UNDERSTANDING THE OIL PRODUCTION: INVESTIGATING FACTORS AFFECTING THE OIL PRODUCTION DECLINE IN BLOCK 3 & 7 OF SOUTH SUDAN (2017-2022).

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A DISSERTATION
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AUGUST 2022

DECLARATION

I, **Jacob Dut Chol Riak** do hereby declare that this is my original work, is not plagiarized and has never been submitted to any other institution for academic award or merit. All other scholars' works have been duly cited and acknowledged. I am therefore responsiblefor any omission herein.

Student Name: Jacob Dut Chol Riak

Signature: 

Date: 28th August 2022

APPROVAL

This is to certify that, this dissertation entitled "**UNDERSTANDING THE OIL PRODUCTION: INVESTIGATING FACTORS AFFECTING THE OIL PRODUCTION DECLINE IN BLOCK 3 & 7 OF SOUTH SUDAN (2017-2022)**" has been done under my supervision and now it is ready for submission.

Signature: _____

Supervisor: Assoc. Prof. Bruno L. Yawe. PhD

Date: 30th August 2022

DEDICATION

To my dear wife Achol J. Dut and my son Deng for the social support and for love of new knowledge.

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LIST OF ACRONYMS AND ABBREVIATIONS

ARCSS	Agreement on the Resolution of the Conflict in the Republic of South Sudan
AU	Augmented Reality
BPD	Barrel Per Day
CPF	Central Processing Facility
CNPC	Chinese National Petroleum Company
DG	Director General
DPOC	Dar Petroleum Operating Company
EUR	Expected Ultimate Recoverable
FPF	Field Processing Facility
FSF	Field Service Facility
IFI	International Flood Initiative
IIOT	Industrial Internet of Things
IPSK	Institute of Petroleum Studies-Kampala
JOCs	Joint Operating Companies
K.I	Key Informant
MOP	Ministry of Petroleum
NILEPET	Nile Petroleum Corporation
OPP	Opposition
ONGC	Oil and Natural Gas Corporation
R-ARCSS	Revitalized Agreement on the Resolution of the Conflict In the Republic of South Sudan
SINOPEC	China Petroleum and Chemical Corporation
SPLM/A-IG	Sudan People's Liberation Movement/Army In Government
SPLM/A-IO	Sudan People Liberation Movement/Army In Opposition
SSOA	South Sudan Opposition Alliance (SSOA)
UN-WFP	United Nations-World Food Programme
USSR	United Socialist Soviet Republic
VR	Virtual Reality
WPB	Work Program and Budget

4th IR	Fourth Industrial Revolution

ABSTRACT

The study has comprehensively examined factors that have led to oil production decline in block 3 & 7 in Paloch of South Sudan as well as appraising solutions to the oil production decline. The study has tested the following three study objectives: to define the concept and origin of oil production decline, to examine factors responsible for oil production decline in block 3 & 7 of South Sudan from 2017-2022 and to appraise solutions to the oil production decline in block 3 & 7 of South Sudan. The study deployed traditional decline analysis theory, which analyzed the decline curve of crude oil production of block 3 & 7 from 2017 to June 2022. The study objectives were subjected through rigorous empirical literature review and the gaps in the literature were filled through field research. During fieldwork, research instruments such as questionnaires and interview guides were used with a target population of 100 people that was later determined via Yamane's formula and ended up with a sample of 80 respondents. The study used SPSS version 21 and Excel (Spreadsheet) for analysis of the field data. The study found systematic and drastic oil production decline of block 3 & 7. From 2017, the average daily production was 131,000 barrels per day (bpd). However, in 2022 the average daily production is 97,267 bpd. The study findings indicate that the causes of oil production are high water cut (produced water), too much sand produced, floods, poor & obsolete technologies and wars & conflicts in block 3 & 7 of Paloch. The study found the solutions to this oil production decline as re- injection of the water to the reservoir, proper reservoir management, laboratory testing for the sand before it accumulates, use of dykes and river Nile dredging for floods prevention, use of modern and relevant technologies and finally maintenance of genuine peace and security across the country. The study recommended the immediate implementation of the solutions to the oil production decline and more importantly carrying out of more

explorations as the current fields are turning brown (old) and there is a need for green fields (new) for optimization and full increase of oil production in block 3 & 7 of South Sudan.

CHAPTER ONE

INTRODUCTION

1.1. General Introduction

Oil production decline has surfaced as a global, regional and national concern. Globally, countries are experiencing production decline. Russia, Venezuela, Saudi Arabia, Iran, Kuwait, United Arab Emirates (UAE), United Kingdom (UK), United Statesof America to mention but a few are struggling to raise their production to peaklevels. At the regional level of continental Africa, crude oil production decline is seen in Nigeria, Algeria, Libya, Angola, Equatorial Guinea and Sudan to mention but a few. At the national level in South Sudan, oil production decline is evident in blocks, 1,2, &4, 5A and 3 & 7. While these oil production declines could be attributed to the global pandemic of Covid-19, these declines had occurred as early as 2017. Production decline refers to the annual reduction in the rate of crude oil production from single field or from a group of fields, particularly, after a peak in production (Hook et al, 2013). These oil production declines could be caused by factors such as the aging of the fields, war & conflicts, sand production, poor reservoir characterization, high water cuts, floods and poor technologies.

1.2. Problem statement

Oil production decline has remained a worry trend for governments, corporate oil organizations, investors and those working in oil and gas industry. With decline of production, then governments' loss revenues, corporate oil organizations loss profits and the staffs working in the oil companies are retrenched. At the block 3 & 7, oil

production drastically declined from 135,000 in 2016 bpd to averaged of 119,309 bpd in 2017-2022 (DPOC Crude Oil Production Report, 2022). The problem is high water cut, sand production, floods, poor technologies and conflicts in the oil fields. Yet, what cause high water cut, sand production, floods, poor technologies and conflicts inblock 3 & 7 is not known and this is the problem. Indeed, this area has been understudied in deeply understanding the factors that cause oil production decline as well as pointing out remedies in preventing or treating oil production decline. While scholars such as Weyler (2020) studied the first decline of oil production, Hossein, et al (2013) noted the effects of sand production in oilfields, Veil, et al (2004) studied the effects of produced water in oil production, Khulud, et al (2013) noted the prediction of reservoir performance, Hook et al, (2013) studied the depletion rates of oil production, Markus (2015) noted the business and politics of oil production,Johnson (2013) studied the international exploration economics & risks and Inkpenand Moffet (2011) explored the management, strategy and financing of oil production,none of the above scholars has studied factors that have led to oil production decline in block 3 & 7 of South Sudan. Inspired by this pedagogical gap, the study is set to fill this gap of knowledge.

1.3. Purpose

The purpose of the study is to investigate factors affecting the oil production decline in block 3 & 7 of South Sudan.

1.4. Objectives

- To define the concept and origin of oil production decline

- To examine factors responsible for oil production decline in block 3 & 7 of South Sudan from 2017-2022.
- To appraise solutions to the oil production decline in block 3 & 7 of South Sudan.

1.5. Research questions

- What is the concept and origin of oil production decline?
- What factors are responsible for oil production decline in block 3 & 7 of South Sudan?
- What solutions can be appraised for oil production decline in block 3 & 7 of South Sudan?

1.6. Content scope of the study

The study covers 2017 to 2022 period and is limited to South Sudan, block 3 & 7 of Paloch Oilfields, Melut County, Upper Nile State in investigating the oil production decline and recommending solutions to the malady. The content scope of the study was chosen given that drastic decline of oil production happened between 2017-2022 in Paloch oilfields of block 3 & 7 and both the Government represented by the Ministry of Petroleum (MOP) and the International Oil Companies (IOCS) representedby Dar Petroleum Operating Company (DPOC) did not investigate this drastic production decline.

1.7. Justification

The study is undertaken on the reason that the Government of South Sudan represented by the Ministry of Petroleum and the partners in the oilfields, particularly, Dar Petroleum Operating Company (DPOC), represented by CNPC, PETRONAS, ONGC, Tri-Ocean and NILEPET have continuously expressing themselves publicly and to further extent, trade blames on the decline of crude oil production without studies and action in block 3 & 7. Neither of the partners has accepted to study this crude oil production decline in Paloch oilfields.

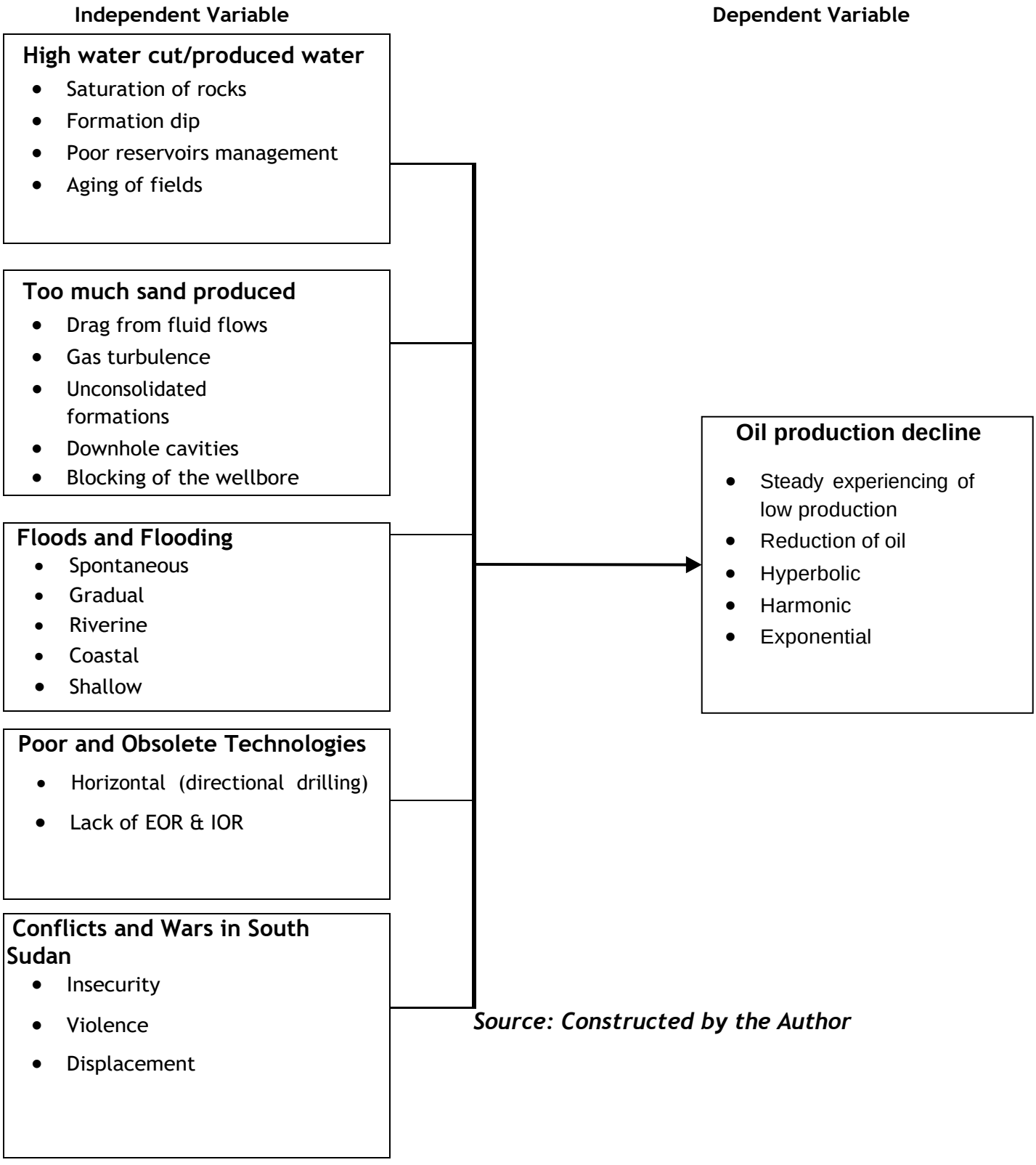
1.8. Significance

The study is very important as it is set to fill the gap of knowledge brought in by the problem of oil production decline in block 3 & 7 of South Sudan. Numerous scholars such as Ngor (2021), Vijonyeh (2017), Rapor (2015) and Khulud, M et al (2013), in oil and gas industry have studied the decline of oil production and argued factors such as high water cut (produced water), sand production, floods, poor technologies, poor reservoir characterization and aging of oilfields as factors responsible for the decline. However, none of these scholars has researched on block 3 & 7 of South Sudan.Decline of oil production in the context of South Sudan is suicidal for the nascent economy as the country relies on oil revenues by 88% to run the state. Studying the factors that have led to the decline of oil production in block 3 & 7 shall help the government to role out a policy to ascertain these factors and more importantly, address this decline. Besides, the study shall assist the oil companies to detect the reasons for decline early and most essentially put resources together to halt this

decline. The study shall be a source of knowledge and empirical literature in the context of South Sudan, particularly; oil and gas field and many academics and researchers shall find it useful to reference.

1.9. Conceptual/Theoretical Framework

1.9.1. Figure1: Conceptual Framework



Source: Constructed by the Author

According to Imenda (2014), a conceptual framework may be defined as an end result of bringing together a number of related concepts to explain or predict a given event, or give a broader understanding of the phenomenon of interest – or simply, of a research problem, objectives and research variables (Imenda, 2014).

The above conceptual framework presents the independent and dependent variables to showcase the relationship between the variables. The independent variables represent factors that cause oil production decline, which include high water cut, too much sand produced, floods, poor & obsolete technologies and wars and conflicts in South Sudan. The dependent variable is production decline, which is explained by the five causes (factors) that are represented by the independent variables. Each variableis explained further. For example, each independent variable is elucidated. Forinstance, high water cut is expounded through saturation of rocks, formation dip, poor reservoirs characterization and aging of fields. Besides, too much sand produced is explained further through dragging from fluid flows, gas turbulence, unconsolidatedformations, downhole cavities and blocking of the wellbore. Moreover, floods are elucidated through spontaneous, gradual, riverine, coastal and shallow flooding. Besides, poor and absolute technologies, is explained through horizontal (directional) drilling and lack of Enhance Oil Recovery (EOR) and Improve Oil Recovery (IOR). Further still, wars and conflicts in South Sudan are elucidated through presence of insecurity, violence and displacement. Finally, the dependent variable, which is oil production decline, is explicated via steady experiencing of low production andreduction of oil. It is further explained through hyperbolic, harmonic and exponential

types of production decline.

1.9.2. Traditional Decline Analysis Theory

The study deploys traditional decline analysis theory. Advanced by J.J. Arps in 1945, the theory argues that all production can be depicted as having an initial transitory flow period trailed by a boundary-dominated flow epoch. During the transitory epoch,the reservoir pressure at the flow boundary stays constant at the initial reservoir pressure and the flow boundary passes outward from the well through the reservoir. This portion of a well's flow is depicted by very high decline rates. When the flow boundary touches an actual reservoir boundary, or meets with a flow boundary of another well, the reservoir pressure commences to decline and the well enters the boundary-dominated flow epoch. It is in this period that traditional decline analysis can be applied. The purpose of traditional decline analysis is to demonstrate the actual decline levels and create a forecast of future production rates to ascertain the possible average production.

Hence, traditional decline analysis theory has depicted through forecast tools how oilfields in block 3 & 7 have experienced oil production decline and forecast on the future to avoid this decline. For instance, in 2017, the average daily production was 131,000 barrels per day that accumulated to 3,930,000 barrels per month then to 47,160,000 barrels for the year 2017. For 2018, the average daily production was 127,000 barrels per day that accumulated to 3,810,000 barrels per month and then to 45,720,000 barrels for the year 2018. For 2019, the average daily production was 125,000 barrels per day that accumulated to 3,750,000 barrels per month then to

45,000,000 barrels for the year 2019. For 2020, the average daily production was 122,000 barrels that accumulated to 3,660,000 barrels per month then 43,920,000 barrels for the year 2020. For 2021, the average daily production was 113,588 barrels that summed up to 3,407,640 barrels per month then to 40,892,000 barrels for the year 2021. For 2022, the year has not ended. So the researcher took the volumes for 6months (January-June). Hence, the average daily production was 97,267 barrels that accumulated to 2,918,010 barrels per month then to 17,508,000 barrels for 6 months for the year 2022. The above dataset was extracted from DPOC summaries of annual crude oil production from 2017-2022 and this dataset supports the traditional decline analysis theory.

Indeed, the above figures systematically demonstrate the decline of crude oil production for block 3 & 7 from 2017 to June 2022. This crystal clearly showcases the oil production decline as explained by traditional decline analysis theory.

CHAPTER TWO

LITERATURE REVIEW

2.1. Introduction

The literature review is based on the specific research objectives and in the context conceptual and of theoretical framework. Oil production decline has remained a topical issue in the world today. From North Africa, Europe, South America, Asia, Oceanic and Africa, oil productions are declining due to various factors. Oil production decline refers to the diminishing or reduction in the quantity of the crude oil produced (Markus, 2015). While production can occur, it has always remained a matter of concern for both the government and the oil companies. Thus, the concept and origin of oil production decline, factors responsible for oil production decline and solutions to the oil production decline should be situated through empirical literature and gaps in the literature should be filled through field research.

2.2. The Concept and Origin of Production Decline

Production decline of oil is a very important concept since it signposts the production outcome of any investment in the hydrocarbons industry. It refers to the steady experiencing of low production of oil in the oilfields (Hook, et al (2013). While the production decline may be systematic, it sometimes occurs abruptly. The etymology of the production decline commenced early as 1800s and later on came to full limelight during second war period in 1940s. This was then attributed to the much destruction that occurred due to the war of superiority known best as the World War II. Europe was very much devastated by the war. That is why a marshall plan was

established and enacted in 1948. This plan, though an American initiative, was meant to recover the economies of Europe by providing foreign aid to Western Europe (Bradford, 1991). Because of the war, production of oil and gas in Northern Africa, Europe and former United Socialist Soviet Republic (USSR) plummeted affecting the entire world.

2.2.1. Types of Production Declines

There are three types of production declines and they are argued as follows:

- **Hyperbolic.** The hyperbolic functions are analogs of the circular function or the trigonometric functions (Rapor, 2015). While the hyperbolic function occurs in the solutions of linear differential equations, calculation of distance and angles in the hyperbolic geometry helps in determining production decline in a reservoir. The hyperbolic production decline indicates a general estimation of production for a specific period such a month, a year as the initial production rate, parameter, and initial decline rates are projected from observed well-levelproduction data.
- **Harmonic.** Harmonic decline is one of three types of production decline in oil or gas production rate in which the nominal decline in production rate per unit of time expressed, is a fraction of the production rate which is proportional to the production rate itself (Weyler, 2020). Unless accumulated, harmonic production decline is always measured in unit of any time series and it is always negligible.
- **Exponential.** This refers to production rate that declines by the samepercentage each time a period is known and it is widely noted as exponential decline (Hook et al, 2013). If the exponential decline rate is 8% per year, it

means that the production rate at the end of the year is 8% less than at the beginning of the year (Weyler, 2020). It can be demonstrated that under conditions such as constant well-back pressure and thinning of wellhead, equation of fluid flow through porous mediums under boundary-dominated reservoir flows are equivalent to exponential decline. However, for the purpose of this study, the empirical nature of this term has a greater significance since it allows the technique to be applied to multiple fluid streams percent ratios.

2.2.2. Decline Rate Analysis

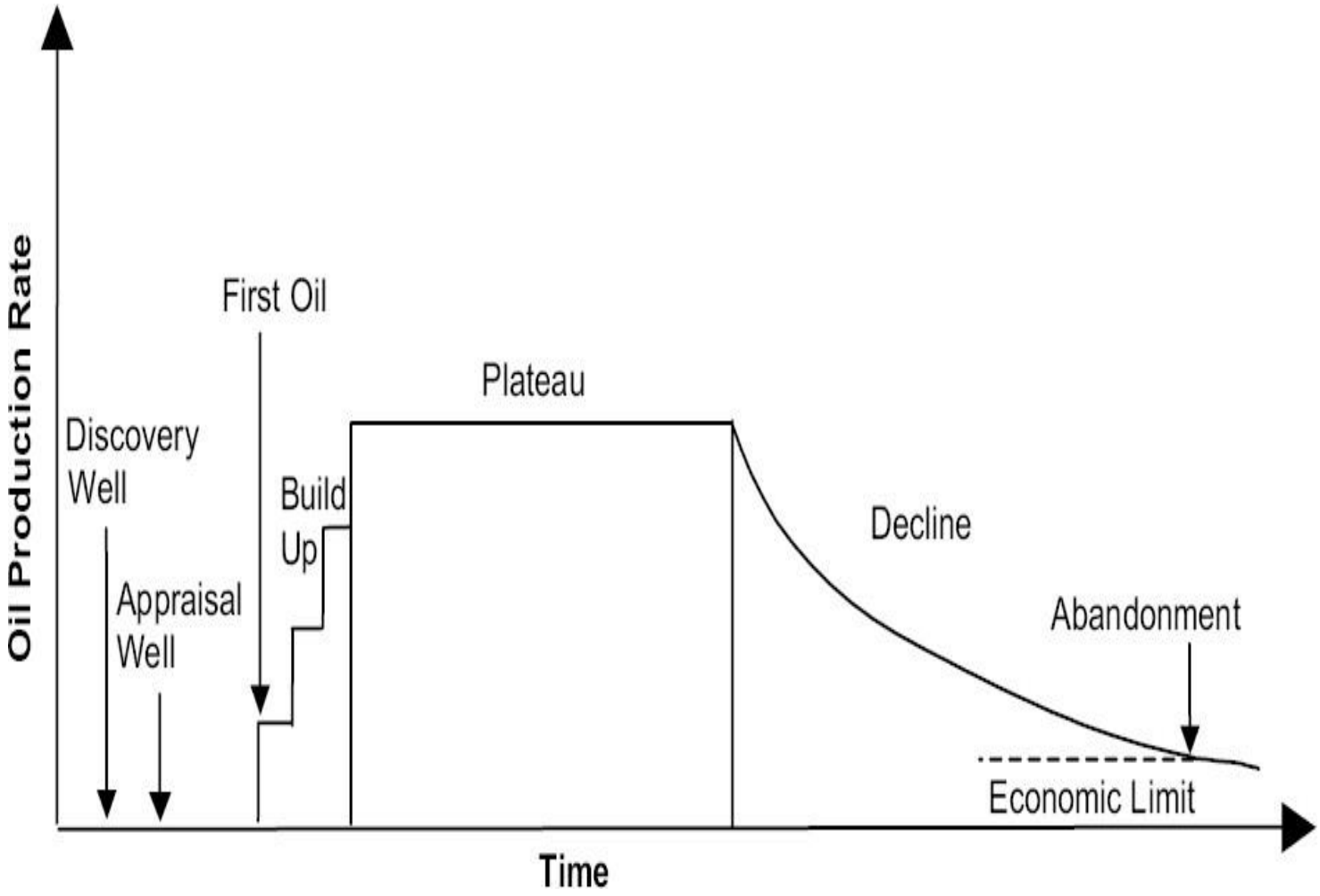
The decline rate refers to the decrease in petroleum production over a period of time (Hook, 2009). In many cases the decline rate is calculated on annual basis, yielding the change in extracted volume of oil produced from one year to another. From a general definition, it should be understood that the decline rate can be positive in some cases, representing a decreasing of production base on natural factors such as high water cut and aging of oilfields or negative in some cases, representing a decreasing production base on man-made factors such as poor management of reservoir and poor and obsolete technologies. Here is its equation:

$$Decline\ rate_{n} = \frac{Production_{n} - Production_{n-1}}{Production_{n-1}}$$

Globally, decline may be caused by socio-economic factors and political factors as well as security factors. These are man-made factors that lead to restrictions on the utilization of a reservoir. It can be caused by natural factors such as depletion of recoverable volumes within a reservoir and the resulting decline in reservoir pressure

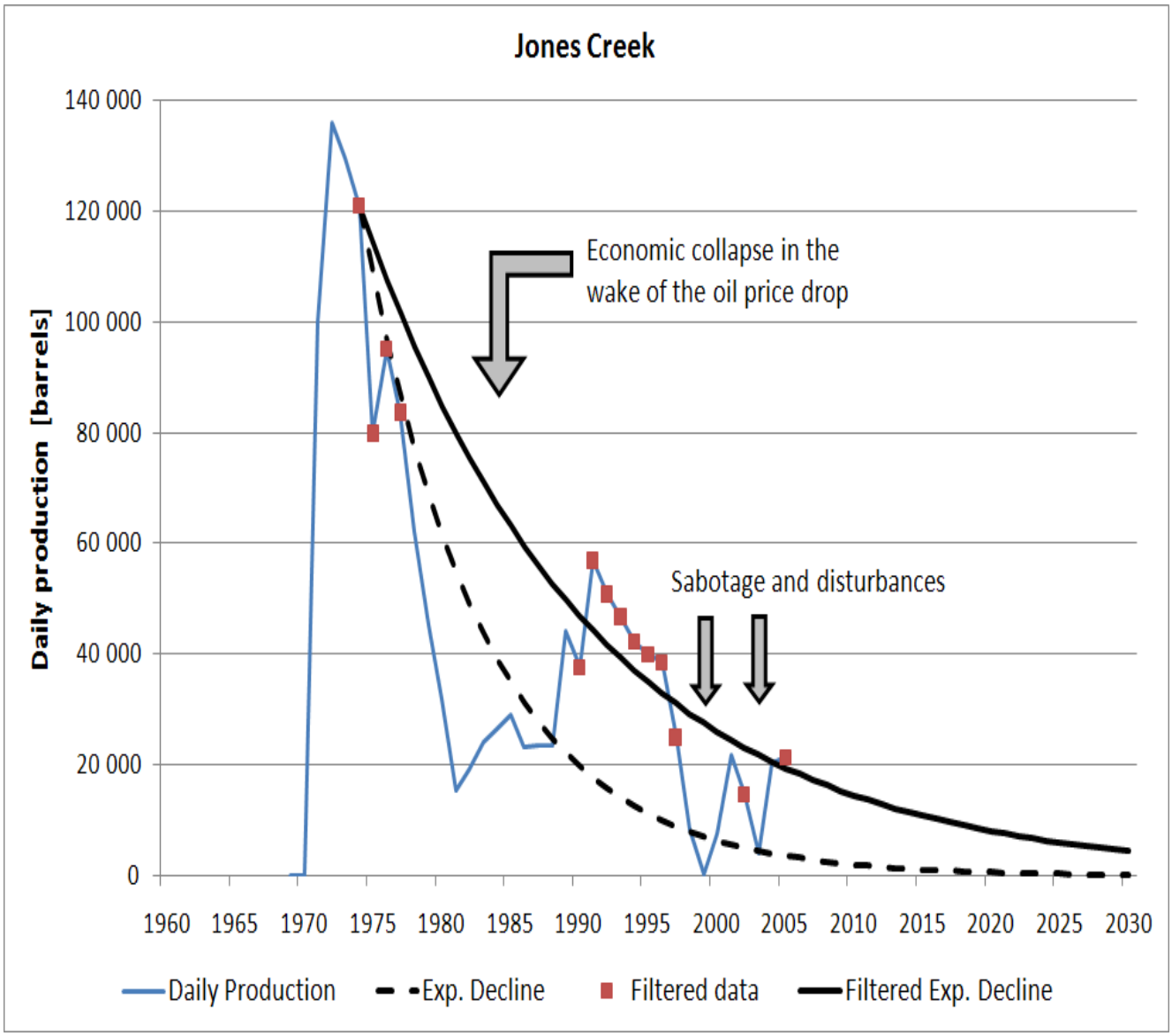
that diminish the flow rates. This can be caused by technical factors such errors during production as well as poor management of reservoir.

Figure 2: Example of Global Oil Production and Decline. Production curve descriptions of various stages of production maturity at any field are demonstrated below.



Source: Robelius (2007)

Figure 3: Example of Global Oil Production Decline in Nigeria. Jones Creek, a giant oilfield in Sub-Saharan Africa, demonstrates several production disruptions caused by the economic collapse of the Nigerian economy in the wake of the oil price drop in the 1980s along with rebels' sabotages.



Source: Hook (2009)

2.3. Factors Responsible for Oil Production Decline in Block 3 & 7

Several factors such as high water cut, sand production, floods, poor reservoir performance, poor technologies and wars and conflicts are responsible for oil production decline.

2.3.1. High Water Cut (Produced Water)

High water cut or produced water is a serious matter that has led to the decline in oil production. Produced water is water trapped in underground formations that is brought to the surface along with oil or gas. It is by far the largest volume byproduct or waste stream associated with oil and gas production. It is worthwhile recalling, in subsurface formations; naturally occurring rocks are generally permeated with fluids such as water, oil, or gas (or some combination of these fluids) (Veil et al, 2004). It is believed that the rock in most oil-bearing formations is completely saturated with water prior to the invasion and trapping of petroleum (Amyx et al. 1960).

According to Veil et al, (2004) that produced water or high water cut results from too much water being produced from the reservoirs (Veil et al, 2004). The production of too much water could emanate either from the aging of the fields or from poor reservoir characterization. Also when petrophysical tools such as loggings and casings of the reservoirs to diagnose the waters are not utilized well, then high water cut can occur spontaneously (Hook, 2009). During the drilling time, reservoir beds should be prepared in away that they suck and separate oil from water underneath and allow oilto float to ensure that it is easily pumped to the field service facility (FSF) (Hook et

al, 2013). The high water cut in block 3 & 7 in Paloch stands between 70-90 percent, making it the highest in the world (Pitia, 2022).

2.3.2. Sand Production

Sand production is one of the hurdles that have continued to lead to oil and gas production decline. Sand production is too severe and it reduces oil production levels and more importantly production of associated gases. Too much sand production blocks the reservoir waves and prevent the flow of oil into the surface to oil gathering manifold, field service facility (FSF), wells and field processing facility (FPF) (Zoback and Mastin, 1985). Besides, Rapor (2015) confirms that sand production can be detrimental if it keeps building in the reservoirs as it can lead to the blockage and possible explosion of the reservoirs due to pressures (Rapor, 2015). Hossein et al, (2013) emphasizes:

> Sand production in oil and gas wells can occur if fluid flow exceeds a certain threshold governed by factors such as consistency of the reservoir rock, stress state and the type of completion used around the well. The amount of solids can be less than a few grams per cubic meter of reservoir fluid, posing only minor problems, or a substantial amount over a short period of time, resulting in erosion and in some cases filling and blocking of the wellbore (Hossein et al, 2013).

However, Rapor (2015) argues that sand production can completely block the flow of the fluid in the reservoir beds and no any fluid (oil, gases and produced waters) can flow (Rapor, 2015). This is when the sand production has filled up and accumulated in large quantities. While sand production can occurs slowly in blocking the reservoir waves, it can surprisingly fill up in huge quantities

hindering oil production (Carlson et al, 1992).

2.3.2.1. Causes of Sand Production

Morita and Boyd (1991) provide an interesting analysis on sand formations. They argue that in totally unconsolidated formations, sand production may be triggered during the first flow of formation fluid due to drag from the fluid or gas turbulence (Morita and Boyd, 1991). This detaches sand grains and carries them into zones of some of the wells and hence this blocks the flow of the fluid. Down-hole wire line log measurements provide continuous profiles of sand data. However, no logging tool yields a direct measurement of rock strength or in-situ stress (Stein, 1998). This has given rise to interpretation techniques that combine direct measurements with sonic and density logs to derive the elastic properties of rock and predict from these the sanding potential (Santarelli et al, 1991).

Although no logging tool can accurately determine a direct measurement of the strength of the sand, potential sand prediction can be done. At its simplest, sand prediction involves observing the performance of nearby offset wells. In exploratory wells, a sand flow test is often used to assess the formation stability. Deruyck et al (1992) argues that a sand flow test involves sand production being detected and measured on surface during a drill stem test (Deruyck et al, 1992). While the quantitative information may be acquired by gradually increasing flow rate until sand is produced, the anticipated flow capacity of the completion is reached or themaximum drawdown is achieved. A correlation may then be established between sandproduction, well data, and field and operational parameters (Morita and Boyd, 1991).

Deruyck et al, (1992) stresses:

> Accurately predicting sand production potential requires detailed knowledge of the formation's mechanical strength, the in-situ earth stress and the way the rock will fail. Laboratory measurements on recovered cores may be used to gather rock strength data. Field techniques like microfracturing allow measurement of some far-field earth underneath formation (Deruyck et al, 1992).

Sand production results to several damages and drawbacks such as surface and down hole equipment erosion, wellbore damage, equipment failure and small maintenance free periods (Vijouyeh, et al, (2017). Obstruction of valves is a typical occurrence in the form of erosive damage for oil and gas explorers especially companies producing from unconsolidated formations.

2.3.3. Floods and Flooding

Floods and flooding are important cause of oil production decline. They are the most common and widespread natural severe weather events. Floods can look very different because flooding covers anything from a few inches of water to several feet. They can also occur quickly or build up gradually. Wabala (2020) defines floods as parts of the earth's natural hydrologic cycle (Wabala, 2020). Floods are occurrence that affected oilfields, reducing the oil production around the world. There are three types of flooding as follows:

- **Riverine flooding:** These are types of flooding that occur as part of overflowing of river. This mostly occurs due to the lack of dredging or cleaning of the river or when the water levels increase spontaneously (Kaboka, 2019).

- **Coastal flooding:** These are types of flooding that occur when the coastal part of the country overflow with water. This type of flooding is difficulty to be noticed as it happens swiftly (Wabala, 2020).
- **Shallow flooding:** These are types of flooding that occur in small scale. They are shallow because they come with little water. Although they negatively affect the household, their effects are not quite devastating (Kaboka, 2019).

A study by the International Flood Initiative (2003) suggests that floods are the most taxing of water related natural disasters to humans, material assets as well as to cultural and ecological resources affecting people and their livelihoods and claiming thousands of lives annually worldwide (IFI, 2003). In the Eastern Africa region, floods have been usual occurrences. From 2015-2022, Eastern Africa countries that include Ethiopia, Eritrea, Sudan, Kenya, Uganda, Tanzania, Rwanda, Burundi, Djibouti and Somalia have experienced devastating floods. Although they have not occurred systematically for the last seven years, they have flip-poppidly occurred and the outcomes have been quite catastrophic (Mwape, 2009).

Floods have severely occurred in South Sudan with huge destructions. The peak of these floods was in February 2021 until the time of writing of this dissertation. All theoilfields in South Sudan in the three blocks: 1,2 & 4, 5A and 3 & 7 were submerged with waters. While floods affected all these blocks, block 3 & 7 in Paloch area was more devastatingly affected. Ngor (2021) emphatically argues that 240 oil wells were submerged in floodwaters in Paloch where block 3 & 7 oilfields are situated between 2020-2021 (Ngor, 2021). While 240 oil wells are flooded, 360 oil wells continued with

production amidst floods threat. From 2020 and 2021 floods, most of the Paloch area was submerged under water. Block 1,2 & 4 in Bentiu was flooded in February-April 2022 but currently the waters have receded. This is also similar to block 5A in Tharjahthat was severely flooded with 1.1 meters raised water levels (Lado, 2022). Although the Tharjah floods receded, the damage on the oil facilities was surmountable. It is critical to argue that the oil production levels were between 130,000 to 135,000 bpd before the floods in block 3 & 7 in 2020. However, due to the continuous flooding, about 200 oil wells have been shutdown bringing the production levels to around 119,000 bpd (Ngor, 2021).

2.3.4. Poor and Obsolete Technologies

Poor technologies are responsible for oil production decline. Internationally, countries have resorted into horizontal drilling (directional) instead of vertical (non-directional) drilling (Johnson, 2003). Studies such as enhance oil recovery (EOR) and improve oil recovery (IOR) are critical for increasing oil production (Ibid). In South Sudan, oil companies are using vertical (non-directional) drilling for oil production, which has not improved the production so far (Deng, 2019). Lual Achuek (2022) argues that South Sudanese government should replace the Chinese technologies as these are obsoletes in increasing production in block 3 & 7 (Achuek, 2022). He emphasizes:

> Remove the inferior Chinese technology from our oilfields. I am sorry to say that. I am not longer a diplomat but currently a researcher. Yes, I am a former Minister of Petroleum in the defunct Sudan. I know what technology means. Bring American technology and we will increase the oil production immediately and make this oil production decline a story. With great technology, we will be able to produce 500,000 bpd or half a

> million barrels per day and let assume the oil prices will be $100 per barrel by the end of the second decade of our independence. We will be getting more than $50 million per day that translate to $18 billion per a year, clean oil money (Achuek, 2022).

However, Lual Achuek forgot that the United States of America has sanctioned over fifteen oil and gas entities in South Sudan including Ministry of Petroleum and thus it is technically impossible for Americans to accept to bring their technologies to South Sudan, a country their government has sanctioned the industry for over three years now. Individual American technological companies cannot supply their products to South Sudan because the United States government has sanctioned the country.Unless, United States government lifts the sanction, Americans technologies will not be in South Sudanese oilfields.

To be certain, enormous resources are required to be earmarked for modern technologies that increase oil production, particularly, in post conflicts countries such as South Sudan. Oil and gas production is going through rapid technological revolution now called Fourth Industrial Revolution (4^{th}IR). This is shaping aspect of our lives from cloud, computing, mobile connectivity, artificial intelligence such as robot and big data analytics, such as real time data (Swine, 2021).

2.3.5. Conflicts and Wars in South Sudan

As if scientific decline is not enough, conflicts have continued to cause oil production decline. Conflicts breed insecurity and fears that lead to the displacement of the

people, including oil contractors (Moro, 2008). When oil contractors left the oilfields in South Sudan, production automatically declined, as many wells were not operating.

The December 2013 and July 2016 civil wars between Sudan Peoples Liberation Movement/Army In Opposition (SPLM/A-IO) and Sudan Peoples' Liberation Movement/Army-In Government (SPLM/A-IG) led to the loss of lives and property. It is estimated over 500,000 people were killed and dozens of property destroyed (Lama, 2018). The wars that begun as a democratic cruelty within the SPLM about the party elections led to President Salva Kiir stifling the freedom of the louder members of the party (Riak, 2021). This led to tension and on the 15th December 2013, serious guns shoots were heard from 9pm in Juba and the fighting spread to the whole country. The following morning, President Salva Kiir, dressed in military fatigue declared a foiled coup de tat against himself by Dr. Riek Machar whom he earlier relieved as the Vice President. Fightings engulfed the country until the signing of Agreement on the Resolution of the Conflict in the Republic of South Sudan (A-RCSS) on August 2015 mediated by Intergovernmental Authority on Development (IGAD). This agreement put Dr. Riek Machar as the 1st Vice President of the Republic of South Sudan. In less than a year, the A-RCSS collapsed due to lack of implementation of the chapter two of the agreement-the transitional security arrangement. To be exact, on the 8th July 2016, gun-violence erupted amongst the bodyguards of Dr. Riek Machar and President Salva Kiir and later spread across Juba leading to over 100 people dead (Riak, 2021). This second war was also halted by IGAD through a mediated deal known as Revitalized Agreement of the Resolution of the Conflict in the Republic of South Sudan (R-ARCSS)

returning Dr. Riek back as the 1st Vice President with other four Vice Presidents in charge of different clusters.

On the two wars, the oilfields were deserted as SPLM/A-IO soldiers were advancing to capture the oilfields. Block 5A and block 1,2 & 4 were captured by the SPLM/A-IO and destroyed. The remaining block 3 & 7, which is the majorly producing block, was highly protected with enough army to push back the rebels. As the rebels advanced, the SPLM/A-IG used all its military might and resources and the block was rescued from the advancing tribal marauding white army (Jiech Mabor). Although the rebels captured the barge that was carrying logistics for the SPLM/A and en-routed tocapture Paloch (block 3 & 7) in thirty minutes time, the government repulsed, hotly pursued the rebels, smoked them out and destructed their capabilities. While Paloch was maintained, the oil workers could not returned to increase the production. About 200 wells were shut down from March 2014-2017 due to insecurity and fears around block 3 & 7 (Marila, 2018). This drastically led to oil and gas production declined.With some spread violence between 2019 and 2020, several oil wells were shut down, particularly, disposal wells, which affected the storage of produced water.

2.4. Solutions to the Oil Production Decline in Block 3 & 7 of South Sudan

2.4.1. Reducing High Water Cut/ Produced Water through Re-injection of Water

One of the ways of reducing high water cut/produced water during production is through the re-injection of the water to the reservoirs (Stephenson, 1992). This helps in lessening too much water that is, a mixture of oil and other waste materials (Ibid). Water is re-injected for reservoir pressure maintenance and for reduction of the

produced water at the field processing facilities as well as at central processing facility. The other way is through studies of the reservoir characterization. This should be done through enhance oil recovery (EOR) and improve oil recovery (IOR). These two studies are quite pertinent in oil and gas industry as they are key in reducing high water cut/produced waters. Once the studies have demonstrated the problem of produced water is in the reservoirs then the solutions of checking the reservoirs beds became very important (Caudle, 2008).

Besides, treating and discharging these waters is another important solution. This treatment and discharge can be done through bioremediation that assists in the separation of dirt, microorganisms and the clean water (Favret et al, 1999). Bioremediation is a holistic treatment of industrial waste materials/waters. Recycling of these waste materials/waters has been quite successful, particularly, in German and the Netherlands. China has joined in the successful control of high water cut/produced waters via bioremediation. While the clean water can be used for domestic purposes, the dirty water is treated in a pool area protected from people and animals due to pollution (Dine, 1998). Although bioremediation can be quite effective, the quality management process in bioremediation should not be compromised (Frankiewicz, 2001).

2.4.2. Cleaning of Reservoir from Sand Production

A number of approaches have been developed to predict or help to understand the sand production problem using physical model testing, analytical and empirical

relationships including numerical models (Rapor, 2015). Routine laboratory tests can only predict the onset of sand production (Carlson et al, 1992). More sophisticated physical models could predict volumetric sand production. They are also time-consuming and expensive. In addition, because of the small sizes of the laboratory setup, boundary effects usually nuance the results (Vijonyeh et al, 2017). Analytical models are fast and easy to use but they are only suitable to predict the onset of sand production and they have limitations. Most of them are only valid for capturing a single mechanism of sanding and under implied geometrical and boundary conditions, which are not usually the case in complicated field-scale problems (Hossein et al, 2013). Numerical models are by far the most powerful tools for predicting sand production. They can be combined with analytical correlations to obtain the results more efficiently (Stein, 1988). Experimental results are also utilized to calibrate or validate a numerical model. Yet, numerical models have their own limitations and extensive efforts have been made to improve them (Santarelli et al, 1991).

Modeling of sand production requires coupling of two mechanisms. The first mechanism is mechanical instability and degradation around the wellbore and the second one is hydromechanical instability due to flow-induced pressure gradient on degraded material surrounding the cavity (e.g., perforation and open hole) (Moritaand Boyd, 1991). In general, numerical methods in the mechanical modeling are categorized under continuum and discontinuum approaches.

2.4.3. Use of Dykes and River Dredging to Control Floods

Use of strong dykes is the most important solution to the floods in the world (Waweru, 2022). While dykes may come in different shapes and forms, strong concrete dykes are quite useful. But depending on the topography and gradient of the area, for example, the lower the area, the difficult in having successful dykes, as these dykes can be over flooded easily by the water.

On the other hand, river dredging is critical for flood prevention as the dredging cleans out the wastes and debris in the rivers to allow faster flows of water. Thus, avoiding restriction of water flows. While this is done worldwide, it is critical for South Sudan floods, particularly, the Nile River flooding. Dredging should begin from Kenya and Uganda side, which is a source of river Nile from the upstream section. Although it is being contested and it has not been agreed on where dredging should first begin, it is proper that it begins from Lake Victoria through river Nile in Entebbe and then to South Sudan (Lado, 2022). However, the independent firm that understands the merits and demerits of dredging of the Nile River should conduct scientific studies such as Environmental Social Impact Assessment (ESIA), geotechnicaland hydrology studies.

The South Sudanese Government is already engaging United Nations World Food Programme (UN-WFP) to construct permanent dykes at the floods hotspots such as Jonglei and Upper Nile states. While at the Upper Nile, particularly, Paloch where block 3 & 7 is located, dykes constructions are critical along Sudd wetlands and a long

river Nile banks to prevent the overflowing of water (Waweru, 2022). The Government of South Sudan is engaging the Arab Republic of Egypt to undertake River Niledredging as soon as possible. Interestingly, the Egyptian government has already brought in the dredging equipment to river Bahr el Naam in Bentiu and the government of unity state had wanted to precede with the dredging. However, the public cried out about executing this enormous life and environmental impact project without feasibility studies and Environmental Social Impact Assessment (ESIA) led to the halting of this dredging by President Salva Kiir Mayardit.

With that public outcry, the national government decided to keep the dredging of river Bahr el Naam on hold waiting international, regional and national experts to do the studies first. Once feasibility studies of this project have been completed to cover the entire river Nile and its tributaries then the commencement of the actual work of dredging shall begin during the dry season (January-March 2023) and will continue for two years (Mathiang, 2022). Although dredging of river Nile has been prioritized by the Government, the citizens continue to feel that it will affect the Sudd wetlands that are vital for aquatic animals and cattle. New studies are being proposed by the citizens and water experts in seeing into it so that dredging project doesn't affect theSudd wetlands (toic), which is a livelihood of the local population in the greaterUpper Nile region (Elkhazin, 2022). Sudd Wetlands is a proposed world heritage site bythe United Nations Scientific and Cultural Organizations (UNESCO).

Nonetheless, dredging has critical benefits that include lessening of flood risks,enabling people to return to original homes after their displacements and to resume their normal livelihood activities, promotion of navigation of the barges, and subsequent promotion of trade and movement of goods and services through the Nile river, including ferrying of petroleum products and other commodities from Unitystate in South Sudan to the market in Sudan which is quite directly beneficial to SouthSudanese people and the government (Tiitmamer, 2022).

2.4.4. New and Relevant Technologies

In providing solutions to the oil production decline, new and relevant technologies are critical as oil and gas industry is technologically driven. New and relevant big data analytics provide complex and real time insights about oil and gas. For example, data analytics is used to improve carbon dioxide sequestration, carryout data modeling for reservoir management and forecast production performance (Gochi, 2018). Besides, Industrial Internet of Things (IIOT) is an important technology that is useful in oil and gas industry. It is defined as a system of interrelated computing devices, machines and people, where data and equipment communicates. For example, in oil and gas, IIOT sensors can be used to gather data and provide instant insights and solutions during exploration, development, drilling and production (Derek, 2020). Finally, Augmented Reality/Virtual Reality (AR/UR) is a solution technology for oil and gas industry. Augmented Reality (AR) creates real-world settings, while Virtual Reality (UR) immerse the viewer in a virtual setting in showcasing the performance ofgeological rocks and reservoirs. Both technologies are used in oil and gas to train technicians to test complex geoscience and reservoir tasks before implementing them

(Gochi, 2018). For the block 3 & 7 to experience oil increase, new explorations should be commissioned and the latest technologies should be applied. Indeed, sophisticated and relevant technologies can be used to evaluate the entire value-chain of oil and gas industry: downstream, midstream and upstream to ascertain the best technologically driven value-chain (Campbell, 1960).

2.4.5. Maintaining Genuine Peace Across the Country

It is quite evident that production of oil will improve when South Sudan is at the mode of relative peace. As it is argued earlier that violence begets violence and discourages the investments. A lot of efforts are required from the parties to the agreement to see into it the truce is systematically and timely implemented. These parties include SPLM-IG, SPLM-IO, FD, SSOA and OPP that have signed the August 2018 peace deal. In addition and more importantly is the commitment of the parties' leaders of the peace accord. As it has been widely argued that South Sudanese leaders sign peace deals but don't implement their provisions. Hence, these leaders are viewed to be suffering from signing syndrome disease (Tekle, 2008). The implementation of revitalized peacedeal known, as Revitalized Agreement on the Resolution of the Conflict in the Republic of South Sudan (R-ARCSS) is quite critical for shoring up oil and gas production and most importantly in encouraging the investors to invest in the nascent country (Doane, 2019). Some provisions in the R-ARCSS such the conduct of the elections at the end of the transition period in February 2023 have been postponed in August 2022. This therefore means the transition period shall end in February 2025not in February 2023 as stipulates in the agreement.

Before the conflict broke out on 15th December 2013, an International Conference for Investment was held in Juba, South Sudan on the 5th-8th December 2013 that attracted over 600 investors in critical sectors such as agriculture, infrastructure, energy (electricity) and petroleum amongst others. Majority of the companies from oil and gas industry immediately registered and established their satellite offices in Juba in order to invest in any of the division value-chain (downstream, midstream and upstream). While investors were interested in the entire value-chain of oil and gas sector, they heavily desired to invest in the upstream. Thus, 70% of the international oil investors showcased their interests in investing in the oil and gas industry (Mun, 2014). However, 'the hell broke loose' and the political conflict and violence engulfed the country, thus sending away the potential investors.

While the hydrocarbon resources require any stability for their enhancement, investors' confident is embedded in sustainable peaceful environments (Riak, 2021).

2.5. Gaps in the literature, which can be filled through, field research

From the above reviewed literature, gaps of knowledge can be identified as follows:

- **The concept of oil production decline.** This needs to be probed through the fieldwork both at Juba and at Paloch to deeply understand its context.
- **High water cut/produced water.** The literature review fell short of discussing this in the context of South Sudan. Fieldwork shall be conducted to understand the effects of high water cut/produced water in the context of block 3 & 7 of South Sudan and the possible solutions.

- **Sand Production.** There is dearth of empirical literature on sand production and its solution in the context of South Sudan. Thus, fieldwork shall further interrogate negative impact of sand production and its solution for the block 3 & 7.
- **Floods in oilfields.** Although the empirical literature discusses negative effects of floods in the context of South Sudan and their solutions, floods in the context of Paloch (block 3 & 7) was not reviewed by the literature due to lack of empirical literature in this area. Thus, fieldwork shall be conducted in Paloch to deeply understand the effects of floods and the practical solution to it.
- **Poor and Obsolete Technologies.** The literature reviewed poor and obsolete technologies: their absence and their necessity in increasing the oil production in South Sudan. However, the literature review fell short of understanding the current technologies being used at block 3 & 7, their negative impacts and the solutions required. This gap will be filled through field research.
- **Wars and Conflicts in South Sudan:** Although the literature showcased the negative impact of wars and conflicts in South Sudan on the oil production decline, the literature fell short to demonstrate how these wars were quite devastating in lowering the oil production in block 3 & 7. Moreover, the implementation of R-ARCSS as the solution of preventing the wars and conflicts fell short on what would happen if R-ARCSS collapses like when ARCSS collapsed in July 2016. This gap shall be filled through field research.

CHAPTER THREE

RESEARCH METHODOLOGY

The study has deployed a robust methodology for data collection and analysis. Methodology is glue that holds all elements in a research project together (Kombo and Tromp, 2006). The methodology is discussed as below:

3.1. Research Design

Research design encompasses qualitative, quantitative or mixed method in a research dissertation (Kombo and Tromp, 2006). The study used both qualitative and quantitative research designs. Paloch Area of Melut County was a case study and ethnographic method was applied to detail the understanding of the depth of the oil production decline, factors that may have caused it and solutions to the decline. Qualitative design was used during surveys and quantitative design was used in form of descriptive research, data acquisition and in the presentation and analysis of the data.

3.2. Area of Study

The study was conducted at Paloch, Melut County of Upper Nile State. Paloch is situated at the northern part of South Sudan and it is the place where block 3 & 7 is located. This is where the oil production has experienced drastic decline from 2017- 2022 without studies to understand this decline. This is where a few surveys were carried out to understand the causes of oil production decline and the appropriate solutions to this decline. Besides, major surveys were carried out in Dar Petroleum

Operating company (DPOC), focusing on staffs from petroleum engineering, reservoir engineering and production departments and the Ministry of Petroleum senior staffs in Juba in comprehending the oil production decline.

3.3. Sources of Information

The study deployed both primary and secondary sources of data. Primary data was acquired through surveys and interviews. Secondary source of data was acquired through content analysis of empirical literatures, reports, periodicals and dataset from Dar Petroleum Operating Company (DPOC).

3.4. Population and Sampling Techniques

The study focused on the selected population in Juba and Paloch and drew a sample. Sampling is a finite part of a statistical population whose properties are studied to gain information about the people (Orodho and Kombo, 2002). According to Kombo and Tromp (2006), target population refers to a group of individuals, objects or items from which samples are taken for measurement (Kombo and Tromp, 2006). The target population was 100 respondents on the reason that the study is technical and required only specialists in oil and gas industry.

3.4.1. Determination of Study Sample

Table 1: Target Population

Category	**Population**
Juba DPOC and MOP Senior Staff	60
Paloch (Block 3 & 7) DPOC Engineers	40
Total	**100**

3.4.2. Sampling Technique and Sample Types

The sample size determination of this dissertation is derived from a formula designed by Taro Yamane (1967) with 95% level of confidence and when the size of the target population is known (Yamane, 1967). The size (n) is determined based on the below formula:

$$n = \frac{N}{1 + (e)^2}$$

Where N= population size, e=level of precision (0.05), n= sample size

$$n = \frac{100}{1 + 100(0.05^{2)}}$$

$$n = \frac{100}{1 + 100(0.0025)}$$

$$n = \frac{100}{1 + 0.25}$$

$$n = \frac{100}{1.25} = \underline{80}$$

Table 2: Sample Size

Category	Population	Sample
Juba DPOC and MOP Senior Staff	60	50
Paloch (Block 3 & 7) Engineers	40	30
Total	**100**	**80**

Sampling types include cluster and snowball. Given that this is a specialized study with limited knowledge to the South Sudanese population, random or purposive samplings were not applied. Snowball sampling, depicting those with knowledge on oil production decline in block 3 & 7 in South Sudan combined with cluster sampling were applied in both Juba and Paloch oilfields. Thus, snowball and cluster sampling were thoroughly applied in this study.

3.5. Variables Definitions and Measurements

Various variables such as dependent variable: *Understanding the oil production* and independent variables such as *high water cut/produced water, sand production,floods & flooding, poor technologies and wars/conflicts in South Sudan* were defined and measured. Other variables such as intervening (moderating) and dichotomouswere clearly defined and measured during the study. Indeed, the variables were measured through nominal scale that specifies the importance and utility of each variable. Moreover, these variables were further measured through pilot study.

3.6. Procedure for Data Collection

A letter of permission to collect the data was obtained from Institute of Petroleum Studies, Kampala (IPSK) of Uganda Christian University (UCU). Another letter was obtained from the Ministry of Petroleum (MOP) to enable the researcher to access the oilfields of Paloch and interview the engineers in block 3 & 7 as well as acquire production data from 2017-2022 from Dar Petroleum Operating Company (DPOC). The researcher then liaised with the administration of DPOC both in Juba and Paloch and engaged the staff and other people with knowledge in oil production decline.

3.7. Data Collection Instruments

The study deployed data collection instruments such as questionnaires and interview guides/schedules to collect the data on oil production decline in Juba and Paloch. Questionnaires and interview guides/schedules were first designed and piloted with experts in DPOC petroleum engineering department, reservoir engineering department and production department to ensure that information being sourced is ascrystal clear as possible. Surveys via questionnaires and interview guides were conducted to deeply understand in detail the oil production decline in block 3 & 7 of South Sudan. The study acquired production data from DPOC from 2017-2022.

3.8. Piloting the study

Pilot study refers to small-scale study, which is conducted before the actual study (Malmqvist, et al, 2019). It is a trial run of the actual study.

The study was piloted to achieve the following:

- To understand the entire process of the research (research problem, research objectives, research questions, empirical literature, research design and the respondents). This shall helped in clarifying issues before larger study;
- To understand the quality control of data collection tools. For instance, it was great checking questionnaires and interview guides if they were properly structured, clearly written and completed; and
- To help in proposing the data analytical tools such as Excel and SPSS.

Hence, this study was piloted by 10% of the sample size (80), which were 8 respondents in DPOC to clearly understand the entire research and make corrections before the larger study. This served time, money and energy. For instance, *questions 3, 14* and *16* in the questionnaire were timely modified to make clear sense to the respondents' base on piloting done.

3.9. Quality/Error Control

The study ensured that quality is observed and errors during the collection of data were avoided. Reliability and validity mechanisms of data collection were deployed toensure that the 80 respondents surveyed were reached on time and the information was recorded. The production data that was acquired from DPOC was double-checked to ensure that it has not errors but a complete dataset for 2017-2022.

3.9.1. Data Processing and Analysis

The study used simple and easy understandable data processing and analysis tools such as SPSS version 21 and Microsoft excel to interpret and present the data. SPSS version 21 and Microsoft excel were chosen because they are convenient to use and

have great functions to analyze different variables appropriately. Cleaning up of the data was done first and later the analysis was presented in the context of research questions and literature review. Explanations were recorded.

3.9.2. Ethical Considerations

The study ensured that ethical considerations were observed. Ethical considerations include the issues of confidentiality, consent, assent, anonymity, integrity and benevolence during the research process. All respondents surveyed and interviewed were kept confidential. There were no any ethical challenges encountered during the entire research process.

3.9.3. Anticipated methodological constraints

It is important to note that methodological constraints were not experienced during the data collection both in Juba and in Paloch. Instruments of data collection such as questionnaires and interview guides were not affected by low levels of literacy in South Sudan and more importantly, sparse knowledge in oil production in the nascent State was not experienced. This is because the study targeted the industry officials only who had wealth of knowledge and experience. Misperceptions about the study to be a threat to South Sudan national security since it is external in nature did not surface as a restriction. A lot of senior staff in oil and gas industry in South Sudan responded well to the study. It is essential to note that the United States of America has sanctioned South Sudan oil and gas industry on the allegation that it has participated in 2013 and 2016 wars and conflicts in South Sudan. This has raised red flag amount the intelligence community in South Sudan on studies being conducted so

that they are not externally sponsored. Moreover, questionnaires and interviewstimings though not sufficient, didn't affect the findings of the study. Hence, study findings are the cornerstones of any study and they can be enhanced by all cost.

CHAPTER FOUR

DATA ANALYSIS, PRESENTATION AND INTERPRETATION OF FINDINGS

4.1. Introduction

This chapter analyzes, presents and interprets the findings within the context of problem statement, research objectives, literature review, conceptual, and theoretical frameworks. Data presentation refers to examining what has been collected in a survey or experiment and making deductions and inferences. It involves uncovering underlying structures, extracting important variables, detecting any anomalies and testing any underlying assumptions (Kombo and Tromp, 2006). Itinvolves scrutinizing the acquired information and making inferences. Kombo & Trompfurther note that the presentation of data refers to ways of arranging data to make it clearly understood (Ibid).

The chapter moreover ensures the scientific analysis, presentation and interpretation of data and this consequently helped in the comprehension of the results of the research study.

4.2. Characteristics of the target population and sample (respondents)

The respondents interviewed by the researcher comprised of both male and female who are graduates and professionals in oil and gas industry working in South Sudan. The respondents are South Sudanese as well as non-South Sudanese who are adultsand above 18 years old. These professionals work in DPOC in Juba, MOP in Juba and DPOC engineers in block 3 & 7 in Paloch as specialists in oil and gas industry. The

researcher targeted population of 100 respondents but ended with determination of sample of 80 respondents using Taro Yamane's (1967) formula. Guided by the research objectives, responses of people interviewed are analyzed in the form of tables, bar charts, pie charts and histogram.

4.3. The Concept and Origin of Oil Production Decline

Table 3: The Origin of Oil Production Decline

Categories		Frequency	Percent
Valid	No	8	10.0
	Yes	72	90.0
	Total	**80**	**100.0**

Source: Fieldwork

As shown in table 3 and when asked about the origin of oil production decline, 72 respondents, representing 90 percent noted with yes, the origin of oil production decline. This 90 percent respondents said that the concept originated in the USA around 1860s given that the discovery of oil in 1859 in the state of Pennsylvania.While some respondents associate the concept to China in 1850s, they also associate the concept with Scotland in 1840s. However, 8 respondents, representing 10 percent don't know the concept and origin of oil production decline as they left the spaces blank.

Table 4: Meaning of Oil Production Decline

	Category	Frequency	Percent
valid	Steady increasing of production rate of a given oilfield	1	1.3
	Steady reduction of production rate of a given oilfield	70	87.4
	Removing the rigs from the oil fields	1	1.3
	Production of waxy crude oil	8	10.0
	Total	**80**	**100.0**

Source: Fieldwork

From table 4 in understanding the meaning of oil production decline, 70 respondents, representing 88 percent define oil production decline as 'steady reduction of production rate of a given oilfield'. On the other hand, 8 respondents, representing 10 percent define oil production decline as 'production of waxy crude oil'. Besides, 1 respondent, representing 1 percent defines oil production decline as 'steady increasing of production rate of a given oilfield'. Finally, 1 respondent, representing 1percent defines oil production decline as 'removing the rigs from the oilfield'.

Figure 4: The country with the highest global oil production decline between 2017-2022

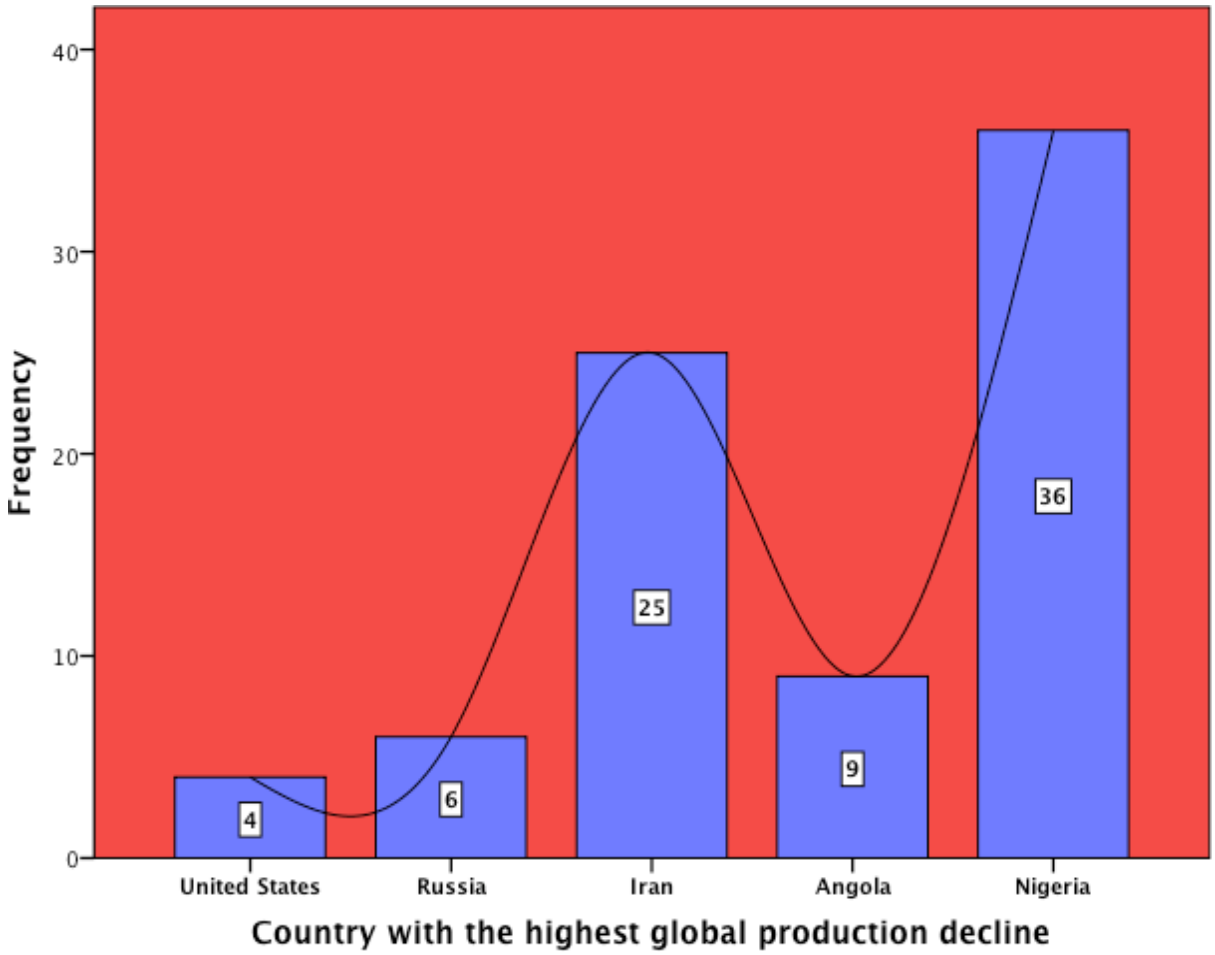
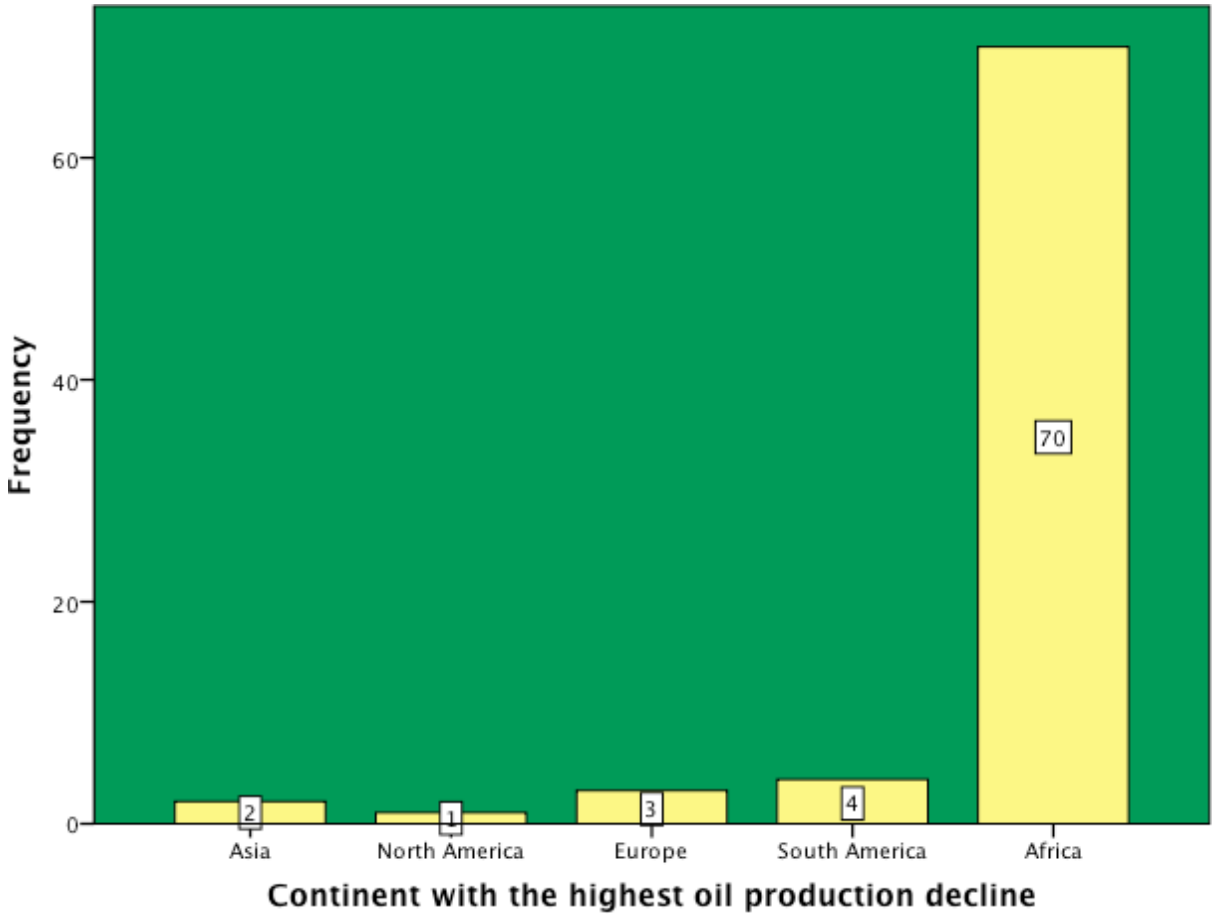


Figure 4 presents the respondents' views on a country that has the highest global oil production decline from 2017-2022. When asked, 80 respondents respondeddifferently. 36 respondents, representing 45 percent responded that Nigeria is the country with the highest global production decline from 2017-2022. They cited reasons such as the insecurity in Nigeria caused by Boko Haram and other insecurity incidences in Niger Delta caused by disruptions by the local people in Nigeria,

particularly, the ogoni people. These insecurity incidences installed fear to the contractors who are extracting oil in Nigeria. Other reasons cited include theft and diversion of crude oil by crooked Nigerians during piping. More reasons include the continuous use of poor technologies. On the other hand, 25 respondents, representing 31 percent argued Iran as the country with highest global oil production decline. They cited reasons such as sanctions that have been propelled on Iran by the USA coupled with poor technologies. Reasons such as the high sand production were cited including the poor quality of crude diet.

Besides, 9 respondents, representing 11 percent cited Angola as the country with highest production decline from 2017-2022. The respondents cited high water production, high depletion of the oil fields and low pressure on the pumps to bring oil on the surface. More still, 6 respondents representing 8 percent cited Russia as the country with highest global production decline. The respondents cited aging of the fields (brown fields), lack of new explorations, high water cut and oil price volatility. These factors coupled with conflict with Ukraine have exacerbated the Russian global decline of oil production. Finally, 4 respondents, representing 5 percent cited United States as the country with the highest global production decline. The respondents cited the aging of the fields, high sand production, global price volatility and covid-19 pandemic as key factors that have contributed to the United States oil production decline.

Figure 5: Continent with the highest oil production decline between 2017-2022



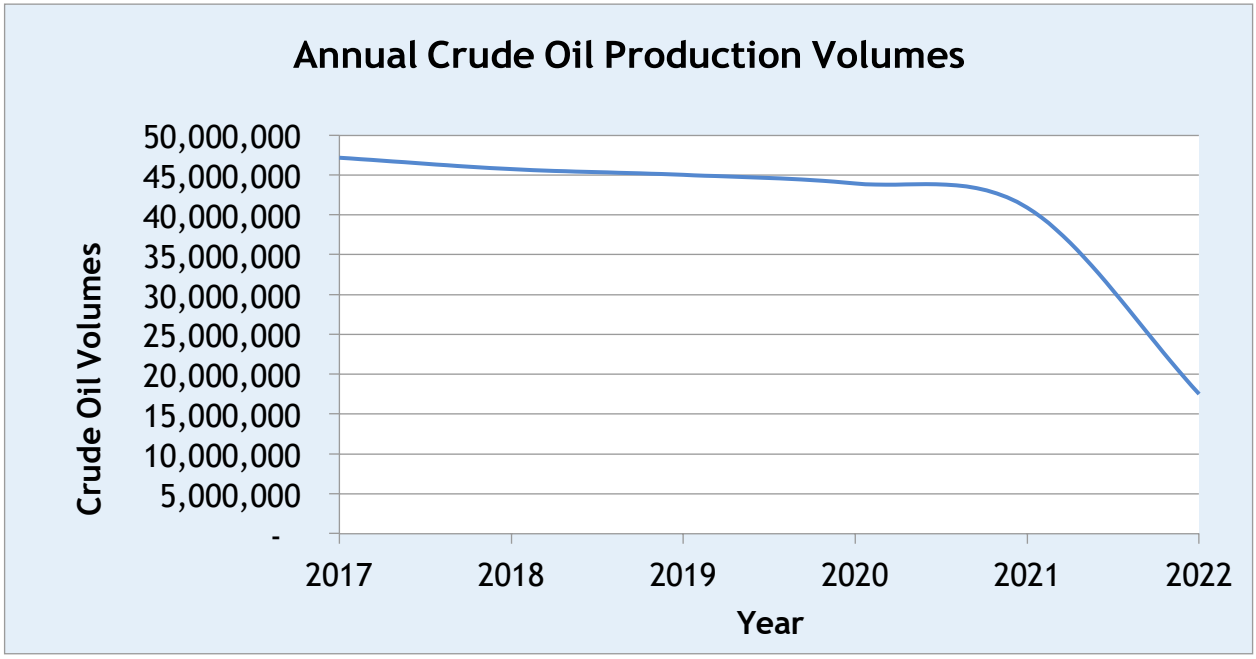
Source: Constructed by the Author

Figure 5 presents respondents' view on continent that has the highest oil production decline between 2017-2022. Asked about a specific continent amongst the provided choices of the continent, 70 respondents, representing 87 percent cited Africa as the continent with the highest oil production decline. These respondents numeratedvarious reasons such as high water cut, poor reservoir management, a lot of sand

production, poor technologies, lack of modern machines (equipment) for work overs, floods and insecurity as the key factors that have made Africa the continent with highest oil production decline. In addition, 4 respondents, representing 5 percentcited South America as the continent with the highest oil production decline. These respondents cited aging of the fields, depletion of pressures in the reservoirs, lack of new explorations and lack of petrophysical studies as the key factors that have led to the production decline in South America. Besides, 3 respondents, representing 4 percent cited Europe as the continent with the highest oil production decline. The respondents noted factors such as matured (brown) fields, lack of new explorations and climate change have led to the oil production decline in Europe.

Moreover, 2 respondents, representing 3 percent cited North America as the continent with the highest oil production decline. The respondents cited Covid-19 pandemic. Aging of the oilfields and swift transitioning of North America from fossil fuels to renewables as the factors that have contributed to the massive oil production decline. Finally, 1 respondent, representing 1 percent cited Asia as the continent with the highest oil production decline. They mentioned reasons such as depletion of pressures, poor reservoir management, high water cut, too much sand production and lack of enhance oil recovery (EOR) and improve oil recovery (IOR) as the factors for oil production making the Asia the continent with the highest oil production decline according to the respondents.

Figure 6. Decline curve analysis of block 3 & 7 of South Sudan from 2017-2022



Source: Constructed by the author with data from DPOC, 2022

Figure 6 demonstrates the decline curve analysis of block 3 & 7 of Paloch from 2017 to June 2022. For 2017, the average daily production was 131,000 barrels per day that accumulated to 3,930,000 barrels per month then to 47,160,000 barrels for the year 2017. For 2018, the average daily production was 127,000 barrels per day that accumulated to 3,810,000 barrels per month and then to 45,720,000 barrels for the year 2018. For 2019, the average daily production was 125,000 barrels per day that accumulated to 3,750,000 barrels per month then to 45,000,000 barrels for the year 2019. For 2020, the average daily production was 122,000 barrels that accumulated to 3,660,000 barrels per month then 43,920,000 barrels for the year 2020. For 2021, the average daily production was 113,588 barrels that summed up to 3,407,640 barrels

per month then to 40,892,000 barrels for the year 2021. For 2022, the year has not ended. So the researcher took the volumes for 6 months (January-June). Hence, the average daily production was 97,267 barrels that accumulated to 2,918,010 barrels per month then to 17,508,000 barrels for 6 months for the year 2022.

The above figures systematically demonstrate the decline curve analysis of the crude oil production for block 3 & 7 from 2017 to June 2022. This crystal clearly showcases the oil production decline.

4.4. Factors Affecting the Oil Production Decline in Block 3 & 7 of South Sudan

4.4.1. South Sudan Experiencing Oil Production Decline in Block 3 & 7

Asked whether South Sudan is experiencing oil production decline in block 3 & 7 or not, all of the respondents noted with yes citing high water cut, pressure depletion, mature fields (brown fields), poor technologies, floods given that 40 percent of wells that are submerged in the waters in Paloch. The respondents also cited too much sandproduction that continues to block bore wells, lack of new explorations, poor reservoir management, formation dip, lack of petrophysical studies and wars and violence that was triggered by the 15th December 2013 political ignominy.

Table 5: Ranking of Factors that are Responsible for Oil Production Decline of Block 3 & 7 in Paloch

The highest factor responsible for oil production decline in block 3 & 7

Category		Frequency	Percent
Valid	High Water Cut	41	51.3
	Poor Technologies	25	31.3
	Too Much Sand Produced	5	6.3
	Floods and Flooding	6	7.5
	Wars and Violence	3	3.8
	Total	**80**	**100.0**

Source: Fieldwork

Table 5 ranks the key five factors that were previously mentioned by the respondents to be responsible for oil production decline in block 3 & 7. Asked to single out the most importance factor, 41 respondents, representing 51 percent cited high water cutas the most factor responsible for oil production decline. The respondents noted geological predicaments such as poor reservoir management and lack of petrophysical studies to address the high water cut (produced water) in block 3 & 7. Moreover, respondents noted that the soil in Paloch is continental, meaning that it is alluvial soildeep with less rocks hence it is geological difficult to easily separate the water from the oil in the reservoir thus high water cut. This requires modern and automated pumps. *K.I.1* notes:

> *Automatic pumps are critical in the realization of production decline as well as production increase. These pumps in DPOC include ESP pumps for service such as maintenance and work over and PCP pumps for*

actual pumping of the oil underneath are not automatic and modern. If the PCP pumps are weak then the pumping will be low and this consequently leads to oil production decline. However, if these PCP pumps are strong then the pumping will be high and this consequently leads to oil production increase (K.I.1).

Respondents unanimously noted the high water cut levels in Paloch is between 70-90 percent, which is the highest in the world.

Besides, 25 respondents, representing 31 percent cited poor technologies as the most disturbing factor that has led to the oil production decline in block 3 & 7. The factor, the respondents noted related to lack of exploration, drilling and production of new technologies such as offshore exploration, vertical drilling and optimize automation production. The respondents acknowledged that for a very long time, DPOC has been using old technologies that have not promoted enhance oil recovery (EOR) and improve oil recovery (IOR) including industrial Internet of things (IIOT). These old technologies have been showcased on digging of vertical wells as well as disposal wells.

In addition, 6 respondents, representing 8 percent cited floods and flooding as the major factor for oil production decline in Paloch. They argued that 40 percent of the 600 wells are submerged in waters and this has drastically reduced the oil production, particularly, at Paloch-FPF, Adar-FPF, Gumry-FPF and Moleeta-FPF. While the floods have affected the four FPF, it has been worse for Paloch-FPF for which central FPF. What is more, 5 respondents, representing 6 percent cited too much sand produced as

the main factor for oil production decline. The respondents argued sand production as detrimental because its blocks the reservoirs beds during geological extractions and more still block the wells during the pumping of oil to the FPF. These blockages impede the normal flow of oil and thus production decline.

Finally, 3 respondents, representing 4 percent cited wars and violence as the most outstanding factor that has led to oil production decline in block 3 & 7 in Paloch. The respondents noted the 15th December 2013 political conflict that was later on followed by 8th July 2016 political violence in South Sudan which later affected the staffs at block 3 & 7. Most of the staffs working in the oil extractions and particularly those holding critical positions in the production in DPOC are Chinese, Malaysians, Indians and Egyptians who decided to abandon the field during the onslaught of the conflicts. This later led to few wells and FPFs being operated. Until at the time of writing this dissertation, any slight insecurity provocations around the oilfields amongst the SPLM-IG soldiers, SPLM/A-IO, SSOA and OPP soldiers will continued to affect the production in block 3 and 7 in Paloch.

4.4.2. Consequences of oil production decline

4.4.2.1. On the Government of South Sudan

Asked about what consequence the oil production decline has on the Government of South Sudan, majority of the respondents noted that the consequence is the loss of oil revenues. The Government of South Sudan was receiving billion of United States dollars annually from 2011-2016 because the government was monthly getting its 600,000 crude oil cargo on time. However, between 2017-2022, the revenues have

drastically dropped as the government takes less than 600,000 crude oil cargo tankers per month. The government take has been swinging between 400,000 to 300,000 crude oil cargo tankers due to production decline in block 3 & 7. Moreover, the Government of Sudan has also given pressure to the Government of South Sudan to keep the production assurance flow rate to 120,000 bpd and above. The Government of South Sudan has not met this as the production went down to 98,000 bpd in March 2022 in block 3 & 7 and at average of 97,267 bpd for the 6 months (January-June) of 2022. Thus, the Government of Sudan has warned that failure to keep to the production flow rate assurance of above 120,000 bpd could lead to the shutting down of the pipeline. Moreover, the Sudanese government at the time of writing this dissertation has refused to bring down the tariffs for processing and transportation of crude oil from 24.1 USD to 5 USD for a barrel as requested by the Government ofSouth Sudan.

4.4.2.2 International Oil Companies (DPOC Consortium)

Asked about what consequence the oil production decline has on international oil companies and in this case, DPOC consortium (CNPC, SINOPEC, PETRONAS, ONGC and Tri-Ocean), majority of the respondents cited loss of profits to these IOCs. As it is well known in the exploration production sharing agreement (EPSA), oil is contractually divided into two: cost and profit oil. In the case of block 3 & 7, cost oil takes 45 percent while profit oil takes 55 percent. This cost oil goes directly to the contractor and in this case it is DPOC and the 55 percent profit oil is shared between contractor consortium and the government. So, the contractor consortium takes 30 percent and shares it base on their individual company equities and the government

takes 70 percent. Hence, since 2017-2022 DPOC has been losing substantive profit. The IOCs such as CNPC, SINOPEC, PETRONAS, ONGC and Tri-Ocean have reported through the respondents to have heavily lost substantial profits. This can delay cost recovery too.

4.4.2.3. South Sudanese Citizens

Asked about what consequence the oil production decline have on the citizens of South Sudan, many respondents cited loss of development such as constructions of roads, schools and hospitals. Moreover, respondents noted that South Sudanese citizens have lost energy related projects such as electricity power connectivity and renewable energies connectivity. Further still, the respondents noted compounded delay of salaries for the government workers and acute decline in the cost of living leading to object poverty and decline in life expectancy. Besides, the future of South Sudanese has been mortgaged through sovereignty guarantee related loans and this has resulted to untold anxiety to South Sudanese citizens. Finally, the South Sudanesecitizens have lost jobs and the economy has turned to shambles due to lack of foreign currency.

4.5. Solutions to the Oil Production Decline for Block 3 & 7

Asked about what they think should be the possible solutions to oil productiondecline, majority of respondents argued that acquisition of relevant technology for EOR/IOR and vertical drilling is a great solution to the production decline. Besides, some respondents said that embarking on the extensive exploration activities could help in increasing oil production in Paloch. In addition, some respondents noted that

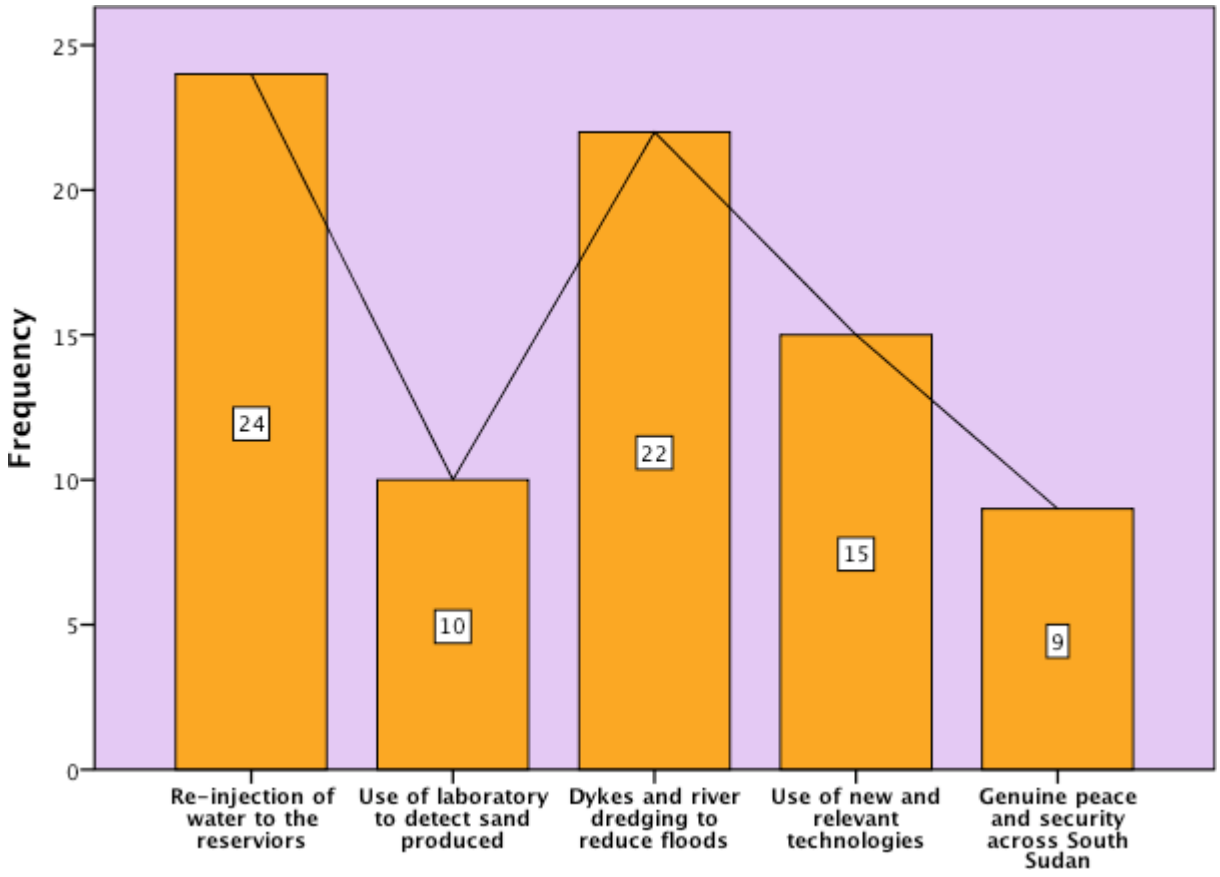
reservoir management need to be improved because this is what has led to high water cut and sand production that has further led to oil production decline. There is a great need to use suitable pumps to produce oil underneath. PCPS pumps are suitable and they can be used efficiently. However, according to *K.I. 2* during the interview:

> *Pumps can be overloaded and get stuck if there is too much sand production and hence they required diligent handling (K.1.2).*

Furthermore, some respondents noted that floods can be curbed through first doing prefeasibility studies and Environmental Social Impact Assessment (ESIA) then to be followed by feasibility studies and then building of strong dykes in Paloch and other FPFS. Finally, majority of respondents also noted that exploration and production of oil and gas take place when the block and the surrounding are secured. They said that proper security need to be put around block 3 & 7 so that workers don't fly away for fear of their lives during the time of conflicts and violence. On top of this is genuine implementation of R-ARCSS so that all parties don't go back to war and all must observe a complete cessation of hostilities.

Figure 7: Ranking of solutions for oil production decline of block 3 & 7 in Paloch

The highest solution for oil production decline in block 3 & 7



Source: constructed by the author

Figure 7 ranks the key solutions for the oil production decline. Asked which of the solutions is the most importance, 24 respondents, representing 30 percent cited re-injection of water to the reservoir as the most importance solution. This, the respondents argue can help in the reduction of the water as well as part of reservoir management. Re-injection of water can help reduces the 70-90 percent high water

cut. As water is re-injected, the re-injected water goes deep to the reservoir well bore depending on the pressure. If the pressure is so high then the water movequickly to the reservoir geological beds. However, if the pressure is low then the re- injected water doesn't move so fast. *K.I.2* during the interview noted:

> *Reservoir management is key for the increase of production. This reservoir management includes timely identification and separation of waters during logging and casing and during processing* (*K.I.2).*

As added by K.I. 3:

> *Petrophysical tools are critical during the reservoir management as petrophyscists help the reserviorists to prepare for either the best or the worst during production (K.1.3).*

K.I 4 during the interview noted in order to avoid high water cut during production, you require all the specialists in this area such as:

> *The production engineers, the reservoir engineers, petrophysicists, petroleum engineers and petroleum technologists are very essential in the realization of production increase (K.I.4).*

K.I. 1 confirmed and argued during the interview that production:

> *Is not about record keeping of the data but of forecast of what will happen in the foresable future (K.I.1).*

While production increase can occur any time, *KI 5* argued that during the interview:

That production increase should be annually planned and should be on the annual WPB because block 3 & 7 got only 35 percent explored, developed, drilled and produced. Hence, production decline is quite shameful and should be reversed with production increase (K.I.5).

Besides, 10 respondents, representing 13 percent cited use of laboratory to test sand during production so that specific chemical solution is provided. The respondents also noted that sand keeps building up, as geologists or petrophysicists don't easily realize that it is being produced. Hence, a specialized laboratory for sand testing need to be built at Paloch so that it helps in testing of sand production at wells, FPFS and at the central processing facility (CPF).

Moreover, 22 respondents, representing 27 percent cited dykes and dredging as the solution for floods at the center of block 3 & 7 at Paloch. These dykes should be built with the concrete wall and the excess water drained via river Nile dredging. While dredging of river Naam and Lake No of Bahr el Ghazal basin is a controversial matter for the Government of South Sudan, these respondents in the oil and gas industry believe that dredging can help open up the river which can assist in evacuating water from Paloch to allow submerged wells to be accessible again.

K.I.6 noted during the interview:

That prevention of floods by use of dykes, dams and river dredging is the work of the government not the DPOC (K.I.6).

What is more, 15 respondents, representing 19 percent cited use of new and relevant

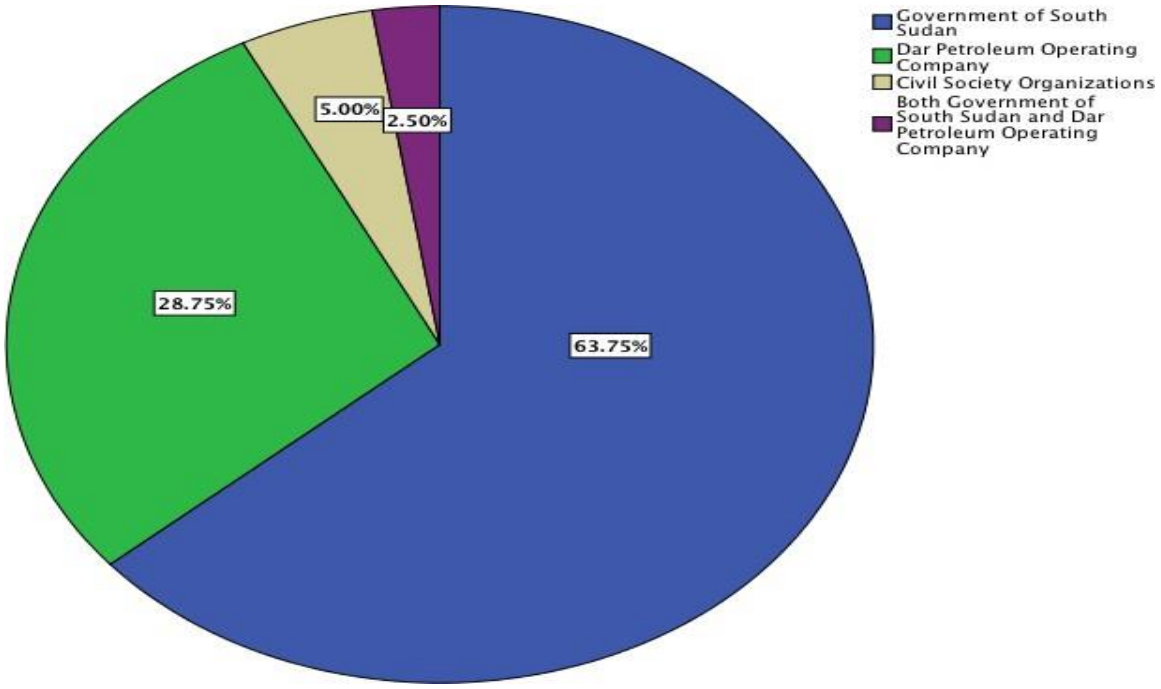
technologies as the most importance solution for oil production decline in block 3 & 7. The respondents noted the use of horizontal drilling, remote sensing of wells and reservoirs characterization coupled with new methods of work over for the rigs and pumps. These include the Industrial Internet of Things (IIOT). Other technologies such as enhance oil recovery and improve oil recovery (EOR/IOR) were cited as very importance for the increase of oil production in block 3 & 7. Finally, 9 respondents, representing 11 percent cited genuine peace and security across the country as a very importance solution to the oil production decline. These respondents also cited the importance of the implementation of R-ARCSS by all the parties. In the implementation of R-ARCSS, chapter two of security arrangement is key as it stipulates the permanent ceasefire and complete cessation of hostilities. The respondents added that partners like CNPC, PETRONAS, ONGC Videsh and Tri-Ocean would only increase the production in block 3 & 7 when they have seen a total return of peace to the country and when the guns are totally silent. This genuine peace and security boost IOCs confident to extract more oil and particularly, DPOC in doing new explorations, as many sub-fields have already been relinquished and new exploration required total and genuine peace and security across the country.

K.I.7 during the interview said:

> *That DPOC has already identified 43 potentials sub-fields for explorations adjacent to block 3 & 7. These 43 fields once explore can aid in the increase of oil production in block 3 & 7 (K.I.7).*

4.5.1. The agency that should provide solutions to the oil production decline in Block 3 & 7 of Paloch

Figure 8: The agency that should provide solutions to the oil production decline



Source: Constructed by the Author

Figure 8 query the agency or actor that should provide already analyzed solutions to oil production decline in block 3 & 7 in Paloch. Asked which agency should do this, 51 respondents, represented by 63.8 percent cited the Government of South Sudan through Ministry of Petroleum (MOP) as a responsible agency to provide solutions to the oil production decline. The respondents noted the constitutional role of the Government of South Sudan as the owner of natural resources including petroleum and which the Government regulates on behalf of the citizens of South Sudan. Having the ownership of these hydrocarbon resources, the Government through the Ministry

of Petroleum should ensure that solutions to oil production decline such as re-injection of water to the reservoir, control of sand production, control of floods, provision of new and relevant technologies and provision of security to block 3 & 7 is its ultimate responsibility. The Government has a say over the contractors budgetsand through the Ministry of Petroleum, it can pressurize Dar Petroleum Operating Company (DPOC) to put aside a budget for resolving oil production decline in tandem to production increase.

Besides, 23 respondents, representing 28.8 percent cited Dar Petroleum Operating Company (DPOC) as the responsible agency for solutions to oil production decline. The respondents argue that DPOC is a company, operating block 3 & 7 and has a license responsibility of ensuring that production increase rather than decline. Every year, DPOC approves the Work Program and Budget (WPB) that ensures the performance of the company in the next financial year. In this WPB, DPOC can budget items that ensure that production is increased. This is the greatest leverage DPOC has over other institutions including the government because it manages cost oil funds and operation budget of the consortiums.

In addition 4 respondents, representing 5 percent cited civil society organizations as the responsible actor for the solutions of oil production decline. The respondents noted civil society as the voice of the citizens who can articulate the citizenry views on the matter of production decline. One of the ways on how civil society can excel isthe advocacy on the environmental protection. For instance, the high water cut

results to too much produced water, which if not treated can lead to environmental pollution that affect both plants, animals and human beings. Moreover, the civil society advocacy for ending of floods and insecurity in block 3 & 7 has been repetitively mentioned by the respondents as the surest way of increasing oil production and preventing the decline.

Finally, 2 respondents, representing 2.5 percent cited both the Government of South Sudan and Dar Petroleum Operating Company (DPOC) as the responsible agencies to solving the oil production decline. The respondents cited the power of the Government through the Ministry of Petroleum (MOP) as the approver of the WPB and this leverage can allow the Government to ensure that WPB prioritizes production increase. However, if it doesn't prioritize the increase of production then MOP can easily refuse to approve. What is more, respondents cited that DPOC has both the technical and financial capacity to ensure that oil production decline is a story, whichcannot take place again in block 3 & 7. This capacity of both the Government and DPOC make them a combined actor responsible for oil production decline.

When interview, the *K.I.8* acknowledged that:

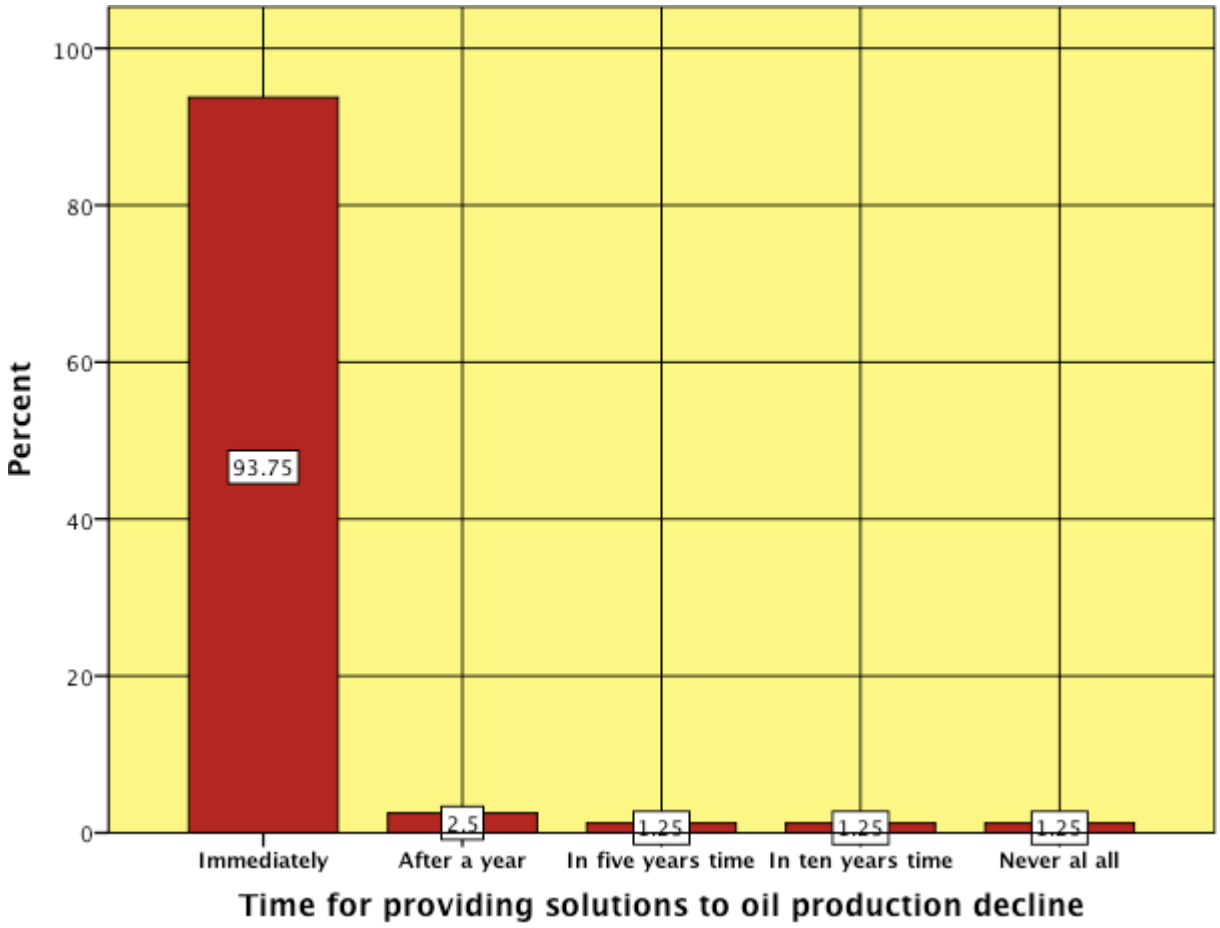
> *The MOP has power to reject the approval of the WPB until the DPOC adjust it accordingly (K.I.8).*

This is a leverage, which *K.I.9* confirmed in an interview:

> *That the MOP has a powerful mandate that can make the JOCs, particularly, DPOC to increase production immediately. The conundrum is that the MOP has not yet realized that it has such constitutional and*

regulatory power (K.I.9).

Figure 9: Time for providing solutions to oil production decline



Source: constructed by the author

Figure 9 showcases the analysis of the time that is suitable for the implementation of solutions of the oil production decline. Ask about when to do that, 75 respondents, representing 93.8 percent cited immediately as the time for implementing the solutions of the oil production decline. These solutions as previously mentioned

include re-injection of water to the reservoir, general reservoir management, and introduction of new technologies, use of laboratory to detect and control sand production, use of dykes and river dredging to control floods and maintenance of genuine security and peace across the country. These respondents noted that time is a great essence and increase of oil production is urgent and need to be done immediately.

K.I.10 noted during the interview:

> *That production should be increased immediately as the situation is not favorable for the government* (*K.I.10).*

On the other hand, *K.I.11* also acknowledged during the interview:

> *The importance of using petrophysical tools on time so that production is increased and that decline should not be allowed to occur again* (*K.I.11).*

On the other hand, *K.I. 5* noted:

> *That DPOC has been ready to increase the production. However, insecurity and economic challenges have led partners, for instance,DPOC big partners (CNPC and PETRONAS to trade carefully) (K.I.5).*

However, *K.I. 12* lamented:

> *The blame on the drastic oil production decline can be apportioned on big partners of DPOC (CNPC and PETRONAS) who have been quite*

reluctant to increase the production budget together with petroleum engineering and petroleum technology departments (K.I.12).

In addition, 2 respondents, representing 2.5 percent argued that these solutions should be provided next year arguing that is not urgent. Besides, 1 respondent representing 1.3 percent argued that the solutions should be provided in five years time when the DPOC management has paid the cost recovery funds to the Government. What is more, 1 respondent, representing 1.3 noted that the solutions should be administered in ten years time as these respondents argue that there shouldbe not hurry in Africa. Finally, 1 respondent, representing 1.3 percent cited never at all to provide solutions of oil production decline as this respondent has lost faith inthe Government and South Sudan as a country.

CHAPTER FIVE

DISCUSSIONS OF FINDINGS

5.1. Introduction

This chapter provides a recap of what has been discussed so far in the entire research study in regard to research findings. It gives in summary the findings of the research which are central to the debates, dilemmas and intricate surrounding the understanding of the oil production: investigating factors affecting the oil production decline in block 3 & 7 in South Sudan from 2017-2022. The chapter then discusses the dissertation findings base on the research questions; draw the implications from the major variables tested from the literature review and fieldwork.

5.2. Overview of the Findings

The dissertation set out to answer the research purpose and specific objectives throughout the period of study. The purpose of the study was to investigate factors affecting the oil production decline in block 3 & 7 at Paloch of South Sudan from 2017-2022. The specific objectives, which were turned into research questions, include defining the concept and origin of oil production decline, examining factors responsible for oil production decline in block 3 & 7 of South Sudan from 2017-2022 and appraising solutions to the oil production decline in block 3 & 7 of South Sudan. The study then subjected the guiding research questions to empirical literature and field survey for testing and explanation. Variables such as dependent and independentvariables were discussed. While the dependent variable include oil production decline,

the independent variables include high water cut, too much sand produced, floods & flooding, poor & obsolete technologies and conflicts and wars in South Sudan. The study used traditional decline analysis theory in analyzing the variables in bothliterature and field surveys. Importantly, the study analyzed and interpreted the dataset for the DPOC decline curve of oil production from 2017-2022.

5.2.1. Concept and origin of oil production decline

The concept and origin of oil production decline was presented to the respondents for their response and interesting findings were demonstrated. Majority of respondents said that the concept originated in the USA around 1860s given that the discovery of oil in 1859 in the state of Pennsylvania. While some respondents associated the concept to China in 1850s, they also associated the concept with Scotland in 1840s. Other respondents cited the concept to have clearly emerged around 1940s after the Second World War that led to the both physical and emotional distress includingglobal oil production decline. This was during the greatest recession where economiesplummeted and financial institutions collapsed. However, few other respondentsdidn't know the concept and origin of oil production decline, as they did not fill the blank spaces.

In understanding the meaning of oil production decline, majority of respondents defined oil production decline as 'steady reduction of production rate of a given oilfield' as a choice amongst other three choices. Few other respondents defined oil production decline as either 'production of waxy crude oil' or 'steady increase of production rate of a given oilfield' or 'removing the rigs from the oilfield' amongst

the remaining other three choices.

5.2.2. Factors responsible for oil production decline in block 3 & 7

Various factors responsible for oil production decline in block 3 & 7 in Paloch were discussed with respondents and resulted into interesting findings. One of the factors the respondents put on the top of the list on the findings is high water cut which is caused by poor reservoir management, production of too much water due to low pressure of oil pump, vertical drilling, lack of work over on the drilling rigs and lack of petrophysical studies such as EOR and IOR.

The other factor is too much sand produced which also got an interesting finding. Majority of respondents noticed that sand built up around the reservoir while unnoticed and this has continued to affect the production of oil and thus production decline. Sand production is detrimental as its blocks wells bore and reservoirs beds during geological extractions and sub surface production. These blockages impede thenormal follow of oil and thus production decline.

Besides, poor and obsolete technologies were found as a factor that has led to oil production decline. Technology is central in the oil and gas industry and failure to embrace it can lead to poor performance of the industry. Poor technologies such as vertical drilling and lack of Industrial Internet of Things (IIOT) coupled with lack of automation and digitization of the production has been found to be a cause of oil production decline in block 3 & 7. DPOC continued to use obsolete technologies in block 3 & 7. Some of these technologies such as manual work over of the rigs, manual

maintenance of ESP pumps and PCP pumps, which are no longer being applied in the world.

What is more, floods and flooding was discussed as a factor for oil production decline. Floods in Melut County, Paloch payam have led to devastation in the oilfields. From 2020 to the time of writing this research, floods have submerged 40% of the 600 wells. This situation has drastically reduced production as the wells cannot be accessed and ESP and PCP pumps cannot do anything at the flooded wells to pump oil to the FPF. Some efforts of rebuilding and raising wells were attempted to avoid flooding but this became expensive and DPOC dropped it. The floods have also displaced people around the oilfields. An interesting thing about these floods is the topography of Melut and particularly, Paloch payam. The area is at lowland from the south and turn highland to the north. This obstructs the movement of water to the northern town of Renk as well as hinders the returning of water to the southern part of river Nile. In nutshell, Paloch is like a dish topographically.

Finally, the last factor discussed is wars, conflicts and violence in the South Sudan that has affected the country from the onset of 15th December 2013 through 8th July 2016 till today. These wars, conflcits and violence emanated from the main ruling party, the SPLM in May 2013. Comrade Salva Kiir, Comrade Riek Machar, Comrade Rebecca Nyandeng De Mabior, Comrade. Pagan Amum Okiech and Comrade James Wani Igga could not contain a leadership disagreement over the direction of the party and failure. Chairman, Comrade Salva Kiir Mayardit carried this blame. This quarrel

led President Salva Kiir to sack the entire cabinet on 23rd July 2013 including his long serving Vice President Riek Machar Teny. The sacking of Riek Machar Teny emboldened the quarrel that led to the eruption of war and violence on 15th December 2013 fitting Dinka against Nuer ethnicities in both towns and rural areas. While the war and violence was halted through IGAD mediated ARCSS, another war and violence commenced on 8th July 2016 between the presidential guards of President Salva Kiir and that of 1st Vice President Riek Machar Teny. The two wars andviolences affected severely the oil production in block 3 & 7 as key technicians had to be evacuated to Juba from Paloch. This led to the oil production decline. Thestopping of these wars and violence was again done by the IGAD during the inking of R-ARCSS between President Salva Kiir Mayardit and 1st Vice President Riek MacharTeny on 12th September 2018 at Addis Ababa, Ethiopia. This agreement though is not being implemented properly, it is has helped halted the cessation of hostilities across major cities in South Sudan. However, any slight provocations amongst the cantankerous parties can return back the country to war and violence and the oil production can drastically decline.

5.2.3. Solutions to oil production decline in block 3 & 7

Various solutions to oil production decline were discussed and interesting findings were noted. For instance, high water cut was found to be resolved through re- injection of water back to the reservoir. This shall ensure that the re-injected water doesn't surface again to increase the water during production. Related to that is the importance of reservoir management. Reservoir has been noted as a very important bed for the production of oil and gas. Once it is poorly managed, then it can result

into weakening its strength of preventing water from moving to the surface and hence causing high water cut during production. More still, high water cut has been caused by lack of studies such as EOR and IOR.

Besides, too much sand produced has been discussed and the solution to its isapplication of laboratory testing so that sand is detected early and thus specific chemicals such as sandize can be applied to reduce this sand. While lab testing is a critical solution, carrying out studies on the sand formations can aid in the preventing of too much sand production. At Paloch oilfield of block 3 & 7, mobile sand testinglabs are necessary so that the oil produced from the well is tested before it proceeds to the FPF and then to the CPF at Jebeleen in Sudan for export. Wells that are identified to be producing too much sand are then selected sand treatment can immediately take place.

In addition, new and relevant technologies were discussed to be the solution to the poor and obsolete technologies. For example, drilling technology such as horizontal drilling can help enhance more crude oil production than the traditional vertical drilling. The use of Industrial Internet of Things (IIOT) such as 'I' cloud, remote sensing and 4^{th} industrial revolution (4IR) are critical for effective management of oilfields to increase the oil production. 4IR is highly being embraced in the oil and gas industry as the production including reservoir characterization and management requires new and updated technology. Artificial intelligence, big data analytics,robotics and drones for water inspections are valuable technologies that are used for

inspections of the oil facilities including wells and ESP pumps to ensure oil production increase.

What is more, floods can be reduced through the proper usage of concrete dykes and dams. Dykes and dams are useful solutions to the floods that come from different sources. The water that floods to block 3 & 7 comes from river Nile in Entebbe, Uganda. Once the river Nile in Uganda raises in water levels, this then affect South Sudan and other downstream countries such as Ethiopia and Sudan. Concrete dykes in Paloch and a dam in Malakal can help in addressing floods and consequently addressing the oil production decline. Dredging of Bhar el Naam and White Nile River was highly discussed as a solution to the floods and flooding in Paloch and itssurroundings such as Adar, Gumry and Moleeta. However, dredging was discussed and it was agreed to be done at surface level only. That is between, 0.2-2 meters. More than 2 meters can quickly gather all the water around Sudd wetlands that can affect Sudd biodiversity and the aquatic living things and this extends to green belt region (Ituri province of DR Congo, Western Equatoria, Western Bahr el Ghazal and Unity State).

The final solution, which is on wars, conflicts and violence, is genuine peace and security across South Sudan. As it has been echoed, peace is investment and investment is peace. The genuine implementation of R-ARCSS by all the parties is a recipe for increasing oil production as this can prevent war and violence in thecountry including oilfields in block 3 & 7. R-ARCSS has eight chapters and all these

chapters mean well for South Sudan. However, the implementation is going on a snail-speed and this is a worrying trend given that a slight disagreement amongst the two belligerent parties (SPLM-IG and SPLM/A-IO) can lead to the 'hell breaking loose' and thus war and violence. It is important for the parties to deploy calm minds, tranquility, sober discussions and above all implement the peace agreement in later and spirit. It has strongly come out from the findings that time is a great essence in the realization of oil production increase. The responsibility of the implementation of the solutions relies on the shoulder of the Ministry of Petroleum who should in turn instruct DPOC to adopt and avail these solutions immediately to block 3 & 7 so as to halt the oil production decline.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1. Introduction

This chapter provides concluding remarks and recommendations. Conclusions cover "so what" about the study, author's experience, opinions and feelings about oil production decline in South Sudan. The recommendations provide "what next" for the study and how various stakeholders and affected cleavages shall use the study for future endeavours.

6.2. Conclusions

The study has made a strong argument about understanding the oil production decline in South Sudan and particularly, investigating factors that have led to this historical decline. While the study appraised this oil production decline and problematized it on factors such as high water cut, too much sand production, floods and flooding, poor and obsolete technologies and conflicts, wars and violence, it also interrogates these factors through the traditional decline analysis theory. Whereas the problem was further expanded into objectives and research questions, these research objectives and research questions were subjected to rigorous literature testing through literature review and further gaps were probed through field research in both Juba and Paloch. The successful distribution and filling of 50 questionnaires in Juba and 30 questionnaires in Paloch in addition to efficacious interviews of 12 senior Government and DPOC officials that were carried out in Juba have made this study quite ground breaking with original findings.

While the factors responsible for oil production decline as mentioned above were identified, solutions such as re-injection of water to reservoirs, laboratory test of sand, new and relevant technologies, use of dykes, dams & dredging of Nile river and maintenance of genuine peace and security across the country were identified as well and tested in both literature review and empirical field research. The implementation of these solutions have been largely mentioned by the respondents and interviewees to be done by the Ministry of Petroleum given that it is the regulator as well as the implementer of oil and gas policies in the Republic of South Sudan. While the Ministry of Petroleum has that role, it can also do this through Dar Petroleum Operating Company (DPOC), which is the operator of block 3 & 7. These solutions should be done immediately as indicated by the respondents. While this study was quite interesting and timely, it was quite technical given that oil production and decline is quite an area of geologists, geoscientists, geophysicists, petrophysicists, reservoir engineers and petroleum engineers. The study has confidently identified the factors and solutions to oil production decline in block 3 & 7 in the Republic of South Sudan.

6.3. Recommendations

Based on the strong conclusions of the research as indicated above, the dissertation makes the following recommendations:

6.3.1. Government of South Sudan (MOP)

1. That the Government of South Sudan should prioritize oil production increase given that it affects the government operations due to reduction of revenues;
2. That the Ministry of Petroleum (MOP) should ensure that Dar Petroleum

Corporation (DPOC) increase oil production by implementing the solutions such as re-injection of water back to the reservoirs, proper reservoir management, control of sand production, use of latest and relevant technologies and carrying out new explorations;

3. That the Ministry of Petroleum (MOP) should ensure that floods are controlled through constructions of concrete dykes, dams and dredging of river Nile to ease movement of water to the north and to Sudan. However, this dredging is a controversial matter, as the public opinion doesn't support it without a credible study given that Sudd wetlands may end up without water. This has adverse effects on the environment and the entire ecosystem in South Sudan;
4. That the Ministry of Petroleum (MOP) together with the Ministry of Environment should champion the Environmental Social Impact Assessment (ESIA) before dredging to ensure that environment and the entire biodiversity is safe for humans and animals during and after dredging of waters in Paloch;
5. That the Ministry of Petroleum (MOP) should urge Dar Petroleum Operating Company (DPOC) to implement the solutions to oil production decline immediately as largely agreed by the respondents.

6.3.2. Dar Petroleum Operating Company (DPOC)

1. That DPOC should ensure that it implements the solutions under its mandate of increasing oil production in block 3 & 7;
2. That DPOC should implement these solutions immediately as said by the respondents;
3. That DPOC should ensure that proper geological, petroleum engineering or

reservoir studies are commissioned immediately to detail and technically understand how each solution can be modeled and applied in reducing oil production decline;

4. That DPOC should carryout new explorations so that it increases the oil production. From the respondents and interviews conducted, block 3 & 7existing wells were first drilled in 1979 and currently, block 3 & 7 is old(brown) fields that need new explorations (green fields) for more oil; and
5. That DPOC should increase its budgets for Enhance Oil Recover (EOR) and Improve Oil Recovery (IOR) and above all new explorations to increase the oil production.

6.3.3. Recommendation for future study

Since this is a new area of scholarship, which I do not sufficiently claim to have exhausted it, future research is hereby recommended to other researchers or scholars in oil and gas industry in order to further investigate; either to confirm or refute each of my five factors and five solutions in explaining oil production decline in block 3 & 7 in Paloch, Melut County of Upper Nile State from 2017 to 2022.

7. REFERENCES

Achuek, L. (2022). Chinese Obsolete Technology and Oil Production Decline in South Sudan. *Eye Radio News*

Adewums, et al. (1992). *Initial Design Considerations for Cost Effective Treatment of Stripper Oil Well Produced Water*. Plenum Press

Almaaw, et al. (2000). Downhole Horizontal Separation: An Alternative Downhole Oil/Water Separation Technology. *12th Annual Deep Offshore Technology Conference on 2nd June-3rd June*. New Orleans.

Amyx, et al. (1960). *The Origin of High Water-Cut in Petroleum Industry*. Britain Printer-London

Arps, J. (1945). Traditional Decline Analysis Theory. *Journal of Science, Vol 6* (2): 112-121

Bradford, J. (1991). *The Marshall Plan: History's Most Successful Structural Programme*. Barry Eichengre Publishers.

Campbell, J. (1960). *Oil Property Evaluation*. Prentice Hall, Inc, Englewood Cliffs

Carlson, J et al. (1992). *Sand Control: Why and How?* Completion and Simulation Publishers

Caudle, D. (2008). Treating Produced Water-Back to Basics. *10th Produced Water Seminar, 6th March-7th March*. Houston, TX.

Derek, P. (2020). *Industrial Internet of Things (IIOT)*. Harvard University Press.

Deruyck, B et al. (1992). Testing Design and Analysis*: Oilfield Review Journal, Vol 4* (2): 28-45

Dine, J. (1999). *Treatment and Discharge of Produced Water for Deep Offshore Disposal*. American Petroleum Institute.

Doane, G. (2019). Trends, Opportunities in South Sudan's Oil and Gas Industry. *Power Lunch East Africa Report*.

DPOC Crude Oil Production Report, 2022

Elkhazin, T. (2022). The Fears of Dredging River Nile. *Hydrology Studies*. University of Curtin.

Favret, et al. (1999). Total System Design for the Treatment of Produced Water and Open Drainage on Offshore Production Facilities. *A paper presented at the 9th Produced Water Seminar, 21st January-22nd January*. Houston, TX.

Frankiewicz, T. (2001). *Understanding the Fundamentals of Water Treatment and Quality Control*. Houston Publishers.

Gagnon, J. (1982). Empirical Research: The Burdens and the Benefits. *Interfaces* 12(4): 98-102

Gochi, M et al. (2018). *Innovation and New Technologies in the Upstream Oil and Gas Industry*. University of Rome Press.

Hook, M et al. (2013). Decline and Depletion Rates of Oil Production: A Comprehensive Investigation. *Journal of Petroleum Studies, Vol 2* (5): 231-253

Hook, M (2009). Depletion and Decline Curve Analysis in Crude Oil Production. *Licentiate Thesis*. Global Energy Systems: Department for Physics and Astronomy, Uppsala University.

Hossein, R et al. (2013). Review of Sand Production Prediction Models. *Journal of Petroleum Engineering, Vol 1* (3): 1-16.

Inkpen, A and Moffet, M. (2011). *The Global Oil and Gas Industry: Management, Strategy and Finance*. Pennwell Corporation.

Imenda, S. (2014). Is there a Conceptual Difference between Theoretical and Conceptual Frameworks? *J Soc Sci, Vol 38* (2): 185-195

International Flood Initiative *Report*, 2003

Johnson, D. (2003). *International Exploration Economics, Risk and Contract Analysis*. Pennwell Corporation

Kaboka, L. (2019). Water Flooding and the Effects on River Nile. *Journal of Water Studies, Vol 6* (2): 110-132

Khatib, Z and Verbeek, P. (2003). Produced Water Management for Sustainable Field Development of Mature and Green Fields. *Journal of Petroleum Technology, Vol 2* (4): 26-48

Khulud, M et al. (2013). Prediction of Reservoir Performance and Applying Decline Curve Analysis. *International Journal of Chemical Engineering and Applications, Vol 4* (2): 81-116

Kombo, D and Tromp, D. (2006). *Proposal and Thesis Writing: An introduction*. Nairobi: Pauline Publications.

Lado, A. (2022). *The Impact of Floods on South Sudan Oilfields*. Nile Fortune Printers

Lama, A. (2018). Death Tolls in South Sudanese Conflicts. *Crisis Group Report*. New York.

Malmqvist, J et al. (2019) Conducting the Pilot Study: A Neglected Part of theResearch Process? Methodological Findings Supporting the Importance of Piloting in Qualitative Research Studies. *International Journal of Qualitative Methods, Vol 18*(1): 1-11

Marila, C. (2018). Civil Wars and Oil Production Decline in South Sudan. *IRIN News.*

Markus, U. (2015). *Oil and Gas: The Business and Politics of Energy*. Palgrave Macmillan Publishers.

Mathiang, K. (2022). Egyptian Government to Dredge River Nile. *Eye Radio News*.

Mohammed, A. (2015). *EOR/IOR Technologies and Production Increase*. University of Khartoum Press

Morita, N and Boyd, P. (1991). Typical Sand Production Problems: Case Studies and Strategies for Sand Control. *Oil and Gas Reservoir Journal, Vol 1* (5): 119-139

Moro, L. (2017). Oil Conflict and Displacement. *Unpublished Thesis.*

Mun, A. (2014). International Conference for Investments Kicked Off in Juba. *Investors Corner Brief*. Juba.

Mwape, P. (2009). An Impact of Floods on the Socio-Economic Livelihood of people: A Case Study of Sikauzwe Community in Kazungula District of Zambia. *PhD Dissertation.* University of the Free State.

Ngor, D. (2021). 240 Oil Wells Submerged in Flood Waters in Paloch. *Eye Radio News,* Juba.

Orodho, A and Kombo, D. (2002). *Research Methods*. Nairobi: Kenyatta University, Institute of Open Learning.

Pitia, L. (2022). The Devastation of High Water Cut in Paloch Oilfields. *Eye Radio News*.

Rapor, F. (2015). A critical Review on Sand Production Prediction Methods and Mitigation for Chemical Enhanced Oil Recovery (CEOR) Wells. *Dissertation*. University Technology of PETRONAS.

Robelius, F. (2007). Giant Oilfields-The Highway to Oil: Giant Oilfields and Importance for Future Oil Production. *Doctoral Thesis*. Uppsala University.

Riak, J. (2021). *South Sudan State Formation: Failures, Shocks and Hopes*. Africa World Books Press.

Santaralli, M eta al. (1991). Optimizing the Completion Procedure to Minimize Sand Production Risks. *Journal of Optimization of Sand, Vol 1* (6): 41-50

Stein, N. (1988). Determine Properties of Friable formation Sands. *World Oil Journal, Vol 206* (3): 33-37

Stephenson, M. (1992). *A Survey of Produced Water Studies*. Plenum Press.

Swine, S. (2021). *Oil and Gas Technological Revolution*. MIT Press

Tekle, T. (2008). South Sudanese Leaders and Signing Syndrome Disease. *Institute of Security Studies*. Addis Ababa.

Tiitmamer, N. (2022). To Dredge or Not to Dredge the White Nile Tributaries: Is the Cart before the Horse? *Weekly Review: The Sudd Institute, Juba.*

Veil, J et al. (2004). White Paper Describing Produced Water from Production of Crude Oil, Natural Gas and Coal Bed Methane. *U.S. Department of Energy: Argonne National Laboratory.*

Vijouyeh, A et al. (2017). Investigation on Sand Production Problems and Its Mechanisms. *Petroleum & Petrochemical Engineering Journal, Vol 1* (4): 111-142

Wabala, W. (2020). Floods and Floodplains. *Journal of Hydrology, Vol 2* (6): 62-81

Waweru, S. (2022). *Dykes as Solution for South Sudan Floods*. Palgrave

Weyler, R. (2020). *The Decline of Oil Has Begun*. Green Peace International.

Yamane, T. (1967). *How to Calculate a Reliable Sample Size in Field Research*. Harvard University Press.

Zoback, D and Mastin, L. (1985). Wellbore Breakouts and In Situ Stress. *Journal of Geophysical Research, 90* (7): 5523-5530.

8. APPENDICES

8.1. Research Questionnaire

Research Questionnaire

Introduction

Hello! My name is **Jacob Dut Chol Riak,** a student of Uganda Christian University (UCU), School of Business of the Institute of Petroleum Studies-Kampala pursuing MBA in Oil and Gas Management. I am carrying out a Study entitled **"Understanding theOil Production: Investigating Factors Affecting the Oil Production Decline in Block3 & 7 of South Sudan (2017-2022)",** as full requirement of award of MBA in Oil and Gas Management. I am humbly requesting you to take your time and answer *All the Questions* herein with honesty and sincerely. Having you as a respondent in this research is vital and mostly appreciated and your response will be treated withutmost confidentiality. This is an advanced Study and the Researcher shall greatly appreciate your critical response to every question.

Part A: Origin and Concept Oil Production Decline

Please tick **(√)** the appropriate box where there are alternative answers and answer the question that follows if provided.

1. Do you know the origin of oil production decline? **Yes** ( ) **No** ( )
2. If Yes, where and when?_____If No, proceed to **Question 3.**
3. Which of the following explain the meaning of oil production decline?
   a) Steady increasing of production rate of a given oilfield ( )
   b) Steady reduction of production rate of a given oilfield ( )
   c) Removing the rigs from the oilfield ( )
   d) Production of waxy crude oil ( )
4. Which of the following countries has the highest global oil production decline between 2017-2022?

a) United States ( )
b) Russia ( )
c) Iran ( )
d) Angola ( )
e) Nigeria ( )

Give reason (s) for any of your choice above:

_____
_____
_____
_____
_____
_____

5. Which continent in average has the highest oil production decline between 2017-2022?

a) North America
b) South America
c) Asia
d) Europe
e) Africa

Give reason (s) for any of your choice above:

_____
_____
_____
_____
_____
_____
_____

PART B: Factors Affecting the Oil Production Decline for Block 3 & 7 of South Sudan.

Please tick **(√)** one box whenever applicable and explain where necessary.

6. Do you think South Sudan is experiencing oil production decline? **Yes** ( ) **No** ( )
7. If yes, what factors are responsible for this oil production decline?

   _____

   _____

   _____

   _____

   _____

8. Rank the following factors in order of importance in oil production decline of block 3 & 7 of Paloch (*5 being the highest and 1 being the lowest*)

   a) High water cut (produced water) ( )

   b) Too much sand produced ( )

   c) Floods and Flooding ( )

   d) Poor Technologies ( )

   e) Wars and violence ( )

9. Base on your choice in question 8, explain the severity of this factor in block 3 & 7 in Paloch

   _____

   _____

   _____

   _____

10. What consequences does this oil production decline have on the following?

a) Government of South Sudan

_____

_____

_____

b) International Oil Companies (IOCS)

_____

_____

_____

c) South Sudanese Citizens

_____

_____

_____

PART C: Solutions to the Oil Production Decline for Block 3 & 7 of South Sudan

Please tick **(√)** the appropriate box where there are alternative answers and answer the question that follows if provided.

11. What do you think are the solutions to the oil production decline?

_____

_____

_____

_____

_____

12. Rank the following solutions in order of importance in improving production in block 3 & 7 of Paloch (*5 being the highest and 1 being the lowest*)

a) Re-injection of water to the reservoirs ( )

b) Use of laboratory to detect too much sand produced ( )

c) Use of dykes and river dredging to reduce floods ( )

d) Use of new technologies such as vertical drilling and Industrial Internet of Things (IIOT) ( )

e) Maintaining genuine peace across South Sudan to improve insecurity in oilfields ( )

13. Base on your choice in question 12, explain the urgency of this solution to raise production in block 3 & 7 in Paloch

_____

_____

_____

_____

14. Whom do you think should provide these solutions to oil production decline?
    a) Government of South Sudan ( )
    b) Dar Petroleum Operating Company (DPOC) ( )
    c) Civil Society Organizations ( )
    d) a & b ( )
15. Give reasons for your choice in question 14:

_____

_____

_____

_____

16. When do you think should these solutions to oil production decline be provided?
    a) Immediately ( )
    b) After a year ( )
    c) In five years time ( )
    d) In ten years time ( )
    e) Never at all ( )

Thank you very much for your cooperation. You are done!!

For any inquiry or further clarification, please contact +211913013886 or email dutsenior@yahoo.com

8.2. Interview Guide/Schedule

Research Interview Guide/Schedule

For Ministry of Petroleum, Dar Petroleum Operating Company (DPOC) and other Senior Oil and Gas Officials in South Sudan

1. Do you know the genesis and origin of the oil production decline?
2. What is oil production decline according to your view?
3. What factors are responsible for this oil production decline globally?
4. What are the solutions for these factors?
5. What factors are responsible for oil production decline in block 3 & 7 of South Sudan?
6. What factor is quite devastating that needs maximum attention?
7. What are the solutions of this oil production decline?
8. What solution do you think is quite urgent to raise the production levels in block 3 & 7?
9. Who should provide this solution in block 3 & 7?
10. When do you think this solution should be availed in block 3 & 7?

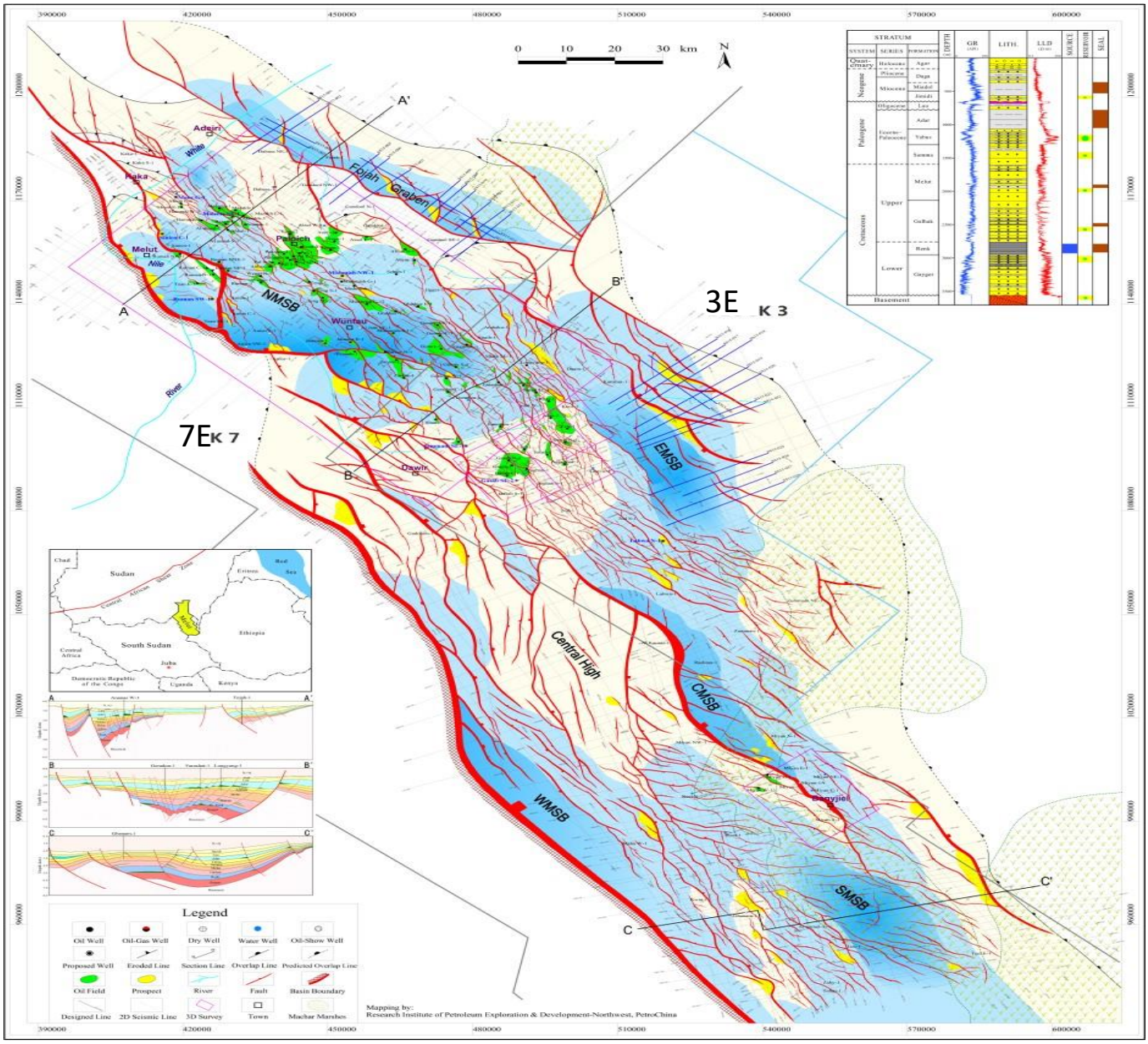
Thank you very much for your attention!

8.3. Research Sites Maps

8.3.1. Map No 1: Research Location Site, Juba City

Source: Voice of America (VOA)

8.3.2. Map No 2: Research Location Site, Block 3 & 7-Paloch



Source: MOP

8.4: Permission Letters to the Field

8.4.1. Letter from Institute of Petroleum Studies-Kampala (IPS-K)

Institute *of* Petroleum
Studies - Kampala

April 27, 2022

TO WHOM IT MAY CONCERN

Dear Sir/Madam

INTRODUCTION FOR MR. JACOB DUT CHOL RIAK TO CONDUCT RESEARCH IN YOUR ORGANISATION

Greetings in the precious name of our Lord.

I wish to introduce to you the above named person, who is a masters student pursuing Masters of Business Administration in Oil and Gas, of Uganda Christian University in affiliation with The Institute of Petroleum Studies Kampala (IPSK).

His proposal has been approved by our vetting committee and is in the process of collecting data. Mr. Jacob Dut would wish to conduct research in your organization.

The title of his research is **"Understanding the Oil Production: Investigating Factors Affecting the Oil Production Decline in Block 3 & 7 of South Sudan (2017-2022)"**

By copy of this letter, all respondents are notified that this study is for academic purposes and as an Institution, we request you to corporate in facilitating this very interesting research project.

Sincerely,

James Mugerwa
Dean of Studies

INSTITUTE OF PETROLEUM STUDIES - KAMPALA
27 APR 2022
DEAN OF STUDIES
TEL: 0776 350 027

Plot 6207 Rose Lane, Off tankhill road Muyenga Kampala - Uganda
Tel: 0414695610 Email: info@ipsk.ac.ug Website: www.ipsk.ac.ug

8.4.2. Letter from Ministry of Petroleum (MOP)

Republic of South Sudan
Ministry of Petroleum
South Sudan Petroleum Authority
DIRECTOR GENERAL'S OFFICE

Date: 1st June, 2022

Ref: **RSS/MoP/J/PA/26/1/2022/1-06/001**

To: **Mr. Hisham Basar**
President,
Dar Petroleum Operating Co. Ltd (DPOC)

Cc: **Mr. Ayuel Akoch Malek**
Vice President,
Dar Petroleum Operating Co. Ltd (DPOC)

Subject: **Recommendation for Mr. Jacob Dut Chol Riak to Conduct Research in Dar Petroleum Operating Company Limited (DPOC)**

Dear President,

Reference is made to the above–mentioned subject; The Ministry of Petroleum is serving you with this letter as a formal recommendation for **Mr. Jacob Dut Chol Riak**, a South Sudanese National who is pursuing Masters of Business Administration in Oil and gas at Uganda Christian University in affiliation with the Institute of Petroleum Studies Kampala (IPSK).

Mr. Jacob Dut Chol Riak has prepared his research proposal with the title **"Understanding the Oil production: Investigating Factors affecting the Oil Production Decline in Block 3&7 of South Sudan (2017–2022)"** which has been approved by the vetting committee of the University for Data Collection.

With regard to that, the Ministry of Petroleum would highly appreciate your facilitation in data collection through his interviews with Office staff and Oilfield staff in the field for the success of his Research Project. Importantly, DPOC is also assured that this study is solely for academic purpose.

Accept the assurances of my highest regards and consideration.

Mr. Simon Chol Martin
Director General for Petroleum Authority
Ministry of Petroleum

Republic of South Sudan - RSS
21/6/2022
DATE
MINISTRY OF PETROLEUM

Cc: Hon. Puot Kang Chol, Minister of Petroleum
Hon. Eng. Awow Daniel Chuang, Undersecretary/MoP
Eng. Deng Lual Wol, Director for Refineries/MoP
File