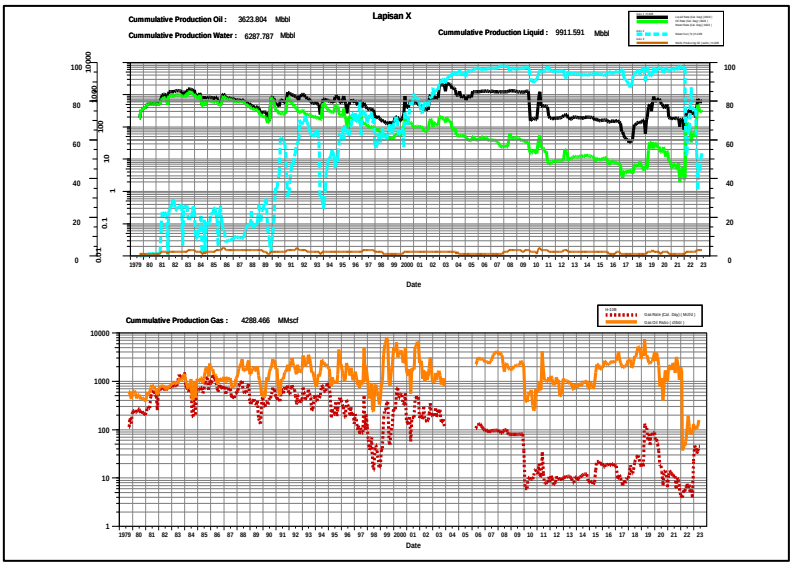


**Figure 2**

Production Profile X Layer

RSL-09 one of successful well intervention at 2020 resolute 100 bopd Cummulative production 43 MSTB, RSL-62 also produces 100 bopd Cummulative production 50 MSTB with followed with RSL-44 with 300 bopd produced in 2022 Cummulative production 501 MSTB . those 3well produced from X Layer

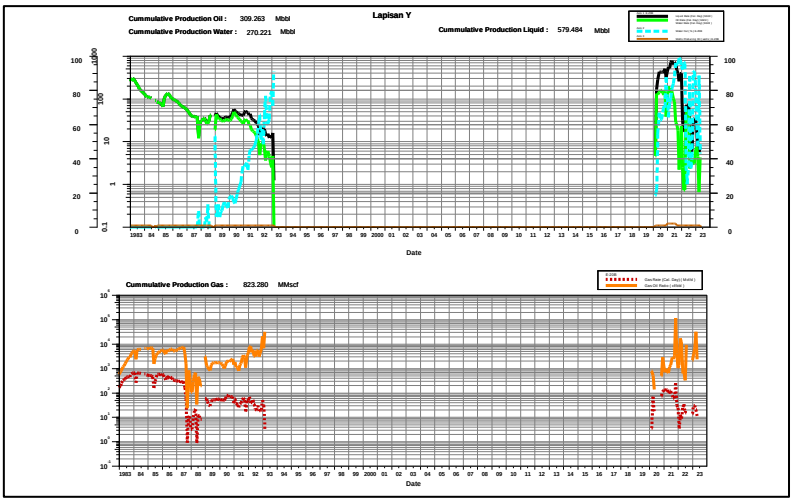


**Figure 3**

Production Profile Y Layer

RSL-38 one of successful well intervention at 2020 resolute 50 bopd Cummulative production 23 MSTB produced from, produced from Y Layer

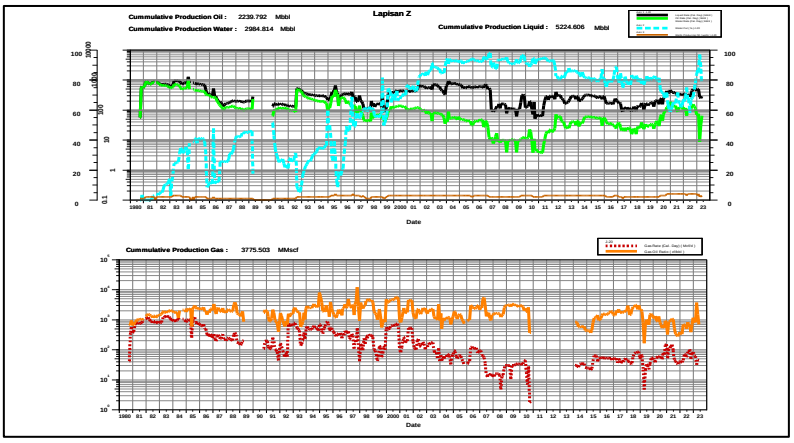


**Figure 4**

Production Profile Z Layer

RSL-59 one of successful well intervention at 2020 resolute 60 bopd, Cummulative production 73.6 MSTB produced from Z Layer

Evaluate from 14 layer so for next step calculation focus on 3 layer , Layer Y, X and Z .

**Analyse Drive Mechanism Analysis and Pressure**

The Ganesh Thakur method is carried out by plotting between production pressure and initial pressure (P/Pi) against the cumulative production with the initial content oil in place (Np/N). After doing calculation obtained P/Pi results and Np/N for each decrease pressure. Based on the results of the overlayed plot with Ganesh Thakur graph shown in Figure 1, it can be seen that the line the Layer Y is parallel to the water influx .

By using the Ganesh Takur method, it can be determined that the type of drive mechanism at Layer Y, X and Z.

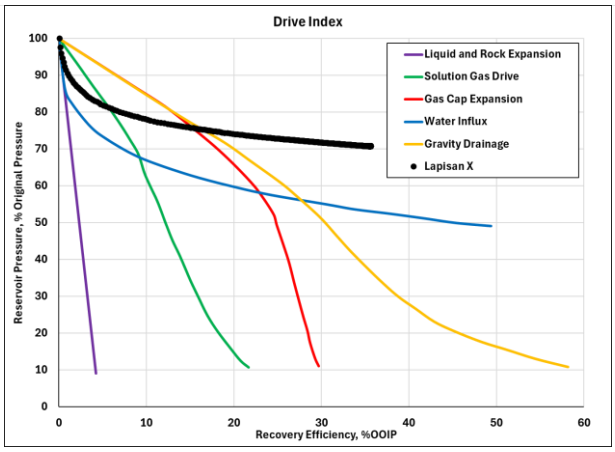


**Figure 5**
Grafik P/Pi versus Np/N Layer Y

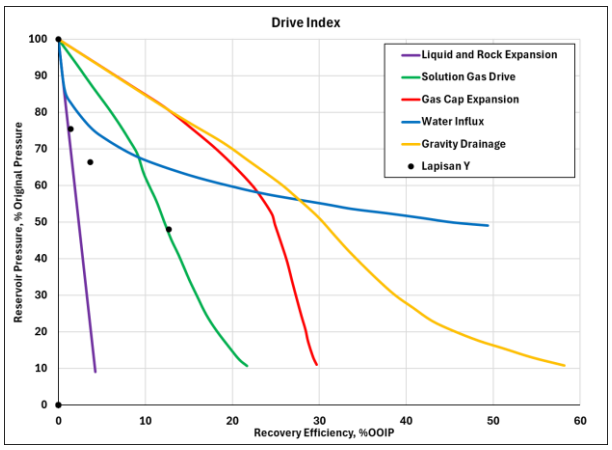


**Figure 6**
Grafik P/Pi versus Np/N Layer X

The Ganesh Thakur method is carried out by plotting between production pressure and initial pressure (P/Pi) against the cumulative production with the initial content oil in place (Np/N). After doing calculation obtained P/Pi results and Np/N for each decrease pressure. Based on the results of the overlayed plot with Ganesh Thakur graph shown in Figure 2, it can be seen that the line the Layer Y is parallel to the solution gas drive .

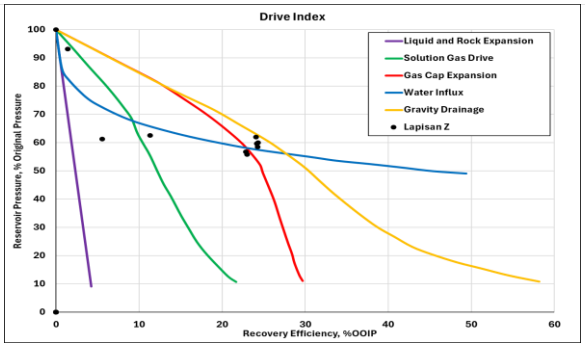


**Figure 7**
Grafik P/Pi versus Np/N Layer Z

The Ganesh Thakur method is carried out by plotting between production pressure and initial pressure (P/Pi) against the cumulative production with the initial content oil in place (Np/N). After doing calculation obtained P/Pi results and Np/N for each decrease pressure. Based on the results of the overlayed plot with Ganesh Thakur graph shown in Figure 3, it can be seen that the line the Layer Y is parallel to the water influx

**Analyse JJ ARPS Analysis**

The analysis indicates 3 layer has different drive mechanism. Therefore, data will be to determine the Estimated Ultimate Recovery (EUR) from evaluate layer reservoirs.

**Tabel 1:** Calculation Remaining reserve ('JJarps')

$$RE_{Water\ Drive} = (54.898) \times \left(\frac{\emptyset(1-S_w)}{B_{oi}}\right)^{0.0422} \times \left(\frac{k}{1000} . \frac{\mu_{wi}}{\mu_{oi}}\right)^{0.0770} \times (S_w)^{-0.1903} \times \left(\frac{P_i}{P_a}\right)^{-0.2159}$$

$$RE_{Solution\ Gas} = (41.815) \times \left(\frac{\emptyset(1-S_w)}{B_{ob}}\right)^{0.1011} \times \left(\frac{k}{1000.\mu_{oi}}\right)^{0.0979} \times (S_w)^{0.3722} \times \left(\frac{P_b}{P_a}\right)^{0.1741}$$

| Lapisan | Drive Mechanism | Recovery Efficiency, % | Ø, Fraksi | Sw, Fraksi | Boi, Bbl/STB | k, mD | $\mu_{wi}$, cp | $\mu_{oi}$, cp | $P_{Initial}$, Psi | $P_{Bubble}$, Psi | $P_{Abandon}$, Psi | Inplace, MSTB | EUR, MSTB | $N_{P\ Existing}$, MSTB | Remaining, MSTB |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| X | Water Drive | 43.99% | 0.25 | 0.44 | 1.31 | 221.42 | 1 | 0.8 | 1174 | 868 | 500 | 11980.00 | 5270.5 | 3650.00 | 1620.5 |
| Y | Solution Gas Drive | 26.58% | 0.19 | 0.50 | 1.21 | 101.00 | 1 | 0.8 | 1021 | 587 | 100 | 1860.00 | 494.4 | 310.00 | 184.4 |
| Z | Water Drive | 29.86% | 0.18 | 0.48 | 1.43 | 118.00 | 1 | 0.8 | 951 | 1130 | 100 | 8710.00 | 2601.1 | 2220.00 | 381.1 |

Paramater data for calculation remaining reserve (Y,X and Z) : Porosity, water saturation water, Oil formation volume factor, permeability, viscosity, oil and water, Initial pressure, Buble pressure, abandon pressure, Inplace layer , Ultimate recovery oil, cumulative production.

Based on the Analysis of the Drive Mechanism of each layer, the calculations in the table above are obtained. Where Layer Y obtained a maximum RF of 43.99% with an estimated remaining reserve of 1620 MSTB, Layer X obtained a maximum RF of 26.58% with an estimated remaining reserve of 184.4 MSTB and Layer Z obtained a maximum RF of 29.86% with an estimated remaining reserve of 381.1 MSTB

From this production data, reservoir and material balance simulations (production data matching history) will be carried out for 3 layers Y, X and Z as the development of the RSL structure field using several scenarios

**Analyse Simulation reservoir**

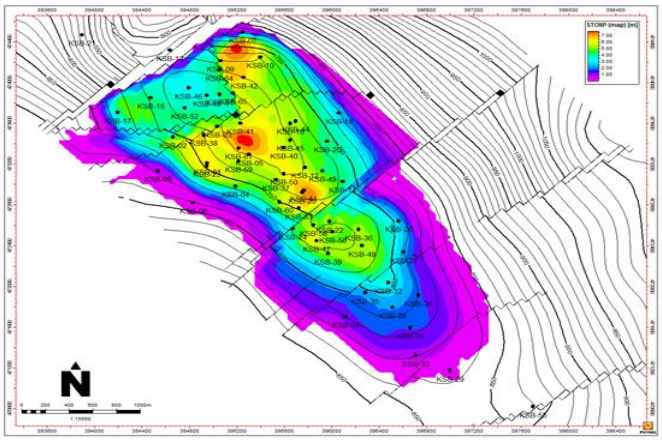

**Figure 8: Static Map RSL Field**

**Tabel-02: STOIIP 2P**

| Layer | STOIIP 2P [MMSTB] | | NP Oil Current (MMSTB) | Current RF Oil to Probabilistic (%) |
|---|---|---|---|---|
| | Deterministik | Probabilistik P50 | | |
| Y | 1.86 | 1.90 | 0.31 | 16.29 |
| X | 11.98 | 11.95 | 3.65 | 30.55 |
| Z | 8.71 | 8.81 | 2.22 | 25.20 |

**Initialization STOIP**

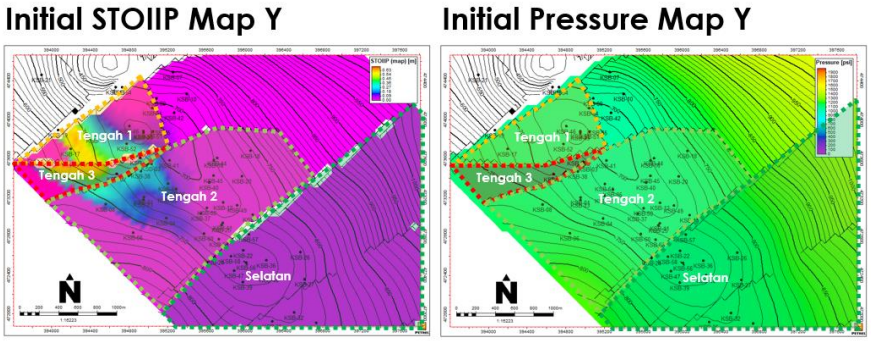


**FIGURE 9**

Initial STOIP and initial Pressure Map Y

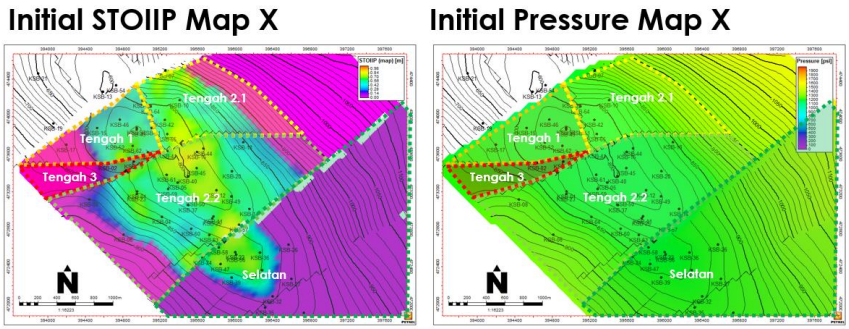


**FIGURE 10**

Initial STOIP and initial Pressure Map X

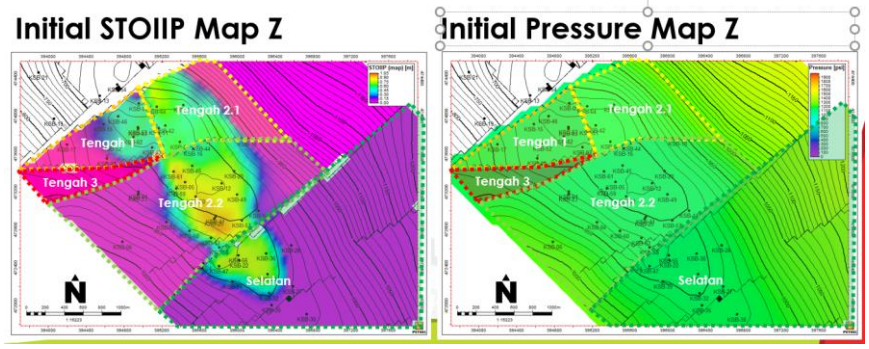


**FIGURE 11:** Initial STOIP and initial Pressure Map Z

**Tabel 3:** Initialization Static VS Dynamic

| Layer | Statis Probabilistic (P50) STOIIP MMSTB | Dinamis STOIIP MMSTB | % Error |
|---|---|---|---|
| Layer Y | 1.90 | 1.88 | -1.2% |
| Layer X | 11.95 | 11.85 | 0.9% |
| Layer Z | 8.81 | 8.85 | 0.5% |

Y

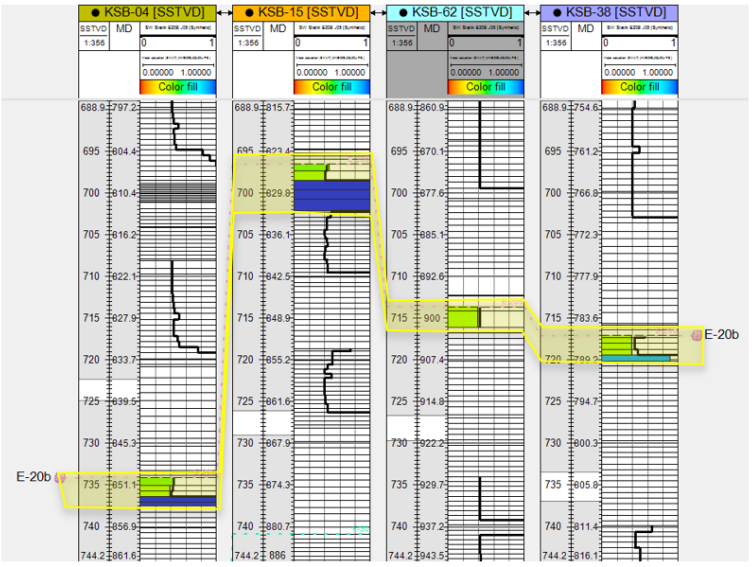


**FIGURE 12:** Comparation SW Static and Dynamic Y Layer

X

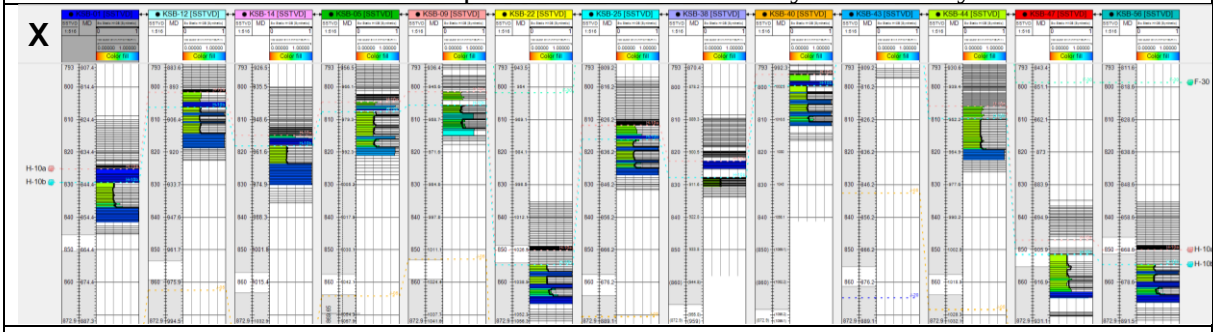

**FIGURE 13:** Comparation SW Static and Dynamic X Layer

Z

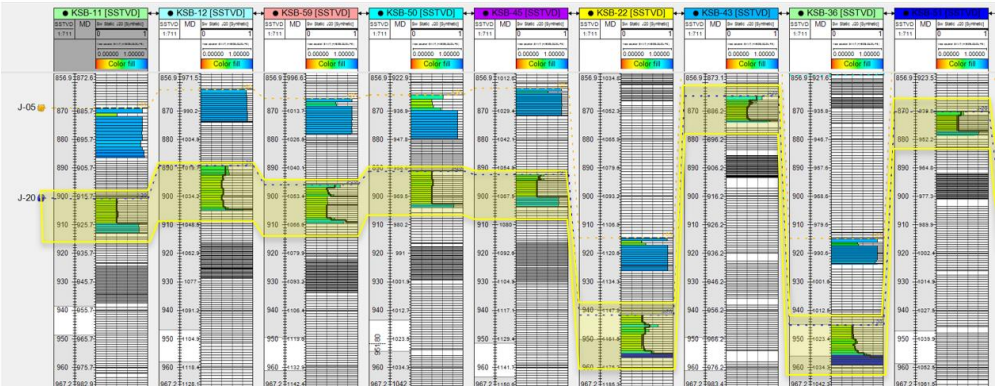


**FIGURE 14:** Comparation SW Static and Dynamic X Layer

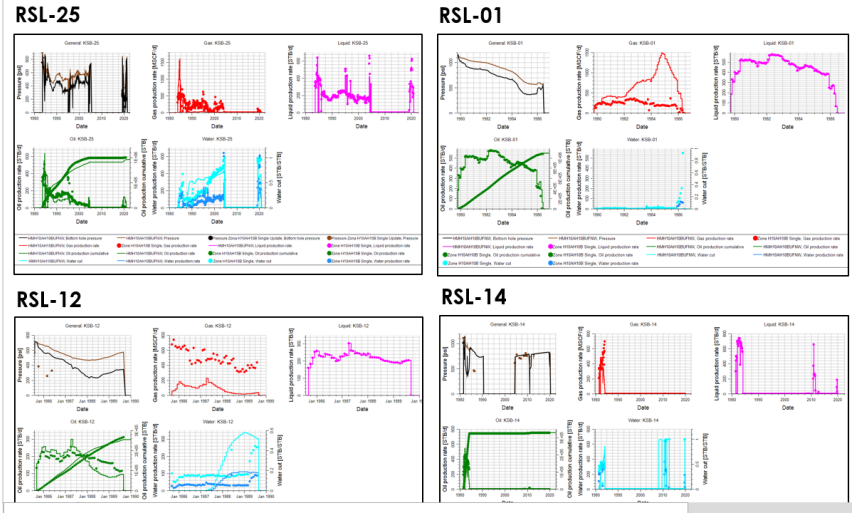


**Figure 15:** Tabel History Matching Layer Y

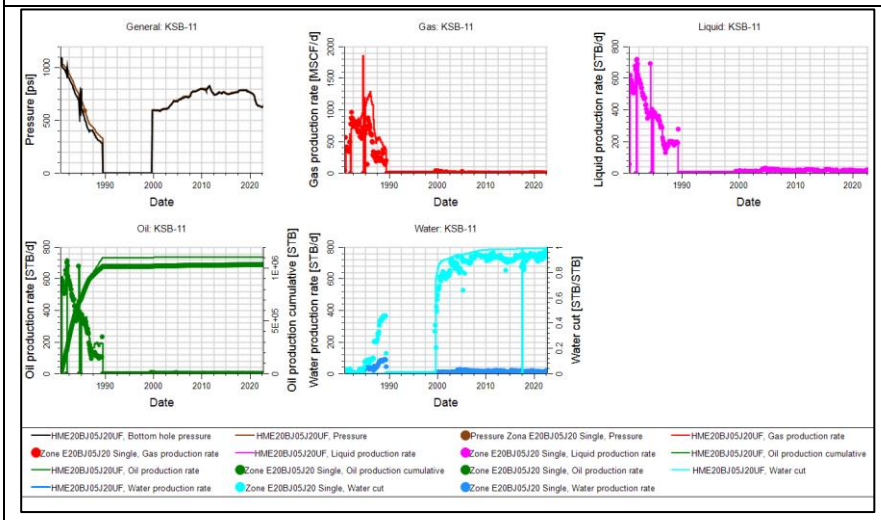


**Figure 16:** Tabel History Matching Layer X

**Layer Z (RSL-50)**

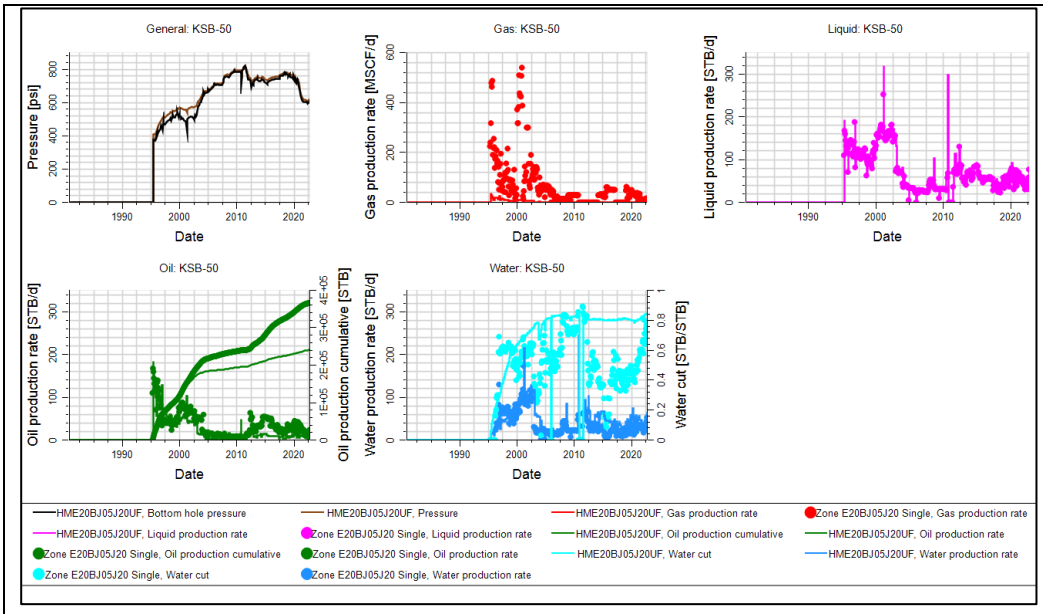


**Figure 17:** Tabel History Matching Layer Z

History matching was exercised by layer and key well. Layer Y (Key well RSL-15 and RSL -62) , Layer X (RSL -25, RSL -01, RSL -05, RSL -12, and RSL -14) and Layer Z (RSL -11, RSL -50,and RSL) . Next step is forecasting 3 layer and set constrain ; minimun BHP, oil rate limit, WC limit, End of Psc contract, last active production well Each of layer will be defined scenario workover well .Current active well Layer Y (RSL-62), current active layer X (RSL-09, RSL -54 and RSL -44) , and current active layer Z ; RSL -11, RSL -50, RSL -57 and RSL -59). Scenario development will be defined as existing, 10 workover well. to prediction incremental production until PSC Contract and economic limit.

## RESULT

On this section will be explained Forecasting 3 layer ;

**Constrain Forecast Basecase (Skenario 1): Layer Y**
Constrain Rate = Last Liquid Rate
Minimum BHP (Artificial Lift) = 50 - 150 Psi
End of PSC = December 2035
Sumur Produksi = **Y** : RSL-62 (1 Oktober 2022)
**Constrain Forecast Basecase + 2 WO (Skenario 2):**
Sumur WO = **Y** : RSL -02, , RSL -61

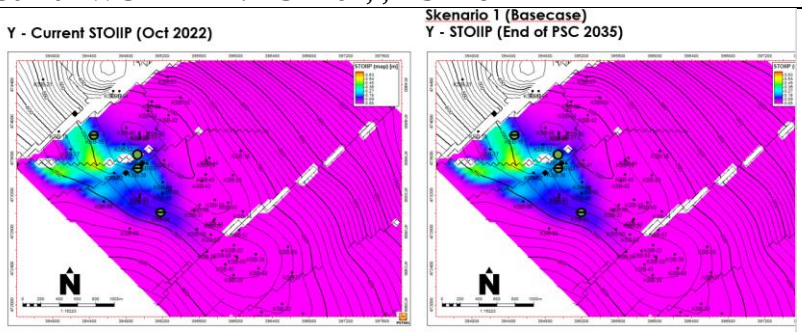


**Figure 18:** Peta HCPV Layer Y baseline

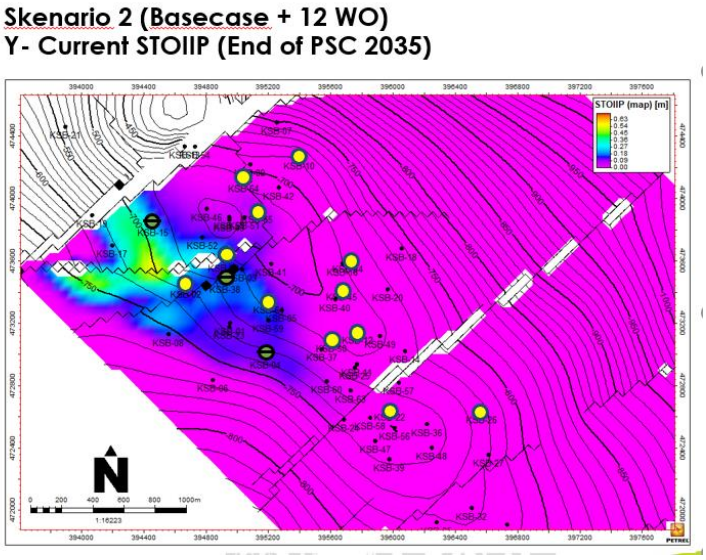


**Figure 19:** Peta HCPV Layer Y Workover

**Constrain Forecast Basecase (Skenario 1): Layer X**
Constrain Rate = Last Liquid Rate
Minimum BHP (Artificial Lift) = 50 - 150 Psi
End of PSC = December 2035
Sumur Produksi = X: RSL -09, RSL -56, RSL -44 (1 Oktober 2022)
**Constrain Forecast Basecase + 9 WO (Skenario 2):**
Sumur WO = X : RSL -02, RSL -65, RSL -62, RSL -45, RSL -61, RSL -12, RSL-50, RSL -50, RSL -22

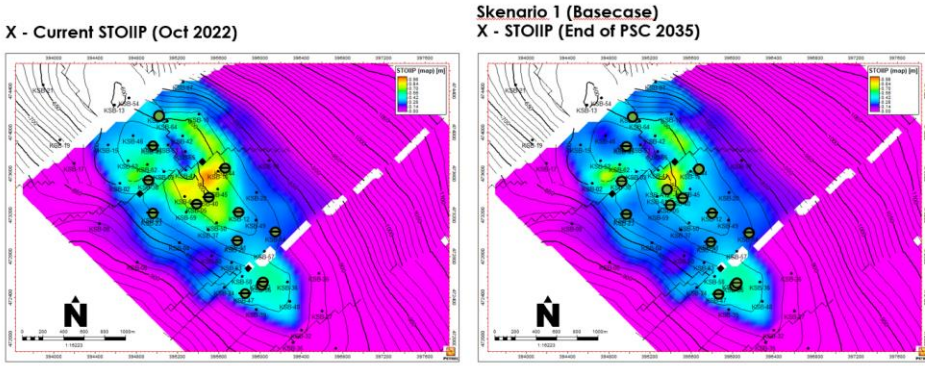


**Figure 20:** Peta HCPV Layer X baseline

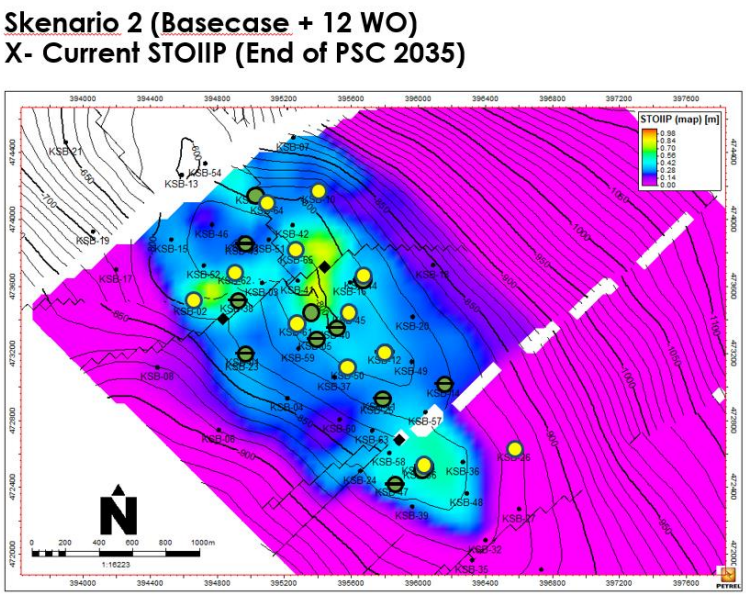


**Figure 21:** Peta HCPV LayerX Workover

**Constrain Forecast Basecase (Skenario 1): : Layer Z**
Constrain Rate = Last Liquid Rate
Minimum BHP (Artificial Lift) = 50 - 150 Psi
End of PSC = December 2035
Sumur Produksi = **Z** : RSL -11, RSL -50, RSL -57, RSL -59
(1 Oktober 2022)
**Constrain Forecast Basecase + 1 WO (Skenario 2):**
Sumur WO = **Z** : RSL -61

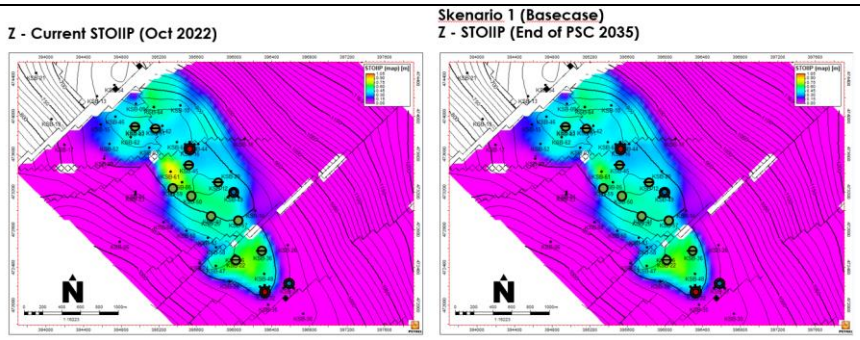


**Figure 22:** Peta HCPV Layer X baseline

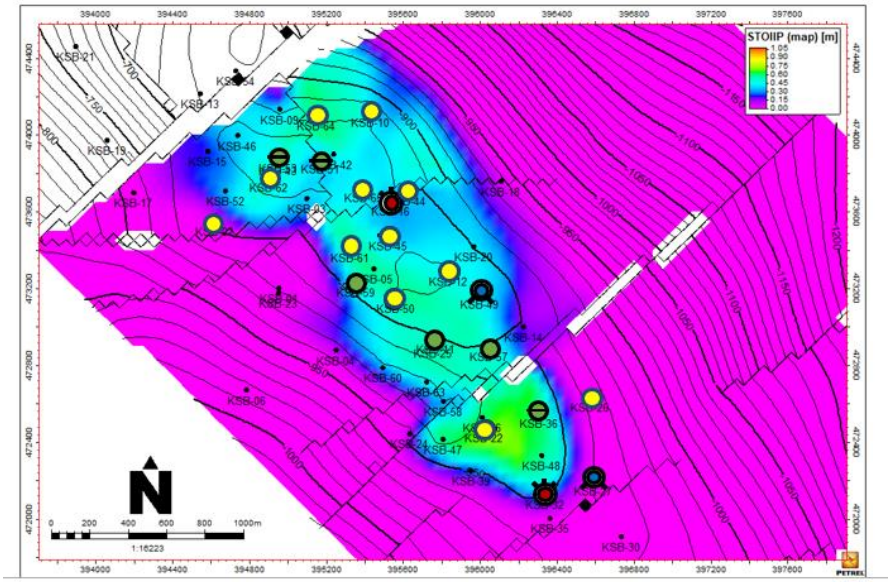


**Figure 23:** Peta HCPV Layer Z Workover

**Tabel 4**

Summary Forecast 3 layers and Scenario development

| Layer | Skenario | OOIP | | Current NP (Sep 2022) | | | 2035 | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | bbl | MMbbl | RF | Incremental | | EUR | RF |
| | | bbl | MMbbl | | | % | bbl | MMbbl | MMbbl | % |
| Y | Basecase | 1902730 | 1.90 | 313563 | 0.31 | 16.5% | 0 | 0.00 | 0.31 | 16.5% |
| | Basecase + 12 WO | 1902730 | 1.90 | 313563 | 0.31 | 16.5% | 68621 | 0.07 | 0.38 | 20.1% |
| X | Basecase | 11947200 | 11.95 | 3825272 | 3.83 | 32.0% | 1014000 | 1.01 | 4.84 | 40.5% |
| | Basecase + 12 WO | 11947200 | 11.95 | 3825272 | 3.83 | 32.0% | 1207073 | 1.21 | 5.03 | 42.1% |
| Z | Basecase | 8810730 | 8.81 | 2247062 | 2.25 | 25.5% | 201877 | 0.20 | 2.45 | 27.8% |
| | Basecase + 12 WO | 8810730 | 8.81 | 2247062 | 2.25 | 25.5% | 230639 | 0.23 | 2.48 | 28.1% |

## CONCLUSIONS

1. By using the Ganesh Takur method, it can be determined that the type of drive mechanism at Layer Y is Solution gas drive, X and Z are water drive.
2. Based on the Analysis of the Drive Mechanism of each layer, the calculations in the table above are obtained. Where Layer Y obtained a maximum RF of 43.99% with an estimated remaining reserve of 1620 MSTB, Layer X obtained a maximum RF of 26.58% with an estimated remaining reserve of 184.4 MSTB and Layer Z obtained a maximum RF of 29.86% with an estimated remaining reserve of 381.1 MSTB
3. The results of reservoir simulation using numerical methods the addition of reserves from the idle layers, namely layers Y, X and Zand an increase in recovery factors in the RSL structure. After forecasting 3 layers with detail data ; Layer Y based on scenario existing and 2 workover with existing (OOIP = 1,9 MMSTB RF=16.5 %) results incremental 0.07 MMSTB (RF= 20.1 %). Layer X based on scenario existing and 9 workover with existing (OOIP = 11,95 MMSTB RF=32 %) results incremental 1.21 MMSTB (RF= 42.1 %). Layer Z based on scenario existing and 1 workover with existing (OOIP = 8,81 MMSTB RF=25.5 %) results incremental 0.23 MMSTB (RF= 28.1 %).

4. Calculation Incremental Production based on method Simualtion result versus JJ Arps method almost similar result such as recovery factor and incremental production of each layer Y, X and Z. Explanation at X layer (incremental 0.07 MMSTB versus incremental 0.18 MMSTB, Explanation at Y layer (incremental 1.21 MMSTB versus incremental 1.62 MMSTB. Explanation at Z layer (incremental 0.31 MMSTB versus incremental 0.23 MMSTB, Explanation at Y layer (incremental 0.38 MMSTB versus incremental 0.22 MMSTB.
5. Based on 2 methodology based layer to be prioritize is Layer Y.

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# CHAPTER 8

# Realizing Economic and Political Democracy through YouTube

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## ABSTRACT

YouTube plays a crucial role in shaping democracy, especially in the fields of education and politics. However, issues related to creator compensation and reactionary narratives pose challenges. In the introduction, YouTube is not only a source of knowledge but also an interactive education platform, connecting non-profit organizations with the public. Unique dynamics, such as "publicly private" and "privately public," create limitations and expansions on democracy. In the literature review, debates about YouTube's role in shaping democracy have emerged, with the adoption of unique behaviors influencing democratic dynamics. Challenges regarding creator compensation and reactionary narratives create tension between freedom of speech and platform control. The research method employs a qualitative and quantitative approach to identify YouTube's impact on democracy through user samples and stakeholders. In conclusion, YouTube has a significant impact on shaping democracy, but challenges related to compensation and reactionary narratives indicate the complexity of its role, requiring further attention in the digital era.
**Keywords:** YouTube; Democracy; Education.

## 1. INTRODUCTION

YouTube is one of the most popular social media platforms recently, and it cannot be denied that it plays a significant role as an influential media in the era of democracy. YouTube serves as a free and accessible source of knowledge for everyone. In the field of education, it not only provides educational videos but also offers examples of classroom activities and discussions that can assist educators in teaching literature and mathematics. With YouTube, classrooms can be digitized, becoming more interactive, allowing educators to create more engaging and relevant learning experiences for 21st-century learners.

In the realm of education, the use of YouTube provides students with broad access to diverse educational content. They can learn independently and tailor their learning to their needs and interests. Educators can also engage students innovatively, such as assigning video-based tasks or hosting online discussions. Thus, YouTube serves not only as a crucial resource in open education but also enables educators to create inclusive learning environments centered around the learners.

Overall, YouTube plays a significant role in supporting open education by providing a wide range of educational videos, offering learning opportunities to anyone with internet access. Educators can leverage these videos to enrich the learning experiences of students, teaching English as a Second Language (ESL), literature, mathematics, and creating digitized 21st-century classrooms. By utilizing YouTube in education, we can foster more innovative, inclusive, and relevant learning for 21st-century learners (Jones & Cuthrell, 2011).

In the political realm, YouTube bridges non-profit organizations to voice their opinions to the general public. Non-profit organizations play a crucial role in realizing a democratic society by providing space for diverse opinions to be expressed. In the digital era dominated by social media, such as YouTube, non-profit organizations have new opportunities to share their ideas. Social media has become a new marketplace where they can build networks, address important issues, and expand their impact.

Research has shown that non-profit advocacy organizations use the YouTube platform ethically to persuade people about their views, especially through one-way communication. They leverage the power of this platform to disseminate messages supporting their goals and raise awareness about the issues they advocate for. This is where YouTube becomes a powerful tool for spreading information, mobilizing support, and expanding the public's understanding of crucial issues (Auger, 2013).

In the social media landscape, particularly on YouTube, there is a unique behavior known as "privately public" and "publicly private," which can have both restrictive and expansive effects on democracy. On one hand, "publicly private" behavior, where individuals share videos with limited access and only attract a few close friends, can be considered a restriction on democracy. By limiting the audience and keeping content within a small circle, this may prevent diverse views and ideas from reaching a wider audience. It has the potential to limit the exchange of information and important perspectives for a thriving democratic society.

On the other hand, "privately public" behavior, where individuals create widely appealing videos and actively promote them, can expand democracy. By leveraging the YouTube platform, individuals can have a voice and participate in public debates, challenging the dominance of mainstream media. YouTube has positioned itself as an empowerment tool for individual users, enabling them to express their individuality and share their perspectives with a broader audience. This can contribute to a more diverse and inclusive democratic landscape, where various voices and perspectives are represented. In summary, "publicly private" behavior on YouTube may limit democracy by restricting access and appeal, while "privately public" behavior can expand democracy by providing a platform for diverse voices and perspectives. The impact on democracy ultimately depends on the choices and intentions of video creators and the extent to which their content reaches and engages a wider audience (Lange, 2007)

However, content creators on YouTube face several challenges, such as minimal income and the adoption of reactionary narratives by some content creators. It cannot be denied that the fluctuating working conditions of YouTubers can have a significant impact on freedom of speech on this platform. Although YouTube claims to be a space for free expression and giving voice to individuals, the reality is more complex than it appears.

One factor affecting the freedom of speech of YouTubers is the YouTube Partner Program. This program determines the eligibility for compensation for content creators. However, not all YouTubers qualify to be part of the YouTube Partner Program. This means that some creators may not have equal access to resources and opportunities that can support their freedom of speech.

Additionally, YouTube also has the authority to demonetize a creator's video. This action can have a significant impact on their work. While there are valid reasons for demonetizing videos, such as inappropriate language, sexual content, violence, misinformation, or radical politics, ASMR tists often face demonetization due to the "roleplay" subgenre and allegations of public impropriety. This indicates that YouTube's regulation strategy is not neutral and can disproportionately affect specific communities and user groups.

Furthermore, the tiered regulation strategy implemented by YouTube contradicts the idea of this platform as an open space for diverse expression. In this strategy, different users are subject to different rules and protections. This exacerbates power imbalances, especially for subcommunities like ASMR, and raises concerns about YouTube's understanding of content within its subculture (What Do Creators and Viewers Owe Each Other? Microcelebrity, Reciprocity, and Transactional Tingles in the ASMR YouTube Community, n.d.).

The presence of reactionary views among micro-celebrities on YouTube can pose challenges to democracy in several ways. Firstly, micro-celebrities with reactionary views often reject mainstream media and promote alternative sources of information, leading to information fragmentation and a lack of shared understanding in society. This can result in individuals relying solely on alternative sources, exposing them to biased or misleading information, hindering decision-making based on accurate information and healthy democratic debates.

Moreover, the rejection of mainstream media by reactionary micro-celebrities can contribute to the destabilization of the worldview of the audience. As individuals become disillusioned with traditional news sources, they may become more vulnerable to radicalization and the acceptance of extreme views. This can deepen polarization in society and limit the diversity of perspectives essential for healthy democratic debates.

Furthermore, YouTube's recommendation algorithm, which often directs users to increasingly extreme content, can be problematic. When political YouTubers with reactionary views collaborate with more extreme guests, it reinforces and legitimizes those views, providing a platform for their dissemination. This algorithmic reinforcement can contribute to the spread of divisive ideologies and hinder open exchange of ideas, crucial for a thriving democracy. In all these aspects, the role of micro-celebrities and the YouTube algorithm in presenting challenges to democracy becomes more complex and worthy of attention (Lewis, 2020).

In conclusion, YouTube has a significant impact on democracy. In the political realm, YouTube has become tool for empowering individuals who previously lacked a voice in mainstream media. However, scholars have questioned this idea by highlighting the phenomenon of self-commodification and influencer marketing involved in online micro-celebrity culture. Platforms like Twitter and YouTube have been criticized for enabling personality-centered authoritarianism, where individual expression can be used for authoritarian purposes. Some political influences have linked micro-celebrity practices to reactionary, anti-progressive, and conspiracy politics. The power competition between

YouTubers and traditional media explicitly has political dimensions, with the formation of relationships between mainstream media, social justice, and progressive politics.

**In the economic field, YouTube has experienced rapid growth since its inception, with a significant increase in the number of uploaded video contents**

## 2. LITERATURE REVIEW

In the field of economics, YouTube can benefit local businesses in various ways. One of them is through the platform provided by YouTube to showcase products or business services through video content. By creating engaging and informative videos, businesses can attract the attention of potential customers and increase their visibility. Additionally, YouTube allows businesses to reach a broader audience, as these videos can be shared and discovered by users worldwide. This provides opportunities for local businesses to expand their reach beyond limited geographical areas.

In the context of theories related to YouTube and its impact on local businesses, there are two highly relevant concepts. Firstly, the concept of remediation through hypermediacy. This theory, developed by Jay David Bolter and Richard Grusin, states that platforms like YouTube make the mediated nature of content highly visible. By understanding and leveraging this hypermediacy, businesses can use YouTube to create authentic and compelling content that resonates with their target audience.

Another relevant concept is media convergence. In an era where videos spread across various media systems, YouTube plays a crucial role as a platform for businesses to reach their audience through various channels. By incorporating YouTube as part of their overall marketing strategy, businesses can harness the power of media convergence to maximize their reach and impact.

Overall, YouTube is a highly useful tool for local businesses. This platform allows them to create engaging and authentic content that reaches a broader audience and contributes to expanding their business impact. By understanding the concepts of remediation through hypermediacy and media convergence, local businesses can optimize the use of YouTube as an integral part of their marketing strategy and reap significant benefits from this platform (Williams' Concept, n.d.).

YouTube has several characteristics that make it more anonymous and less individual compared to Facebook. Some of these characteristics include:

1. Limited personal information: Unlike Facebook, YouTube does not require users to provide detailed personal information or elaborate profiles. Users can participate on this platform without having to disclose their offline individual identities.
2. Pseudonymity: On YouTube, comments begin with contributor pseudonyms unrelated to their offline identities. Users can use aliases or usernames that do not reveal their identities, further enhancing anonymity and reducing user individuality.
3. Lack of social cues: YouTube is a platform that lacks social cues, such as photos or visual icons associated with contributors. The absence of visual representations makes it challenging for users to know exactly with whom they are interacting, reducing the sense of individuality in user interactions.
4. Reduced responsibility: Due to anonymity and lack of individuality on YouTube, users may feel less accountable for their opinions and behavior. This can lead to lower levels of politeness, appropriateness, and tolerance in user discussions.
5. Democratization potential: These characteristics suggest that YouTube may have the potential to be more democratic in some aspect. With anonymity and lack of individuality, the platform may offer greater opportunities for users to participate without fear of judgment or limitations based on their identities.

The results regarding the influence of media capabilities on democratic indicators vary significantly. This study measured factors such as participation equality, politeness, appropriateness, argumentation level, and message length. However, specific details about these effects were not provided in the given context.

This study has several limitations. It only analyzed Facebook and YouTube accounts managed by the White House, limiting generalization about communication and deliberative patterns overall from users on other social media channels or accounts managed by different federal institutions. Additionally, it's challenging to determine whether the authors are individual citizens.

Deliberation, in the context of this study, refers to a genre or form of communication characterized by the implementation of a series of communicative behaviors that promote careful group discussions. Deliberation is considered a key factor in shaping consensus in society, enhancing tolerance, highlighting opportunities for participation, and encouraging involvement in public life (Halpern & Gibbs, 2013).

In the realm of YouTube content creator well-being, the YouTubers Union is mentioned as an effort to improve working conditions on YouTube. This document highlights the crucial role played by this workers' union in advocating for the rights of YouTubers and improving transparency in the relationship between YouTube and content creators. Furthermore, the document discusses the potential influence of regional or national legislation on the future of YouTube. In this regard, it indicates that changes in regulations and government policies can significantly impact the transformation of YouTube and the working conditions of YouTubers.

To address this external pressure, YouTube needs to undergo a transformation in its business model. This document emphasizes the importance of YouTube integrating standards and values desired by various entities, including corporations, countries, legal entities, and civil society. In this regard, YouTube needs to become more accountable and consider public interests in managing its platform. Additionally, the document highlights several external factors that can influence YouTube's transformation, such as decisions on GDPR in the European Union, antitrust legislation, and cases of false labor.

The YouTubers Union faces challenges and opportunities in its efforts to improve working conditions on the YouTube platform. One challenge is the potential exploitation of this group by right-wing content creators and other fringe groups seeking to influence discussions. This indicates the risk that the YouTubers Union may be used for purposes contrary to its original goals. Additionally, the composition of the group, largely consisting of males, poses a challenge as it does not reflect the overall diversity of the platform. Many large content creators are reluctant to join this union, indicating there are still barriers to gaining widespread support.

However, the YouTubers Union also has the potential to bring positive change and improve working conditions on the YouTube platform. One potential lies in its ability to form coalitions with other marginalized groups affected by changes on YouTube. By collaborating with these groups, the YouTubers Union can strengthen its voice and increase its influence in advocating for desired changes. Although there are challenges regarding leadership and hierarchy within the platform, the strategies adopted by the YouTubers Union, such as organizing through Facebook groups, enable collaborative efforts in addressing complaints, discussing platform changes, and coordinating strategies against corporations. Thus, the YouTubers Union has the potential to achieve its goals in improving working conditions on the YouTube platform.

Furthermore, the YouTubers Union publicly revealed the controversial aspects of YouTube's recommendation engine. This led to their representatives being invited to speak with YouTube in their headquarters in Switzerland and Silicon Valley. Although YouTube made some informal concessions, they failed to establish a formal relationship allowing co-determination through these discussions.

When discussions did not result in sustained changes, the YouTubers Union decided to collaborate with IG Metall in Germany. IG Metall is a workers' union that has supported workers in the gig economy. Collaboration with this recognized workers' union provides the YouTubers Union with additional resources and expertise to further strengthen their efforts in improving working conditions on YouTube. Thus, the YouTubers Union can continue to fight for the rights of workers on the YouTube platform (Niebler, 2020).

There are several strategies used by students in evaluating online content. One strategy they employ is relying on in-class interactions and information provided by instructors. They consider how video content relates to the topics taught and whether it aligns with the opinions of the instructors. Additionally, some students use comparison methods and a "gut feeling" to assess whether the video is reliable academic content. The experience of watching a large number of videos and using comparative methods allows them to sense within five minutes whether the video is credible or not. Furthermore, they also consider the language used in the video, as the use of academic language indicates the likelihood of reliable content. Finally, students also consider the presented perspective in the material to assess its reliability and academic nature.

In this study, it was found that students heavily rely on interactions with instructors, their own intuition, and the alignment of video content with course materials in evaluating the materials they find on YouTube for self-learning. These findings indicate that students consider interactions with instructors as a crucial factor in understanding and evaluating the materials they learn. Additionally, their intuition plays a role in determining the success of their self-learning. Students tend to choose materials that align with their intuition and that align with the course materials they are currently studying. Therefore, it is important for instructors and content creators to pay attention to these factors when creating effective learning materials on the YouTube platform.

The research method used is three focus groups led by an independent researcher. Additionally, the document also discusses questions posed to students during the focus groups, such as how they use YouTube independently, strategies for searching for materials, how they evaluate the materials they find, and whether they integrate this material into other social media platforms.

Thematic analysis was conducted on the transcripts of focus groups using a foundational theoretical approach. In this study, common themes and activities that emerged from the data were analyzed and discussed in-depth. The theoretical approach used in this analysis provides a strong foundation for understanding and interpreting the obtained data. The results of this research provide a deeper understanding of the themes that emerged in focus groups and related activities. Thus, this thematic analysis significantly contributes to expanding our knowledge of the researched topic.

In the context of online self-directed learning, YouTube plays a crucial role in enhancing digital literacy. Through various educational videos available, students can gain visual and interactive insights that make learning more engaging. Additionally, YouTube enables collaborative learning and community building among fellow learners. The platform also allows students to learn at their own pace. However, in accessing content on YouTube, students must also develop critical thinking skills and media literacy to evaluate the reliability and accuracy of the information they encounter. Finally, YouTube also provides opportunities for students to actively participate in creating and sharing their own educational content, thus developing digital literacy skills in video production, editing, and effective communication. Overall, YouTube provides a platform that enhances digital literacy through access to educational content, interactive learning experiences, collaboration among peers, self-directed learning, critical thinking, and content creation (Tan, 2013).

In this document, there are two main theories that discuss the dynamics of public controversy, especially in the context of climate policy debates. The first theory is ethno-epistemic assemblages, which emphasizes the importance of interactions between experts and non-experts and the influence of digital spaces in shaping public discourse. The second theory is networked forms of expertise, which focuses on the development of networks and the role of various forms of expertise in public debates.

Both of these theories make significant contributions to understanding how controversy is shaped and negotiated in the information-rich and digitally connected world today. Furthermore, this document also emphasizes the importance of the involvement of ordinary individuals in public debates through digital spaces such as social media platforms, online news sites, and blogs.

In this context, the concept of "ethno-epistemic assemblages" suggests that truth claims are debated within assemblages consisting of various combinations of experts and the public. This recognizes that expertise is not limited to conventional experts and includes individuals with relevant knowledge, experience, and skills.

By actively participating in public debates through digital spaces, ordinary individuals can challenge widely spread extremist narratives. Their contributions may involve sharing perspectives, opinions, and evidence, thereby offering alternative viewpoints that counter extremist narratives. The involvement of ordinary individuals is crucial for promoting diversity and inclusivity in public debates.

Overall, the theories presented in this document provide a foundational understanding of the development of public controversy while also emphasizing the importance of the participation of ordinary individuals in challenging dominant narratives. By engaging in public debates and sharing their knowledge and expertise, ordinary individuals play a significant role in shaping narratives and promoting a more balanced and informative discussion on complex issues (Allgaier, 2020).

## 3. RESEARCH METHOD

The research methodology employed is a combination of qualitative and quantitative methods (Figure 1). This combination aims to provide a comprehensive understanding of the impact of YouTube on economic and political democracy, involving various aspects in the research.

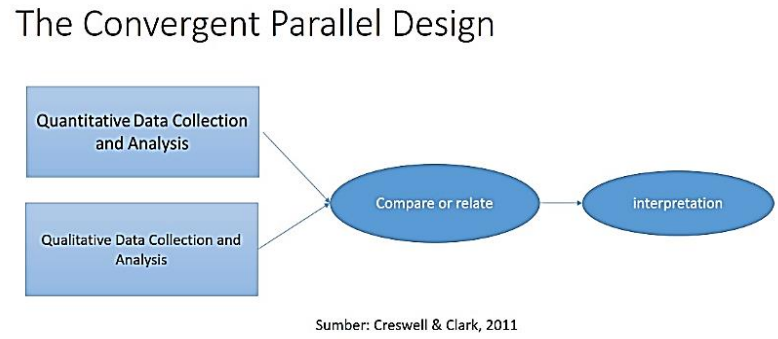


**Figure 1.** The convergent parallel design

The following are the research stages conducted:

- Research Design:
  - Identify the sample to be studied, including YouTube users and stakeholders in economic and political democracy.

  - Develop research instruments such as questionnaires, interview guides, or tools for analyzing YouTube video content.
- Data Collection:
  - Conduct surveys or interviews with YouTube users and relevant stakeholders to gain qualitative insights into the influence of YouTube on economic and political democracy.
  - Analyze YouTube video content to measure its impact in political and economic contexts.
- Data Analysis:
  - Perform quantitative data analysis to measure the relationships between the variables under study.
  - Conduct qualitative data analysis to identify trends and in-depth findings.
- Interpretation of Results:
  - Interpret findings in the context of economic and political democracy.
  - Discuss the implications of findings and their relevance to literature and practices.
- Report Compilation:
  - Create a research report outlining the methodology, findings, analysis, and conclusions.
- Conclusion and Recommendations:
  - Present your research conclusions regarding the impact of YouTube on economic and political democracy.
  - Provide recommendations for policymakers and further research.

The research on "Realizing Economic and Political Democracy through YouTube" is a complex and multifaceted topic. To deeply understand the impact of YouTube on economic and political democracy, a combined qualitative and quantitative method is highly suitable and relevant. This essay discusses why this combined approach is more effective in unraveling crucial aspects of this research.

The qualitative method allows researchers to explore the context and meaning inherent in the studied phenomenon. YouTube is a platform filled with content from diverse sources. With the qualitative method, researchers can conduct in-depth analyses of the types of content shared on YouTube, identify dominant narratives, and understand their impact on the audience. Interviews with YouTube channel owners, users, or commentators can provide valuable insights into how YouTube influences their political and economic views. Additionally, through content analysis and interviews, researchers can delve into meanings and perspectives that may not be measurable in numbers (Setiadi *et al.*, 2019; Komunikasi *et al.*, n.d.; Setiawan *et al.*, n.d.; Alamsyah, 2021).

Furthermore, the use of a combined method allows for data triangulation, comparing findings from both methods to ensure the research results are more reliable and valid. For example, qualitative data can be used to explain the statistical results found in quantitative analysis, enriching the interpretation and meaning of the obtained findings.

In the research on "Realizing Economic and Political Democracy through YouTube," a combined qualitative and quantitative approach will provide a more holistic and in-depth understanding of how YouTube influences political views and economic behavior, and how its impact can be measured on a broader scale. This combined method is a powerful tool for exploring the complexity of this topic and contributes valuable insights to our understanding of YouTube's role in the modern democratic world.

Identifying correlations and relationships between YouTube usage and political thought or economic behavior becomes feasible through the combination of qualitative and quantitative methods. Thus, the combined qualitative and quantitative methods will provide a more comprehensive understanding of the impact of YouTube on economic and political democracy (Aini *et al.*, 2022; Setiawan *et al.*, n.d.; Alamsyah, 2021).

When combining qualitative and quantitative methods, a more comprehensive understanding can be obtained. Qualitative methods will uncover the meanings, narratives, and contexts underlying the use of YouTube in supporting or disrupting economic and political democracy. On the other hand, quantitative methods will provide a stronger overview of the extent to which this impact can be generalized to a wider population (Setiawan *et al.*, n.d.; Alamsyah, 2021).

Moreover, the use of a combined method allows for data triangulation, comparing findings from both methods to ensure that the research results are more reliable and valid. For example, qualitative data can be used to explain the statistical results found in quantitative analysis, enriching the interpretation and meaning of the obtained findings.

In the research on "Realizing Economic and Political Democracy through YouTube," a combined qualitative and quantitative approach will provide a more holistic and in-depth understanding of how YouTube influences political views and economic behavior, and how its impact can be measured on a broader scale. This combined method is a powerful tool for exploring the complexity of this topic and contributes valuable insights to our understanding of YouTube's role in the modern democratic world.

## 4. RESULT AND DISCUSSION

In examining political communication on YouTube, it is evident that the platform prioritizes web 2.0 functions over traditional informative elements compared to other platforms. The videos are evaluated based on their interactive features rather than relying on clear slogans, with a primary focus on specific issues or the use of images. Notably, the presence of political candidates on screen is a common feature, indicating a deliberate emphasis on personalization and image formation. However, interesting differences arise when the main topics in these videos differ from those identified by Eurobarometer as crucial for EU citizens, often centered around elections or national issues indirectly related to the EU. Additionally, the production landscape reveals the dominance of videos from political parties affiliated with the EPP group, followed by the S&D and ALDE groups, with minimal representation from Newropeans. YouTube videos exhibit longer durations, ranging from 17 seconds to 9 minutes and 14 seconds, significantly differing from the conventional 30-second ads commonly found on television. Furthermore, approximately one-third of the analyzed videos involve a narrator, with right-wing parties showing a higher prevalence compared to left-wing parties. Despite YouTube's dynamic capabilities as a medium, the underutilization of its potential for innovative content delivery suggests a diminished focus on the informative element compared to other platforms. This analysis highlights the shift in political communication strategies on YouTube, where engagement and visual elements seem to take precedence over traditional informational messaging (Vesnic-Alujevic & Van Bauwel, 2014).

**Table 1.** Illustrating web 2.0 functions overall and by political group and country (%)

| Total | | EPP | S&D | ALDE | NEWROPEANS | FRANCE | IRELAND | ITALY | SLOVENIA |
|---|---|---|---|---|---|---|---|---|---|
| Talking Head | 47,76 | 47,1 | 42,1 | 62,5 | 14,3 | 28,6 | 60 | 42,1 | 100 |
| Visual Clips | 26,86 | 41,2 | 42,1 | 16,7 | 71,4 | 57,1 | | 39,5 | 0 |
| Montage, cinema, verite | 8,85 | 0 | 10,5 | 16,7 | | 0 | 20 | 13,2 | 0 |
| Other | 16,53 | 11,7 | 5,8 | 4,1 | 14,3 | 14,3 | 20 | 5,2 | 0 |

Talking Head:

- This is the most commonly used function, with a total usage of 47.76%.
- It is particularly high in ALDE (62.5%) and Slovenia (100%), while the Newropeans show the lowest usage (14.3%).

Visual Clips:

- Visual Clips are used in 26.86% of cases overall.
- France (57.1%) and Newropeans (71.4%) show a higher preference for Visual Clips, whereas Italy (39.5%) and Slovenia (0%) have much lower or no usage.Montage, Cinema Verité:
- With a low overall usage of 8.85%, this function is less common.
- It is most notable in ALDE (16.7%) and Italy (13.2%). Neither EPP, France, nor Slovenia report using this style.

Other:

- Usage of "Other" functions stands at 16.53% overall.
- Ireland has the highest use of "Other" styles (20%), while ALDE reports minimal use (4.1%).

**Table 2.** Depicting overall production techniques and by political group and country (%)

| Total | | EPP | S&D | ALDE | NEWROPEANS | FRANCE | IRELAND | ITALY | SLOVENIA |
|---|---|---|---|---|---|---|---|---|---|
| Mobilize | 59,7 | 88,2 | 68,4 | 39,1 | 42,9 | 66,6 | 68,4 | 60 | 40 |
| Information | 14,9 | 5,9 | 5,3 | 21,7 | 42,9 | 16,7 | 10,5 | 0 | 20 |
| Both | 25,4 | 5,9 | 26,3 | 39,1 | 14,3 | 16,7 | 21,1 | 40 | 40 |

Seen from the top of table, Production techniques vary:

- Mobilize: Most prominent among the EPP group (88.2%) and significant in Ireland (68.4%) and France (66.6%).
- Informative Content**:** More frequently used by Newropeans (42.9%) and ALDE (21.7%).
- Combination of Both**:** Found in a balanced distribution, especially within ALDE (39.1%) and countries like Slovenia (40%)

**Table 3.** Types of slogans overall and by political group and country (%)

| Total | | EPP | S&D | ALDE | NEWROPEANS | FRANCE | IRELAND | ITALY | SLOVENIA |
|---|---|---|---|---|---|---|---|---|---|
| No Slogan | 46,3 | 52,9 | 57,8 | 30,4 | 57,1 | 14,3 | 20,0 | 39,5 | 100,0 |
| Issue | 43,3 | 29,4 | 21,1 | 37,5 | 0,0 | 71,4 | 20,0 | 20,0 | 0,0 |
| Image | 10,4 | 17,7 | 21,1 | 32,1 | 42,9 | 14,3 | 60,0 | 40,5 | 0,0 |

Overall Distribution:

- No Slogan: The most common approach, accounting for 46.3% of the content. This suggests a trend towards communication styles that focus more on visuals and interactivity rather than direct slogans.
- Issue-Based Slogans: Used in 43.3% of cases, indicating a significant portion of the content is issue-focused, likely addressing specific topics relevant to the audience.
- Image-Based Slogans: The least common overall at 10.4%, reflecting a focus on the candidate's image or persona rather than explicit messaging or issues

Country-Specific Trends:

- France: Strongly emphasizes Issue-based slogans (71.4%), indicating a clear preference for addressing specific topics directly.
- Ireland: Has a mix, with Image slogans as the most common (60%), showing a preference for candidate-focused or visual messaging.
- Italy: Primarily uses No Slogan (39.5%), with a fairly balanced approach across other types.
- Slovenia: Only uses No Slogan (100%), indicating a complete lack of slogan-based messaging in favor of other communication methods.

General elections, particularly the 2019 presidential election, play a crucial role in determining executive and legislative leaders in a democracy like Indonesia. Facing this contestation, political campaigns effectively utilize social media as a tool. Research data is sourced from various reliable outlets, including official news, books, previous studies, and trustworthy websites like Twitter, Facebook, and Instagram.

One emphasized aspect is the use of social media for negative campaigns during the 2019 presidential election, which can harm candidates in the context of Indonesian democracy that encourages public participation in freedom of expression through this platform. The research also discusses the relationship between negative campaigns and the democratic conditions in Indonesia, especially through social media during the 2019 presidential election, associated with increased public participation in freedom of expression.

The importance of general elections as a measure of democracy is explained in the context of the simultaneous elections held in 2019. Although simultaneous elections are believed to have a positive impact on voter participation rates, challenges arise regarding the limited knowledge and information of voters, which can negatively impact choosing the right candidate. Furthermore, the role of democracy in the distribution of power is described as crucial, with the state's power obtained through legitimacy from the people through general elections. However, the low level of democracy education among the people and personal or group interests of political elites can lead to disappointing results in the democratic mechanism (Harahap, 2020).

Several studies have revealed the significant role of social media in mobilizing social movements and facilitating public participation in protests. The research by Sitowin & Alfirdaus (2019) on rejecting the establishment of a cement factory in Rembang Regency shows that advocacy through social media can strengthen the community's movement against the project. A study by Lee S. (2018) in Korea discusses the role and mechanisms of social media in mobilizing public participation in protests. The results of the study emphasize that social media plays a crucial role in facilitating citizen involvement in protests, providing a space for expression and coordination. The influence of social media on political activities is also highlighted in Valenzuela's research (2013). The study indicates that the use of social media can mediate the relationship between overall social media usage and protest behavior, showing a positive impact on increasing political activity. Research by Tusa (2013) explores the influence of social media and internet-based communication on social movements. The results show that social media not only mobilizes society but also plays a key role in the framing and organization processes of social movements.

In a broader context, data indicates that the global number of internet users has exceeded 4.66 billion, highlighting the widespread penetration of social media across various layers of society. For over a decade, social media has been a primary tool in facilitating protests worldwide, as seen in the Arab Spring of 2011, where the movement was successfully mobilized through social media platforms. Other examples include demonstrations in Spain in 2004 organized via text messages and the Red Shirt Uprising in Thailand in 2010, involving

the use of social networks to occupy central Bangkok. All of these instances demonstrate that social media has a significant impact on shaping and strengthening social movements and plays an integral role in contemporary political dynamics (Apriyani, 2021).

## 5. CONCLUSION AND RECOMMENDATION

The conclusion provides an extensive discussion of the impact of YouTube on various aspects of life, ranging from education, politics, economy, to social and controversial issues. In the field of education, YouTube is recognized as a free and accessible source of knowledge for everyone. The platform not only offers educational videos but also provides examples of classroom activities and discussions that can assist educators in teaching various subjects. YouTube enables the digitization of classrooms, creating more interactive, relevant, and inclusive learning experiences.

In the political realm, YouTube serves as a crucial tool for non-profit organizations to voice their opinions and mobilize support. These organizations utilize the platform to disseminate messages supporting their goals and raise awareness of the issues they advocate. YouTube also allows the use of authoritative figures to convey messages, strengthen legitimacy, and maximize the impact of non-profit organizations in influencing public opinion.

However, challenges exist in the use of YouTube, especially in the context of political issues. There is "publicly private" and "privately public" behavior that can either limit or expand democracy. "Publicly private" behavior, where individuals restrict content access to close friends, may be seen as a limitation to democracy by reducing diverse idea exchange. On the other hand, "privately public" behavior, where individuals share content widely, can expand democracy by voicing various perspectives.

In the economic context, YouTube provides opportunities for local businesses to market their products or services. By creating engaging video content, businesses can enhance their visibility and reach a wider audience. YouTube also allows businesses to leverage the concept of remediation through hyper mediation and media convergence, optimizing the use of this platform as an integral part of their marketing strategy.

Nevertheless, challenges exist in the working conditions of YouTube content creators. The YouTube Partner Program, the authority to demonetize videos, and tiered regulation strategies can impact freedom of speech and the livelihood of YouTubers. The YouTubers Union attempts to advocate for the rights of content creators and improve transparency in the relationship between YouTube and creators, but they also face challenges and risks.

In the context of digital literacy and self-directed learning, YouTube plays a significant role in enhancing digital literacy through access to educational content, interactive learning experiences, and self-directed learning. Students use various strategies to evaluate online content, including class interactions, information from faculty, comparison methods, and "gut feelings." YouTube also provides opportunities for students to actively participate in creating and sharing their educational content, thus developing digital literacy skills in video production, editing, and effective communication.

This document also highlights the importance of ordinary individuals' engagement in public debates through digital spaces. They can challenge extreme narratives, provide alternative perspectives, and promote diversity and inclusivity in public discourse. The concepts of "ethno-epistemic assemblages" and "networked forms of expertise" provide a deeper understanding of the dynamics of public controversy and the role of individuals in shaping discourse. Overall, this document illustrates the impact of YouTube on various aspects of life, emphasizing the benefits and challenges associated with the use of this platform in different contexts.

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# CHAPTER 9

# Sustainable Development in Educational Institutions: Implementation of the ISM (Interpretive Structural Model) Method in Promotional Aspect

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## ABSTRACT

The COVID-19 pandemic has not only impacted the manufacturing industry but has also led to a decline in new student applications at higher education institutions, particularly at the university level. Promotional efforts, such as those through social media, virtual campus tours, and on-site visits, have not succeeded in increasing applicant interest. Therefore, promotional development is needed to support one aspect of university sustainability: the increase in interest from prospective new student applicants. This research aims to identify the key actors, primary needs, and main obstacles in developing promotions at universities using the Interpretive Structural Modeling (ISM) method. ISM elements for university promotional development are categorized into three criteria: (1) Stakeholders and actors involved in university promotion, (2) Needs for developing university promotion, and (3) Challenges or obstacles faced in university promotion. The findings indicate that key elements in the actor category include University Public Relations, Faculty Public Relations, and the Study Program Promotion Team. For promotional needs, the primary element is identified as promotion through social media platforms (Website, YouTube, Instagram, TikTok). The main obstacle identified is a limited promotional budget and a shortage of human resources with expertise in digital marketing. The relationship among these elements emphasizes the need for collaboration and synergy between University Public Relations, Faculty Public Relations, and Study Program Promotion Teams to intensify promotion through social media. This collaboration should be supported by recruiting digital marketing experts and allocating sufficient budgets to support promotional activities at the university.

**Keywords:** Interpretive Structural Modeling (ISM), University Promotion, ISM Elements.

## 1. INTRODUCTION

The COVID-19 pandemic has had significant impacts across various sectors, including educational institutions, particularly at the university level (S. S. Osadare, 2022). A decrease in the number of new students is one of the impacts felt by universities (D. Syahputra, 2021). The economic crisis caused by the pandemic has influenced the selective attitude of the community in choosing universities (A. Irawan *et al., 2021*). In addition to the economic crisis, another impact caused by the COVID-19 pandemic is the rapid development of technology, intensifying the competition among private universities (F. Dwiyama, 2021). Efforts and strategies are being undertaken to attract the interest of prospective new students to pursue their education at their universities (F. Dwiyama, 2021). One of the efforts being made is through aggressive and extensive promotional activities.

Promotion is one of the strategies used to introduce and showcase the excellence of a university, encompassing both quality infrastructure and facilities and successful graduates who have pursued professional careers. This is done by leveraging information technology for widespread awareness (F. Morimura *et al.,* 2018). Promotions conducted by universities should have well-thought-out strategies to achieve their desired goals. Things to consider in promotional activities include the effectiveness of communication and clearly defining the target market to ensure that the promotional strategy is effective (E. Gil-Cordero *et al.,* 2023). Various efforts have been made by universities to attract the interest of prospective students, including promotions through social media, conducting Virtual Campus Tours, and organizing on-site campus visits. However, despite these efforts, it seems that they have not been able to increase the interest of new students who apply (C. Larasati, 2023). Therefore, based on this issue, this research is conducted with the aim of identifying the main actors, primary strategic needs, and main obstacles in developing university promotions using the Interpretive Structural Model (ISM) method.

The implementation of the ISM model has been widely used for solving complex problems, such as decision-making in the evaluation of renewable energy development strategies (M. C. Mukeshimana *et al.,* 2021), the development of sharia cooperatives in Indonesia (J. Nazarian-Jashnabadi, *et al.,* 2022), improving patient satisfaction (P. Chen *et al.,* 2022), analysis of blockchain technology constraints (N. Lamba *et al.,* 2020), management green supply chain (U. Awan, *et al.,* 2018), successful implementation of social sustainability practices in manufacturing firm (J. Liu, *et al.,* 2020), and promoting wind energy consumption (D. P. Darmawan, 2017).

The ISM method, when implemented in the development of university promotions, can be considered suitable because the issue is complex (D. P. Darmawan, 2017). This research is expected to contribute or serve as a consideration for universities in formulating promotion policies, developing and improving current promotional efforts, so that the goal of enhancing competitiveness and attracting new prospective students can be achieved.

## 2. METHODS

ISM, or Interpretive Structural Modeling, is a decision-making method that utilizes descriptive modeling with a structured arrangement to depict the relationships among elements of variables (D. P. Darmawan, 2017). The ISM method was first introduced by John N. Warfield in 1974 as the most popular method for identifying the hierarchical structure of relationships

between criteria (J. Nazarian-Jashnabadi, *et al.,* 2022). The ISM model describes the complexity of a problem in a system and is presented in graphical form or descriptive sentences (S. Shekhar, R *et al.,* 2022; A. Zainal *et al.,* 2023).

The development of the ISM model is carried out through several stages presented in Figure 1, including (P. Darmawan, 2017): (1) Identification of variable elements by conducting literature reviews, observations, and interviews with experts in the field of promotion, (2) Formation of the Structural Self-Interaction Matrix (SSIM) from expert assessments in the field of promotion using the VAXO questionnaire, (3) Development of the Reachability Matrix (RM) by converting the results of V, A, X, O symbols into binary numbers (0 and 1), (4) Development of the ISM Model.

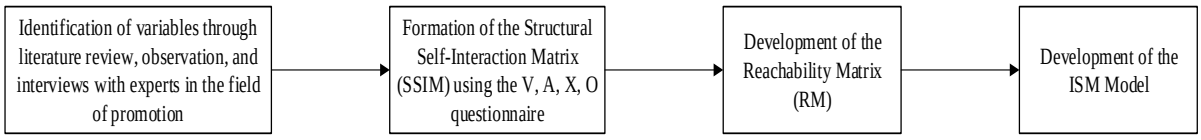


**Figure 1.** Stages of ISM model development

## 3. RESULT AND DISCUSSION

### 3.1. Situational Analysis

The impact of the COVID-19 pandemic has resulted in a decrease in the number of new students in universities. Due to the economic crisis, people have become more selective in choosing universities, supported by the rapid development of technology, which has intensified competition among universities, especially private ones. Various efforts have been made by universities to promote their institutions, but they have not succeeded in attracting the interest of prospective new student applicants. This needs further identification of what needs to be developed, improved, or enhanced to support the development of university promotions. The development of promotions in universities is crucial to increase the number of new students and the competitiveness of the university as one aspect of sustainability. Here are the results and discussions at each stage of the promotion development using the ISM method.

### 3.2. Identification of Variable Elements

The identification of variable elements was obtained through interviews with experts specializing in university promotion and the results of literature reviews (E. Gil-Cordero *et al.,* 2023; K. Dmitrijeva *et al.,* 2012; T. Czapla *et al.,* 2023) There are three variables identified in this study, namely, the actors involved, needs, and constraints in university promotion. Each variable has several elements. Table 1 shows the results of identifying variable elements obtained from interviews with university promotion experts.

**Table 1.** Variable Elements

| | | |
|---|---|---|
| Actors | A1 | University Public Relations |
| | A2 | Faculty Public Relations |
| | A3 | Study Program Promotion Team |

| | | |
|---|---|---|
| | A4 | Faculty Members |
| | A5 | Student |
| | A6 | Alumni |
| Needs | B1 | Social Media Promotion (Website, Instagram, YouTube, TikTok) |
| | B2 | Social Activities (Blood Donation, Equipment Grants) |
| | B3 | Employee Development Activities |
| | B4 | Creating Prospective Collaborations with the Acceleration Center and Engineering Center |
| Constraint | C1 | Financing/Budget Limitations |
| | C2 | Insufficient Human Resources with Expertise in Digital Marketing |
| | C3 | Limited Workshops or Training in Digital Marketing for the Promotion Team |
| | C4 | Limited Knowledge and Understanding of Digital Marketing within the Promotion Team |
| | C5 | Human Resource Limitations in the Promotion Team |

### 3.3. Formation of Structural Self-Interaction Matrix (SSIM)

The results of forming the Structural Self-Interaction Matrix (SSIM) are obtained by inputting the expert assessments for each variable element. If element-i has more influence or affects more than element-j, it is denoted as V; notation A if element-j has more influence or affects more than element-i; notation X if both element-i and element-j have equal influence or mutually influence each other, and notation O if both elements, namely element-i and element-j, do not influence or affect each other (A. Santana *et al.,* 2018). The results of forming SSIM for each variable element are shown in Table 2.

**Table 2**. SSIM Elements

| Needs | B1 | B2 | B3 | B4 |
|---|---|---|---|---|
| B1 | | X | V | V |
| B2 | | | A | A |
| B3 | | | | A |
| B4 | | | | |

| Constraints | C1 | C2 | C3 | C4 | C5 |
|---|---|---|---|---|---|
| C1 | | X | V | V | V |
| C2 | | | V | X | X |
| C3 | | | | V | X |
| C4 | | | | | V |
| C5 | | | | | |

| Actor | A1 | A2 | A3 | A4 | A5 | A6 |
|---|---|---|---|---|---|---|
| A1 | | X | X | V | V | V |
| A2 | | | X | V | V | V |
| A3 | | | | V | V | V |
| A4 | | | | | X | X |
| A5 | | | | | | X |
| A6 | | | | | | |

### 3.4. Development of Reachability Matrix (RM)

After the development of SSIM, the next step is the development of the Reachability Matrix (RM) by converting symbols into binary numbers 0 and 1. The conversion is done based on the following rules: (1) if the input (i,j) in SSIM is V, then the value of (i,j) is 1 and (j,i) is 0; (2) if the input (i,j) in SSIM is A, then the value of (i,j) is 0 and (j,i) is 1; (3) if the input (i,j) in SSIM is X, then both values of (i,j) and (j,i) are 1; (4) if the input (i,j) in SSIM is O, then both values of (i,j) and (j,i) are 0[15]. The results of the development of the Reachability Matrix (RM) for actor, needs, and constraints elements are shown in Table 3-5.

**Table 3.** Development of reachability matrix for actor elements

| | A1 | A2 | A3 | A4 | A5 | A6 | Driver Power | Rank | Dependence |
|---|---|---|---|---|---|---|---|---|---|
| A1 | 1 | 1 | 1 | 1 | 1 | 1 | 6 | 1 | 3 |
| A2 | 1 | 1 | 1 | 1 | 1 | 1 | 6 | 1 | 3 |
| A3 | 1 | 1 | 1 | 1 | 1 | 1 | 6 | 1 | 3 |
| A4 | 0 | 0 | 0 | 1 | 1 | 1 | 3 | 2 | 6 |
| A5 | 0 | 0 | 0 | 1 | 1 | 1 | 3 | 2 | 6 |
| A6 | 0 | 0 | 0 | 1 | 1 | 1 | 3 | 2 | 6 |

**Table 4**. Development of reachability matrix for needs elements

| | B1 | B2 | B3 | B4 | Driver Power | Rank | Dependence |
|---|---|---|---|---|---|---|---|
| B1 | 1 | 1 | 1 | 1 | 4 | 1 | 2 |
| B2 | 1 | 1 | 0 | 0 | 2 | 3 | 4 |
| B3 | 0 | 1 | 1 | 0 | 2 | 3 | 3 |
| B4 | 0 | 1 | 1 | 1 | 3 | 2 | 2 |

**Table 5.** Development of reachability matrix for constraints elements

| | C1 | C2 | C3 | C4 | C5 | Driver Power | Rank | Dependence |
|---|---|---|---|---|---|---|---|---|
| C1 | 1 | 1 | 1 | 1 | 1 | 5 | 1 | 2 |
| C2 | 1 | 1 | 1 | 1 | 1 | 5 | 1 | 4 |
| C3 | 0 | 0 | 1 | 1 | 1 | 3 | 2 | 4 |
| C4 | 0 | 1 | 0 | 1 | 1 | 3 | 2 | 4 |
| C5 | 0 | 1 | 1 | 0 | 1 | 3 | 2 | 5 |

### 3.5. Development of the ISM model

The formed Reachability Matrix is converted into an ISM model by transforming the nodes of factors with a statement summarizing the key elements in each variable. The key elements will be evident in the ISM Model for each variable. The ISM Model for actor, needs, and constraints elements is shown in Figure 2, Figure 3, and Figure 4, respectively.

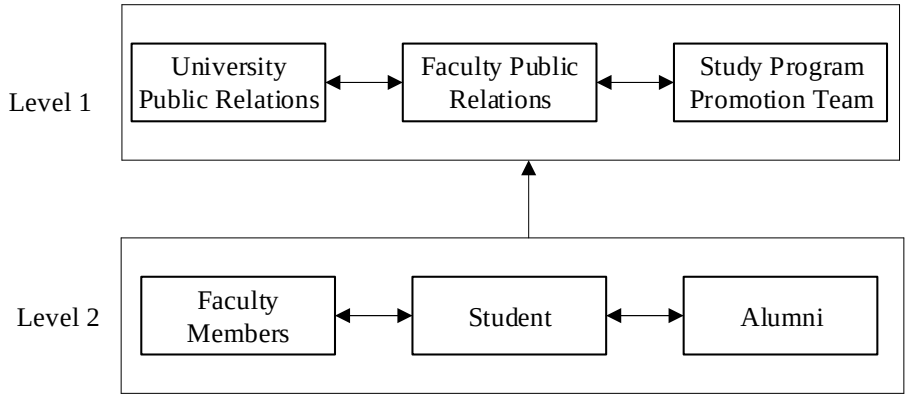


**Figure 2.** Development of the ISM model for actor elements

The results of the ISM model development in Figure 2 indicate that the University Public Relations, Faculty Public Relations, and Study Program Promotion Team are key actors in the development of university promotion. Additionally, this model also illustrates the need for synergy and good cooperation between University Public Relations, Faculty Public Relations, and the Study Program Promotion Team, assisted by collaboration between Faculty Members, Students, and Alumni to support the success of the promotion.

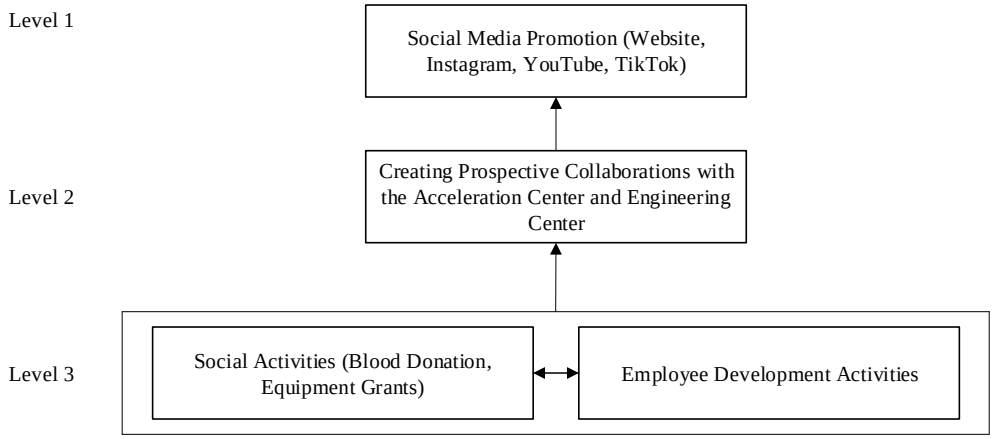


**Figure 3.** Development of the ISM model for needs elements

Furthermore, the results of the ISM model development in Figure 3 indicate that Promotion through social media (Website, Instagram, YouTube, TikTok) is a primary need in the development of university promotion. University Public Relations, Faculty Public Relations, and the Program Promotion Team need to intensify promotions through digital platforms as they can reach potential new students widely and enhance the creation of engaging content with appealing visualizations. Additionally, showcasing the university's strengths, fostering prospective collaborations with the Acceleration Center and Engineering Center of the University, Social Activities (Blood donation, Equipment Grants), and Employee Development Activities are also necessary in the promotion development.

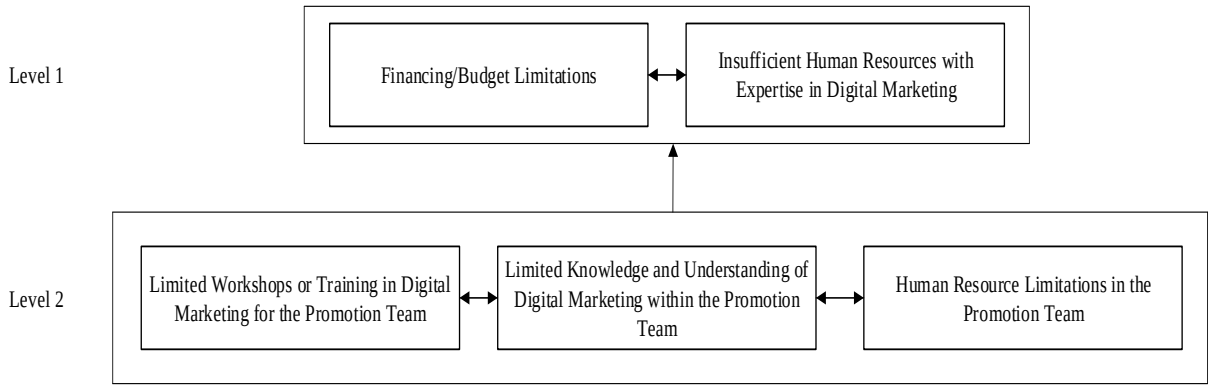


**Figure 4.** Development of the ISM model for constraints elements

The results of the ISM model development for constraint elements in Figure 4 indicate that financing or budget constraints, and the inadequacy of human resources with digital marketing expertise are major constraints in the development of university promotion. Other interrelated constraints include the limitation of workshops or training in digital marketing for the promotion team, the limited knowledge and understanding of digital marketing within the current promotion team, and the human resource constraints in the promotion team. In creating engaging content for social media promotion, human resources with expertise in digital marketing and funding or budget for content creation are needed for optimal results. Therefore, special training for the promotion team and the recruitment of a team specialized in digital marketing are essential.

## 4. CONCLUSION

The development of university promotion using the ISM (Interpretive Structural Modelling) method, based on the assessments of experts in the field of promotion, is divided into three frameworks: actor elements, needs, and constraints. Based on the results of the ISM model development for each element, it is found that in the Actor element, the main actors in the development of promotion are the University Public Relations, Faculty Public Relations, and the Program Promotion Team. Next, in the Needs element, the primary needs in the development of university promotion are promotion through social media (Website, Instagram, YouTube, TikTok) supported by engaging content and visualization.

Then, in the Constraints element, the main constraints in the development of university promotion are financing or budget constraints and the inadequacy of human resources with digital marketing expertise. This indicates the need for improvement within the university's internal processes for promotion, such as the necessity of synergy among University Public Relations, Faculty Public Relations, and the Promotion Team in creating compelling content distributed through digital social media platforms, supported by adequate budget and human resources.

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# CHAPTER 10

# Implementation of Interpretative Structural Modelling for Water Resources Infrastructure Asset Data Processing Management Information System

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## ABSTRACT

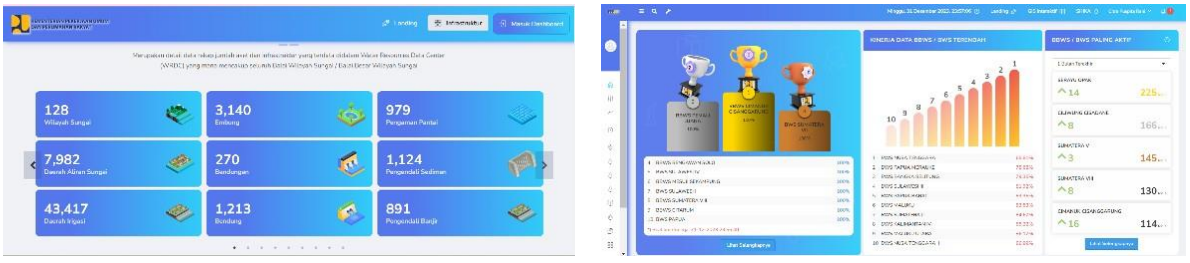
The Directorate of Water Resources Engineering has a management information system (MIS) for processing infrastructure asset data. The purpose of this research is to plan a strategic formulation to support the success of the MIS implementation for processing SDA infrastructure data. The strategy for implementing the information system involves the use of Interpretative Structural Modelling (ISM) techniques. The ISM elements used in this formulation are: (1) Needs in Programme Implementation; (2) Main Constraints in Programme Development; and (3) Actors Involved in Programme Success. The Needs element comprises the Directorate of Technical Development, Availability of Funds, and Availability of Human Resources to Complete Field Data. The Constraints element of the programme includes limited Human Resources (HR), a lack of understanding of Natural Resources, the absence of Regulatory Policies, and insufficient Data support. The actors involved and influential in the programme's implementation are the Directorate General of Natural Resources and the River Basin Agency (B/BWS). To successfully implement the SDA information system, the involvement of the Directorate General of Natural Resources and the existing B/BWS is necessary. This includes the role of the Directorate of Bina Teknik in terms of funding preparation and ensuring the availability of human resources to complete the data.
**Keywords:** Interpretive Structural Modeling (ISM), Management Information System (MIS), Strategic

## 1. INTRODUCTION

An information system is a tool that agencies use to process data, with the aim of improving work efficiency and effectiveness Asidhiqi and Hartanto (2013) state that information technology, particularly information systems, is essential in the field of water resource mapping to expedite information processing and facilitate decision-making based on field data (Saptoriantoro, P. *et al.,* 2017). Implementing information systems benefits from presenting data digitally, allowing for universal access from any location at any time (Kurniawan, Y *et al.,* 2019). A website-based information system facilitates secure data storageand provides faster access to information.

Water is a fundamental human need, as stated in Indonesian Law No. 17 of 2019 on Water Resources. Article 4 outlines the scope of regulation for water resources, which encompasses the water resources information system (Presiden Republik Indonesia Undang-Undang Republik Indonesia Nomor 17 Tahun 2019). The management of water resources at both federal and local levels is governed by the regulations of the Ministry ofPublic Works. The Ministry is responsible for developing infrastructure, planning technically, supervising equipment, maintaining and repairing copyright works, spatial planning, sanitation, and landscaping.

The Directorate of Water Resources Engineering (SDA) manages and assesses data related to water resource infrastructure assets. The data is processed through a web-based management information system. The information system aims to help manage, monitor, and evaluate infrastructure assets in Indonesia's Balai Besar Wilayah Sungai (BBWS) or Balai Wilayah Sungai (BWS), as shown in Figure 1 (b). By integrating systems, data will be readily available, and comprehensive analysis can generate valuable insights. The system serves as a monitoring tool for infrastructure assets related to natural resources. The infrastructure that is managed includes embankments, weirs, dams, coastal protection, and sediment control assets (Bina Teknik SDA WRDC (Water Resources Data Center). Bintek SDA carries out the implementation of the information system during the construction of a water resources management system. The system will function as a website-based data centre. Figure 1 (a) shows the system. Information on the landing page is accessible to the public.




(a) (b)

**Figure 1.** Capture of water resources infrastructure asset data processing management information system: (a) Landing page for external; (b) Dashboard page for internal.

The research problem is how to implement and use a management information system for processing SDA asset data. Users within the Directorate SDA need to be able to use this system effectively. The problem formulation was derived from forum discussions and internal reports on data performance from B/BWS every month. The results showthat three elements can guide the implementation strategy of this information system: the need for a program in the implementation strategy, awareness of the primary obstacles in program development, and

identification of the actors that influence program success. The ISM method can be used to design a relationship model and group strategic objectives based on priorities for decision making (Hidayat, M.A. *et al.,* 2019). The ISM approach can transform an unclear model into a well-defined one to support decision-making. These models help identify key factors related to the problem (Lamba, N. *et al.,* 2020). The study employed the ISM method to conduct a qualitative analysis of the interrelationships between causal factors. An ISM model of causal factors in the emergency process was established, and the direct, indirect, and root factors that cause secondary accidents were identified (Yuan, C *et al.,* 2019). ISM is a useful tool for identifying the relationships between variables to improve and develop a supply chain to achieve a specific goal (Beikkhakhian, Y *et al.,* 2015. Interpretive Structural Modelling (ISM) can assist managers in intuitively recognising the causes and consequences of existing factors by creating hierarchical relationships (Chen, P *et al.,* 2022). Using the methodologies of interpretative structural modeling (ISM) and analytic network process (ANP) in a fuzzy logic environment, the authors have calculated the optimal opportunity to compare BC with the conventional approach used to support SC (Yadav, S. *et al.,* 2020). The removal of barriers to blockchain technology in electricity data trading, taking into account the unique characteristics of the electricity industry can analyze the hierarchical structure and facilitate this process, the article proposes an extension of DEMATEL with fuzzy theory, clustering algorithms, and ISM (Chen, P *et al.,* 2022). The ISM technique can be used to identify the key factors that affect student mobility. Relevant variables can then be extracted and organised into a comprehensive and systematic model (Razavisousan, *et al.,* 2022). The ISM methodology is a qualitative mathematical approach that domain specialists use to break down complex socio-economic problems into smaller underlying factors (Mondal, J *et al.,* 2021). The use of the ISMs model and the Drivers and Dependents Diagram will enable the city to systematically understand the complexity of the relationships and identify areas where action could be taken (Sarabi, S *et al.,* 2020). The most serious issue can be determined by developing a hierarchical scheme of factors using the Interpretative Structural Modeling (ISM) method (Kim, *et al.,* 2023). The objective of this study is to create a strategic plan for the successful implementation of the Management Information System for Directorate SDA Infrastructure Data Processing. To enhance its strategic and long-term planning effectiveness, the research employs Interpretative Structural Modeling (ISM). The ISM technique is used to transform imprecise or inadequately expressed mental models of a system or task into a clear model to help identify critical elements associated with issues or problems. The study aimed to develop a strategic roadmap for improving the efficiency of existing information systems.

## 2. METHOD

The Directorate SDA and 37 B/BWS in Indonesia use the Water Resources Infrastructure Asset Data Processing Management Information System. This study followed a case study methodology, gathering data through stakeholder interviews and forum group discussions. Secondary data was obtained from reports at the Directorate SDA and library searches. Primary data was collected through in-person interviews with experts using questionnaires. The study's experts involved stakeholders. These included the team leader of the data and information system development and a representative of the person in charge of records and assets (Bina Teknik SDA WRDC (Water Resources Data Center)).

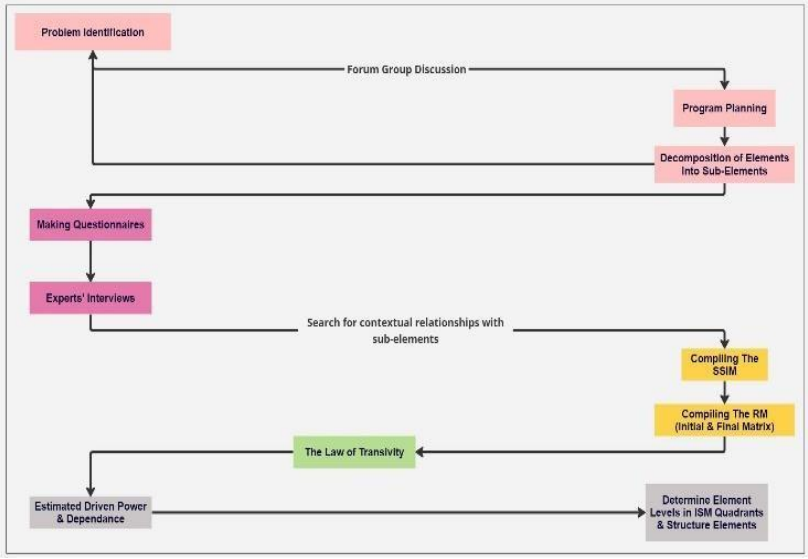



**Figure 2.** Research stages and framework

The strategic plan uses the ISM modelling technique, which evaluates groups of structural models to produce a detailed system description using words and pictures. Figure 2 illustrates the steps taken in this research.

## 3. RESULT AND DISCUSSION

The VAXO method was used for data processing with ISM, and the steps are explained in this study (V: i-th sub- element that has a relationship with the j-th sub-element, while the j-th sub-element has no relationship with the i-th sub-element. A: j-th sub-element that has a relationship with the i-th sub-element, while the i-th sub-element has no relationship with the j-th sub-element. X: i-th sub-element that has a reciprocal relationship with the j-th sub-element, while O: i-th sub-element that has no reciprocal relationship with the j-th sub-element) (Rachman Jaya, M *et al.*, 2011).

### 3.1. Compilation of SSIM Matrix Questionnaire

In the use of ISM for modelling, expert opinions or judgements are expressed in the form of V, A, X, O to represent their contextual relationships (Rachman Jaya, M *et al.*, 2011). The SSIM matrix was constructed and the results are presented below.

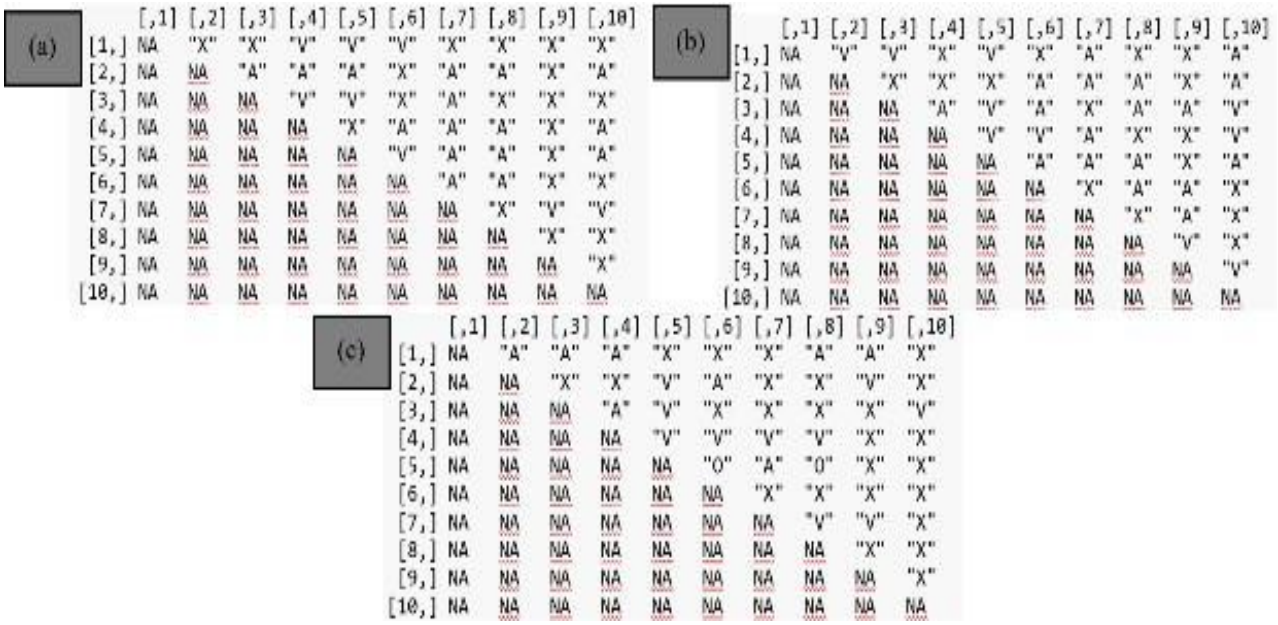



**Figure 3.** Capture of The SSIM matrix result: (a) SSIM matrix of needs elements for programme delivery; (b) SSIM matrix of the main constraints for developing the programme; (c) SSIM matrix of actors involved

### 3.2. Compiling SSIM Matrices into Reachability Matrices

In order to transform the SSIM into a Reachability Number Matrix, consider the contextual relationships between the sub-elements in the form of a matrix with cells in the form of VAXO. Then, transform the existing SSIM into a binary matrix by replacing the symbols V, A, X, and O with 1 or 0, respectively. Follow these substitution rules: If Fi to Fj=V, then Fij=1 and Fji=0. If Fi to Fj=A, then Fij=0 and Fji=1. If Fi to Fj=X, then Fij=1 and Fji=0. If Fi to Fj=O, then Fij=0 and Fji=0.

### 3.3. Reachability Matrix Transformation Test

To test the reachability matrix, perform Boolean operations on numbers. If the matrix satisfies the reflexive and transitive conditions, it can proceed to the next step. Otherwise, the matrix condition must be modified by performinga recursive multiplication operation to form a closed matrix condition, which can create a causal loop and generate the final reachability matrix.

The current sub-elements of the SDA Infrastructure Asset Data Processing Management Information System demonstrate its successful implementation. Table 1 is required for program implementation.

### 3.4. SSIM Matrix Compiling Results

The expert questionnaire results, based on the sub-elements described in Table 1 are organised into an SSIM matrix, as shown in Figure 3(a), (b), and (c). Figure 3 (a) illustrates the SSIM matrix of the requirements element, Figure 3 (b) illustrates the SSIM matrix of the development constraints element, and Figure 3 (c) illustrates the SSIM matrix of the actors involved.

**Table 1.** Sub-elements: (1) of the needs to support programme implementation strand; (2) of 'Major constraints to programme development; (3) Actors Involved in Programme Success

| | Sub Element 1 | Sub Element 2 | Sub Element 3 |
|---|---|---|---|
| A1 | Orientation of the Technical Development Directorate | Limited human resources | PUSDATIN |
| A2 | Orientation of PUSDATIN | IT Expert | Directorate General of Natural Resources |
| A3 | Availability of data and information | IT operators have not received training | Directorate of Natural Resources Engineering |
| A4 | Regional IT operators | Lack of understanding of natural resources | B/BWS |
| A5 | Participation of the central IT operator | Information technology not yet evenly distributed | Local Government |
| A6 | Availability of technology | Conflict of interest between echelons | IT Expert |
| A7 | Availability of funds | Lack of regulatory policy | Data and Information Coordinator |
| A8 | Availability of human resources to complete field data | Availability of data | Central IT Operator |
| A9 | Coordination between sectors | Limited resources | Regional IT Operator |
| A10 | Regulatory policy support | Unclear data source | Database Administrator |

### 3.5. Reachability Matrix Transformation Test Results

The SSIM matrix results are converted into a binary matrix by replacing the V, A, X, and O symbols with 1 or 0 for each case. Figure 4 (a), (b) and (c). Subsequently, the reachability matrix test is conducted. The transitivity matrix test is used to check its transitivity and modify the Reachability Matrix. The final Reachability Matrix is obtained as shown in Figure 5 (a), (b), and (c). The canonical matrix results obtained from the ISM software explain the Driver Power, Rank, Dependency, and Hierarchy of the element. Figure 6 (a), (b) and (c).

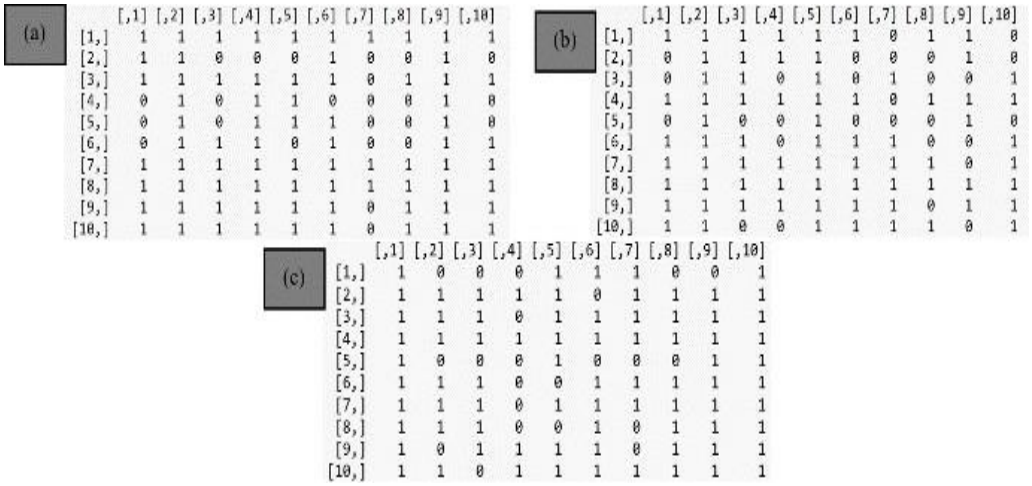



**Figure 4.** Capture of Initial Matrik Reachability: (a) Number of elements needed for programme implementation; (b) Number of elements of main constraints to programme development; (c) Number of elements of actors involved.

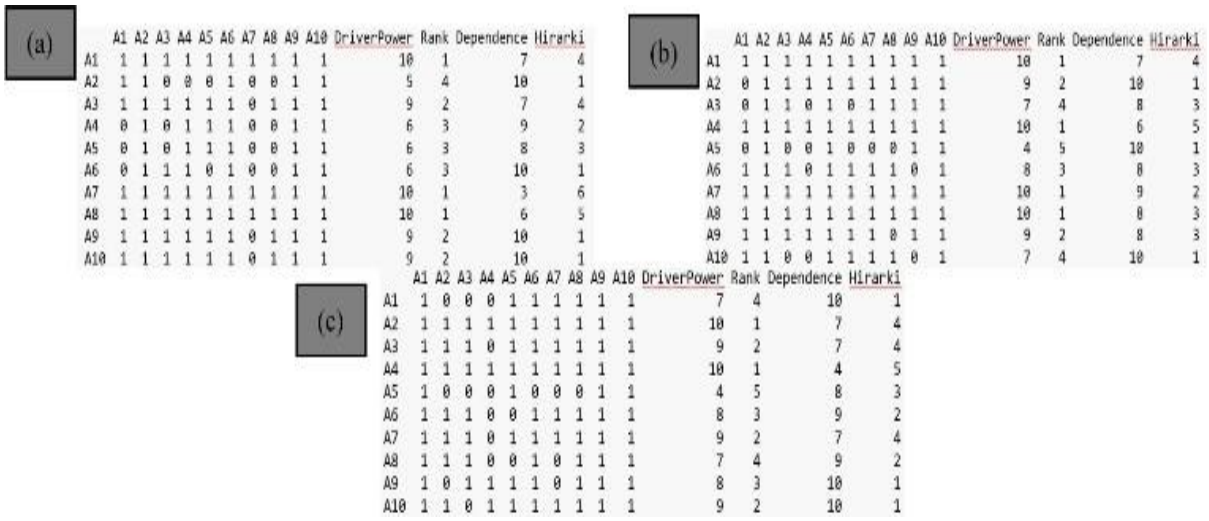



**Figure 5.** Capture of Final Matrik Reachability: (a) Number of elements needed for programme implementation; (b) Number of elements of main constraints to programme development; (c) Number of elements of actors involved.

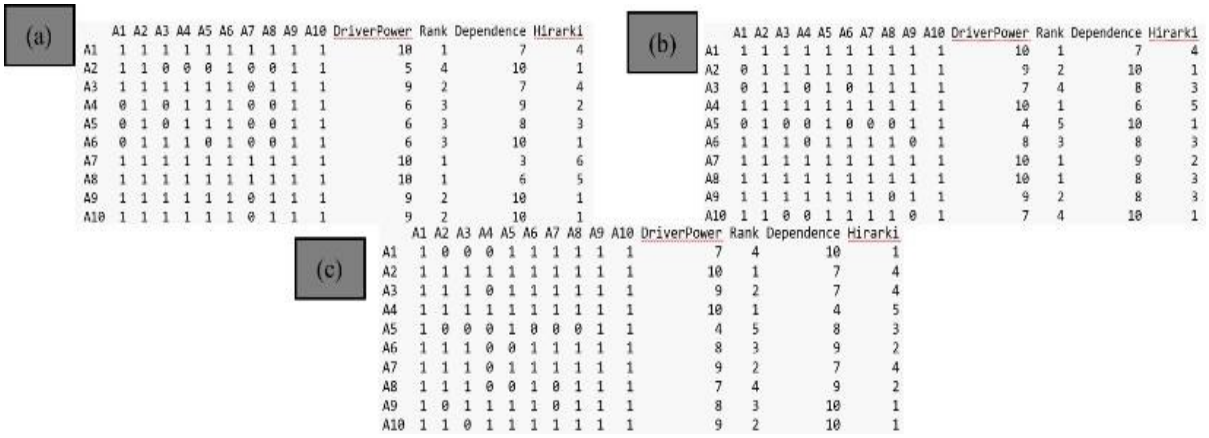



**Figure 6.** Capture of Canonical matrix: (a) Elements of the need for programme implementation; (b) Elements of key constraints to programme development; (c) Actor Element Number of elements needed for programme implementation.

The canonical matrix produces an ISM graph that classifies the matrix into four quadrants. Quadrant I (Q1) is classified as Autonomous, Quadrant II (Q2) as Dependent, Quadrant III (Q3) as Linked, and Quadrant IV (Q4) as Independent. If the element is located in Q1, it is weakly related to the system or considered a Weak Driver - Weak Dependent. If the element is located in Q2, it is interrelated or considered a Weak Driver - Strong Dependent. If the element is located in Q3, it is sensitive and unstable or considered a Strong Driver - Strong Dependent. Finally, if the element is located in Q4, it is an independent element or considered a Strong Driver - Weak Dependent. The results of the ISM graph on the three elements studied are presented below on Figure 7 (a), (b), and (c).

Based on the results of Grap ISM, key elements (level 1) were identified for the implementation of the programme. These include the Directorate of Bina Teknik, availability of funds, and availability of human resources to complete field data, as shown in Figure 8 (a) and (b).

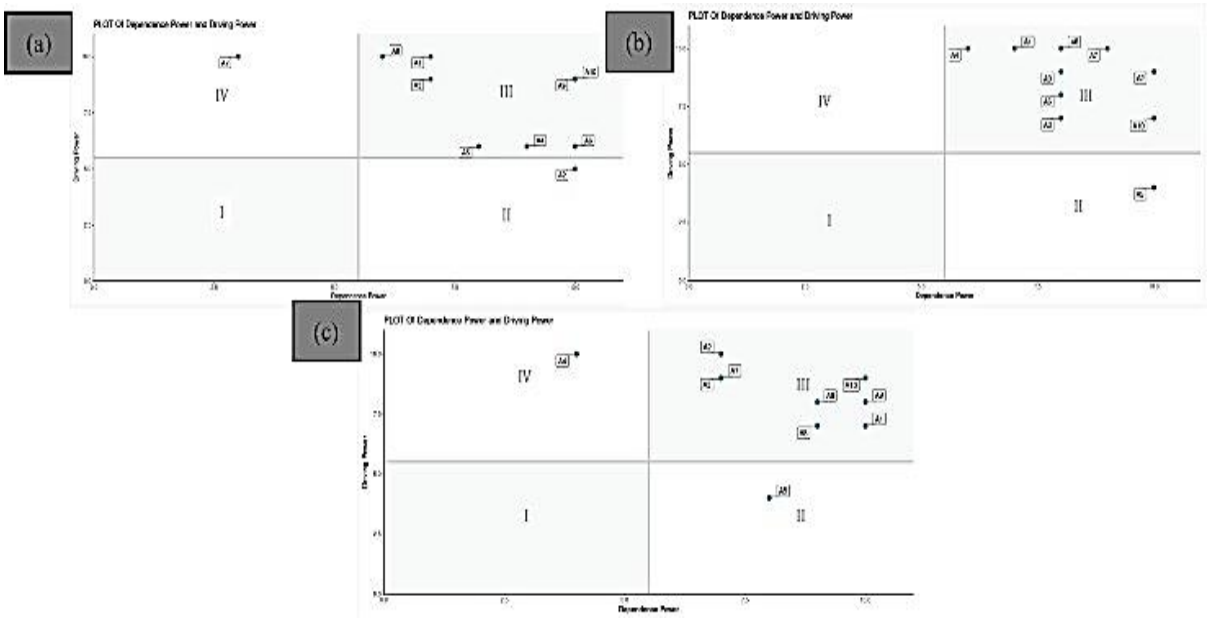



**Figure 7.** Capture of ISM Graph: (a) of items required to implement the programme; (b) c of the main constraints to developing programmes; (c) of actors involved in the success of the programme.

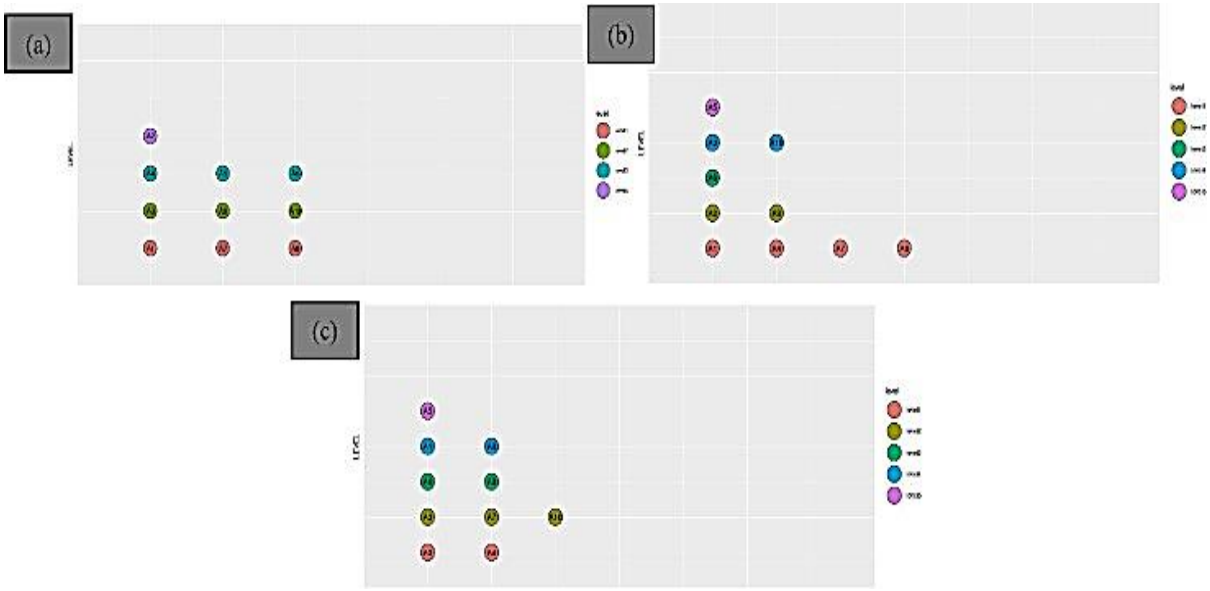



**Figure 8.** Capture of Graph Level: (a) Programme implementation requirements; (b) Programme development constraints; (c) Actors contributing to the success of the programme

Table 2 shows a classification of key elements that can be used as strategies for successfully implementing the Information System for the Management of SDA Asset Data Processing within the Directorate SDA.

a. The implementation of the program's needs resulted from the strategic activity of establishing a data processing management system for natural resource assets. The program's needs sector primarily comprises aligning the Bina Teknik Directorate, securing funding, and ensuring sufficient human resources to complete the field data on Figure 8 (a). The

output of the detailed analysis produces the ISM graph, as shown in Figure 7 (a) presents the ISM graph for the Needs element, which is essential for the program's execution.

b. The system's program development is limited by ten sub-elements. Limitation sector is mainly due to the scarcity of human resources, lack of knowledge of natural resources, absence of regulatory policies, and unavailability of data that facilitates system deployment on Figure 8 (b). The ISM graph's sub-elements are divided into two quadrants, Q2 and Q3. The sub-element A5, which pertains to information technology inequality, is located in Q2, making it dependent and susceptible to influence from other sub-elements. On the other hand, all other sub-elements are situated in Q3, indicating mutual influence.
c. The success of the SDA system's program is attributed to the performers involved. The participation of actors from the Directorate SDA and B/BWS is an essential component of this sector on Figure 8 (c). The sub-elements are dispersed among the three quadrants (Q2, Q3, and Q4) of the ISM graph. The analysis indicates that the local government (A5) is reliant on other sub-elements and has a weak driving force, placing it in Q2. B/BWS (A4) is in Q4 (independent), indicating that the availability of funds is a significant motivator.

**Table 2.** Sub-elements of Major constraints to programme development

| No | System Elements | Key Elements |
|---|---|---|
| 1 | Programme implementation needs | a. Technical Development Directorate<br>b. Availability of funds<br>c. Availability of human resources to complete field data |
| 2 | Main Constraints in Programme Development | a. Limited human resources,<br>b. Lack of understanding of natural resources,<br>c. No regulatory policy<br>d. Availability of data |
| 3 | Actors Involved in Programme Success | a. Directorate-General for Natural Resources<br>b. B/BWS |

## 4. CONCLUSION

The role of the participants within the Directorate of Natural Resources, the existing B/BWS and the need to budget funds and manpower to complete the field data collection under the supervision of the Directorate of Bina Teknik are important factors in developing a plan to ensure the efficient operation of this Natural Resource Information System. In addition, industry challenges such as limited human resources, insufficient expertise in natural resource management, weak regulations and lack of support are issues that need to be addressed. To enable the relevant parties within the Directorate General of Water Resources to carry out planning by considering the above points as a basis for the implementation or development of future water resource information systems supported by the local government. With the support of the local government, the community in the loyal area can take part as one of the human resources that help in terms of data completeness.

The results of this research are expected to be used as recommendations for related parties within the Directorate General of Water Resources, both other governments and the community.

## 5. ACKNOWLEDGMENTS

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# CHAPTER 11

# Decision Support System for Railways Spare Parts Inventory Control

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## ABSTRACT

Decision-making in inventory management plays a very important role in controlling operational costs and production effectiveness within an industry. Electric rail trains (KRL) as a means of public transportation in Jabodetabek, requires good maintenance management to maintain operational reliability. In the current management of the KRL maintenance system, fast and accurate decisions on controlling the KRL spare parts inventory are needed so that the maintenance process runs smoothly and minimal operational costs are obtained. This research aims to design a decision support system (DSS) for KRL spare parts inventory control decisions. This research begins with a PIECES (Performance, Information, Economy, Efficiency, Control, Service) analysis to understand system requirements. The designed DSS consists of 4 sub-models, which are 1) spare parts demand forecasting model with Monte Carlo simulation, 2) s & Q parameter calculation model for continuous review system, 3) inventory control scenario evaluation model based on total cost and service level criteria, and 4) decision assessment model with simple additive weighting method. The data required by DSS are spare parts data, spare parts demands, inventory control costs, and supplier data. Results of DSS examination on KUR 12313 and KUR 12314 spare parts show that the system is able to provide decisions in determining needs and ordering spare parts quickly and precisely. In conclusion, the designed DSS can be implemented in the spare parts inventory control system for all types of spare parts in the KRL maintenance process.
**Keywords**: DSS, Railways Spare Part, Iventory

## 1. INTRODUCTION

In the development of Industry 4.0, Decision Support System (DSS) has become one of the tools with great impacts on improving the decision-making process in inventory management in an industry (Yardani *et al.,* 2017; Scott J *et al.,* 2015). DSS in the field of inventory management helps decision-making to monitor inventory levels effectively and ensure continuous availability of goods [3]. This is very relevant in the inventory control system of railway spare parts which have irregular demand patterns and difficult to be predicted (Scott J *et al.,* 2015). Determining decisions in selecting suppliers and the number of orders assigned to suppliers is also involved as an inventory management problem (Vidal, G.H. de P *et al.,* 2022) DSS could provide good indications in the context of decision-making in inventory management (Deb M *et al.,* 2019).

Electric rail trains (called KRL in Indonesia) are public rail transportation that is considered as a sustainable transportation option for the daily needs of the people of Jabodetabek (Hidayati, 2023). The operational reliability of KRL depends on the maintenance system it has. One of the factors that influences the KRL maintenance system is the availability of spare parts. Decision-making in determining needs (demand) and ordering KRL spare parts is the main objective of KRL spare parts inventory management. With a variety of spare parts in the KRL maintenance process, decisions regarding KRL spare parts inventory often take a very long time and provide less than optimal results. Fast and accurate decisions regarding inventory control are needed so that the maintenance system is maintained smoothly and the company profits are obtained as much as possible.

A decision support system is a computer-based information system that is interactive, flexible, and easy to adapt, developed to build a decision support system using data, expert knowledge, and models to support company decision-making in selecting alternatives based on certain criteria to achieve company goals or resolve existing problems. complex (Septiani *et al.,* 2021; Septiani *et al.,* 2020).

Monte Carlo simulation as a form of forecasting spare parts needs is applied to the system. This method is based on a randomization process that involves uncertain parameters in the form of probability distributions from past data to capture the stochastic behavior of real systems (Hussain *et al.,* 2019; Li M *et al.,* 2016). The Continuous Review (s, Q) policy model aims to fulfill probabilistic demand patterns that implement an inventory policy with an exponential distribution process that is carried out continuously, where orders are placed when the stock point reaches a certain point (Baek J W *et al.,* 2018; Silver E A *et al.,* 1998). The use of the Simple Additive Weighting (SAW) method in DSS helps managerial decisions in determining alternative choices more quickly and accurately (Sahir S H *et al.,* 2017).

This research aims to design a decision support system for the KRL spare parts inventory control system. The proposed system aims to facilitate decision-making in controlling KRL spare parts inventory with a more systematic, more documented, and objective system to provide an effective, fast process, and accurate results.

## 2. METHODS

### 2.1. Research Flow and Data Collection Method

The stages of DSS modeling in this research will be explained further as depicted in Figure 1. In general, the stages of DSS modeling are carried out by designing a conceptual model,

designing a system model, designing a system menu, designing an interface design, and testing the model.

The data that will be used in the DSS as input data or analysis data are spare part information, spare part cost and historical demands, spare part stock quantity, inventory control costs (purchasing cost, inventory cost, stockout cost), and supplier data. Data collection was carried out at PT. Kereta Commuter Indonesia as a company that provides and maintains KRL operating in Jabodetabek. Data collection techniques were obtained by interviews with local employees, system observations, and requests for data related to decision-making systems in controlling KRL spare parts inventory. The system will be tested using the black box method to test the validity of the system, then the system is tested for verification by comparing the conceptual model with the system that has been created.

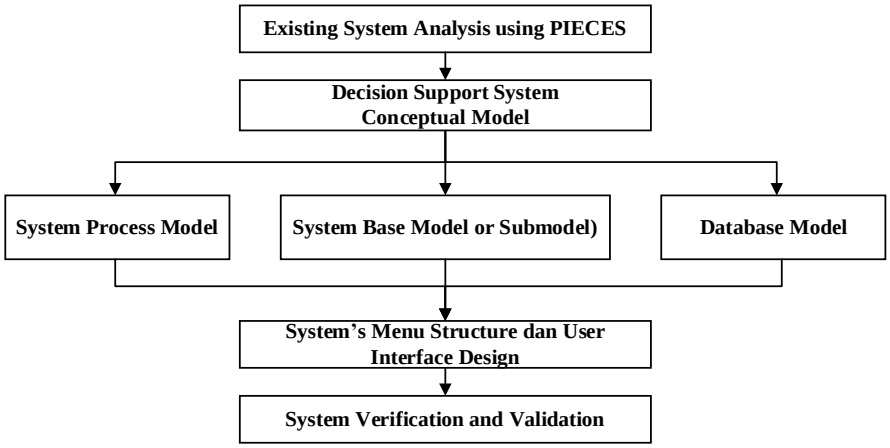


**Figure 1.** Research methodology flowchart

## 3. RESULT AND DISCUSSION

### 3.1. KRL Spare Parts Inventory Control

The KRL spare parts inventory control system includes 4 stakeholders that have a role in planning the KRL maintenance spare parts inventory. These stakeholders consist of the CTP unit (maintenance planning division), CTR unit (rolling stock division), warehouse unit, and suppliers. The CTP unit, as the main role, functions as a unit that determines decisions in controlling spare parts inventory. The control process begins with collecting data from the warehouse (logistics) unit and the CTR unit. Next, inventory control is simulated using the data that has been received. The results of the control are in the form of spare parts needs which will become a report for the logistics unit to be submitted to the CTP unit as the maintenance implementer. Orders through suppliers will be made when inventory stock does not meet demand.

### 3.2. PIECES analysis

The PIECES analysis was made using information obtained from the company based on interviews and observations. The results of the PIECES analysis are presented in Table 1. This analysis will be used as specifications needed in DSS design to correct the shortcomings of the current system.

**Table 1.** PIECES analysis of the decision-making system on KRL spare parts inventory control

| No. | Indicators | Existing Decision-Making System on Inventory Control | Proposed System with DSS |
|---|---|---|---|
| 1 | Performance | The decisions taken in determining the need for spare parts are currently not considered accurate judging from the effectiveness of the service level for spare parts which is not yet optimal | More accurate decisions which improves the service level performance of KRL spare parts usage |
| 2 | Information | Information data for decision analysis is stored in separate files and uses hard file documentation | Implementation of a database data collection system to facilitate access to information as decision analysis data |
| 3 | Economy | Inventory and operational costs (downtime due to stockouts) are quite large based on the results of the decisions taken | More accurate decisions that can provide more efficient inventory and operational costs |
| 4 | Controls | Unreliable spare parts inventory control method | Improved inventory control methods assisted with alternative assessments |
| 5 | efficiency | Time consuming decision-making process for determining spare parts needs | Faster decision-making process |
| 6 | Service | The decision-making process is quite complicated and does not make things easy for users | Systematic and user-friendly decision-making process |

### 3.3. Decision Support System Design

The designed DSS consists of 5 main components that interact with each other. The components in this DSS are depicted in the conceptual model in Figure 2.

The base model which plays the role of creating a simulation picture of inventory control as a form of decision is run sequentially from the first model to the 4th model. The results of these 4 models will be output to determine decisions regarding spare parts needs and ordering. Database will be included to be used in inventory control simulations and decision analysis by users. The data that will be used in the base model are spare parts data including demand history, stock amount in the warehouse, lead time, price, and control costs. The process model and data will be represented in Figure 3. Model testing will be carried out using KUR 12313 and KUR 12314 spare parts based on the ABC classification results. The objects of this model are not limited to groups that have been classified using the model and can be used for all types of spare parts in the KRL maintenance process.

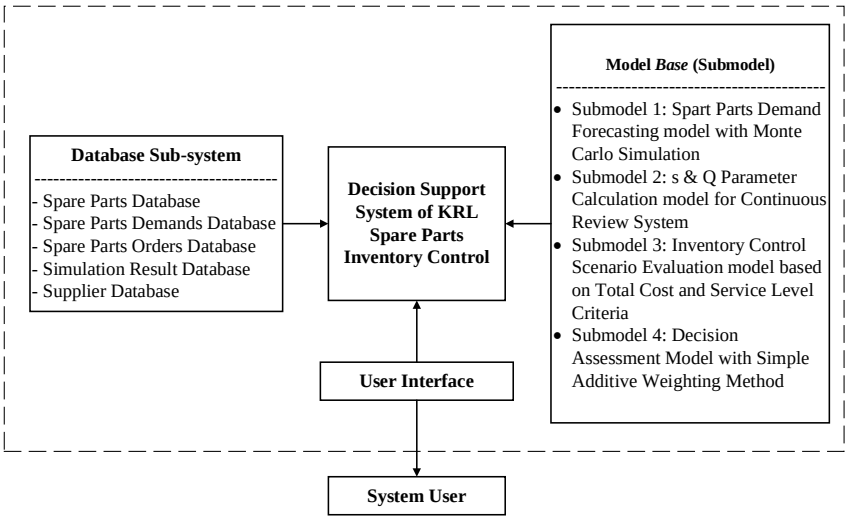


**Figure 2.** Conceptual model of the KRL spare parts inventory control DSS

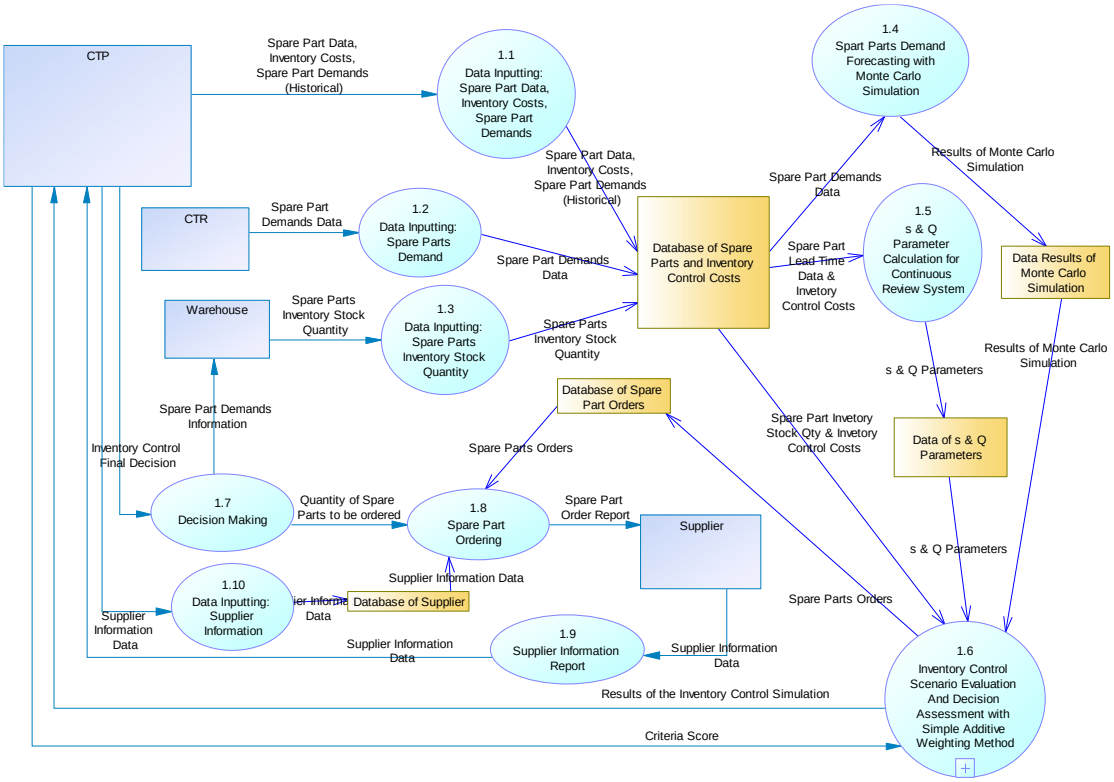


**Figure 3.** Data flow diagram of the KRL spare part inventory control DSS

### 3.4. KRL Spare Part Inventory Control Sub-Model Design

The first sub-model is called spare parts demand forecasting model with Monte Carlo simulation on historical demand data. To run a spare parts demand forecasting model with Monte Carlo simulation, the user must input historical data and the year the demand will be forecasted. The stages of Monte Carlo simulation in inventory control DSS are described as follows (Guslan D *et al.,* 2020; Harrel C *et al.,* 2000).

a. Calculation of the probability of occurrence of the request frequency and determining the range
b. Generation of random numbers and conversion of random number values into request values
c. Validation testing of the number of simulation replications with the following rules:

1) Determining the hw value with the formula:

$$hw = \frac{(t_{n-1,a/2}) \times s}{\sqrt{n}}$$

2) Determining the value of n' through the equation:

$$n' = \left(\frac{(z_{a/2}) \times s}{e}\right)^2$$

3) Testing validity by comparing the value of n' with the initial value of n, if n' > n, then replications need to be added until the number of replications becomes n' (return to stage B), if n' ≤ n, then proceed to the next stage.

d. Calculate the final results of the Monte Carlo simulation of demand values in the form of total demand and standard deviation.

The second sub-model, namely the s & Q parameter calculation model for the continuous review system, is a calculation model that takes into account the parameters s (safety stock) and Q (order quantity) in inventory control using the continuous review (s, Q) method. the stages and calculations of the model for determining the s & Q parameters from the continuous review (s, Q) method are carried out using the following parameters and equations (Table 2) (Sipper D *et al.,* 1997).

Input Parameters:

| | | |
|---|---|---|
| D = total demand (sub-model 1) | s= standard deviation (sub-model 1) | A = order cost (Rp) |
| H = holding costs (Rp) | B = stockout costs (Rp) | L = lead time |

Sub-model inventory control scenario evaluation model based on total cost and service level criteria as the 3rd sub-model executes 2 types of spare parts inventory control scenarios, namely control using the company policy method and Continuous Review (s, Q) policy. Using inventory control cost data, the parameters are calculated using the following equation:

$$\begin{aligned} Total\ Inventory\ Control\ Costs \\ = (spare\ part\ price \times total\ demand) \\ + (inventory\ costs \times end\ of\ period\ stock) \\ + (backorder\ costs \times total\ backorders) \\ + (ordering\ costs\ x\ ordering\ frequency) \end{aligned}$$

Service levels = $\frac{total\ demand - total\ backorder}{total\ demand} \times 100\%$

**Table 2.** Formulation of s & Q parameter calculation model for continuous review system

| Step | Parameter | Formulas |
|---|---|---|
| 1 | D.L | DL = L x D |
| 2 | σL | σL =$\sigma\sqrt{L}$ |

| Step | Parameter | Formulas |
|---|---|---|
| 3 | Q0 (Iteration 0) | $Q0 = \sqrt{\frac{2 \times A \times D}{H}}$ |
| 4 | f(z) for s0 | $f(z) = 1 - \frac{H \times Q_0}{B \times D}$ |
| 5 | s0 | $s0 = DL + f(z) \times \sigma L$ |
| 6 | b(s0) (Iteration 1) | $b(s0) = \sigma L \; xz(f(z))$ (Where the value of z(f(z)) is taken from the normal distribution table z(NORMDIST) using the f(z) value) |
| 7 | Q1 | $Q1 = \sqrt{\frac{2D(A+B \times b(S_0))}{H}}$ |
| 8 | f(z) for s1 | $f(z) = 1 - \frac{H \times Q_1}{B \times D}$ |
| 9 | s1 | $S1 = DL + f(z)s1 \times \sigma L$ |

The 4th sub-model is the decision assessment model with a simple additive weighting method. This model calculates simple additive weighting using a criteria weighting method with criteria objects in the form of total costs (C1) and service level (C2) from the results of inventory control scenarios with company policy (A1) and inventory control scenarios with continuous review policies (s, Q) (A2) in sub-model 3. The simple additive weighting calculation model in this sub-model follows the following stages (Kusumadewi S *et al.,* 2006).

a. Converting criteria weight values to criteria importance values:

$$\text{Criteria importance (kCn)} = \frac{C_n \; criteria \; weight}{C_1 criteria \; weight + C_2 criteria \; weight}$$

b. Perform normalization (r) on each criterion:

$$For \; total \; cost \; criteria: \quad r_{C_1 A_n} = \frac{Min \; C_1 \; \times \; C_1 A_n}{C_1 A_n}$$

$$For \; service \; level \; criteria: \quad r_{C_2 A_n} = \frac{C_2 A_n}{Max \; C_2 \; \times \; C_2 A_n}$$

c. Calculating the preference value of each alternative:

$$\text{Alternative preferences value} = (\; r_{C_1 A_n} \times \text{kC1}) + (\; r_{C_2 A_n} \times \text{kC2})$$

### 3.5. System's Menu and Interface Structure

The DSS menu designed consists of a database menu and a simulation menu for KRL spare parts inventory control for analysis and decision-making in controlling KRL spare parts inventory. The system's menu will be represented in Figure 4. In the visualized interface, green indicates columns that can be typed by the user, while orange indicates an interface that can be clicked. An overview of the user interface of this system is presented in Figure 5.

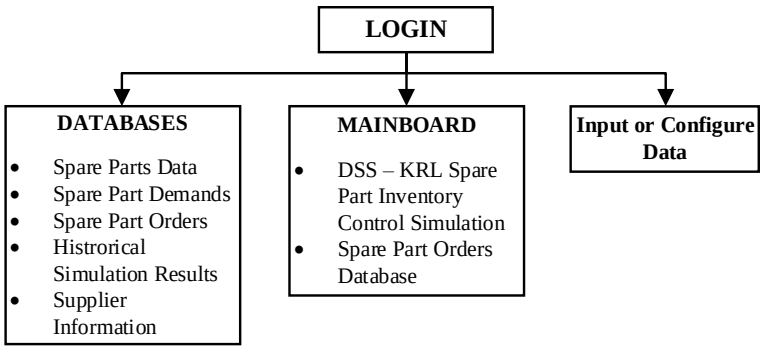


**Figure 4.** System's menu of the KRL spare parts inventory control DSS

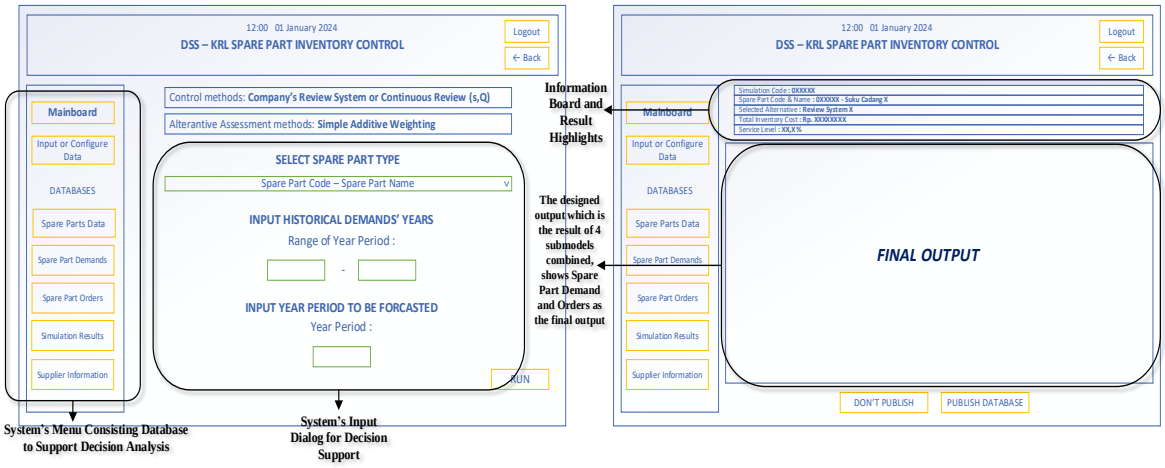


Figure 5. User interface design of the KRL spare parts inventory control DSS

### 3.6. Validation and Verification

System testing was performed using KUR 12313 and KUR 12314 spare parts from the ABC classification results as test samples. As a result of the system being built, the system has followed the conceptual model that has been built, stating that the system has been verified. The system model that has been tested produces the same results as calculations carried out manually with slight differences in rounding of results, so the system is declared valid. Another test result is that the system can be used on other KRL spare parts.

## 4. CONCLUSION

The proposed decision support system (DSS) makes decision-making for inventory control more systematic thus creating an easier decision-making process. The result of testing the DSS shows that decisions given by the DSS are more accurate and less time-consuming than the current decision-making system. Other results of testing the decision support system shows that the system model can be used on all KRL spare parts and is in accordance with the model proposed in this research. More research and development would be recommended to further improve the DSS and give more essentials to its functions.

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# CHAPTER 12

# The Effect of Green Marketing Mix Program on Green Consumer-Based Brand Equity & Word of Mouth in Oil & Gas Companies

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## ABSTRACT

This work investigates the impact of the Green Marketing Mix on Green Consumer-Based Brand Equity (CBBE) and Word of Mouth (WOM) in the Indonesian oil and gas sector. Together, Green Product, Green Price, Green Place, and Green Promotion initiatives constitute the Green Marketing Mix, each so much impacting Green Brand Image, Green Brand Trust, Green Satisfaction, and Green Loyalty. Purposive sampling from 465 respondents utilizing a quantitative research methodology guarantees a focus on consumers with almost six months of involvement with green marketing strategies by companies like Pertamina, Shell, BP, and Vivo since data was acquired. Structural equation models (SEM) analysis revealed that the Green Marketing Mix significantly raises CBBE and encourages positive WOM. While Green Price had less of an impact, Green Product, Place, and Promotion projects had a major influence on CBBE. Green Brand Image, Green Satisfaction, and Green Loyalty all became clear WOM drivers; Green Brand Trust had only indirect influence. These findings underscore the strategic need of adding sustainable practices into marketing to raise WOM, enhance brand equity, and strengthen consumer loyalty. Emphasizing the interaction of green strategies and consumer perceptions, the study enhances marketing theory by offering practical recommendations for companies seeking competitive advantages in a market sensitive to environmental concerns.
**Keywords:** Green Marketing Mix, Green Consumer-Based Brand Equity, Word of Mouth, Oil and Gas Industry.

## 1. INTRODUCTION

Driven by the world urgency to battle climate change, countries all over have committed to decreasing greenhouse gas emissions; Indonesia has set an ambitious objective to achieving Net Zero Emissions by 2050 (International Energy Agency, 2021). Government rules by themselves help to promote this commitment; nevertheless, increasing environmental consciousness in different countries reinforces it. While fossil fuels still account for more than 60% of national energy consumption, major enterprises especially in the energy sector find tremendous difficulty reducing their carbon footprint (Kementerian ESDM, 2021).

Major players in the energy sector, oil and gas companies are adapting to welcome renewable energy sources. Beyond operational changes, these include strategic marketing efforts including the Green Marketing Mix, which has proved indispensable in expressing company commitment to sustainability (Qayyum et al., 2023). Elements of the Green Marketing Mix greatly affect Green Consumer-Based Brand Equity (CBBE), which includes Green Brand Image, Green Brand Trust, Green Satisfaction, and Green Loyalty (Pancić et al., 2023). Green Product, Green Price, Green Place, and Green Promotion all affect it greatly. Emphasizing their relevance for the future of the energy industry, the effective application of green marketing strategies increases brand perception, creates customer trust, and promotes loyalty (Martínez, 2015).

Moving to net-zero emissions presents several challenges even with the anticipated benefits. High implementation costs resulting from contemporary technologies and infrastructure impose financial stress smaller firms and developing nations (Ghosh et al., 2020). Moreover, undermining customer confidence is greenwashing, the phenomena whereby companies pass for environmentally favorable measures (Szabo & Webster, 2021). Moreover, compounding the change are social and financial upheavals including job losses in established industries like oil and gas (Mustafin et al., 2023). Technical and infrastructure restrictions including the underdeveloped state of energy storage alternatives (Yakovleva & Miller, 2021) further impede progress.

Positively, increasing environmental awareness among consumers drives demand for sustainable products, so enabling companies applying the Green Marketing Mix to get competitive edge and support Word of Mouth (WOM). Happy consumers are more likely to share positive experiences, so enhancing the brand of a company (Guerreiro & Pacheco, 2021). Studies reveal that elements like Green Brand Image and Green Satisfaction are very crucial in generating excellent consumer perceptions and inspiring WOM (J. L. Chen, 2023).

The Stimulus- Organism-Response (SOR) paradigm helps to logically justify this approach. The theory helps to explain how outside stimuli—such as green marketing campaigns—affect internal consumer impressions, therefore generating responses including stronger loyalty and positive WOM (Jacoby, 2002a). Under this paradigm, the Green Marketing Mix components act as stimuli; consumer views of sustainability represent the organism and provide responses like improved brand equity and WOM (Huang et al., 2024).

Given these features, this study aims to find how Green Marketing Mix programs influence Green Consumer-Based Brand Equity and thereby influence WOM in the oil and gas sector of Indonesia. By filling up the gaps in present research, this study provides understanding on how strategic green marketing may raise consumer involvement and support sustainability in the energy sector.

## 2. LITERATURE REVIEW

### 2.1. Theoretical Background

According to the Stimulus-Organism-Response (SOR) theory, outside stimuli (S) influence internal organisms (O) and start reactions (R) from specific individuals (Jacoby, 2002b; Mehrabian, 1974). Marketing uses the SOR theory to describe how marketing stimuli such the Green Marketing Mix (Jacoby, 2002b; Mehrabian, 1974) affect customer perceptions (organism) and thus behavior such brand loyalty and word-of-mouth (response). The stimulus in this research is represented by the Green Marketing Mix, which comprises of Green Product Programs, Green Price Programs, Green Place Programs, and Green Promotion Programs (Ahmed et al., 2023; Hadi et al., 2023; Huang et al., 2024; Nguyen-Viet, 2023). Every element of the Green Marketing Mix serves as an outside stimulation obtained by consumers (Ahmed et al., 2023).

Through four main components—eco-friendly offers, pricing strategies, distribution systems, and promotional activities—green marketing mix mixes environmental sustainability into product promotion (Sohail, 2017). By means of marketing strategies, this approach aims to inspire companies to embrace more sustainable practices since they have shown the capacity to increase consumer loyalty among environmentally conscious consumers and thereby improve brand value. Using the Green Marketing Mix can help companies have a competitive edge in a market growing more ecologically aware.

Environmentally friendly products are aimed to avoid negative effects on the environment from the choice of raw materials to the application of efficient, low-emission manufacturing techniques (Nguyen-Viet, 2023). Creating eco-friendly products means emphasizing the complete life cycle with an eye toward sustainability, so improving value for consumers who give environmental responsibility top importance (Mohd Suki, 2015). Studies reveal that consumers' perspective of a company's commitment to environmental issues greatly influences the efficacy of eco-friendly products, which in turn increases customer loyalty and strengthens brand reputation by means of which (D'Souza et al., 2007; Y. S. Chen, 2010) is promoted. Good marketing of environmentally friendly items can increase brand credibility, especially under conditions when these products are considered as premium and good for the environment (Y. S. Chen & Chang, 2013). Furthermore, environmentally friendly items affect consumer satisfaction since those who recognize actual environmental benefits from their purchases usually feel happier (Cronin et al., 2000; Moise et al., 2018). Different strategies for environmentally friendly products could cause consumer uncertainty, particularly in relation with false environmental assertions, companies who effectively promote environmentally friendly products can build enduring customer loyalty—necessary for recurrent business and

good recommendations (Y. S. Chen & Chang, 2013). All things considered, environmentally friendly products are crucial for building company reputation, raising consumer satisfaction and loyalty, and influencing purchase decisions (Y. S. Chen, 2010).

Dropzdenko et al. 2011 define a "green price"—that is, pricing that show a company's commitment to environmental sustainability while nevertheless being competitive. This pricing shows the costs related to sustainable manufacturing methods, so benefiting consumers who think they are helping to protect the surroundings (Sohail, 2017). Studies show that matching the cost with the benefits of environmentally friendly products will help to build consumer loyalty (Y. S. Chen & Chang, 2013). Green Price increases customer confidence in the environmental responsibility commitment of a company, so fostering loyalty and continuous purchasing (Lakatos et al., 2021). Moreover, appealing to consumers that pay environmental sustainability top attention is a strategic price method aimed to establish businesses apart from their competitors (Dinh et al., 2023). Pricing policies should be used with great care by companies to avoid building an exclusive image that could alienate present customers (Y. S. Chen & Chang, 2013). Generally, Green Price is a strategy to highlight environmental expenses and improve company identification, so enhancing consumer happiness and loyalty (Y. S. Chen, 2010).

Green Place links to low-emissions, energy-efficient distribution strategies implemented all during the delivery process (Wang et al., 2024). By showing a social consciousness, companies who use sustainable distribution methods can increase customer loyalty (González-Viralta et al., 2023). Green Place offers long-term operating cost savings by using energy-efficient solutions (Agyabeng-Mensah & Tang, 2021). Moreover, it strengthens emotional ties to companies that match sustainable values and consumer confidence building by means of which Green Place can help to differentiate brands in a competitive environment, hence improving brand perception and influence on buying decisions (Sun et al., 2020). By means of sustainable distribution tactics, Green Place offers value and enhances overall corporate-consumer interactions (Hameed et al., 2022).

Green Promotion underlines the need of spreading a company's commitment to environmental sustainability (Román-Augusto et al., 2022). Emphasizing shared values in sustainability helps to encourage environmentally friendly products, thereby improving business reputation and promoting customer loyalty (Alamsyah & Febriani, 2020). Constant support of environmentally friendly products can help to generate strong word-of-mouth and increase the brand of a firm (Agyabeng-Mensah & Tang, 2021). This strategy helps consumers to accept the claims of brand sustainability (González-Viralta et al., 2023). Good environmentally friendly marketing, according to studies, increases consumer pleasure and loyalty, thereby creating lifetime relationships (Yan et al., 2024). Overall support of environmentally friendly activities can assist a company show its attention to sustainability and improve brand reputation (Román-Augusto et al., 2022).

Based on their viewpoint of a company's dedication to environmental sustainability, customers seem to value **Green Consumer-Based Brand Equity**. Studies show that Green CBBE is much influenced by components including Green Brand Image, Green Brand Trust, and Green

Satisfaction, all of which raise brand value in the perspective of customers (Ted Rogers, 2017). Encouragement of environmentally friendly behavior allows companies to build closer ties with their customers, therefore fostering customer loyalty and good word-of-mouth (Heck & Yidan, 2013).

The view of a brand's environmental friendliness—that which results from the company's sustainability and environmentally friendly policies—that of the consumer (Majeed et al., 2022) is known as **green brand image.** Strong green brand image affects consumer buying decisions since people want brands that complement their sustainability ideals (Arham & Dwita, 2021). It improves the company's profile as well, thereby encouraging good word-of-mouth (Çavusoglu et al., 2021). Choosing goods from companies with a green image helps consumers feel they help to preserve the environment (Majeed et al., 2022). Moreover, a strong green brand image promotes loyalty since consumers are more likely to follow companies that give sustainability top attention (Román-Augusto et al., 2022).

The confidence of consumers in companies which follow environmental responsibility and sustainability is known as **green brand trust** (Hameed & Waris, 2018). Customers develop this confidence when they feel a business is really dedicated to environmental concerns by means of its goods and services. Studies reveal that consumer loyalty is much influenced by Green Brand Trust (Alamsyah & Febriani, 2020), particularly for companies whose main emphasis is sustainability. Growing this confidence requires open presentation of environmentally friendly initiatives (Alamsyah & Febriani, 2020). High Green Brand Trust consumers are more inclined to participate in loyalty activities and support corporate sustainability programs (Majeed et al., 2022).

**Green satisfaction** (Moise et al., 2018) is the degree of consumer satisfaction with environmentally friendly products or services satisfying sustainability expectations. Higher likely to repurchase and show more brand confidence; satisfied consumers help to reinforce brand loyalty; Studies show that good word-of-mouth (Lakatos et al., 2021) is much influenced by satisfaction with environmentally friendly items. High degrees of green satisfaction inspire customer involvement in corporate green marketing activities (Yan et al., 2024).

The degree of consumer loyalty for companies dedicated to environmentally friendly corporate operations is known as **green loyalty** (Dabija et al., 2018). Customers that view a brand as ethical and eco-friendly are more likely to stick to it (Ha, 2022). Regular declaration of environmental duties by businesses helps to build this loyalty (Román-Augusto et al., 2022). Green loyalty improves good word-of-mouth, therefore increasing brand exposure, apart from keeping consumers (Sun et al., 2020).

**Word of Mouth (WOM)** (Guerreiro & Pacheco, 2021) is the way consumers openly tell others about their either positive or negative experience with a good or brand. Positive WOM definitely depends on green marketing if businesses dedicated to sustainability want to have their reputation strengthened (Simanjuntak et al., 2023). Research reveal that consumers value suggestions from friends or relatives more highly than those of conventional advertising

(Román-Augusto et al., 2022). As happy consumers inspire others to purchase environmentally friendly products, WOM can greatly increase brand loyalty (González-Viralta et al., 2023).

Ideas of Green CBBE, Green Brand Image, Green Brand Trust, Green Satisfaction, Green Loyalty, and WOM are linked and much help businesses targeted on sustainability to improve brand equity and competitive advantage (Yan et al., 2024).

### 2.2. Hypothesis Development

Since they enable to improve Green Brand Image by means of favorable customer attitudes, Green Product Programs greatly influence green consumer-based brand equity (Nguyen-Viet, 2023). Good Green Products attract environmentally concerned customers and support the development of great credibility in the sustainability dedication (Qayyum et al., 2023). Constant promotion of eco-friendly items allows one to develop strong brand image (J. L. Chen, 2023).

Green Product Programs assist to build Green Brand Trust as people are more ready to support businesses showing moral environmental goals (J. L. Chen, 2023). Constant promotion of environmentally friendly products raises consumer confidence (Nguyen-Viet, 2023) and trustworthy green products particularly when they provide real advantages (Gelderman et al., 2021).

Green Product Programs so help to increase Green Satisfaction (Amin & Tarun, 2021) as environmentally friendly items make customers cognizant of sustainability. Value-wise, special green products raise consumer happiness (Román-Augusto et al., 2022). Contentment with green products matches loyalty and persistent buying behavior (González-Viralta et al., 2023).

Green Product Programs create Green Loyalty (Dabija et al., 2018) as Green Product Users gain from the company more linked to it. Through sustainability research and environmental responsibility, activities (Gelderman et al., 2021) might help to boost brand impressions and drive repeat business. Great green goods attract delighted consumers who develop loyalty (Román-Augusto et al., 2022), thereby improving long-term brand partnerships (Gelderman et al., 2021).

Green pricing strategies help to create Green Brand Image (Creignou & Nuangjamnong, 2022) thereby enabling consumers to feel they support environmental activities by way of a relationship between price and sustainable principles. Fair pricing reflecting quality helps to increase brand image (Dinh et al., 2023) and customer confidence (González-Viralta et al., 2023).

Green Price Programs serve to develop Green Brand Trust by means of fair pricing linked with sustainability concepts, therefore inspiring customer confidence (Dinh et al., 2023). While a simple price increase brand integrity (Creignou & Nuangjamnong, 2022), pricing in line with green values helps to build brand confidence (González-Viralta et al., 2023).

Green pricing rules help to increase green satisfaction as people find suitable prices verifying environmental pledges (Dinh et al., 2023). Although ethical pricing raises customer happiness

(González-Viralta et al., 2023), competitive price improves the picture of environmental preservation (Creignou & Nuangjamnong, 2022).

Green pricing policies equally generate green loyalty as fair price reflecting sustainability does (Dinh et al., 2023). Those who feel their fair price strikes a balance between environmental benefits most generally stay loyal; sustainable pricing helps to establish emotional ties to the company (Creignou & Nuangjamnong, 2022).

Through means of sustainable distribution strategies reducing environmental effect, Green Place Programs serve to improve Green Brand Image (Agyabeng-Mensah & Tang, 2021). Businesses that use sustainable distribution techniques improve their status as socially concerned (Huang et al., 2024) and raise customer awareness of sustainability pledges (Nguyen-Viet, 2023).

Green Place Programs increase customer confidence by means of environmentally friendly distribution methods, therefore cultivating Green Brand confidence (Agyabeng-Mensah & Tang, 2021). Studies of companies using green distribution strategies reveal, depending on brand responsibility and transparency.

Green Place programs commend environmentalists by means of green distribution incentives, thus raising Green Satisfaction (Agyabeng-Mensah & Tang, 2021). Understanding green distribution methods, clients usually feel good as they believe they help to protect the environment (González-Viralta et al., 2023).

Projects in green areas support Although green loyalty improves ties to companies (Agyabeng-Mensah & Tang, 2021), environmentally friendly distribution boosts them. Green distribution by customers who know about it indicates to higher loyalty and increases positive recommendations and repeat business (Widyastuti et al., 2019).

Regarding Green Promotion Programs, they help the company to create a Green Brand Image by means of improved image as environmentally concerned (Amoako et al., 2020). Effective green marketing enhances brand impression and brand image thus strengthening the brand (Dinh et al., 2023).

By means of campaigns highlighting sustainability, Green Promotion Programs serve to establish Green Brand Trust and thereby raise customer trust (Amoako et al., 2020). Real promotions let companies that are dedicated to sustainability (Dinh et al., 2023) show long-lasting effects and enhance brand confidence (Dinh et al., 2023).

Moreover, proving corporate environmental awareness, Green Promotion Programs help to establish Green Satisfaction (Amoako et al., 2020). Green-oriented advertising creates demand for businesses that really exhibit attempts at sustainability (Creignou & Nuangjamnong, 2022) and consumer happiness (Dinh et al., 2023).

Long-term interactions between customers and companies allow Green Promotion Programs at last to generate Green Loyalty (Amoako et al., 2020). Studies on important attention to sustainable practices show that customer loyalty rises (Gelderman et al., 2021).

Happy customers are more inclined to share great experiences; consequently, Green Consumer-Based Brand Equity—which includes of Green Brand Image, Green Brand Trust, Green Satisfaction, and Green Loyalty—positively affects Word of Mouth (J. L. Chen, 2023). Strong green satisfaction and loyalty contribute to enhance Word of Mouth (González-Viralta et al., 2023); Great Green Brand Image and Trust inspire customers to support companies even in other industries (González-Viralta et al., 2023).

Emphasizing that Green Marketing Mix impacts Green Consumer-Based Brand Equity, which in turn affects excellent Word of Mouth, the paper offers a conceptual framework analyzing the link between Green Marketing Mix and Green Consumer-Based Brand Equity.

Based on the theoretical basis above, this study will use a conceptual framework that examines the relationship between Green Marketing Mix, Green Consumer-Based Brand Equity, and Word of Mouth . The following are the basic concepts underlying this study (Ahmed et al., 2023; Hadi et al., 2023; Huang et al., 2024; Nguyen-Viet, 2023):

a) Green Marketing Mix (Green Product, Green Price, Green Place, Green Promotion) influences Green Consumer-Based Brand Equity which consists of Green Brand Image, Green Brand Trust, Green Satisfaction , and Green Loyalty.
b) Green Consumer-Based Brand Equity will in turn influence positive Word of Mouth

### 2.3. Conceptual Framework

The study integrates the Green Marketing Mix with Green CBBE dimensions to assess their combined impact on Word of Mouth. The conceptual framework positions Green Marketing Mix elements as predictors of brand equity dimensions, which subsequently influence Word of Mouth, aligning with the SOR model (Jacoby, 2002).

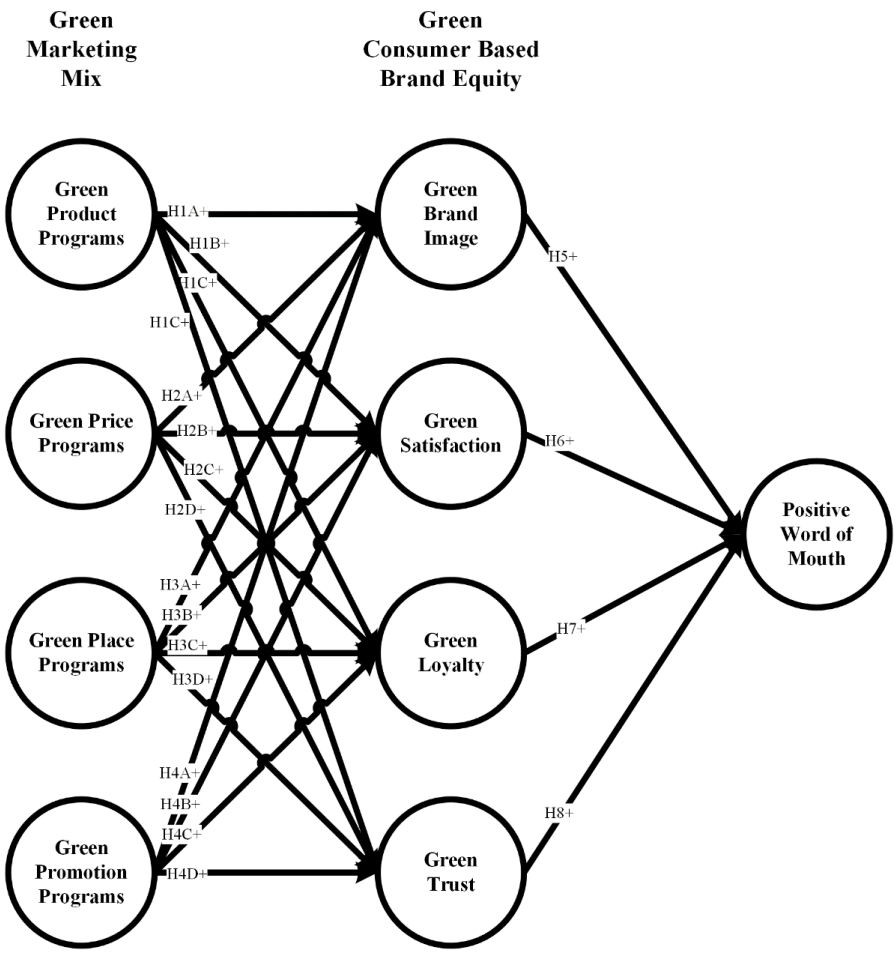


Figure 15 Conceptual Framework

**Source:** (Ahmed et al., 2023; Hadi et al., 2023; Huang et al., 2024; Nguyen-Viet, 2023)

## 3. RESEARCH METHOD

### 3.1. Research Design

Extending previous research by Nguyen-Viet (2023) and Huang et al. (2024), this one investigates the idea that green marketing features positively influence on green consumer-based brand equity (Huang et al., 2024; Nguyen-Viet, 2023). Designed for observing relationships between variables, the research employs causal analytic techniques and survey instruments (Weyant, 2022). It especially pays attention on how the green marketing mix influences word-of-mouth (Huang et al., 2024; Nguyen-Viet, 2023) and green consumer-based brand equity. The study used a survey research approach obtaining personal data (Sekaran & Boogie, 2017) to more totally understand behavior and preferences. Surveys were used to compile data from people who had been customers of oil and gas companies for more than six months, therefore fairly capturing their points of view. Many times, research focuses on certain customers of these companies (Sekaran & Boogie, 2017).

### 3.2. Data Collection & Sampling Method

Designed to evaluate numerous recognized factors, including demographic data and major comments on Green Marketing Mix, Green Consumer-Based Brand Equity, and Word of Mouth (Huang et al., 2024; Nguyen-Viet, 2023), the research employed a questionnaire technique for data collection. Online surveys enabled broader client reach, therefore increasing efficiency and assuring consistent data gathering (Dillman et al., 2014).

Sampling was done using both intentional and non-probabilities; individuals were chosen based on certain criteria, so not every population element had an equal possibility of being picked (Sekaran & Boogie, 2017). With an eye on customers of firms like Pertamina, Shell, Total Energies, British Petroleum, and Vivo in Indonesia, the research focused on consumers who had utilized products or services from oil and gas companies after the Green Marketing Mix campaign.

| Description | Category | Count | Percentage (%) |
|---|---|---|---|
| How long have you been a customer of Oil & Gas companies | 6 Months | 25 | 5.4 % |
| | More than 6 Months | 440 | 94.6 % |
| Which company's products do you use the most? | Pertamina | 420 | 90.3 % |
| | Shell | 35 | 7.5 % |
| | British Petroleum | 2 | 0.4 % |
| | Vivo | 8 | 1.7 % |
| Gender | Male | 336 | 72.3 % |
| | Female | 129 | 27.7 % |
| Age | Below 20 | 29 | 6.2 % |
| | 21-30 | 220 | 47.3 % |
| | 31-40 | 111 | 23.9 % |
| | Above 40 | 105 | 22.6 % |
| Education | High School | 157 | 33.8 % |
| | Diploma | 33 | 7.1 % |
| | Bachelor’s Degree | 201 | 43.2 % |
| | Postgraduate | 74 | 15.9 % |
| Occupation | Civil Servant (PNS) | 71 | 15.3 % |
| | State-Owned Enterprise Employee (BUMN) | 84 | 18.1 % |
| | Private Sector Employee | 148 | 31.8 % |
| | Entrepreneur (Business Owner) | 35 | 7.5 % |
| | Student | 36 | 7.7 % |
| | Other | 91 | 19.6 % |
| Income/Monthly Allowance | Less than Rp 2,500,000 | 51 | 11.0 % |
| | Rp 2,500,001 - Rp 5,000,000 | 125 | 26.9 % |
| | Rp 5,000,001 - Rp 10,000,000 | 107 | 23.0 % |

| Description | Category | Count | Percentage (%) |
|---|---|---|---|
| | Rp 10,000,001 - Rp 20,000,000 | 88 | 18.9 % |
| | More than Rp 20,000,000 | 94 | 20.2 % |
| Total | | 465 | 100 % |

Calculated based on the number of indicators in the study model, 465 respondents made up the sample, therefore assuring a representative sample to back up research conclusions (Joseph F. Hair et al., 2021). At least six months of usage of oil and gas goods were required of the respondents; 94.6% of them having more than six months of experience, thereby suggesting knowledge with the Green Marketing Mix activities (Sekaran & Boogie, 2017).

With most respondents, 94.6%, having been consumers for more than six months, demographic data suggests a steady connection with their chosen oil and gas suppliers. Pertamina was the most used brand (90.3%), thereby displaying high local brand loyalty even if most respondents (72.3%) were male and aged 21 to 30 years. Among the respondents, 43.2% hold a bachelor's degree; majority, 31.8%, work in the private sector (Sekaran & Boogie, 2017).

Reflecting a moderate to upper-class consumer foundation, income distribution revealed most respondents earned between IDR 2,500,001 – IDR 5,000,000 (26.9%). This demographic profile indicates that most oil and gas users are young, educated males employed in official sectors highly conscious of energy efficiency and environmental problems (Joseph F. Hair et al., 2021).

The purposeful sample technique assured respondents had relevant experience with oil and gas goods, thereby enabling a greater grasp of the Green Marketing Mix and Consumer-Based Brand Equity (Huang et al., 2024; Nguyen-Viet, 2023). This method aimed to provide a realistic and accurate image of the population in keeping with the broader research goals (Sekaran & Boogie, 2017).

### 3.3 Data Testing Methodologies

Particularly the Green Marketing Mix (Joseph F. Hair et al., 2021), validity testing assures that measuring indicators properly show the variables in the study. Analyzing whether statements on latent variables are seen as intended with outer loading values > 0.6 reveals substantial correlations and allows one to ascertain convergent validity (Joseph F. Hair et al., 2021). Analyzing relationships between constructs tests discriminating latent variables with an average variance extracted (AVE) value greater than 0.5 validating various latent variables (Sekaran & Boogie, 2017; Joseph F. Hair et al., 2021).

Reliability testing ensures that, via consistent measurement results across numerous treatments, indicators properly evaluate the intended latent variables (Joseph F. Hair et al., 2021). Composite reliability measures internal consistency: a score of 0.7 or higher indicates dependability (Joseph F. Hair et al., 2021). This testing ensures accurate Green Marketing Mix therefore confirming the veracity of the conclusions (Joseph F. Hair et al., 2021).

**Validity and Reliability Testing for Green Marketing Mix**: results All twenty-two indicators of the Green Marketing Mix were judged real with outer loading values above 0.6 and AVE values over 0.5, therefore displaying great convergence (Joseph F. Hair et al., 2021). Exceeding 0.7, the Composite Reliability value confirms the correctness of the used indicators (Joseph F. Hair et al., 2021).

**Result of Validity and Reliability Testing for Green Consumer-Based Brand Equity (CBBE)**: Comprising nineteen indications, the validity test for CBBE confirmed that, with outer loading values larger than 0.5, every indicator was valid. The AVE value also over 0.5 clearly showed strong interaction across indicators. The Composite Reliability value confirmed the indication dependability over 0.7 (Joseph F. Hair et al., 2021).

**Validity and Reliability Testing Results for Word-of- Mouth (WOM)**: Comprising six indications, the validity test for the WOM variable found that, with outer loading values larger than 0.5, all indicators were valid. The AVE value of 0.819 confirmed the dependency of the indicators while the Composite Reliability value of 0.965 demonstrated strong dependability (Joseph F. Hair et al., 2021).

## 4. RESULT AND DISCUSSION

### 4.1 Descriptive Statistics

| Item | Outer Loading | AVE | Composite Reliability | Mean | SD |
|---|---|---|---|---|---|
| **Green Product Programs** | - | 0,71 | 0,93 | 3,97 | |
| My preferred Oil & Gas company produces environmentally friendly products. | 0,84 | - | - | 3,76 | 1,20 |
| My preferred Oil & Gas company strives to improve the quality of its products to be more environmentally friendly. | 0,88 | - | - | 4,04 | 1,04 |
| My preferred Oil & Gas company is a pioneer in introducing environmentally friendly products to the market. | 0,86 | - | - | 3,72 | 1,12 |
| Environmentally friendly products are a solution to environmental issues. | 0,79 | - | - | 4,25 | 1,07 |
| The quality of these environmentally friendly products is better. | 0,84 | - | - | 4,06 | 1,06 |
| **Green Price Programs** | - | 0,62 | 0,89 | 3,89 | |
| Consumers will buy this product because it is affordable. | 0,76 | - | - | 4,03 | 1,11 |
| Consumers will still buy this product even if it is more expensive than other brands. | 0,65 | - | - | 3,30 | 1,20 |
| Consumers will buy this product when there are special promotions. | 0,71 | - | - | 4,02 | 1,09 |
| The price of this product matches its quality. | 0,88 | - | - | 4,03 | 0,98 |
| The price of this product matches the benefits provided. | 0,89 | - | - | 4,06 | 0,92 |
| **Green Place Programs** | - | 0,71 | 0,94 | 3,97 | |
| The location of this company's gas stations is strategic. | 0,83 | - | - | 4,18 | 1,00 |
| There are several gas stations in the same city. | 0,79 | - | - | 4,17 | 1,04 |
| It is easy to find trash bins at this company's gas stations. | 0,84 | - | - | 4,07 | 1,10 |
| Environmentally friendly products or services are always available at this company's gas stations. | 0,86 | - | - | 3,82 | 1,11 |
| Environmentally friendly products or services are easy to find in your area. | 0,88 | - | - | 3,81 | 1,12 |

| Item | Outer Loading | AVE | Composite Reliability | Mean | SD |
|---|---|---|---|---|---|
| Environmentally friendly products or services are available in many places. | 0,85 | - | - | 3,76 | 1,13 |
| **Green Promotion Programs** | - | 0,78 | 0,96 | 3,87 | |
| This company provides a lot of information about environmentally friendly products in its advertisements. | 0,86 | - | - | 3,89 | 1,07 |
| This brand offers discounts or subsidies for the purchase of environmentally friendly products. | 0,85 | - | - | 3,70 | 1,12 |
| I have read about this company's environmentally friendly products in newspapers, social media, or other advertising media. | 0,87 | - | - | 3,86 | 1,09 |
| I find the advertisements for this company's environmentally friendly products attractive. | 0,92 | - | - | 3,84 | 1,06 |
| These advertisements contain messages about environmental friendliness. | 0,91 | - | - | 3,93 | 1,02 |
| These advertisements show that the company cares about the environment. | 0,89 | - | - | 3,99 | 1,02 |
| **Green Brand Image** | - | 0,86 | 0,97 | 3,89 | |
| This brand can serve as an example of environmental commitment. | 0,92 | - | - | 3,89 | 1,06 |
| This brand has a good reputation regarding the environment. | 0,94 | - | - | 3,89 | 1,05 |
| This brand demonstrates good environmental performance. | 0,93 | - | - | 3,91 | 1,03 |
| This brand is known for caring about the environment. | 0,93 | - | - | 3,88 | 1,05 |
| This brand is trustworthy in fulfilling its promises related to the environment. | 0,91 | - | - | 3,78 | 1,07 |
| This brand has a positive image/reputation. | 0,93 | - | - | 3,98 | 1,01 |
| **Green Brand Trust** | - | 0,89 | 0,98 | 3,86 | |
| You feel this brand’s environmental commitment is generally reliable. | 0,94 | - | - | 3,89 | 1,03 |
| You feel this brand’s environmental performance is generally trustworthy. | 0,96 | - | - | 3,87 | 1,03 |
| You feel this brand’s environmental arguments are generally credible. | 0,95 | - | - | 3,87 | 1,03 |

Using mean values, standard deviations, and maximum-minimum values, the descriptive statistics analysis of this study provided insights on many latent variables connected to green products, pricing, place, promotion, brand image, trust, satisfaction, loyalty, and word-of-mouth (Sekaran & Boogie, 2017)

Respondents for Green Product Programs, with an average mean score of 3.967, usually perceived their oil and gas company as committed to produce environmentally friendly products. Though perceptions of the company's activities were positive, variations in responses exposed varied consumer opinions (Joseph F. Hair et al., 2021). About Green Price Programs, respondents appreciated the affordability and fit of product prices with quality and benefits, thus average 3.887. Still, opinions varied about whether one was willing to pay more for a brand than others (Sekaran & Boogie, 2017). Regarding Green Place Programs, the overall average was 3.968, therefore even if some expressed concerns about the consistent availability of environmentally friendly products, consumers thought of the locations of gas stations as strategic and easily accessible (Sekaran & Boogie, 2017). With an overall score of 3.867 for Green Promotion Programs, the company's ads—which were seen as intriguing and educational—show good client perceptions of it. Less thrills, however, for discount or subsidy programs (Sekaran & Boogie, 2017).

Though respondents highlighted the brand's environmental commitment and strong reputation, trust in the brand's promises varied substantially (Sekaran & Boogie, 2017). The Green Brand Image obtained an overall average of 3.649. With an average green company confidence score of 3.862, the environmental initiatives and performance of the company obviously inspire a great degree of consumer trust (Sekaran & Boogie, 2017). With its environmental commitment and performance, Green Satisfaction—average 3.880—indicates that consumers were generally delighted with their brand of choice (Sekaran & Boogie, 2017). With an overall average of 3.882, Green Loyalty reveals a notable predisposition among consumers to stay devoted to the company due of its ecologically friendly ideas (Sekaran & Boogie, 2017).

At conclusion, the Word of Mouth (WOM) statistics, average 3.846, reveal that consumers actively share their excellent experiences and brand recommendations, thus significantly influencing purchase decisions (Sekaran & Boogie, 2017).

The overall findings highlight the importance of environmental sustainability in consumer decision-making as they show that the green marketing strategies of the company have effectively raised positive customer attitudes and behaviors in many different spheres.

### 4.2 Research Results & Discussion

| Hypothesis | | Coefficient | $T_{statistic}$ | P-value | Decision |
|---|---|---|---|---|---|
| H1A | *Green Product Program Positively Affects Green Brand Image* | 0.351 | 5.803 | 0.000** | Supported |
| H1B | *Green Product Program Positively Affects Green Brand Trust* | 0.223 | 3.459 | 0.000** | Supported |
| H1C | *Green Product Program Positively Affects Green Satisfaction* | 0.188 | 2.924 | 0.002** | Supported |
| H1D | *Green Product Program Positively Affects Green Loyalty* | 0.251 | 3.881 | 0.000** | Supported |
| H2A | *Green Price Program Positively Affects Green Brand Image* | 0.058 | 0.980 | 0.163 | Not Supported |
| H2B | Green Price Program Positively Affects Green Trust | 0.100 | 1.586 | 0.056 | Not Supported |
| H2C | *Green Price Program Positively Affects Green Satisfaction* | 0.070 | 1.216 | 0.112 | Not Supported |
| H2D | *Green Price Program Positively Affects Green Loyalty* | 0.152 | 2.557 | 0.005** | Supported |
| H3A | *Green Place Program Positively Affects Green Brand Image* | 0.145 | 2.576 | 0.005** | Supported |
| H3B | *Green Place Program Positively Affects Green Trust* | 0.142 | 2.468 | 0.007** | Supported |
| H3C | *Green Place Program Positively Affects Green Satisfaction* | 0.135 | 2.031 | 0.021** | Supported |
| H3D | *Green Place Program Positively Affects Green Loyalty* | 0.068 | 1.063 | 0.144 | Not Supported |
| H4A | *Green Promotion Program Positively Affects Green Brand Image* | 0.390 | 6.102 | 0.000** | Supported |
| H4B | *Green Promotion Program Positively Affects Green Trust* | 0.453 | 6.914 | 0.000** | Supported |
| H4C | *Green Promotion Program Positively Affects Green Satisfaction* | 0.504 | 7.393 | 0.000** | Supported |

| Hypothesis | | Coefficient | $T_{statistic}$ | P-value | Decision |
|---|---|---|---|---|---|
| H4D | *Green Promotion Program Positively Affects Green Loyalty* | 0.439 | 6.609 | 0.000** | Supported |
| H5 | *Green Brand Image Positive to Positive Word of Mouth* | 0.345 | 3.366 | 0.000** | Supported |
| H6 | *Green Trust on Positive Word of Mouth* | -0.061 | 0.625 | 0.266 | Not Supported |
| H7 | *Green Satisfaction on Positive Word of Mouth* | 0.224 | 2.831 | 0.002** | Supported |
| H8 | *Green Loyalty on Positive Word of Mouth* | 0.440 | 5.978 | 0.000** | Supported |

Reversing the null hypothesis (H0), the study of Hypothesis 1a shows that with an estimated coefficient of 0.351 and a significant t-value of 5.801 Green Product Programs favorably influence Green Brand Image. Chen X. S., 2010 This result is in line with previous research demonstrating environmentally friendly product advertisements improve customer impressions of organizations dedicated to sustainability. Moreover, indicated by the data are the extent of consistent marketing of green products influences the quality of a good brand in the very competitive energy industry (Hanh et al., 2023).

With a p-value of 0.000 (Y. S. Chen, 2010) and an estimated coefficient of 0. 223 and a t-statistic of 3.459, hypothesis 1b shows similarly that Green Product Programs strongly impact Green Brand Trust. This implies that customers of items showing real environmental care are more inclined to trust businesses. The results highlight even more how transparent communication on the environmental advantages of goods builds customer trust and loyalty (Lakatos et al., 2021).

With an anticipated coefficient of 0. 188 and a p-value of 0.002 Hypothesis 1c shows a good impact on green satisfaction (Gelderman et al., 2021). Green Product Programs so help to raise customer satisfaction. This gratification comes from the emotional pleasure of supporting environmental sustainability as well as from the quality of products; so, it enhances brand loyalty (Thoria et al., 2017).

With an estimated coefficient of 0. 251 and a p-value of 0.000 (Baktash & Talib, 2019), hypothesis 1d finally shows that Green Product Programs favorably affect Green Loyalty. This result emphasizes the need of green projects in encouraging consumer loyalty as environmentally concerned consumers usually stick to companies that show a dedication to sustainability (Kewakuma et al., 2021). All things considered, the findings support one another to show that in a market more environmentally conscious Green Product Programs are efficient strategies for improving brand image, trust, satisfaction, and loyalty (Kewakuma et al., 2021).

Understanding how Green Price Programs affect several facets of brand impression helps one to come up with some creative ideas. Though the results revealed a coefficient of 0.058 and a p-value of 0. 163 which resulted in the acceptance of the null hypothesis and indicated that Green Price Programs do not quite influence brand image, hypothesis 2a tested the positive effect of Green Price Programs on Green Brand Image (D'Souza et al., 2015). This is consistent with earlier studies showing that brand image is defined by attributes like sustainability and

product quality (Majeed et al., 2022). more than only rules for pricing policy. Likewise considering Hypothesis 2B on the interaction between Green Price Programs and Green Brand Trust. Establishing a coefficient of 0.107 and a p-value of 0.056 (Nguyen-Viet, 2023) also lacking apparent impact. The results imply that while Green Price Programs could increase brand confidence, they are insufficient on their own without support from other variables including corporate transparency and product quality (Bathmathan & Rajadurai, 2019).

Regarding customer satisfaction, Hypothesis 2C showed that Green Price Programs have a coefficient of 0.070 and a p-value of 0.112, thus suggesting that they do not particularly raise green satisfaction (Gil & Jacob, 2018; Vishal, 2020). This explains why customers evaluate happiness—hashish et al., 2022; Lam et al., 2016—environmentally performance and product quality above price. With a coefficient of 0. Lindsey and a p-value of 0.005, Hypothesis 2D at least indicated a statistically significant correlation showing a positive impact of Green Price Programs. This implies that when customers see green pricing as in line with sustainable values, they develop brand loyalty (Amoako et al., 2020).

Green Price Programs basically limit their influence on brand image, trust, and satisfaction even if they raise brand loyalty without other components in the Green Marketing Mix, including excellent quality and strong communication of sustainability initiatives. This all-encompassing strategy assists Vietnamese as well as Indonesian environment to develop powerful and long-lasting corporate image (Nguyen-Viet, 2023).

By means of a coefficient of 0.145 and a p-value of 0.005, the investigation of Hypothesis 3A reveals that Green Place Programs favorably influence Green Brand Image, therefore supporting the acceptance of the alternative hypothesis (Martínez, 2015b). This implies that environmentally friendly distribution techniques improve brand impression among customers who see such behavior as a commitment to sustainability as such (Wang et al., 2024). Furthermore, shown by the studies is how consumers see companies using sustainable distribution strategies to boost brand loyalty (Ha, 2020). Furthermore, stated as basic distinguishing feature dividing businesses in competitive marketplaces apart are Green Place Programs, thus improving brand reputation (Qomariah & Prabawani, 2020).

Testing Hypothesis 3B confirming the alternative hypothesis (Thoria et al., 2017) clearly indicates how Green Place Programs impact Green Brand Trust as a coefficient of 0.142 and a p-value of 0.007. This result underlines how customers are more likely to trust companies showing a dedication to reduced environmental impact by way of green distribution networks (Wu & Liu, 2022). Moreover, successful Green Place Programs not only foster trust but also brand loyalty when customers appreciate major efforts toward sustainability (Shafiq, Khan, et al., 2023).

Third hypothesis, C: With a coefficient of 0.135 and a p-value of 0.021 Green Place Programs favorably boost Green Satisfaction and thus acceptance of the alternative hypothesis (Rahbar & Wahid, 2011). This suggests that customers like using certain environmentally friendly items, thereby enhancing their emotional connection with the business (Jonathan & Sari, 2023).

Moreover, more likely are customers to follow companies with extremely relevant green concepts (Amoako et al., 2020).

Conversely, Hypothesis 3D supports the null hypothesis (Astuti et al., 2021) showing with a coefficient of 0.068 and a p-value of 0.144 that Green Place Programs have least impact on Green Loyalty. This implies that, even if green distribution is valued, it might not be enough to inspire customer loyalty on its alone as other factors such general experience and product quality have a more essential influence (Wang et al., 2024). The results emphasize the requirement of a full green marketing strategy with several components, including Green Product and Green Promotion, to sufficiently raise customer loyalty (Agyabeng-Mensah & Tang, 2021).

With an estimated coefficient of 0.390 and a p-value of 0.000, the analysis of Hypothesis 4A shows that Green Promotion Programs favorably impact Green Brand Image; hence, the null hypothesis (Ho) is rejected, and the alternative hypothesis (Ha) is accepted. This implies that successful green campaigns improve consumer brand impression as companies supporting sustainability are seen as accountable businesses. These initiatives also strengthen good brand images by helping emotional ties between companies and customers to be reinforced (Juliantari et al., 2019). Studies by Eneizan et al. (2019) confirm even further the idea that advertising stressing environmental values have a major influence on company image, therefore improving customer trust by means of open sustainability initiatives (Eneizan et al., 2019).

With a coefficient of 0.453 and a p-value of 0.000, Hypothesis 4B similarly shows that Green Promotion Programs greatly increase Green Brand Trust, therefore validating the beneficial impact of these initiatives (Nazim et al., 2020). Constant green marketing show a company's dedication to sustainability, hence building customer confidence and emotional ties (Tan et al., 2022). Good green promotions also help businesses to become sustainability leaders, therefore encouraging long-term brand loyalty (K. U. Khan et al., 2022).

With a coefficient of 0.504 and a p-value of 0.000, Hypothesis 4C shows that well-designed promotions improve customer satisfaction (Dabija et al., 2018). Green Promotion Programs therefore favorably effect Green Satisfaction. Moreover, these initiatives greatly support Green Loyalty with a coefficient of 0.439 and a p-value of 0.000 as customers are more inclined to stick to companies that actively support environmental commitments (Martínez, 2015b). Green Promotion Programs inspire customers to advocate for businesses, therefore boosting long-term development even as they promote loyalty (Kumar et al., 2017). These results highlight generally the strategic relevance of including sustainability ideals into marketing plans to improve brand-consumer interactions in a market sensitive to environmental issues (Kumar et al., 2017).

Strong green brand image motivates customers to share great experiences, hence improving Word of Mouth (Mehdikhani & Valmohammadi, 2022) with an anticipated coefficient value of 0.345 and a p-value of 0.000. This is consistent with recent research demonstrating customers are more ready to help businesses seen to be environmentally conscious, therefore enhancing brand loyalty and confidence (Moisescu, 2018). Strong green brand image also creates

emotional linkages, which inspire customers to support sustainable goods, thus improving brand reputation (I. Khan & Fatma, 2023).

Green Brand Trust, on the other hand, has little effect on Word of Mouth shown by a p-value of 0.266 and an estimated coefficient of -0.061, suggesting that trust by itself may not inspire proactive sharing behaviors (Nguyen-Viet, 2023). Although trust forms the foundation of loyalty, research show that it does not necessarily transition into word-of- mouth until first-hand customer experiences (Alamsyah & Febriani, 2020).

Conversely, Green Satisfaction indicates a positive impact on Word of Mouth with an estimated coefficient of 0.224 and a p-value of 0.002, thereby verifying that happy customers are more inclined to talk about their good experiences (Issock Issock et al., 2020b). This pleasure is connected to the alleged advantages of environmentally friendly goods, which not only improves WOM but also drives brand loyalty (Mehdikhani & Valmohammadi, 2022).

Green loyalty finally has a big impact on Word of Mouth; loyal customers are more inclined to tell others about companies (Agyabeng-Mensah & Tang, 2021). Calculated coefficient of 0. 440 and p-value of 0.000 characterize this effect. By means of unofficial recommendations, this loyalty fosters a strong emotional connection and increases brand recognition, therefore strengthening the emotional link and helping the growth of a strong brand reputation in a market of competition. All things considered, the results underline the need of creating a strong green brand image, satisfaction, and loyalty to promote efficient customer communication and improve firm placement in a market oriented on sustainability (Agyabeng-Mensah & Tang, 2021).

## 5. CONCLUSION AND RECOMMENDATIONS

### 5.1 Conclusion

This article aims to explore how Green Marketing Mix program influences Green Consumer-Based Brand Equity and Word-of- Mouth in Oil & Gas Companies. Results of hypothesis testing let one to many important conclusions. First, real data supports most of the hypotheses in this study by implying that the use of green marketing strategies greatly raises environmental-based brand equity. Second, activities like Green Product, Green Place, and Green Promotion greatly impact Green Consumer-Based Brand Equity—which consists of factors including Green Brand Image, Green Brand Trust, Green Satisfaction, and Green Loyalty. This positive effect implies that by means of better satisfaction and confidence, green marketing strategies may increase customer trust, strengthen brand image, and increase loyalty to the company. Green Brand Image, Green Satisfaction, and Green Loyalty—which imply that consumers who are satisfied and see the brand favorably frequently share their experiences with others—also clearly influence Word of Mouth.

Although the evidence helps most of the hypotheses to be verified, some of them lack such support. Notable results neither come from the theory on the impact of the Green Price Program on Green Brand Image, Green Brand Trust, or Green Satisfaction nor from the Green Place Program on Green Loyalty. These findings reveal that, in the framework of the oil and gas

industry, certain elements of the Green Marketing Mix might be less significant even if others serve to build brand equity. Moreover, missing support was the theory analyzing the influence of Green Trust on Word of Mouth, implying that active sharing of Green Trust experiences cannot always be inspired by consumer trust in green goods. This might be so that consumers have a more intense experience to encourage Word-of- Mouth spreading.

This study shows generally that the Green Marketing Mix program greatly influences certain word-of-mouth and Green Consumer-Based Brand Equity. Still, certain elements of the Green Marketing Mix have no direct influence on customer experience sharing behavior. This underlines the necessity of a more integrated approach to increase the effect of green marketing strategies in numerous sectors of brand equity and consumer communication in the future.

### 5.2 Managerial Implications

This article highlights many managerial issues for companies in the oil and gas sector aiming to enhance their Green Marketing Mix strategies, hence boosting Brand Equity and Word of Mouth. First, companies should change their pricing strategies for environmentally friendly products to boost their competitiveness by means of incentives or subsidies and consumer education on long-term benefits. Second, increasing discount and subsidy programs would assist to generate more effective campaigns promoting consumer engagement and emotional bonds with firms.

Moreover, by means of open information campaigns and partnerships with environmental organizations, bettering the image of green products will help to inspire customer faith in their value. Furthermore, crucial is ensuring availability in less urban areas and thus improving access to key locations, so maximizing the distribution of green commodities. Businesses should also focus on encouraging consumers to submit their experiences on social media and by providing incentives for reviews, therefore strengthening positive word of mouth.

Strongening the green brand image by means of transparent sustainability reporting and consumer education can assist to create trust and loyalty. Key is to increase customer satisfaction by ensuring that product quality meets expectations and by educating about long-term benefits. Appealing loyalty programs helps to enhance consumer loyalty to environmentally friendly products and activities.

Moreover, clear communication and genuine claims serve to promote confidence in environmental commitments, hence countering concepts of greenwashing. Lastly, using taglines with sustainability in mind will assist to stress the brand's commitment to sustainable energy and appropriately engage consumers. In the oil and gas industry, achieving sustainability goals and raising consumer loyalty and Word of Mouth relies on focusing on price, distribution, and promotion strategies for green products generally.

### 5.3 Limitations of the Study

This study points out numerous limits that should be considered for further studies and the assessment of its conclusions. First, the use of a quantitative survey technique can overlook the

complexity of customer experiences, implying that a mixed methods approach including qualitative insights would be beneficial in next investigations. Second, while the study concentrates on the effect of the Green Marketing Mix on Green Consumer-Based Brand Equity and Word of Mouth, it ignores other important outside variables including government policies and public opinions, therefore suggesting a need of further investigation of these elements. Thirdly, even if the indicators utilized were verified, subjective elements that may not be completely reflected by a basic Likert scale influence consumer impression, thereby stressing the need of more complex measuring methods such as text analysis or behavioral observations. Finally, the focus of the study on the Oil & Gas industry may limit the application of its findings to other sectors, thereby underlining the need of doing comparable research across many sectors to assess the larger consequences of green marketing tactics (iv). Through addressing these constraints, further studies may increase methodological rigor and extend the field of investigation, therefore enabling a better outcome.

### 5.4 Recommendations for Future Research

The report identifies many avenues of research to address its flaws and further understanding of the Green Marketing Mix program. First, it recommends utilizing mixed methodologies integrating qualitative and quantitative approaches to capture consumers' in-depth perceptions as the quantitative focus of the current study may neglect complicated insights (a). Second, a further background should be investigated to provide Green Marketing in the oil and gas industry (b) additional elements including government legislation and consumer understanding of sustainability. Thirdly, it recommends the use of more complex measurement techniques beyond the simple Likert scale to better represent the many natures of consumer attitudes regarding Green Marketing projects (c). At last, it encourages similar study in other industrial sectors to confirm the effectiveness of Green Marketing strategies in other contexts, therefore enhancing the relevance and use of the outcomes (d). By considering these ideas, future research might significantly assist various sectors to develop effective green marketing strategies.

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# CHAPTER 13

# Determination of the Decision to Use Indonesian Islamic Bank Products Among the People of Jakarta

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## ABSTRACT

This study aims to analize the influence, knowledge, religiosity, subjective norms, promotion, service quality on costumer decisions to use Indonenesian Islamic bank products in DKI Jakarta. The population in this study were Indonesian Islamic bank customers in DKI Jakarta. The sampling method used purposing sampling with a sampling size of 360 respondents, spread across five municipalities, Central Jakarta, West Jakarta, North Jakarta, South Jakarta, and East Jakarta. Data collection techniques with questionnaires via google form. The data analysis method used is descriptive statistical analysis with the help of SPSS and Structural Equation Model (SEM) from the AMOS software package. The results of this study indicate that the variables of subjective norms, religiosity and service quality have a positive and significant effect on customer decisions to use Bank Syariah Indonesia products in DKI Jakarta. Meanwhile, the variabels of knowledge and promotion have no effect on customer decisions to use Bank Syariah Indonesia products in DKI Jakarta.
**Key words:** Knowledge, religiosity, subjective norms, customer decisions, Bank Syariah Indonesia

## 1. INTRODUCTION

Bank Syariah Indonesia (BSI) is a merger of three Islamic banks, namely BRI Syariah, Bank Syariah Mandiri and BNI Syariah. BSI was inaugurated on February 1, 2021 which aims to strengthen the performance of national Islamic banking (Meilani & Sugiarti, 2022). This merger of Islamic banks is expected to channel the advantages of these three Islamic banks to provide more complete services. Wider reach and stronger capital.

The merger of the three Islamic banks will certainly affect customers in assessing the quality of BSI services before and after the merger. The difference in service will definitely be felt by customers, both in terms of quantity and quality. BSI relocates branch offices, adjusts service facilities and unites the organizational culture of human resources. Based on Sharia Banking Statistics data for January 2021, the total number of BSI branch offices before the merger was 270, while the number of BSI branch offices after the merger decreased to 263. The total number of BSI sub-branch offices before the merger was 987, while the number of BSI sub-branch offices after the merger was 72, while the number of cash offices after the merger decreased to 60 (OJK, 2021). Indonesia is a country with the largest Muslim population of 245.93 million people with a percentage of 87.08% of the population. Ironically, the market share of Islamic banking in Indonesia as of July 2024 has only reached 7.32%. Therefore, there needs to be an effort - so that Islamic banking can improve its performance. Continuous product innovation needs to be done. s

In Indonesia, Islamic banking began to see its development after the enactment of the Islamic Banking Law No. 21 of 2008 by the DPR RI. This is certainly not only seen from the aspect of legal certainty and the existence of Islamic banking formally legally (Masnita et al, 2024 dalam (Tarar, n.d.)). The significant growth of Islamic banking is also supported by a strategic Islamic banking network, especially in DKI Jakarta (Rianto, 2021) Jakarta as the center of the Indonesian economy makes many investors and companies a strategic target market. Islamic banking is one of the many businesses that have become Jakarta as a target market with 252 branches spread across the DKI Jakarta area.

The high and low interest of customers in using Sharia products is influenced by external factors and internal factors, one of which is Sharia banking knowledge. Customer knowledge is information owned by customers regarding various kinds of products and services and other knowledge related to Islamic banking products and services. The pattern of behavior that customers have is influenced by their knowledge, with the level of knowledge they have, consumers can process new information, make considerations and make decisions. According to Rachmawati (2017), (Ramadhani et al., 2019), product knowledge has a significant effect on customer decisions in saving. With a good understanding of Islamic banking knowledge, it will increase interest in saving at Islamic banks.

One factor that is quite important in shaping people's behavior is the factor of religiosity (Zuhirsyan & Nurlinda, 2021). The values of religiosity, apart from being practiced in worship, must also be practiced in business, for example, the attitude in choosing products that are used in accordance with Islamic principles. In doing business, a religious person will avoid usury practices by switching from using conventional bank products to Islamic banks (Masruroh, 2015). According to (Sugiharto et al., 2022), (Ramadhani et al., 2019) (Romdhoni & Sari, 2018) the level of religiosity has a positive and significant influence on customer interest in using Islamic banking products. In contrast to the findings of (Sodiq et al., 2022) Religiosity has no effect on interest in saving at Islamic banks.

In making decisions, a person often gets influence from his environment which is called Subjective Norms. (Fuadi et al., 2020) in his research found that subjective norms have a

positive effect on people's decisions to use Islamic bank products. In line with this research, (Angrico & Susanti, 2024) also found in their research on Bank Tabungan Negara Padang Branch where Subjective Norms have a significant effect on customer deposit interest at PT Bank Tabungan Negara Padang Branch.

With intense competition, financial institutions, especially Islamic banks, are also competing in attracting customers, one of which is by conducting promotions. Promotion includes a series of marketing activities and economic activities by conveying a message in this case the product to the public. The promotions carried out by Islamic banks vary, holding an activity that mediates, and collaborating with several large agencies. In addition, attractive offers are also often made by Islamic banks, such as wadiah products that do not have monthly administration fees or provide gifts in the form of bonuses for customers who use other funding products in large quantities (Muryani, 2019). According to research (Wahyulkarima, 2018) promotion affects people's decisions to use Islamic bank products.

Services, in addition to information, promotion, and religion, are thought to influence people's decisions to use Islamic banking products. The quality of services provided by banks is closely related to public satisfaction. Good service can encourage banks to have a good relationship with the community. Efforts to provide satisfaction to the community are made so that customers continue to believe in using Islamic bank products and minimize customer decisions to switch to other banks (Muryani, 2019). In his research, (Firmansyah 2019b) states that service quality affects people's decisions to use Islamic bank products.

## 2. LITERATURE REVIEW

### 2.1 Theoretical Background

#### 2.1.1 Knowledge

Knowledge can be interpreted as one of the results obtained by humans by combining or cooperating between subjects who can understand and objects that are understood. It consists of everything known about a particular object. According to Notoatmodjo in W N Suhaila (2020), knowledge is a product of human measurement, or understanding of an item through the five human senses.

#### 2.1.2 Religiosity

Religiosity is the ritual activity of Magda worship or Goyle-Magda worship, the activity of carrying out religious studies through the community. Religiosity is implemented in the realms of culture, legal politics, and expressed in social and economic life. An individual's level of belief determines his or her economic behavior, which in turn shapes consumption habits and production activities in the marketplace. Saving behavior is also influenced by perspective. Saving is an activity to control oneself from a consumptive attitude and as a form of gratitude for the food given by God (Nengsi, 2021).

#### 2.1.3 Subjective Norms

Subjective norms are a determining aspect in explaining certain behaviors of an individual. This means that an individual's behavior is not only determined by the individual's wishes, but is also influenced by the perceptions of their social environment. So it can be said that social perceptions can have an impact on the actions that individuals will take, meaning that an individual can perform certain behaviors by ignoring their own preferences (Coşkun & Yetkin Özbük, 2020).

#### 2.1.4 Promotion

Promotion is an activity to communicate and introduce products carried out by a company to its marketing targets. Several forms of promotion that are spread among the public, namely: advertising, personal selling, sales promotion, public relations, and direct marketing

tools used by companies to achieve their advertising and marketing goals (Damayanti & Sudarmanto, 2021).

### 2.1.5 Service Quality

Service quality is an effort to deliver services to meet customer needs and desires and delivery accuracy to balance customer expectations. Consumer expectations are consumer beliefs before trying or buying a product which are used as a reference in assessing the performance of the product (Izzuddin & Muhsin, 2020).

## 2.2 Conceptual Framework

Conceptual framework is illustrated in Figure 1 as follows:

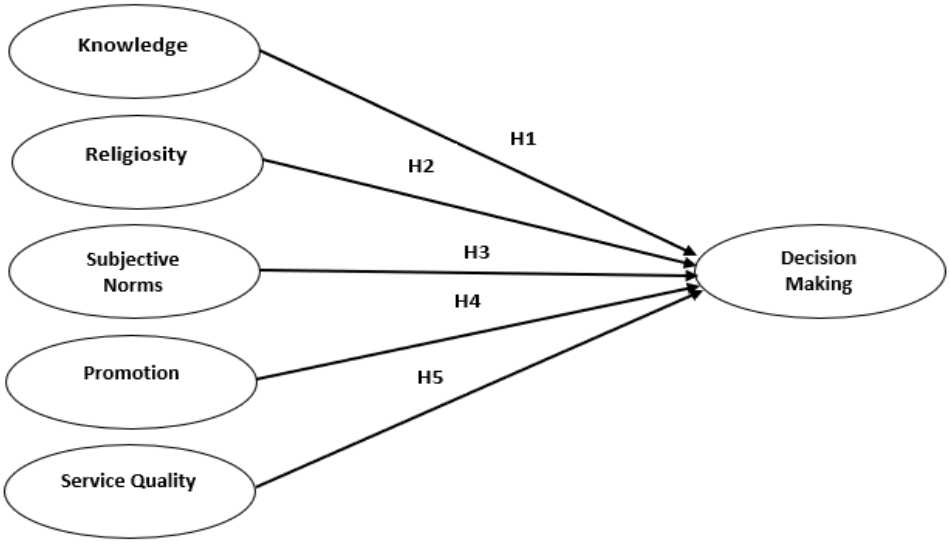


**Figure 1:** Conceptual Framework

## 2.3 Hypotheses Development

### Knowledge Product

According to (Irmayani et al., 2022) Product knowledge is a collection of various information about a product. Attributed to the knowledge of Islamic banking products including: Islamic banking products, such as Islamic savings, Islamic deposits, Islamic pawnshops, Islamic financing. Akad used in Islamic banks. Requirements for opening an account and the minimum initial deposit when opening an account. The difference between Islamic banks and conventional banks. Knowledge of the products offered can be a consideration for customers in choosing a bank (Maulana et al., 2020). According to (Hasibuan & Wahyuni, 2020) Knowledge is a factor that greatly influences customer choice of Islamic banking products.

H1: Knowledge Product (P) Significantly influences the decision to use Bank Syariah Indonesia products.

### Religiosity

Religiosity is a belief in the existence of God that influences one's actions to harmonize one's life with God (Saifuddin & Andriani, 2019). The Quran states that the concept of religiosity is articulated through the values of tawhid. Religiosity is implemented in the realm of culture, legal politics, and expressed in social and economic life. According to Ancok in (Nengsi, 2021) the dimensions of religion consist of five dimensions, the first is the belief or ideological dimension, namely the extent to which a person believes in God, angels, heaven,

hell or accepts dogma in his religion. Second, the dimension of religious or Ritualistic practice, reflected in rituals, obedience, worship and showing one's firm stance on religion. Third, the dimension of experiential experience, is a component of feelings or experiences, including feelings as a result of religion or worship. For example, fear of sinning, feeling close to God and so on. Fourth, the dimension of religious or intellectual knowledge, relating to how much a person knows about his religious beliefs. This dimension includes an understanding of the scientific principles of the Koran, Islamic law, Islamic economics/banking, and knowledge about believing and doing what is already known about Islam. Fifth, the consequence dimension is used to assess how much a person's social life is influenced by religious teachings. According to research (Hasibuan 2020) a person's religiosity can influence their decision to adopt Islamic bank products. People are beginning to realize that conducting financial transactions must apply Islamic values.

H2: There is an influence of religiosity on the decision to use Bank Syariah Indonesia products.

**Subjective Norms**

An individual's impression of societal pressure to do or not do something is referred to as subjective norms. Subjective norms can be defined and measured as a set of normative beliefs that agree/disagree with key cues for behavior. Subjective norms consist of three parts, namely intention to worship, intention to submit, and intention to sacrifice (Dewi, 2016). Consideration of others can drive actions and decisions (Pangestika, 2017). According to Zamroni (2018), the indicators of subjective norms consist of Normative beliefs are beliefs about other people's wishes for themselves. These are characteristics that should or should not be thought about to broadcast this behavior. Beliefs about the thoughts of figures or other people who are significant and influential on people or role models. Motivational to comply is defined as the drive to achieve these goals. (Fuadi 2020) in his research said that subjective norms have a positive effect on people's decisions to use Islamic bank products. In line with research by (Fauzi, 2017) which explains that it means that normative belief which is a perception of other people's expectations of him and means to fulfill these expectations has an effect on interest in saving at Islamic banks.

H3: There is an influence of subjective norms on the decision to use Bank Syariah Indonesia products.

**Promotion**

Financial institutions, especially Islamic banks, are certainly competing in attracting customers, one of which is by conducting promotions. Promotion includes a series of marketing activities and economic activities by conveying a message in this case the product to the public. The promotions that have been carried out by Islamic banks vary, holding an activity that mediates, and collaborating with several large agencies. In addition, attractive offers are also often made by Islamic banks, such as wadiah products that do not have monthly administration fees or provide gifts in the form of bonuses for customers who use other funding products in large quantities (Muryani, 2019). According to research (Wahyulkarima, 2018) the existence of promotions with understanding will influence people's decisions to use Islamic bank products. Based on the explanation above, the hypothesis proposed is:

H4 : There is an influence of promotion on the decision to use Bank Syariah Indonesia products

### Service Quality

Service quality consists of all activities that make it easy for customers to contact related parties and get help, answers, and solve their problems in a timely and satisfactory manner (Jusrianti, 2022). Efforts to provide satisfaction to the community are made so that customers continue to believe in using Islamic bank products and minimize customer decisions to switch to other banks (Muryani, 2019). In his research, (Firmansyah 2019b) states that service quality affects people's decisions to use Islamic bank products. Based on the explanation above, the hypothesis proposed is:

H5: There is an influence of service quality on the decision to use Bank Syariah Indonesia products.

## 3. RESEARCH METHOD

The approach used in this research is quantitative research with associative research type. The data used are primary data and secondary data. Primary data was obtained using nonprobability sampling with purposive sampling technique, where the population consisted of Bank Syariah Indonesia (BSI) customers in DKI Jakarta province. Determination of the minimum sample size with SEM according to (Hair et al., 2019) is : (Number of indicators + number of latent variables) x (5 to 10 times). Based on these guidelines, the minimum sample size is (30 +6) x 5 = 180 respondents, while the maximum sample is (30 + 6) x 10 = 360 respondents. In this study, the sample used was 360 respondents who were collected using the google form platform. The Likert scale functioned to express respondents' agreement using 1 to 5, from strongly disagree to strongly agree. The data processing method uses Structual Equation Modeling (SEM) with the help of AMOS 21 and SPSS 25 software.

## 4. RESULT AND DISCUSSION

### 4.1. Respondent Demographic Characteristics

Respondents in this study totaled 360 people, are customers of Bank Syariah Indonesia (BSI) who live in DKI Jakarta consisting of 191 women (53.1%) and the rest are men, the majority of respondents aged 17 to 25 years as many as 150 people (41.7%), followed by ages 26 to 35 years as many as 142 people (39.4%), ages 36 to 50 years as many as 61 respondents (16.9%, the remaining age above 50 years is 1.9%. The majority of education levels are Diploma/Bachelor by 71.7%, followed by SMA / SMK 19.4%, and S2 by 6.9%, the rest are S3 and SD/SMP. The majority of income is Rp 5 million - Rp 10 million by 58.9% followed by income below Rp 5 million by 29.7%, while those with income of Rp 10 million - Rp 20 million are 9.7% and above Rp 20 million are only 1.7%. The dominant profession is private employees at 47.2%, followed by self-employed 19.2%, civil servants 15.8% and BUMN employees 10.6%, the rest are others (Table 1).

Table 1. General Description of Respondents

| Characteristics | Category | Research Result | |
|---|---|---|---|
| | | Frequency | (%) |
| Gender | Male | 169 | 46.9% |
| | Female | 191 | 53.1% |
| Total | | 360 | 100% |
| Age | 17-25 years old | 150 | 41.7% |

| Characteristics | Category | Research Result | |
|---|---|---|---|
| | | Frequency | (%) |
| | 26-35 years old | 142 | 39.4% |
| | 36-50 years old | 61 | 16.9% |
| | > 50 years old | 7 | 1.9% |
| Total | | 360 | 100% |
| Education | Elementary/Middle School | 3 | 0.8% |
| | SMA/SMK | 70 | 19.4% |
| | Diploma/S1 | 258 | 71.7% |
| | S2 | 25 | 6.9% |
| | S3 | 4 | 1.1 |
| Total | | 360 | 100% |
| Region of Residence | West Jakarta | 85 | 23.6% |
| | East Jakarta | 73 | 20.3% |
| | North Jakarta | 58 | 16.1% |
| | South Jakarta | 71 | 19.7% |
| | Central Jakarta | 73 | 20.3% |
| Total | | 360 | 100% |
| Revenue | < Rp. 5 million | 107 | 29.7% |
| | Rp. 5 million -Rp. 10 million | 212 | 58.9% |
| | Rp. 10 million -Rp. 20 million | 35 | 9.7% |
| | > Rp. 20 million | 6 | 1.7% |
| Total | | 360 | 100% |
| Profession | Civil Servant | 57 | 15.8% |
| | Private Employee | 170 | 47.2 |
| | Self-employed | 69 | 19.2% |
| | Profesional | 15 | 4.2% |
| | SEO Employee | 38 | 10.6% |
| | More | 11 | 3.1% |
| Total | | 360 | 100% |

### 4.2. Validity dan Reliability

This study uses a loading factor analysis approach to test validity according to (Hair et al., 2019) if the sample size is 380, the indicator is declared valid if it has factor loading > 0.35. Based on the results of the validity test that has been carried out from the five statement items used to measure the subjective norm variable, there are 2 items NS1 and NS5 that are invalid because factor loading <0.35 so they will not be used in further calculations. For Islamic banking knowledge variables, religiosity, promotion variables, service quality, and banking decision making factor loading> 0.35 means that the statement items to measure these variables can be used.

According to (Hair et al., 2019) to ensure that the research instrument is consistent and accurate, reliability testing is used using the Cronbach alpha coefficient, if Cronbach's coefficien Alpha ≥ 0.6 then the statements in the questionnaire are suitable for use. From the results of the reliability test that has been carried out, all variables are declared reliable because the contruct reliability value is greater than or equal to 0.6.

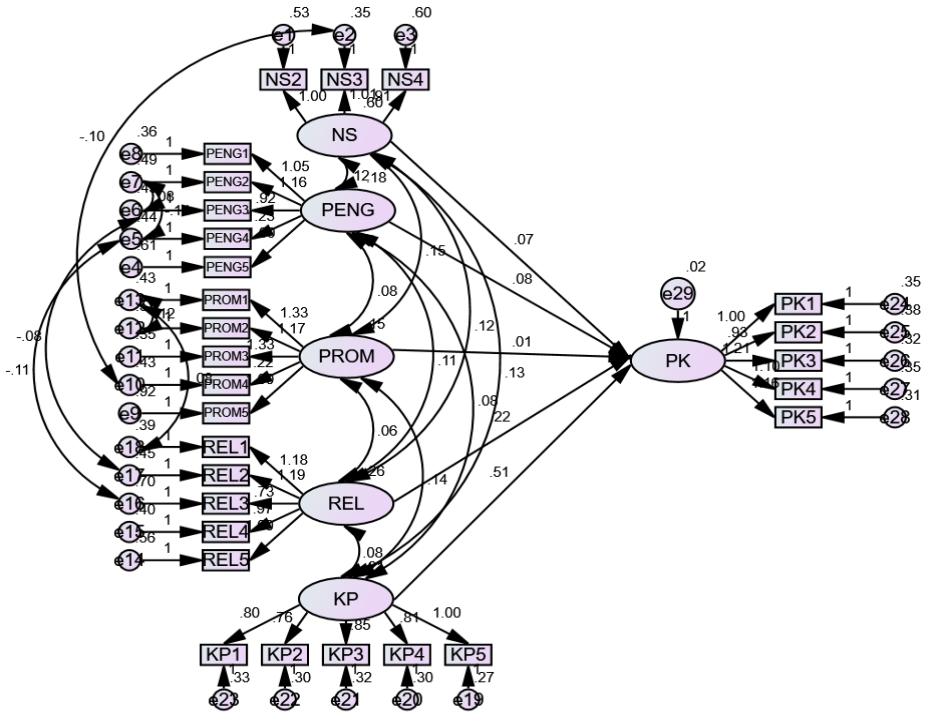


**Figure 2: Path Diagram**

Based on the results of SEM data processing, it shows that Knowledge has 5 indicators, Religiosity has 5 indicators, Subjective Norms have 3 indicators, promotion has 5 indicators, Service quality has 5 indicators, and Decision making has 5 indicators. These results have gone through several stages of data quality testing Figure 2.

### 4.3. Hypotheses Testing Result and Discussion

The overall model has variables that have a causal relationship between endogenous and exogenous variables. For hypothesis testing, the method used is to determine the significance by looking at the p-value of the causal relationship in the overall model. If the estimated value in the analysis results shows positive and the p-value <0.05, the hypothesis is proven significant and supported by the data. If the estimated value shows negative results and the p-value <0.05, the hypothesis is not proven significant and is not supported by the data. The following is a table analyzing the data results of the overall model (Table 2)

Table 2. Hypothesis Test Results

| **Hypothesis** | ***Path*** | ***Estimate*** | ***P-Value*** | **Conclusion** |
|---|---|---|---|---|
| H1 | Knowledge → Decision making | 0.083 | 0.239 | H1 Not supported |
| H2 | Religiosity → Decision making | 0.218 | 0.000 | H2 is supported |
| H3 | Subjective Norms → Decision making | 0.069 | 0.046 | H3 is supported |
| H4 | Promotion → Decision making | 0.011 | 0.947 | H4 Not supported |
| H5 | Service Quality → Decision making | 0.506 | 0.000 | H5 is supported |

Source: Data processed using SPSS 25 (attached)

**H1: Knowledge has a positive and significant effect on public decisions in using Bank Syariah Indonesia products (Case Study of the DKI Jakarta Community).**

Based on the results of statistical testing, it is known that the coefficient of knowledge is 0.083, meaning that the higher the perception of knowledge, the higher the perception of purchasing decisions. The test results show a p-value of 0.239> 0.05 (alpha 5%), it is concluded that statistically at a 95 percent confidence level there is no effect of knowledge on public decisions in using Bank Syariah Indonesia products in the DKI Jakarta community. The implication is that public knowledge has no effect on the use of Islamic banking products. This opinion is supported by the results of (Mujaddid & Ramadan, 2019) that knowledge has no effect on the use of Islamic banking products. This is different from the research of Wahyulkarima (2018), Handida (2018), (Romdhoni & Sari, 2018), (Firmansyah 2019b) , (Hasibuan & Wahyuni, 2020), and (Asy'ari, 2021) that knowledge has a significant effect on people's decisions to choose Islamic bank products.

**H2: Religiosity has a positive and significant effect on public decisions in using Bank Syariah Indonesia products (Case Study of the DKI Jakarta Community).**

Based on the results of statistical testing, it is known that the coefficient of the religiosity variable is 0.218, meaning that the higher the perception of religiosity, the higher the public decision to use BSI products. The test results show a p-value of 0.000 <0.05 (alpha 5%), it is concluded that statistically at a 95 percent confidence level there is an influence of religiosity on people's decisions to use BSI products in the DKI Jakarta community. These results are in line with research by (Romdhoni & Sari, 2018), (Mujaddid & Ramadan, 2019), (Hasibuan & Wahyuni, 2020), (Aprilia, 2020) where religiosity has a significant effect on the decision to choose Islamic banking products. People began to realize that conducting financial transactions must apply Islamic values.

**H3: Subjective Norms have a positive and significant effect on Public Decisions in using Indonesian Islamic Bank products (Case Study of the DKI Jakarta Community).**

Based on the results of statistical testing, it is known that the coefficient of the Subjective Norm Variable is 0.069, meaning that the higher the perception of Subjective Norms, the higher the public decision to use Indonesian Islamic bank products. The test results show a p-value of 0.046 <0.05 (alpha 5%), it is concluded that statistically at a confidence level of 95 percent there is an influence of subjective norms on people's decisions to use Bank Syariah Indonesia products in the DKI Jakarta community. These results are supported by research by (Fuadi et al., 2020), (Pangestika, 2017), Subjective norms influence people to use Islamic banking products.

**H4: Promotion has a positive and significant effect on public decisions in using Bank Syariah Indonesia products (Case Study of the DKI Jakarta Community).**

Based on the results of statistical testing, it is known that the coefficient of promotion is 0.011, meaning that the higher the perception of promotion, the higher the perception of purchasing decisions. The test results show a p-value of 0.947> 0.05 (alpha 5%), it is concluded that statistically at a 95 percent confidence level there is no effect of promotion on people's decisions to use Bank Syariah Indonesia products in the DKI Jakarta community. This contradicts the results of research by (Alhifni, 2017), (Wahyulkarima, 2018), (Muryani, 2019), where promotion affects public interest in using Islamic banking products.

**H5: Service quality has a positive and significant effect on public decisions in using Bank Syariah Indonesia products (Case Study of the DKI Jakarta Community).**

Based on the results of statistical testing, it is known that the coefficient of the service quality variable is 0.506, meaning that the higher the perception of service quality, the higher

the public decision to use BSI products. The test results show a p-value of 0.000 <0.05 (alpha 5%), it is concluded that statistically at a confidence level of 95 percent there is an influence of service quality on public decisions in using Bank Syariah Indonesia products in the DKI Jakarta community. This research is supported by the results of research (Astuti et al., 2020) where service quality affects customer loyalty in using Islamic banking products.

## 5. CONCLUSION AND RECOMMENDATIONS

### 5.1 Conclusions

Based on the results of research and literature studies presented in the previous discussion, it can be concluded that there is a significant influence between religiosity variables and customer decisions in using Bank Syariah Indonesia products. There is a significant influence between the subjective norm variable and customer decisions in using Bank Syariah Indonesia products. There is a significant influence between service quality variables and customer decisions in using Bank Syariah Indonesia products. Meanwhile, the variables of knowledge and promotion have no effect on customer decisions in using Bank Syariah Indonesia products.

### 5.2 Recommendations

For recommendations for further research, in choosing respondents to be more proportional to all clusters in terms of age, education, profession, and income so that the conclusions drawn can be more precise. The questionnaire can be run off line so that the data obtained is more accurate. Other variables can be used that are more representative in making customer decisions in using Bank Syariah Indonesia products.

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