

Developing thin oil rim reservoirs in Nigeria: A review of investment decisions, local content, and economic development

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Abstract

This study assesses the economics of developing thin oil rim reservoirs located in Nigeria. Due to their unique structure, thin oil rims present production challenges and are economically marginal. As such, this study analyzes how decisions regarding the development of thin oil rim reservoirs are interrelated to returns to operators; job creation and skill development; energy security; and overall economic development of Nigeria. Despite being the largest contributor to Nigeria's export earnings and a substantial source of government revenues, less consideration is given to the economics aspects than to the technical aspects. This paper reviews relevant literature pertaining to both technical and economic issues related to thin oil rims. Based on our analysis, we conclude that the value of an oil rim depends on three factors: The order and timing of decision-making regarding the asset; The operating company's ability to effectively manage/operate the asset; and the regulatory/fiscal/market environment within which the asset operates. Of particular importance is ensuring access to a gas market. All prior studies examined primarily limited themselves to analyzing reservoir performance and relied on simulated results using synthetic models. While prior studies identified plausible relationships between reservoir performance, energy security, job creation/skill development and economic growth; however, previous studies failed to adequately test those relationships. Our study found that major limitation to employment is due skill & local contractors. It provided conceptual framework linking operator decisions to commercial viability and national development outcomes. Identified six propositions that require further empirical testing and provides recommendations for operators, regulators/policymakers and researchers.

Keywords: Economic Development, Investment Decisions, Local Content, Nigeria, Oil and Gas Economics.

1. Introduction

1.1 Background to the Study

Oil is located beneath the earth's surface in a rock known as a reservoir. Typically, many reservoirs contain 3 fluids layered. Gas floats on top of oil in the middle layer, while water rests at the bottom. The gas layer at the top is referred to as the "gas cap," whereas the water layer at the bottom is referred to as the "aquifer." When a reservoir contains only a thin oil rim, the layer of oil within the middle of the

reservoir will be quite thin. Thin oil rims are defined to be no greater than 100 feet thick. Ultra-thin oil rims exist if the thickness is below 30 feet (Molokwu et al., 2024; John et al., 2025). Thin layers of oil are challenging to produce due to their nature. Fluid moves toward a well when a well is producing. Due to the limited space available in a thin oil rim layer, the draw caused by pulling oil from the formation creates both upward movement of water

through the bottom of the formation and downward movement of gas through the top of the formation. Both gas and water move toward the well in a conical pattern creating what is known as "coning" once either gas or water reach the well, there is less oil being produced and more gas or water being produced (Onukwuri & Azubuike, 2020; Amirul & Woobaidullah, 2022). Both the gas cap and aquifer assist with pushing oil toward wells providing energy for natural drive for the reservoir (Smithson, 2024; Baruah et al., 2021). However, since removing gas causes a drop in pressure and reduces this energy source, oil companies have typically preferred to develop thicker oil layers. Consequently, numerous oil rims have remained undeveloped or developed only during secondary phases of gas production. Developing an oil rim is also an economically based business decision and a relatively small asset base, thus the fixed costs associated with wells and processing facilities must be recovered from a small volume of oil. Additionally, whether or not the operation makes money will depend upon several factors including: timing of oil and gas production, capital expenditures associated with drilling wells, and potential revenue generated from sales of gas. Why this topic is important for Nigeria was stated earlier. Petroleum remains the backbone of the Nigerian economy. These reservoir characteristics are technical issues; however, they impact the cost of a project, the associated risks, and ultimately, a manager's decision to fund the project. That managerial decision will be based upon factors outside the reservoir including the degree of dependence on petroleum by the nation, how the government assigns/charges for an area, and whether there is a domestic market for the gas. Those national trends are illustrated in the table below for Nigeria.

The Nigeria Extractive Industries Transparency Initiative (NEITI) reported that petroleum products accounted for approximately 72 percent of all total export revenues and foreign exchange earnings and approximately 41 percent of government revenue. The NEITI report also indicated that the companies operating within the petroleum industry provided employment to approximately 19,000 individuals (NEITI, 2024). The National Bureau of Statistics (NBS) provides data showing a similar trend for crude oil exports for Q3-2025. Total crude oil exports were 12.81 trillion-naira accounting for approximately 56.14% of total export earnings of 22.81 trillion naira (AllAfrica, 2025). The differences in percentages are likely related to time frame and metrics used. The government has offered additional marginal field opportunities to operators so that existing discoveries may begin production. In April 2024, for example, the regulatory body announced a call for bids on 17 new fields. Five had been previously advertised and failed to attract bidders and therefore were carryovers from the previous year's round. The agency estimated that successful development of the fields could generate tens of billions of dollars (Udi, 2024; News Agency of Nigeria, 2024). Thinly oil rim reservoirs represent one type of marginal field opportunity. Producing the gas above the thin layer could provide additional sources of energy domestically. Therefore, who develops thinly oil rim reservoirs, and how they are developed impacts energy supplies, employment/skills and fiscal revenue for Nigeria.

1.2 Statement of the Problem

Petroleum engineers have researched on oil rim reservoirs. Researchers from economics/management have studied very few topics regarding oil rim reservoirs. While research papers comparing recovery rates have been prolific among petroleum engineers' publications; few have gone

further. Resource economists and authors writing on local content have discussed national-level benefits resulting from developing thin-layered reservoirs; however, neither group has considered how technical decisions made to develop those reservoirs impact the final outcome at the national level.

This disparity creates problems in terms of making poor choices. While a plan designed to maximize recovery may provide the greatest amount of recoverable hydrocarbon reserves, it will often require additional wells, and potentially hold gas off line for longer periods of time. As a result, this plan may be more costly than alternative plans that are less effective from a recovery standpoint but do not require holding large amounts of gas off-line (and thus providing cash flow). Additionally, when a company selects a development plan strictly on the basis of percent recovery, it may select a plan that is economically inferior to other alternatives. Furthermore, companies may select development plans that result in no net gain for the nation; i.e., they may forego producing hydrocarbons that would generate revenue for both themselves and the nation.

It exists primarily due to different objectives being pursued by engineers and economists/managers. Engineers seek to determine methods to produce the maximum amount of hydrocarbon from the reservoir. Economists/managers seek to identify which development plan provides the largest return relative to the level of risk. Because engineers rarely evaluate economist/managers findings, and vice versa, neither group evaluates whether their recommended plan(s) represents either the technically superior plan or the economically superior plan.

1.3 Aim, Scope and Contribution

This study attempts to describe how decisions relating to development of thin-layered oil rim reservoirs affect

profitability for the operator and national-level outcomes in Nigeria, mainly, employment/skill-building energy independence, and general economic development. This study represents a narrative review. Technical articles/papers, economics texts/laws/institutional reports relevant to thin-layered oil rim reservoirs are read and compared. Also included in this study are four case studies from Norway, Indonesia, Malaysia, and Nigeria. The most significant contribution of this study lies in presenting a straightforward framework linking three stages. Stage 1 relates to decisions made by operators. Stage 2 describes the commercial viability created as a result of these decisions. Stage 3 presents national outcomes resulting from stage 2 decisions. Petroleum engineering literature rarely links these stages together. Simulation results are not presented as part of this study. Technical aspects are kept low enough so that readers with backgrounds in economics/business can understand the logic behind this study's arguments.

Research Questions

- RQ1. What technical/commercial characteristics makes developing thin oil rim reservoirs as finally risky investment?
- RQ2. How do the development plan, the timing of production, and decisions on wells and injection affect the value of an oil rim to the operator?
- RQ3. What do fiscal, regulatory and local content conditions imply for employment and skills in oil rim development?
- RQ4. Under what conditions can oil rim development contribute to energy security and economic development in Nigeria?

2. Literature Review

2.1 Thin Oil Rims as an Investment Problem

An oil rim is distinguished by the geometry of the oil layer itself rather than the geologic quality of the rocks that contain it. Typically, the oil layer is much thinner

than both the gas cap above it and the aquifer beneath. Therefore, under typical operating conditions, the boundaries between these three separate fluids remain relatively flat. However, once oil begins to flow through a well, then the decrease in pressure surrounding the well causes additional drawdown toward the well. Coning theory provides an upper limit on this drawdown. The limit is referred to as the "critical rate." Critical rate is defined as the maximum amount of oil that can be produced before a cone forms and touches the wellbore (Meyer & Garder, 1954).

The critical rate is dependent upon the size of the oil layer. If the oil layer is particularly thin, then the critical rate will be quite low. As such, many rates that appear attractive to an operator would actually result in a cone reaching the well and thus greatly limiting production. There are three major practical limitations resulting from the existence of cones.

First, there is a significant likelihood that gas will arrive at the well prior to achieving commercial quantities of oil, causing a rapid increase in gas/oil ratios. Gas/oil ratios are expressed as volumes of gas produced per unit volume of oil produced. At sufficiently high values of gas/oil ratio, the well is no longer economically viable. Secondly, water arrival will cause an increase in water cut. Water cut is defined as the percentage of total fluid produced by water. Producing water requires lifting and separation from hydrocarbons followed by disposal at considerable expense (Amirul & Woobaidullah, 2022; Onukwuri & Azubuike, 2020). Finally, since the gas cap, oil layer, and aquifer are hydraulically interconnected, a reduction in pressure within one of them results in decreased pressure within the others. Decreased pressures allow movement of oil from the oil rim into the gas cap. Due to its very small pore space, recovering oil from the gas cap is extremely difficult.

Screening typically addresses these issues. Screening involves determining whether or not the proposed development plan corresponds to the thickness of the oil layer as well as to the size of both the gas cap and aquifer (Lawal et al., 2010, 2020; Samsundar et al., 2005). Since screening represents a preliminary step that can be used to identify incorrect plans prior to finalizing them at greater financial risk than necessary, it is typically conducted initially. Many textbooks provide detailed descriptions of coning and those factors that influence it (Ahmed, 2010; Economides et al., 2013). Other studies describe physical phenomena relevant to coning and drawdown. Permeability controls how quickly water moves into the well bore relative to oil flow (Zhang et al., 2018). Permeability changes due to dissolved gas (Liao et al., 2024). Gravity drives downward drainage of oil (Zobeidi et al., 2022). Review articles cover flow problems encountered in wells (Asheesh, 2023) while general reviews of reservoir mechanics are provided by Aminian (2016), Ibbelwaleed et al. (2023), and mechanistic/field studies support these findings (Alokla et al., 2020; Igamberdieva et al., 2024). Each reservoir requires careful planning for optimal placement and ordering of wells. In addition to being physically challenging, these planning challenges represent significant investment risks due primarily to irreversibility.

Once gas is produced and/or once pressure decreases in an oil rim reservoir it becomes very costly to restore that pressure again. Platforms, wells and pipelines are examples of sunk costs, they cannot be recovered if a project were terminated. Further complicating matters is that future cash flow from an oil rim ultimately depends on both a functioning gas market and tax system over which an operator has little control. Such investments represent irreversible spending under uncertainty, e.g., investment decision.

2.2 The Masoudi Development Concepts

Masoudi et al. (2013) defined four concepts for developing oil rims. Each concept responds to the same issue. The two fluids (oil and gas) exist in interdependent zones of a reservoir. Therefore, decreasing the pressure required to support either fluid with the extraction of one will decrease the pressure needed to extract the other fluid. As such, the recovery of each fluid depends upon the order in which the other fluid was extracted. The four concepts discussed

within Masoudi et al. (2013), as stated in Table 1 are explained in simple terms: Concurrent Production: Producing both oil and gas simultaneously from the beginning. Although revenue is generated earlier, the oil is exposed to cone effects from the top and bottom. Sequential Production: Extracting one fluid before extracting the second. Operators may prefer to extract the oil first to protect it from being damaged during the extraction process.

Table 1. The Four Masoudi Development Concepts in Qualitative Terms

Concept	Core idea	Main exposure	Typical fit
Concurrent	Oil and gas produced together from the start	Pressure falls quickly; coning from both sides	Larger oil columns with a moderate gas cap
Sequential	One fluid produced first, the other held back	Deferred revenue from the held-back fluid	Stronger oil column, smaller gas cap
Swing	Production moves between oil and gas as conditions change	More complex operations; facility switching	Where flexibility is valued
Gas cap blowdown	Gas cap produced down as the main energy source; oil timed against pressure decline	Permanent oil loss if timing is wrong	Very large gas cap, thin oil layer, strong gas market

Note. Qualitative summary based on Masoudi et al. (2013) and the studies discussed in the text. The “typical fit” column is a guide, not a rule.

Conversely, operators may choose to extract the gas first to generate immediate revenue. Swing Production: The focus shifts between oil and gas depending on changing reservoir conditions. This provides the most flexibility of the four options; however, it complicates operations. Gas Cap Blowdown: The primary source of revenue is generated by producing the gas cap downward. Simultaneously, the oil is extracted while maintaining optimal pressure decline.

A key factor regarding an operator's investment perspective is that these concepts represent alternative methods of allocating revenue, risk and money. Gas cap blowdown generates revenue from gas early in the life cycle of a reservoir. However, if timing is incorrect, it could permanently reduce oil recoverability. Sequential production prioritizes protecting one revenue stream over generating revenue from the other (Masoudi et al., 2013; Olabode et al., 2022). Recent research conducted in Nigeria studied these alternatives. Two recent studies were focused on oil rim development. One of these studies analyzed concurrent production of the gas

cap and oil rim simultaneously in a saturated reservoir (Alaigba et al., 2024). Another study utilized simulation to

evaluate oil productivity resulting from gas cap blowdown (Oluwasanmi et al., 2022).

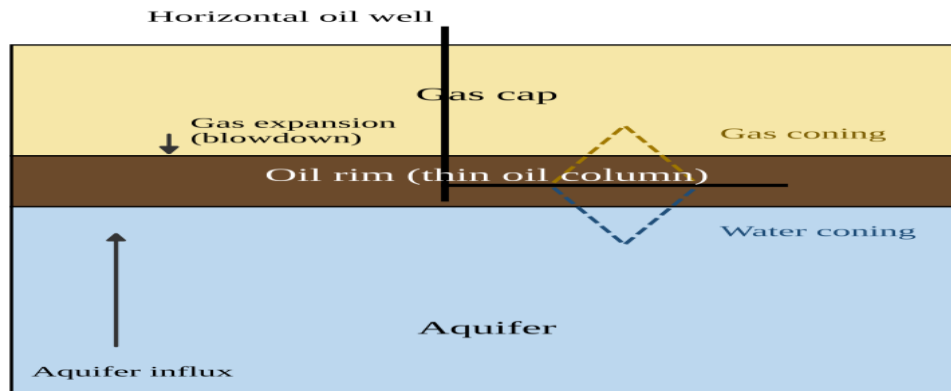


Figure 1. Schematic of a thin oil rim between a gas cap and an aquifer (not to scale)

2.3 Theoretical Framework

The Resource-Based View Theory states that a firm develops a sustainable competitive advantage through resources and abilities that are difficult to duplicate and/or are scarce (Barney, 1991). Within oil rim development, examples include describing reservoirs, designing horizontal and smart wells, coordinating simultaneous oil and gas production and managing produced water. This theory explains why one firm can economically develop an asset that another firm views as subeconomic. Additionally, this theory aids in explaining why many marginal fields change ownership. Investment Under Uncertainty Theory addresses situations in which irreversible capital expenditures occur and future outcomes are uncertain (Dixit & Pindyck, 1994). Waiting has a financial value in such cases. The timing of investments and oil production constitutes a valuable decision-making choice (Dixit & Pindyck, 1994). Net Present Value (NPV) and Internal Rate of Return (IRR) are typically used to evaluate investment opportunities (Chen, 2022). NPV translates all future cash flows into today's dollars, whereas IRR

represents the discount rate at which NPV equals \$0.00. Both measures treat each decision as "now or never," thereby potentially undervaluing the option to delay. This potential drawback is especially relevant for oil rims due to their dependency on sequence of production. Institutional Theory posits that organizations are shaped by rules, norms and institutions (DiMaggio & Powell, 1983; North, 1990). Examples of institutions include tax regimes, licensing practices and local-content requirements. Institutions determine how much of a project's value remains with the organization, workers and government. National-Outcome Theory defines energy security as availability, affordability and reliability of energy supplies (Yergin, 2006; Kruyt et al., 2009). Resource Curse Theory cautions that wealth derived from natural resources alone does not automatically lead to economic growth; rather, the quality of institutions determines whether wealth results in growth (Sachs & Warner, 1995; Ross, 2015). The four theories provide empirical support that an oil rim contributes national value when a capable organization successfully coordinates decisions under uncertainty and when institutions facilitate sharing of benefits. This assertion forms

the basis of discussion presented in Section 4.

2.4 Empirical Review of Decision Levers

Oil rim engineering studies commonly examine a limited set of decision variables. A decision variable is an action taken by an operator that can vary. Most oil rim engineering studies use reservoir simulation to test one decision variable at a time. Reservoir simulations involve running computer models of reservoir behavior. Models are commonly either synthetic models constructed with

assumed reservoir rock and fluid properties or based on actual field data. Table 2 organizes findings related to decision variables and identifies gaps in economic analysis.

The table has all of the other information about the source of data for each element (the type of well, the general reading or measurement of the data and the missing economics) as shown in Table 1; therefore, this is additional information beyond that which can be presented by the table.

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Table 2. Decision Levers in the Oil Rim Literature and Their Economic Relevance

Lever	Sources	General reading	Missing economics
Timing sequencing	Masoudi et al. (2013); and Onukwuri & Azubuike (2020); Olabode et al. (2022)	Timing of oil relative to gas production is decisive	Value of waiting rarely priced
Well design placement	Aladeitan & Akinyede (2016); Ikputu et al. (2022); John et al. (2025)	Horizontal wells delay breakthrough but cost more	Cost and benefit rarely compared
Production rate	Olabode et al. (2018)	Controlled rates reduce coning and decline	Trade-off with gas revenue not studied
Reservoir attributes	Molokwu et al. (2024); Obinaba et al. (2024)	Gas cap size and aquifer strength decide feasibility	Screening not tied to appraisal
Pressure maintenance	Olabode (2020); Olabode et al. (2021); Hofmann et al. (2022); Onyekonwu et al. (2023)	Injection restores energy and recovers residual oil	Water and gas sourcing costs overlooked

Note. The “general reading” column is the authors’ summary of the sources named. It shows direction only.

Timing and sequencing

When we look at what happens during gas cap blowdown, timing is seen as being the most important factor. Onukwuri and Azubuike (2020) studied gas blow down as a method for increasing the recovery of oil from an oil rim in Nigeria’s Niger Delta. Olabode et al. (2022) developed a synthetic data set to enable comparison between the results of oil wells commencing production

at various points in time. Their model contains a large gas cap, a very strong aquifer and an oil layer less than 30 feet thick. According to their model, if there is a large gas/oil ratio in the first phase of production then the pressure will drop rapidly and reserve loss will occur. They published their model as a template for future research into secondary recovery.

Well design and placement

Horizontal drilling is now commonly adopted for oil rims. Horizontal drilling means that the wellbore extends sideways

across the width of the oil-bearing formation, thereby spreading the draw-down on the fluids across a much greater length of the formation and delaying coning. However, this requires additional costs for drilling (Aladeitan & Akinyede, 2016; Ikputu et al., 2022). There are also proposals for multi-purpose well placements (John et al., 2025). Additionally, researchers seek to determine what type of well is best suited to oil rims with large gas caps and strong aquifers (Shadrach et al., 2018; Nwakama et al., 2020). Some researchers investigate how horizontal wells should be positioned to optimize both oil and gas co-production (Oluwasanmi et al., 2021), while others examine how the positioning of wells can reflect the location of fluid boundaries (Sunny, 2024). Also, other researchers have modeled the behavior of gas and water coning subsequent to breakthrough (Oluwasanmi et al., 2019). All of these studies acknowledge that cost is a significant factor but do not typically quantify it. Therefore, the engineering justification for using horizontal wells is stronger than the economic justification that can be provided for use of horizontal wells.

Production rate and reservoir attributes

As seen in Table 2, controlling the flow rate will help prevent coning. The size of the gas cap and the potential of an aquifer will determine if it is possible to control the flow rate. There is also another conflict that is not shown in the table. If you are implementing a gas led program, then the gas cap must have enough flow to generate income from the gas operation, while the oil layer must be operated with very low flow rates. However, few researchers have addressed the issue of determining how much of the total flow rate should go to the gas wells versus the oil wells within a single plan.

Intelligent completions and multilateral wells

A completion refers to the equipment used to connect a well to its respective producing reservoir. Smart completions allow operators to control flow from individual intervals remotely and have been suggested to mitigate unwanted gas and water ingress (Naziru et al., 2019; Afuekwe & Bello, 2019; Usiosefe & Onaiwu, 2021). Multi-lateral wells have multiple branches from a common borehole and have been assessed using fiber optic monitoring (Konstantinovich et al., 2021); smart horizontal wells were used in Malaysia (Keng et al., 2014). While these technologies can add cost, their potential value is dependent upon whether they reduce the number of wells required to complete an oil rim development or increase ultimate recovery per well. Most studies report on technical advantages rather than comparing cost to benefits.

Pressure maintenance

Maintaining the reservoir pressure via either water or gas injection maintains reservoir pressure and usually accompanies depletion schemes. There is consensus that the strategy employed, injection rate, and location of injection significantly impact performance (Hofmann et al., 2022; Onyekonwu et al., 2023; Olabode et al., 2021; Du & Nojabaei, 2020). Additional work compares secondary recovery techniques for oil rims (Nnaemeka et al., 2023); investigates the effectiveness of water injection (Onwukwe et al., 2019); and evaluates foam and alternating gas-water injection (Olabode et al., 2018). Enhanced Oil Recovery general reviews provide context for these approaches (Malozyomov et al., 2023; Karimov & Toktarbay, 2024).

What the levers show together

The general trend of the various studies are shown in Table 2. All the studies have identified the same direction of the levers (capillary pressure and relative

permeability), but they did not reach agreement on the magnitude due to differences in model assumptions regarding reservoir characteristics such as gas cap size, aquifer strength, rock permeability and base cases. A user looking to use a numerical value for investment evaluation will not be able to move the result to another basin. Additionally, most of the quantitative work was conducted using black oil simulators that treat oil and gas as simply a mixture with assumed or averaged properties (Dhya et al., 2025; Olabode et al., 2022). Black oil simulators are well-suited for evaluating different scenarios under controlled conditions. However, the results generated from these types of simulators are dependent upon the base case selected.

Economic evidence

A limited number of studies applied discounted measures to evaluate oil rim development options (Onwukwe, 2018). For all fields outside of oil rims, however, there is much more information available related to the economic viability of producing gas when no commercial market exists. A World Bank study conducted by Tractebel Engineering (2015) evaluated both compressed and liquefied natural gas supply chain alternatives for low volumes of associated gas and concluded that gas volume and transportation distances were the two primary factors driving costs. These are key considerations for an oil rim. Gas from the cap or from associated production can represent a small volume far from commercial markets and therefore the same cost drivers would determine if the gas is to be produced and sold, retained or flared. The remaining missing link is fiscal terms, which will be addressed in section 2.6. Overall, while useful, the existing literature has many gaps. Most studies isolated single variables (i.e., capillary pressure and/or relative permeability), reported recoverable reserves without accounting for the

additional burdens created by produced water and ended their analysis before addressing economic issues.

2.5 Illustrative Cases

Troll, Norway

One of the most recognized examples of thin oil developments is Troll. The Norwegian Offshore Directorate (no date) reports that Troll Vest was initially found to contain approximately 22 to 26 meters of original hydrocarbon column height beneath a small gas cap. Oil production occurs by way of long horizontal wells drilled through the thin oil column immediately above the oil/water contact. After decades of production, the remaining oil column thickness has decreased to approximately 1 to 5 meters, and there is a substantial amount of remaining oil located below this column.

This example illustrates two aspects of thin oil development emphasized throughout the literature. Design of horizontal wells is critical to successfully producing a thin column. Additionally, accessing oil remaining in the reservoir after decades of production can be challenging and costly. Troll also demonstrates the importance of sequence of operations. Gas production in the field commenced in 1995, followed by the start-up of oil production from Troll C in 1999 and finally gas production from Troll Vest commenced in late 2021 (Norwegian Offshore Directorate, no date). The Troll Field was developed first as a gas project with subsequent oil production occurring based upon the constraints created by the gas development. This represents a similar logic to that employed in a gas-led plan. Equinor (2015) provided additional information regarding Troll. At the end of 2015, Troll had produced approximately 1.56 BBO from approximately 200 wells and all wells producing oil were horizontal. At this time, the oil recovery factor was 40%; however, the operator's objective was to achieve an ultimate recovery factor of 52%.

Gunung Kembang, Indonesia

The Gunung Kembang field in the South Sumatra Basin represents a more conservative example than Troll. Febrianto and Aimar (2008) described a carbonate reservoir containing a thin oil rim having a gross pay of approximately 25-40 feet with a very large gas cap and a considerable aquifer. Horizontal wells had been employed since 1992 to mitigate coning. Despite these efforts, at the time of their study, oil recovery was less than 3%. A horizontal well drilled in 2004 encountered water break-through and ultimately lost its integrity. The authors viewed this event as indicative that risk levels increase as pressure decreases. They concluded that employing horizontal oil wells in the upper portion of the thin oil rim proximal to the gas/oil interface represented the optimal strategy for integrating hydrocarbon production from the Gunung Kembang field. They also advocated for utilizing the produced gas to fulfill a gas commitment within the Plan of Development. As such, oil recovery was anticipated to increase to approximately 8%. The example clearly illustrates how narrow the margin may be; how rapidly risk grows as pressure declines; and how commitments related to gas utilization can influence actions with respect to oil.

Smart horizontal wells in Malaysia

A recent article published in the *Journal of Petroleum Technology* (2015) presents examples of "smart" horizontal wells drilled in thin oil rims in Malaysia where drilling, completions engineering, well placement and trajectories were considered collectively. The authors indicated that such an approach could decrease the number of wells required to produce reserves and enhance overall recovery rates per well; however, due to lack of data, they were unable to present specific metrics. From an economic perspective, fewer wells with enhanced designs result in lower capital expenditures and decreased

exposure to coning. Discounted cash flow-based appraisals would capture this benefit; however, comparative evaluations of recovery factors would fail to recognize this advantage.

The Nigerian marginal-field programme

The fourth example presented involves Nigerian fields. The Nigerian National Petroleum Corporation announced awarding 57 fields to 161 companies during its 2020 Marginal-Field Round (Arise News, 2021). The regulator announced its second Bid Round offering 17 fields in 2024; twelve were entirely new and five were carry-over from the regulator's previous round (News Agency of Nigeria, 2024). The regulator stated that it would ensure fairness and transparency during each stage of the bidding process pursuant to Section 73(1) of the Petroleum Industry Act. It also indicated that it would review awarded acreage for active versus inactive status (News Agency of Nigeria, 2024). The regulator's public comments focused on increasing revenues rather than establishing employment or local capability requirements. Accordingly, a license may assign operationally demanding acreage to an operator lacking the necessary technical skill or financial resources to develop those assets.

2.6 The Nigerian Policy Context

the Nigerian policy context is of relevance to thin oil rims. Firstly, there is an enormous reliance by the federal government on oil for both revenue and foreign exchange; secondly, there is a history of the government's preference for marginal and undeveloped assets as evidenced by the previous licensing rounds (Udi, 2024); thirdly, the regulatory framework governing the industry has changed with the passage of the Petroleum Industry Act 2021. The Petroleum Industry Act 2021 transformed the sector. In addition to other reforms, one provision of the Petroleum Industry Act 2021 requires

operators to establish a trust fund from which they will provide funding to host communities. The trust is required to be funded at a minimum of three percent of each operator's total operating expense annually (Federal Republic of Nigeria, 2021).

Fiscal Terms of the Petroleum Industry Act
The changes made by the Petroleum Industry Act 2021 to fiscal terms create a differential impact upon marginal fields and deep-water assets, and it is this difference that affects how much oil rims can produce. The royalty rate paid on crude oil is fifteen percent in all onshore areas, 12.5% in shallow water and 7.5% in deep water. The royalty rate drops to five percent where a field produces less than fifty thousand barrels per day of oil. There is also a hydrocarbon tax that replaced the petroleum profits tax. The hydrocarbon tax rate is thirty percent on all petroleum mining leases located in onshore areas or in shallow waters. The hydrocarbon tax does not apply to profits earned in deep water (Morgan, Lewis & Bockius LLP, 2021). Therefore, operators of marginal fields must pay both hydrocarbon tax at fifteen percent plus their corporate income tax at thirty percent. When combined these taxes lower the headline tax rate from eighty-five percent to forty-five percent. However, there may still be additional taxes owed due to restrictions placed on deducting interest expenses and capping deductions based on sixty-five percent of gross receipts (Gbenga-Dada, 2022). With respect to thin oil rims, this cap could have adverse impacts since a large number of wells and significant amounts of water handling increase costs associated with production and sales of very low volumes of oil. Gas is treated more favorably. The royalty rate applied to natural gas is five percent and drops to 2.5% when the gas is utilized domestically. Additionally, natural gas whether associated or unassociated with oil production is exempt from

hydrocarbon taxation. Finally, companies utilizing gas as a feedstock for manufacturing purposes can receive a five-year tax holiday (Morgan, Lewis & Bockius LLP, 2021). Consequently, the favorable treatment afforded to domestic sales of gas favors those conceptual approaches that include domestic sale of gas such as those described in Chapter 2. The reserve information provided above indicates why the gas is significant. On 1 January 2025 the National Upstream Regulatory Council (NUPRC) stated that Nigeria's proven plus probable reserves (2P) at that date were 31.44 billion barrels of crude oil and 5.84 billion barrels of condensate, resulting in total reserves of approximately 37.28 billion barrels. At that date gas reserves were approximately 210.54 trillion cubic feet (tcf), of which approximately 101.03 tcf, or around 48%, was associated gas (i.e., gas found together with oil). The reserve life for these reserves was approximately 64 years for oil and approximately 93 years for gas (ThisDay, 2025). Therefore, all of the gas that will be produced when developing an oil rim field will be classified as associated gas.

The Nigerian Oil and Gas Industry Content Development Act 2010 encourages local participation in the upstream sector. The key components of this legislation are outlined in a legal review of this Act (Mondaq, 2015.). This Act requires operators to consider first the opportunity to utilize Nigerian goods, services and labor. In order to bid on a license to operate a project within Nigeria operators must prepare a Nigerian Content Plan prior to bidding on the license and prior to commencing operations. Similarly, prior to commencing operations, operators must prepare and submit an employment and training plan. There is a cap on expatriate personnel employed in managerial positions for each project of five percent. Furthermore, a company is considered a Nigerian company if it has a minimum of

fifty-one percent shareholding by Nigerians (Federal Republic of Nigeria, 2010; Mondaq, 2015). All of these regulations directly impact the amount of economic benefit that can reach into the broader economy from any technical innovation.

The published gas volumes indicate the size of the domestic gas market into which rim gas would flow. In respect of July 2025, the Federal Pipeline Agency reported that daily natural gas production had increased from approximately 6.99 billion cubic feet per day in July 2024 to approximately seven point five nine billion cubic feet per day in July 2025. The percentage of production flared was 7.16% representing the lowest since at least two years ago and the domestic gas delivery obligation was 72.5%. Similarly, according to this report, during the period to date in 2025 twenty-seven-point eight two percent of production had been delivered into the domestic gas market and natural gas being supplied to power plants was in excess of eight hundred sixty-three million cubic feet per day (Sweetcrude Reports, 2025).

Therefore, while there appears to be both increasing volumes of gas entering the domestic market and an increasing proportion of production being directed toward meeting the requirements of domestic demand, it is also evident that there continues to exist a substantial portion of output that is not utilized domestically. Consequently, for an operator involved in the development of an oil rim field there is clearly an existing potential outlet for gas; however, accessing this outlet will depend upon the availability of adequate pipeline infrastructure, processing facilities and appropriate supply terms.

In addition to these physical aspects related to the transportation and distribution of gas into the domestic market, there are also other aspects that relate to the ability to

deliver sufficient quantities of gas into the domestic market. These include the existence of regulatory frameworks designed to support such deliveries and local content arrangements. Local content results are generally reported as totals rather than segmented by individual category. However, in respect of total content levels the Nigerian Content Development and Monitoring Board states that overall Nigerian content levels increased from five percent in 2010 to sixty-one percent (Nairametrics, 2026) and that a one percent deduction for funding purposes to support content development activities continued until at least 2025 (Nairametrics, 2026). Although no definition is available for what constitutes "Nigerian Content" in this context, it is apparent that this number represents the Nigerian Content Development and Monitoring Board's own metric regarding Nigerian Content rather than as a share of employment.

2.7 Energy Security and the Resource Curse in the Nigerian Setting

National questions about energy security are framed within two bodies of knowledge. Energy security research identifies multiple aspects of security of supply. Availability, Affordability, Reliability and Diversity all relate to potential indicators of security of supply (Yergin, 2006; Kruyt et al., 2009). Producing countries face many different challenges than do consuming ones. Although Nigeria is a major oil producer and exporter, there continue to be many challenges related to providing electricity and accessing fuel to end-users. Therefore, for Rim Gas, the issue is not simply how much is produced but also if it reaches consumers in a reliable manner. This will depend upon both the physical distribution infrastructure and the price of the product as much as it will depend on the quality of the reserve. Resource curse literature examines why countries rich in resources

typically grow at lower rates. Initial cross-country analyses reported a significant inverse correlation between resource richness and economic growth (Sachs & Warner, 1995). One possible explanation is that increased demand for a country's export commodity increases the relative price of exports during periods of high demand creating disincentives to export-related investment (Corden & Neary, 1982). Another possible explanation is that wealth derived from natural resources negatively impacts economic growth when political institutions favor rent seeking over productive activities (Mehlum et al., 2006). Reviews completed since then note that the impact of wealth from natural resources depends on the level of institutional effectiveness and how effectively wealth generated from natural resources is used (Ross, 2015; Auty, 1993), and that the relationship between natural resource wealth and economic growth is likely to vary across regions and among nations. At the project level such as oil rims, the resource curse literature highlights three additional questions. Do revenues generated by the project provide sufficient revenue for government to use in a way that benefits society? Are local businesses and employees able to benefit from being involved with the project? Do the project either create conditions favorable to good governance or undermine those existing before the project began? Each of these questions guide our discussions in section 4.

3. Methodology

3.1 Research Design and Approach

This is a narrative literature review. Narrative reviews explain and compare previous publications regarding a subject and involve no empirical testing using new data. The focus of this review is on the economic factors associated with developing thin oil rim reserves in Nigeria. The study combines academic journals,

conference papers, books, laws and institutional documents. Together they address thin oil rims, concepts for developing reservoirs, petroleum economics, theoretical frameworks related to resource-based economies and institutional theory as well as current Nigerian energy policy.

3.2 Sources and Selection

Sources were found through Google Scholar, ScienceDirect, OnePetro, Crossref and publisher websites, and laws and reports were taken from the issuing bodies. The main search terms were “thin oil rim”, “oil rim”, “gas cap blowdown”, “coning”, “marginal field”, “local content”, “Petroleum Industry Act”, “energy security” and “resource curse”, used alone and in pairs. Searches were run in 2026, and the oil rim literature found covers about 2005 to 2026, with older foundational work such as Meyer and Garder (1954) added where needed. A source was kept if it was a journal article, conference paper, book, law or official report, was written in English, and spoke directly to one of the four research questions. Duplicates, papers on unrelated reservoir types and sources with no accessible full text were left out. Each kept source was then read for the claim it supports.

3.3 Analytical Procedure

The analysis was conducted according to a four-step process. The first step was reading the materials selected for inclusion in the study to determine how previous researchers identified their problems in the context of their literature. The second step was grouping similar statements into categories corresponding to each of the research questions. In the third step, similar ideas from multiple sources were compared to identify areas where studies agree and differ. Finally, the categorized ideas were reviewed against the four theoretical perspectives presented in

Section 2.3 and organized into the framework presented in Section 4.5.

3.4 Trustworthiness and Limits

The evidence included in this study is secondary in nature. Because the selection criteria were purposeful in nature, we acknowledge that we cannot establish cause-and-effect relationships between variables and there may exist some degree of selection bias in our results. To reduce the likelihood of this occurring we took four steps. All claims made in this paper include references to specific named sources. We separated what sources report from what we inferred from those sources. Where applicable we indicated links to national outcomes as speculative rather than established through direct measurement. Technical findings were summarized in terms of direction due to reliance on synthesized models which would not apply universally across all reservoirs. As such, the framework developed here should be viewed as a foundation for future empirical assessments.

3.5 Ethical Considerations

We limited ourselves to using published and publicly available information only. Thus, we did not require ethics approval because we did not involve any human subjects. We cite all sources appropriately throughout the document and attempted to represent all parties fairly. In addition, we referenced our own prior works where appropriate in the conclusions.

4. Results and Discussion

4.1 What Makes Oil Rims a Difficult Investment (RQ1)

Three characteristics distinguish oil rims from other types of reservoirs in terms of how they are studied in the literature. The first characteristic is that oil rims operate as single systems throughout. While gas can be significantly compressed versus oil, once gas caps are produced pressure drops across entire rim. Consequently, decisions

concerning gas operations affect oil recovery while decisions affecting oil recovery also affect gas operations (Obinaba et al., 2024; Amirul & Woobaidullah, 2022).

The second distinguishing factor is that risks are asymmetrically distributed. While lost gas can sometimes be compensated for with subsequent development projects, once oil leaks into gas caps it usually cannot be recovered. Timing of oil production is therefore the initial operational challenge facing developers of oil rims.

Thirdly, the viability of a commercial operation based on an oil rim depends on external factors beyond those confined solely to geology of the reservoir itself. Foremost among these are whether gas can be processed and marketed commercially. Together these features encourage the existence of capabilities (i.e., capabilities that allow an operator to integrate planning for the reservoir, wells, and processing facilities; capabilities that allow operators to manage produced water etc.) necessary to successfully develop an oil rim. Conversely, an operator lacking such capabilities may view the very same resource as uncommercial.

The evidence provided here stems from prior research as well as the theoretical framework we are employing. It has however, not been empirically verified using company level data.

Published information relevant to the thesis' central arguments are collected into Table 3. These publications were written by either government agencies or professional organizations, and are therefore independent. Each publication directly relates to its respective supporting argument.

Table 3. Published Data Points Supporting the Argument

Data point	Value	Source	Claim it supports
Crude oil share of exports, Q3 2025	56.14% (N12.81 trn of N22.81 trn)	AllAfrica (2025), from NBS	Oil remains central to national revenue
Oil and gas share of exports and government revenue	About 72% and 41%	NEITI (2024)	Public finances depend on the sector
Oil and condensate reserves, 1 Jan 2025	37.28 billion barrels	ThisDay (2025), from NUPRC	Large resource base to develop
Gas reserves, 1 Jan 2025	210.54 tcf; 101.03 tcf associated	ThisDay (2025), from NUPRC	Gas market access matters for rims
Marginal fields awarded, 2020 round	57 fields; 161 companies	Arise News (2021)	Licensing alone does not guarantee production
Troll oil recovery rate, 2015	40%; target 52%	Equinor (2015)	Horizontal wells and long-run effort pay off
Gunung Kembang oil recovery	About 3%; plan to reach about 8%	Febrianto & Aimar (2008)	Thin rims can give very low recovery
Nigerian content, 2010 to date	5% to 61%	Nairametrics (2026)	Local content is a sustained policy effort

Note. Figures are quoted as reported by the sources named. Shares differ by year and by measure, so they are only a guide.

4.2 How Development Decisions Affect Value (RQ2)

While recovery factor and cumulative oil can provide useful information, neither measure tells an investor if the project is profitable. A new concept could potentially increase recovery factor and still be unprofitable. An operator may have to spend significant amounts of money on additional wells, a high volume of produced water, or a non-existent gas market. Typically, discounted metrics are employed to determine profitability of projects (Chen, 2022) and have previously been applied to decision making related to developments in oil rim economics (onwukwe, 2018).

There are two factors that complicate the determination of whether a project is

economically viable compared to what appears to be a straightforward evaluation. first, oil and gas revenues typically move together. Therefore, the appropriate unit of analysis should be the entire development (oil and gas combined) rather than just the oil. If an operator loses some oil but gets gas revenue sooner, then he/she/they may still end up with a net gain. second, costs occur in discrete units. There are many parameters that affect the number of wells drilled, their trajectories, the type of injection equipment required, and how the water will be handled; these all vary depending upon the proposed concept. As a result, a screening study that only accounts for the cost of drilling will always favor the concept that requires less wells drilled.

In addition to considering cash flows, investment theory also addresses the fact that waiting to invest has value. While

there is an economic equivalent to the finding from engineers regarding timing (Olabode et al., 2022; Dixit & Pindyck, 1994), there is currently no documented estimate of the value of this trade-off. Based on this reasoning, a practical approach to evaluating alternative production sequences is to test multiple production sequences across a range of price and cost assumptions. Using a single base case scenario is insufficient.

As shown in figure 4-2, each of the Masoudi concepts has a unique economic profile. Concurrent production generates revenue early while spreading fixed costs over time, but it exposes the oil to coning from both directions. By protecting one phase first and delaying the other revenue stream, sequential production provides protection to one phase but requires longer financing. Swing production offers flexibility which has an option value (the ability to respond to changes in demand), but it requires facilities and processes that require funding and expertise. Gas cap blow down generates revenue from gas early, but has the greatest potential for loss since once oil is lost to the gas cap, it is permanently lost. No one of these options is inherently superior to another. Instead, the best option will depend on the specific circumstances of the operating company (Masoudi et al., 2013).

Gas sales deserve special attention. In project finance, an offtake agreement is a contract in which a buyer agrees to purchase the output at specified volumes and prices. This provides bankability to future revenue (Global Trade Funding, 2024). A rim development without such an agreement will have difficulty raising capital.

A simple example illustrates the point. Consider two operators with the same rim. Both have all of their wells drilled and completed but only one has a pipeline from his wellhead to a processing plant that processes the gas into natural gas liquids (ngls) and then sells them to a nearby refinery. The other operator has none of these facilities. For the first operator, producing gas early may be economical because the gas can pay for wells and facilities earlier than delaying the oil would cost him/her/them any money. For the second operator, producing gas early would waste the gas and put the oil at risk. Therefore, a sequence that protects the oil may be better for the second operator. Neither option is wrong. What differentially impacts the choice between options are the commercial conditions under which they must operate. As such, recovery factor alone cannot be used to rank alternatives.

Quantities that can be derived from published information are shown in Table 4. Troll's published production of 1.56 billion barrels at 40% recovery rate implies about 3.9 billion barrels of oil in place. Meeting the target of 2.1 billion barrels would add about 0.54 billion barrels (equinor, 2015). At Gunung Kembang, the planned increase in recovery factor from 3% to 8% is about 2.7 times the starting number however from a very low base (Febrianto & Aimar, 2008). In Nigeria, approximately 48% of gas reserves is associated gas (ThisDay, 2025); in July 2025 flaring still took approximately 0.54 bscf/d out of the 7.59 bscf/d produced (sweet crude reports, 2025). Gas to power was only about 11.4% of total output.

Table 4. Quantities Derived from the Published Figures

Indicator	Working	Result	What it shows
Troll: oil in place implied by production to 2015	$1.56 \div 0.40$ (billion bbl)	About 3.9 billion bbl	A thin oil column can hold a very large resource
Troll: extra oil if the 2.1 billion bbl target is met	$2.1 - 1.56$	About 0.54 billion bbl	Value of continued effort in a mature rim
Troll: recovery gain targeted	$52\% - 40\%$	12 percentage points	Gains need long horizontal wells and time
Gunung Kembang: recovery gain planned	$8\% \div 3\%$	About 2.7 times	Large relative gain from a very low base
Share of gas reserves that is associated gas	$101.03 \div 210.54$ tcf	About 48%	Nearly half of gas reserves depends on oil development
Gas flared, July 2025	$7.59 \text{ bscf/d} \times 7.16\%$	About 0.54 bscf/d	Gas that finds no outlet is lost
Gas supplied to power, July 2025	$0.863 \div 7.59$ bscf/d	About 11.4% of output	Domestic use of gas is still small

Note. Calculated by the authors from figures reported by Equinor (2015), Febrianto and Aimar (2008), ThisDay (2025) and Sweetcrude Reports (2025).

Working: (a) Troll oil in place = oil produced $\div$ recovery rate = $1.56 \div 0.40 = 3.9$ billion bbl; (b) $2.1 - 1.56 = 0.54$ billion bbl; (c) $52 - 40 = 12$ percentage points; (d) $8 \div 3 = 2.67$, rounded to 2.7 times; (e) $101.03 \div 210.54 = 0.480$, or 48%; (f) $7.59 \times 0.0716 = 0.543$ bscf/d; (g) $0.863 \div 7.59 = 0.114$, or 11.4%. The Troll figure in (a) treats the 40% recovery rate as applying to all 1.56 billion bbl produced to 2015, so it is an implied estimate and not a reported reserve. Results are rounded.

4.3 Employment, Skills and Local Content (RQ3)

In the upstream sector, job creation is limited because of high capital requirements, and there are a relatively low number of firms involved. There were approximately 19,000 jobs reported in the companies covered by the NEITI report (NEITI, 2024) which is minimal compared to the total labor force; however, many indirect jobs are created within the service

industries, fabrication and supply. A rim develops employment opportunities in several areas including well engineering, drilling, completions, facility construction, gas processing and produced-water treatment. The majority of these jobs require significant skill. In regards to human resources management, the limitation of developing a rim appears to be based upon having sufficient numbers of trained reservoir, well and production engineers and technicians. The number of available positions is less concerning than having adequate qualified personnel. The types of skills needed to develop a rim may be categorized into four skill areas. The subsurface skills required for developing a rim involve defining the reservoir characteristics, simulating the behavior of the reservoir and observing the flow of gas and water within the reservoir. Well skills involve designing, drilling and completing horizontal and intelligent wells. Production skills involve managing produced water and gas. Facility skills involve designing and operating the separation and processing facilities. The Content

Development Act provides regulatory direction intended to ensure that a portion of the work associated with developing a rim is provided to Nigerian firms and workers. Through provisions related to first consideration, a Nigerian content plan and an employment and training plan provide regulatory bodies with mechanisms to inquire how a rim project will utilize local people and firms (Mondaq, 2015.) (Federal Republic of Nigeria, 2010). Whether or not the regulations are effective in regards to oil rim projects will depend upon factors such as project size, existence of local contractors, amount invested in employee training and enforcement. None of these issues may be determined through studying reservoirs.

The 5% limit on expatriates in management relates this to rim operations. A thin oil rim requires special subsurface, horizontal well and produced water expertise. Thus, a marginal field operator is generally a small operation that can rarely afford to hire its own foreign specialists. The limit refers to managerial positions; thus, the rule alone will not prevent an operator from hiring foreign experts for specific tasks. However, what it will do is force the operator to develop Nigerian managers and technical leaders as soon as possible or purchase the required technical expertise through local contractors.

4.4 Energy Security and Economic Development (RQ4)

Energy security generally refers to availability, affordability, reliability and diversification of supply (Yergin, 2006); (kruyt et al., 2009). A rim may contribute in two ways to increase energy security. Firstly, a rim may produce additional amounts of oil from those accumulations left behind using conventional practices. Secondly, a rim may accelerate gas production that would have been delayed until later stages of a field's life cycle when

a thinning oil column requires more gas to maintain pressure. This issue is particularly relevant in countries that rely heavily on natural gas as a source of fuel for generating electricity and industrial processes. Regardless of the magnitude of either benefit, it is dependent upon existing infrastructure and market demand for gas as much as the reservoir itself. If unprocessed gas cannot be transported, sold, etc. Then it contributes little to security. However, how the benefits are distributed among stakeholders has equal importance as how large each benefit is. Revenue generated from a rim flow through the economy via three channels. The first channel is through payment of taxes and royalties collected by the government. The Second channel is through payments made to suppliers and employees. The third channel is through community funds. Each channel has different stakeholders receiving monies under varying circumstances of reliability. Government revenues depend upon fiscal terms established during negotiations with producers and how monies are expended. Suppliers create income to the economy only if the suppliers are local. Community funds generate income only if they are properly administered.

The 3% Host Community Development Trust connects the community channel with the rim. The Petroleum Industry Act establishes the payments as being 3% of the settlers' prior year operating expenditures (Afriwise, 2021). These are based on operational spending and not on revenue; each \$US 100 million spent will lead to a \$US 3 million payment the next year. For a thin oil rim development, operational costs increase once coning starts due to increased lifting, separation and disposal of water. As such, the additional host community trust fund contributions will be directly tied to the increasing water-cut levels that occur during the time in which declining oil

revenues are occurring. Because there is a one-year delay between the beginning of coning and the first additional contribution to the host community trust fund, operators need to provide for the funding before they experience a drop-off in their production and associated oil revenues.

Finally, the resource curse literature reminds us that resource wealth alone does not lead to economic growth (Ross, 2015); (Sachs & Warner, 1995). Institutions determine what happens to resource wealth. Gas utilized domestically for electric generation or industrial processes has greater potential for broader development impacts than gas utilized as an export product or flared. Therefore, the gas market presents itself as one of the most important variables throughout the entire process.

4.5 Risks and a Consolidated Framework

Table 5 identifies major risks facing oil rims. Once oil losses occur due to poor exploration/production techniques or

Table 5. Main Risks in Oil Rim Development and Who Bears Them

Risk	How it arises	Main bearer	Possible response
Irreversible oil loss	Gas cap produced before oil is recovered	Operator and state	Early screening; timing plan
Gas market	No outlet or price for produced gas	Operator	Gas offtake agreements; pipelines
Produced water	Water coning and injection returns	Operator; society	Water-handling capacity; rate control
Fiscal and regulatory	Terms unsuitable for marginal assets	Operator; state	Workable terms; clear timelines
Community and social	Flaring; host-community disputes	Local people	Community trust funds; monitoring
Capability gap	Small operators lack skills and capital	Operator; workforce	Partnerships; training

Note. Authors' summary from the sources cited in the text. It is a guide only.

Technical performance decisions typically relate to: Development concept: timing of project implementation, well design: injection scheme: partners involved: capital allocation. Secondly, technical

negligence; they cannot be recovered. While development plans assume that gas will ultimately be sold, uncertainty exists regarding off-take agreements (i.e., buyers), pipeline routes and pricing arrangements. Also affecting license to operate are produced water management and flare operations for unsold gas; as well as relations with host communities. Finally, fiscal terms that discourage investment in small, complex assets could negate any technical gains achieved by implementing an oil rim strategy. A capability gap can also result in leaving a viable conceptualization of a rim project in the possession of an operator incapable of realizing that conceptualization.

To summarize, Figure 2 represents three sequential decision-making steps toward creating energy security while increasing employment and economic development. Firstly, strategic and operational decisions relating to a particular project influence technical performance.

performance along with costs and risks associated with the project influence commercial value. Thirdly, once commercial value is realized; energy security will be influenced by: Fiscal terms: regulation: infrastructure: access to gas markets: governance.

4.6 Reading the Cases through the Framework

A good example of how fragile that relationship is shown by Gunung Kembang. The fact that after many years of horizontal drilling there was a recovery of approximately 3%, and a well was lost due to water breakthrough, illustrates that as the pressure falls within the reservoir, the

risks associated with making decisions based upon those declining pressures increases. Also, the use of produced gas to fulfill a gas commitment for a project demonstrates that the business environment surrounding the reservoir influences the way the reservoir will be managed (Febrianto & Aimar, 2008).

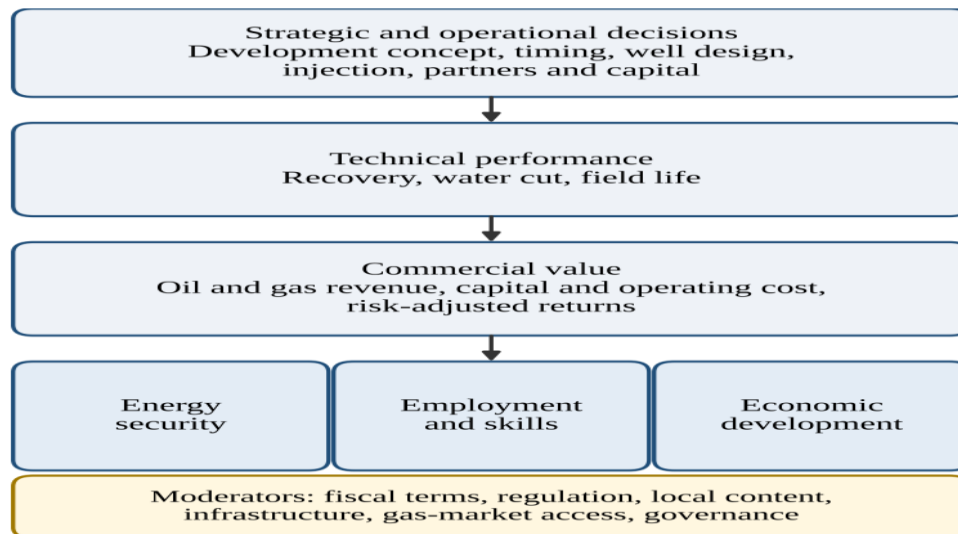


Figure 2. Conceptual framework linking firm-level decisions to national outcomes. Additionally, the Nigerian marginal-field case exemplifies the last link, namely from commercial value to national outcomes. By granting licenses to marginal fields, the state gives assets to newly appointed operators. The State's own intention to evaluate both active and inactive assets indicate that just creating value does not occur automatically. Capabilities, financing and infrastructure have to be present (News Agency of Nigeria, 2024). Thusly, taken together, the two examples illustrate that every stage relies on factors beyond the reservoir itself. They also demonstrate why evaluating national outcomes cannot end with simply looking at recovery.

4.7 Policy Design Considerations

There are several policy design points that derive from the preceding analysis. With respect to licensing, award criteria for

licenses should take into account both the technical capabilities of licensees and their ability to financially develop the asset as well as provide a valid development plan. Likewise, regulators should ensure that the awarded assets are being developed. The announced 2024 round's stated intention to review active and inactive assets follows this perspective (News Agency of Nigeria, 2024).

With regard to local content, the Content Development Act specifies requirements for plans, first consideration of employment and training plans and the board has reported high overall levels of Nigerian content (Federal Republic of Nigeria, 2010; Nairametrics, 2026). However, it is an open question whether the tools available to apply specifically to the required skills needed to manage a rim, e.g., horizontal well engineering and produced-water management, can be effectively utilized. Furthermore, it remains unknown whether the 1%

development fund is utilized for developing such capabilities.

4.8 Implications for Theory and Practice

This discussion can be reduced to six testable propositions. Firstly, the amount of value an oil rim provides to an operator is dependent on the order of production decisions rather than solely on recovery. Secondly, capability in managing a reservoir, wells and water will enhance the chances of successful development of a marginal rim. Thirdly, availability of a gas market enhances commercial viability of gas-based projects while decreasing the risk of gas becoming stranded. Fourthly, fiscal and regulatory terms favorable for marginal assets will lead to an increased number of rims entering production. Fifthly, local content provisions enhance employment opportunities nationally only if local firms and skilled labor exist to fulfill said provisions. Finally, national benefits arising from the development of oil rims are greater when gas is consumed domestically as opposed to when it is flared or exported. These propositions follow from both theoretical perspectives and empirical evidence discussed in this chapter. None have yet been empirically examined.

5. Conclusion

Oil rims represent a technological challenge; however, they also represent an investment challenge as well as a public policy challenge. Literature in the area of reservoir engineering explains very clearly why timing, well construction, rate control and pressure maintenance are important for successful development of an oil rim. The literature typically fails to explore the costs involved in controlling rate and maintaining pressure nor discuss gas-market conditions necessary for commercial success nor consider workforce impacts or national outcomes. Links between oil-rim development and energy security, employment and

economic growth are reasonable and germane to public policy considerations. For now, these links represent hypotheses until empirical data supports them. Therefore, an oil rim should be evaluated as part of a complete system including gas markets, operating company capabilities and regulatory framework (i.e., fiscal terms and local-content regulations) in addition to evaluating the reservoir characteristics. Therefore, answers can be provided to each of the research questions identified above. To RQ1, oil rims are challenging because they are physically connected; because loss represents a one-sided permanent risk; and because their commercial feasibility is dependent on a gas market external to the reservoir. To RQ2, timing of operations; well design; rate control; pressure maintenance all influence successful oil rim development but their relative economic importance depends on field-specific conditions and market conditions which have historically gone unvalued. To RQ3, oil rim development creates conditions conducive to employment and skill-formation but the limiting factor is more likely to be the supply of trained personnel/contractors locally rather than job openings themselves. To RQ4, any potential contributions toward energy security and development are contingent upon access to a gas market; favorable fiscal terms; effective application/enforcement of local-content regulations; as well as effective governance.

Limitations of this Study:

It is limited by virtue of being a narrative review that lacks a systematic search protocol, therefore potentially excluding other relevant studies. A significant portion of literature on oil rims originates from a small group of researchers as well as simulations based on artificial models. Data regarding the Nigerian economy serve only as rough estimates as definitions and time periods vary widely. Background

information related to prior simulation-based research conducted by authors on oil rims inform background information presented in this study; however, none of results were presented here.

Recommendations

For operators

Evaluate the potential of their screen rims to determine if it would be worthwhile to develop them and what type of concepts or plans could be used to develop the assets. They also should plan the sequence of oil and gas production development and conduct sensitivity analyses based on different price and cost assumptions. We also encourage the operators to build the skills that are required by complex assets.

For regulators and policymakers

Policies regarding the natural-gas market and infrastructure must be aligned with the policies of upstream oil-and-gas development so that rim gas may have an outlet to sell its product. Also, the fiscal terms provided in the Petroleum Industry Act of 2021 be made workable for both marginal and complex assets. In addition, we recommend that when evaluating applicants for developing marginal fields that the applicants demonstrate both technical and financial capabilities in addition to simply providing a bid. Finally, the impact of local-content requirements at the project level be tracked, published and included in future evaluations of the effectiveness of local-content requirements.

Research agenda

Five hypotheses can be derived from these gaps; each hypothesis can be examined using an integration of discounted cash flow (DCF) methods with black-oil simulation in commercial software packages like ECLIPSE or CMG.

Hypothesis H1: Gas cost, process costs, water treatment costs and the petroleum

industry act 2021's fiscal terms, which include the 3% royalty trust fund, when factored into the analysis will result in different rankings of the four Masoudi ideas based on net present values compared to the previous method of only evaluating the oil recoveries. Test: Run all four concepts through a black-oil model while applying the same DCF calculation methodology to all cases.

Hypothesis H2: For a thin oil rim at a given thickness there is positive value to waiting prior to gas cap blow down, therefore, a real options valuation methodology will produce a higher net present value for sequential development strategies compared to a static net present value evaluation. Test: Compare the results from static evaluations (net present value) with those from real option valuations (net present value) which have been developed from simulated production histories across multiple price scenarios.

Hypothesis H3: Companies operating onshore fields with both in-house subsurface and well teams, will achieve greater hydrocarbon recoveries or net present values than companies relying solely on third-party contractors. Test: Conduct case study analyses or conduct interviews with Nigerian onshore marginal-field operators coupled with providing access to data relative to each of their fields.

Hypothesis H4: As local employment and training expenditures increase with respect to increasing numbers of wells drilled and larger scale development projects, this trend will continue. Test: Collect project-specific information regarding job creation, training expenses and contracting activities relative to individual projects from both the operator(s) and regulatory agency sources.

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