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An Examination of Enhanced Oil Recovery and Reservoir Management in Nigeria's Oil and Gas Sector

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ABSTRACT
Nigeria is one of Africa's largest oil producers, but a significant portion of its hydrocarbon resources remains trapped in reservoirs that conventional production methods cannot fully reach. During the initial stages of production, operators rely on natural reservoir pressure to push oil to the surface, but this primary phase quickly wears out, leaving the vast majority of the oil stuck underground. What happens to the rest of this trapped resource depends entirely on how well operators manage their reservoirs and whether they apply Enhanced Oil Recovery (EOR) techniques to access what these early methods leave behind. This paper examined Enhanced Oil Recovery and reservoir management in Nigeria's oil and gas sector by looking at the core principles that drive reservoir behavior, the methods used by operators, and how applicable they are to Nigeria's specific reservoir conditions. It also assessed how Nigerian operators currently manage their reservoirs, the challenges limiting the widespread rollout of these technologies, and the policy and regulatory environment shaping the future of enhanced oil recovery techniques in Nigeria. Findings showed that while enhanced oil recovery techniques have significant potential to extend the productive life of Nigeria's maturing oil fields as well as increase its overall national production capacity, its adoption has been slow across local assets due to high implementation costs, data gaps, technical capacity shortfalls, and an investment climate that has not consistently supported long-term EOR commitments. The study concluded that deliberate policy support and stronger reservoir data management are essential to lower investment risks so that Nigeria's oil industry can fully unlock its trapped reserves and secure its long-term energy future.
Keywords: Enhanced Oil Recovery, reservoir management, polymer flooding, CO2 injection, thermal recovery, petroleum industry, secondary recovery.

INTRODUCTION

Every oil field goes through a natural decline and eventually loses the pressure required to keep fluids flowing at high rates. When a reservoir is first tapped, the pressure trapped underground is usually enough to push oil to the surface on its own, a process known as primary recovery. But that pressure drops as production continues, and a field that once flowed easily starts to slow down. This decline is the reason Enhanced Oil Recovery, or EOR, and reservoir management exist as a discipline (Ogolo and Agwu, 2021).

Reservoir management is the practice of planning and monitoring a field carefully throughout its lifespan, while Enhanced Oil Recovery covers the specific techniques used to recover oil that primary and secondary methods leave behind (Oyedeko and Susu, 2015). Together, these two approaches determine how much value a company can get from a reservoir before it's no longer producing. It also helps operators avoid costly operational mistakes, and the Nigerian oil and gas industry depends heavily on these strategies to maintain national production levels (Okonkwo, 2024). This paper examines Enhanced Oil Recovery and Reservoir Management with a specific focus on Nigeria's oil and gas sector. It covers the fundamentals of reservoir management, the main categories of EOR methods, and how each approach applies to the conditions found in Nigerian oil and gas fields. It also considers the role reservoir simulation plays in planning these projects, the challenges that limit progress, and the policies currently shaping the industry. The aim is to provide a clear, well-grounded view of where Nigeria stands with EOR today and what needs to happen to move the sector forward.

Statement of the Problem

Nigeria oil and gas sector continues to depend on primary and secondary recovery, yet production is declining. EOR could unlock billions of additional barrels, but deployment is minimal due to technical, economic, and institutional barriers. There is also limited documented research on which EOR methods — thermal, chemical, or gas injection — fit Nigeria's specific reservoir conditions of high temperature, high salinity, and complex geology. The problem is: How can reservoir management be improved and which EOR methods are technically and economically applicable to Nigeria's oil and gas sector, and what challenges must be addressed?

Aim and Objectives of the Study

The main aim of this study is to examine reservoir management practices and the applicability of Enhanced Oil Recovery methods in Nigeria's oil and gas sector. In specific terms, the study is guided by the following objectives:

1. To provide an overview of reservoir management practices in Nigeria's oil and gas sector.
2. To examine the principles and classification of Enhanced Oil Recovery methods.
3. To evaluate thermal EOR methods and their applicability to Nigerian reservoir conditions.
4. To assess chemical EOR methods and their applicability in Nigeria.
5. To analyze gas injection and miscible EOR methods for Nigerian fields.
6. To identify the challenges of EOR and reservoir management in Nigeria and propose solutions.

Research Questions

1. What is the current state of reservoir management in Nigeria's oil and gas sector?
2. What are the principles and classifications of EOR methods relevant to Nigeria?
3. How applicable are thermal EOR methods to Nigerian reservoirs?
4. How applicable are chemical EOR methods to Nigerian reservoirs?
5. What is the potential of gas injection and miscible EOR methods in Nigeria?
6. What are the major technical, economic, and policy challenges to EOR and reservoir management in Nigeria?

Significance of the Study

The significance of the study lies in the fact that:

1. The study adds to existing body of knowledge as it reviewed literature on reservoir management practices and the applicability of Enhanced Oil Recovery methods.
2. The study provides operators with a decision guide on which EOR method to pilot first.
3. Informs NUPRC and Ministry of Petroleum on fiscal and policy incentives needed.
4. It equally shows the pathway to increase reserves and extend field life without new exploration.
5. Conversely, the study highlights skill and technology gaps for universities and service companies.

Scope and Limitation of the Study

Scope

The focused on:

1. The overview of reservoir management practices in Nigeria's oil and gas sector.
2. The principles and classification of Enhanced Oil Recovery methods.
3. Thermal EOR methods and their applicability to Nigerian reservoir conditions.
4. Chemical EOR methods and their applicability in Nigeria.
5. Gas injection and miscible EOR methods for Nigerian fields.
6. The challenges of EOR and reservoir management in Nigeria and propose solutions.

Limitations

1. Proprietary reservoir data from operators limits depth of technical analysis.
2. Economic analysis uses estimates and analogs due to lack of public EOR project cost data in Nigeria.
3. The findings may not be generalized or applied to all reservoirs due to geological heterogeneity.
4. Security, community issues, and global energy transition impacts are acknowledged but not quantified.

LITERATURE REVIEW

OVERVIEW OF RESERVOIR MANAGEMENT IN NIGERIA'S OIL AND GAS SECTOR

Definition and Principles of Reservoir Management

Reservoir management is the practice of planning, monitoring, and controlling how a reservoir is developed and produced over its entire life (Oyedeko and Susu, 2015). It is an ongoing process that involves collecting data, adjusting production rates, and making sure a field is developed in a way that petroleum industries get the most value out of it. And for over five decades, many oil and gas industries have relied on core reservoir management principles and practices.

The first principle is understanding the reservoir properly before making major decisions, since poor characterization leads to poor planning. This enables engineers to estimate reserves accurately and design better drainage strategies (Oyatobo et al, 2021). It also minimizes operational risks, and without solid geological data, any field development plan will fail. The second principle is flexibility. Reservoirs don't always behave exactly as predicted, so engineers regularly update their subsurface models as new data comes in. The data collected from daily production logs, pressure tests, and well logs reveals true underground fluid movement, and because this behavior changes over time, it enables engineers to adjust production strategies before major problems occur (Aladeitan 2020).

Aside from adapting to new data, reservoirs must be managed with a long-term view. Decisions made early in a field's life, like well placement or injection strategy, affect how much oil can be recovered decades later. Good reservoir management tries to balance short-term production goals with the long-term health of the field (Oyatobo et al, 2021). This prevents premature pressure depletion and maximizes overall hydrocarbon recovery.

Nigeria's Reservoir Types and Characteristics

Nigeria's oil and gas reserves sit mainly within the Niger Delta basin, but the reservoirs within this basin are not all the same. They generally fall into two broad categories: onshore and offshore, and these differ significantly in terms of geology, operational costs, and security risks:

1. Onshore Reservoirs: Onshore reservoirs are found across the Niger Delta's swamp and land areas. Many of the fields have been in production for a long time, some since the 1960s and 1970s, which makes them mature by industry standards. They tend to be shallower and easier to access than offshore fields, and this historically made them cheaper to develop (Adeyanju and Oyekunle, 2021). However, because they have been producing for decades, a lot of onshore reservoirs now face declining pressure and falling output, and some have also been affected by pipeline vandalism and community disputes that limit access.
2. Offshore Reservoirs: Offshore reservoirs, including both shallow water and deepwater fields, are generally younger and were developed more recently than most onshore assets (Adegoke and Oyedele, 2025). Deepwater fields, in particular, tend to be larger and hold more reserves, but they come with higher pressure, higher temperature, and more complicated rock formations. Developing these fields requires more advanced technology and much higher upfront investment, because they are an important part of Nigeria's production, especially as onshore fields continue to decline. Each of these reservoirs, both onshore and offshore, presents unique technical challenges that require tailored reservoir management approaches.

Primary Recovery and Its Limitations in Nigerian Fields

Primary recovery is the first stage of oil production, where natural reservoir pressure alone pushes oil to the surface (Izuwa et al, 2015). It is the cheapest and simplest way to produce oil, since it does not require injecting anything into the reservoir to maintain pressure. However, the problem with it is that it only captures a small fraction of the oil actually present in a reservoir — often less than a third of the total volume in many cases (Orakwue and Onyekonwu, 2024). And as fluid extraction continues, pressure drops, and the rate of oil flow slows down. This rapid decline limits ultimate oil recovery, particularly in Nigeria’s older Niger Delta fields.

In Nigeria, many onshore fields that have been producing for decades have already moved well past their primary recovery stage, with pressure levels too low to sustain production without additional support. This is one of the main reasons operators eventually turn to secondary recovery methods, and later, EOR, to keep these fields productive. Although, it is worth noting that primary recovery alone can leave up to 70% of the original oil in place underground.

Secondary Recovery Methods Applied in Nigerian Fields

In mature field operations, once natural pressure is not enough to maintain good production, operators turn to secondary recovery methods to restore pressure and push remaining fluids out. This stage involves injecting fluids into the reservoir to maintain pressure and push additional oil toward production wells. In the Nigerian petroleum industry, two secondary recovery techniques are commonly used to achieve this:

1. Water Injection: Water injection is the most common secondary recovery method used in Nigeria. It involves injecting water into the reservoir, usually through dedicated injection wells, to maintain pressure and physically push oil toward producing wells (Isebor and Onyekonwu, 2023). It is relatively inexpensive compared to other methods though, because water is generally easier to source and manage than other injection fluids. Many mature fields in the Niger Delta rely on this strategy to keep production going long after primary recovery has tapered off.
2. Gas Injection: Gas injection works on a similar principle to water injection but uses natural gas instead of water. During secondary recovery operations, gas is injected into the reservoir, often into the gas cap above the oil zone, to maintain pressure and support oil production. This expands the gas cap, forces the oil downward toward production wells, and improves overall displacement efficiency, and for many oil and gas industries, gas re-injection is more efficient in specific reservoir types than water flooding (Obibuike et al, 2022). In Nigeria, gas injection has an added advantage, since it gives operators a productive use for associated gas that might otherwise be flared (Obibuike et al, 2022). This aligns with Nigeria's broader push to reduce gas flaring and make better use of the gas produced alongside oil. It also helps operators comply with statutory environmental guidelines while maximizing energy efficiency.

In essence, both the gas and water injection methods extend the productive life of a field beyond what primary recovery alone could achieve, but neither one recovers all the oil left behind. This is what eventually opens the door to Enhanced Oil Recovery.

PRINCIPLES AND CLASSIFICATION OF ENHANCED OIL RECOVERY

Enhanced Oil Recovery, or EOR, is a set of methods used to get oil out of a reservoir that primary and secondary recovery cannot reach (Lake et al, 2018). By the time a field needs EOR, natural pressure is gone and water or gas injection alone is not enough to keep production at a good level. EOR changes the physical or chemical conditions inside the reservoir, making the remaining oil easier to move and produce because without it, a lot of oil will stay trapped underground permanently. Therefore for mature onshore and offshore fields, EOR is often the only way to add meaningful years of production.

Classification of EOR Methods

Enhanced Oil Recovery methods fall into three broad categories, they include:

1. Thermal Methods: Thermal EOR is a method that uses heat to make oil less thick and easier to flow through rock pores. This means injecting steam or hot water into the reservoir, or in some cases, setting off a controlled burn underground known as in-situ combustion (Amanze et al, 2019). The heat reduces the oil's viscosity, so it moves more easily toward production wells and expands the trapped oil volume to increase drive pressure. Engineers frequently select thermal methods for shallow reservoirs because the method works best on heavy oil, where the oil is too thick to flow well on its own.
2. Chemical Methods: Chemical EOR involves injecting substances like polymers, surfactants, or alkaline chemicals into the reservoir. These chemicals change how oil and water interact underground and improve sweep efficiency across complex rock formations (Ogolo et al, 2015).

Polymers thicken the injected water, so it pushes oil more evenly instead of bypassing it. Surfactants reduce the tension between oil and water, freeing up oil that would otherwise stick to the rock. Alkaline chemicals work in a similar way to surfactants, sometimes combined with surfactants and polymers for a stronger effect.

3. Miscible Gas Injection: Miscible Gas Injection is a method that involves injecting gases, like carbon dioxide, nitrogen, or hydrocarbon gas to restore reservoir pressure under a condition where gas mixes completely with oil in a reservoir (Nmegbu and Shagbaor, 2020). The injected gas dissolves into the oil, and when this happens, the oil becomes less thick and flows more easily. This significantly lowers capillary trapping forces, and it also gives operators a way to make use of gas that might otherwise go to waste.

How EOR Differs from Primary and Secondary Recovery

Unlike EOR, primary recovery relies entirely on natural reservoir pressure where nothing is injected. Oil simply flows to the surface until internal energy drops below sustainable rates. The process is cheap though, but it only recovers a small share of the oil in place.

Secondary recovery on the other hand goes a step further by injecting water or gas to maintain pressure which physically pushes oil toward production wells. It also extends a field's productive life, but it still leaves a significant amount of oil behind — oil that is either too thick to move or trapped in parts of the reservoir where injected water or gas cannot reach effectively.

But unlike the primary and secondary recovery methods, EOR is different. EOR is different because it does not just maintain pressure but changes the actual properties of the oil or the rock-fluid interaction, which makes oil that was previously unreachable move more freely. This is why it typically comes after primary and secondary recovery, because once those methods have done what they can and a significant amount of oil still remains trapped underground, EOR becomes the final option to unlock that remaining resource.

THERMAL EOR METHODS AND THEIR APPLICABILITY IN NIGERIA

Types of Thermal EOR Methods

Thermal EOR covers a few different methods of heat injection, but these methods all work on the same basic idea which is add heat to the reservoir, until the oil becomes thinner and easier to produce. How that heat gets into the reservoir though is what separates one method from another. The main types include:

1. Steam Flooding: Steam flooding involves injecting steam continuously into a reservoir through dedicated injection wells, while oil is produced from separate wells nearby (Akinsete and Isehunwa, 2021). The steam heats the oil, reduces its viscosity, and also helps push it toward the production wells. This method works well for large, continuous reservoirs, where steam can spread out and heat a wide area over time.
2. Cyclic Steam Stimulation: Cyclic steam stimulation works differently unlike the steam flooding method. Instead of using separate wells for injection and production, for cyclic steam stimulation, the same well is used for both, just at different times though. Steam is injected into the well for a period of several days to weeks, then the well is shut in to let the heat soak into the surrounding rock. After that, the well is switched back to production, and the heated oil, now thinner and easier to move, flows out. This cycle can be repeated multiple times on the same well. However it is often used before switching to full steam flooding, or in reservoirs where continuous injection is not practical (Akinsete and Kayode, 2024).
3. In-Situ Combustion: In-situ combustion takes a more aggressive approach in heat generation than the cyclic steam stimulation method. Instead of injecting steam from the surface, air or oxygen is injected into the reservoir to ignite a portion of the oil underground, which starts a slow, controlled burn (Ifeanyichukwu and Appah, 2021). This burn then generates heat directly inside the reservoir, which reduces the viscosity of the surrounding oil and pushes it toward production wells (Ubani and Ifeanyichukwu, 2021). Although In-Situ Combustion is technically demanding

to control and monitor, since an underground fire is not something one can manage the same way as surface equipment. But it can be effective in reservoirs where injecting steam from the surface is not practical or efficient.

Applicability to Nigeria's Heavy Oil Reserves

Thermal EOR is built for heavy oil i.e. oil that is naturally too thick to flow well without help. And Nigeria does hold some heavy oil deposits, particularly in parts of the Niger Delta. Though these heavy oil deposits make up a smaller share of the country's reserves compared to lighter, more easily produced crude. It remains a valuable resource for future recovery, and thermal methods make sense in theory to unlock these dense reserves, since heat is one of the most direct ways to get thick oil moving (Kerunwa et al, 2017). However its application in Nigeria comes with practical concerns. The Niger Delta's swampy terrain and environmental sensitivity make large-scale steam operations more complicated than they would be in a drier, more open setting. In-situ combustion, in particular, carries added risk in a region already dealing with environmental and community concerns around oil operations.

Current Status of Thermal EOR in Nigerian Fields

Thermal EOR is not widely used in Nigeria today. Most of the country's EOR efforts have focused on secondary recovery methods like water and gas injection, with far less large-scale investment in steam-based or combustion-based projects. Where heavy oil deposits exist, operators have mostly stuck to smaller pilot studies rather than full field-scale thermal projects.

Part of this comes down to economics. Thermal EOR is expensive to run, and Nigeria's heavy oil reserves aren't large enough, in most cases, to justify the scale of investment thermal projects usually need. There's also the added cost and complexity of operating in the Niger Delta's terrain, which makes thermal projects harder to plan and execute compared to conventional water or gas injection. For now, thermal EOR remains more of a future possibility for Nigeria than an active, widely applied strategy.

CHEMICAL EOR METHODS AND THEIR APPLICABILITY IN NIGERIA

Types of Chemical EOR Methods

Chemical EOR works by changing how oil, water, and rock interact underground to release trapped hydrocarbons (Ogolo et al, 2015). It uses different chemical agents which target different trapping mechanisms in the subsurface. The main types include:

1. Polymer Flooding: Polymer flooding involves adding polymers to the water used in injection. On its own, injected water tends to move faster than oil through the reservoir, which means it can bypass a lot of oil instead of pushing it along (Ndem, 2025). Polymers thicken the water, slowing it down and making it move more evenly through the rock. This helps the water sweep through more of the reservoir; thereby pushing more oil toward production wells instead of leaving it behind in areas the water never reaches (Ndem, 2025).
2. Surfactant Flooding: Surfactant flooding tackles a different problem than polymer flooding. During surfactant flooding, a lot of oil stays trapped in the rock because of tension between the oil and water, the same kind of tension that makes oil and water resist mixing. Surfactants reduce the tension, and frees up oil that would otherwise stick to the rock surface (Adesina and Olabisi, 2025). And once that tension drops, the trapped oil moves more freely as well as joins the flow toward production wells.
3. Alkaline Flooding and Combined ASP Flooding: Alkaline flooding uses chemicals that react with certain components naturally found in crude oil, which creates a soap-like substance inside the reservoir (Uzoho et al,2016). This reaction reduces the tension between oil and water, similar to what surfactants do, but the chemical process is triggered internally by natural crude acids. And through this in-situ reaction, the cost of adding extra synthetic chemicals is reduced (Atiatobe et al, 2023).

   Alkaline flooding is also sometimes combined with surfactants and polymers in what is called ASP flooding, short for Alkaline-Surfactant-Polymer flooding. This combination brings all three

effects together: better sweep from the polymer, reduced tension from the surfactant and alkaline chemicals, and a stronger overall push to recover oil that single methods might leave behind (Atiatobe et al, 2023).

Chemical EOR Pilot Projects in the Niger Delta

Chemical EOR has not been widely adopted in Nigeria's oil fields at full field scale, but it has shown real promise in controlled field trials. A few pilot projects have tested polymer and surfactant flooding in parts of the Niger Delta, mainly to see how these methods perform in Nigeria's specific reservoir conditions before committing to larger investments (Afolayan and Onyekonwu, 2023). These projects have given operators useful data on how local rock and fluid properties respond to chemical injection, even though most of this work has stayed limited in scale. Still, the projects have helped build a foundation of local knowledge that could support wider adoption if the economics improve — specifically oil prices rising enough to cover high chemical procurement costs.

Challenges of Chemical EOR in Nigeria's Reservoir Conditions

Chemical EOR faces real obstacles in Nigeria and reservoir temperature is one of them. Some Nigerian reservoirs run hotter than the conditions many chemicals, especially polymers, are designed to handle, which can cause them to break down before doing their job properly (Adepoju et al, 2018). This thermal degradation has limited chemical performance and more so shortened the effective lifespan of injected solutions.

Another major challenge is water salinity. Since high-salinity brine is common in some Niger Delta formations, it can reduce how well certain surfactants and polymers perform. And no matter what chemicals are selected, performance can drop rapidly because saline water breaks down polymer chains and neutralizes surfactant activity (Ogolo and Agwu, 2021).

Aside from high temperature and water salinity, cost of chemical imports is another barrier that limits widespread adoption. Chemical EOR needs a steady, well-managed supply of specialised chemicals, and sourcing these consistently in Nigeria can be expensive and logistically difficult. On top of that, chemical EOR requires close monitoring and precise control to work well, which demands a level of technical expertise and infrastructure that is not always available, especially for smaller indigenous operators. This leaves chemical flooding mostly out of reach for companies with tight operational budgets. In essence, chemical EOR remains technically viable in Nigeria but economically risky under current market conditions.

GAS INJECTION AND MISCIBLE EOR METHODS

Types of Gas Injection Methods

Gas injection works by pushing gas into a reservoir under conditions where it mixes with oil, or comes close to mixing with it. When this happens, the oil thins out and flows more easily as well as swells in volume to build up displacement pressure (Nmegbu and Shagbaor, 2020). However, different gases are used depending on what's available and what suits the reservoir though. The main types include:

1. Carbon Dioxide (CO_2) Injection: CO_2 injection is one of the most widely used gas injection methods worldwide. Under the right pressure during injection, CO_2 dissolves into the oil, reducing its viscosity and causing it to swell slightly. This then helps push more of the oil out of the rock (Onoja and Isehunwa, 2017).

   CO_2 also has the advantage of being relatively easy to source in some regions, and this carries an added environmental angle. Since injecting CO_2 underground can double as a way to store it instead of releasing it into the atmosphere, it helps operators reduce their carbon footprint while boosting oil recovery (Obeta and Ekiyor, 2026).
2. Hydrocarbon Gas Injection: This method uses gases like methane, ethane, or propane, often gases already produced alongside oil in the same field. When injected under the right conditions, hydrocarbon gas mixes with the reservoir oil and reduces its thickness, similar to CO_2 (Ikeokwu et al, 2020). One practical advantage here is that operators don't always need to source gas from

outside the field, since associated gas produced during normal operations can sometimes be reinjected for this purpose.

3. Nitrogen Injection: Nitrogen injection works a bit differently than CO2 or hydrocarbon gas injection. Instead of the common miscible gas processes, nitrogen does not mix with oil as easily, so it is simply used for maintaining reservoir pressure rather than for directly thinning the oil (Okwara et al, 2025). It is a practical option when CO2 or hydrocarbon gas is not available in sufficient quantities, and since nitrogen can be produced relatively cheaply from the air. It works best in reservoirs with high pressure, where it has a better chance of achieving miscibility with the oil (Daramola and Simpa, 2025).

Gas Injection in Nigerian Offshore Fields

Gas injection has found more traction in offshore developments than the onshore fields in Nigeria. Offshore fields, particularly in deepwater areas, tend to have the high pressure and reservoir conditions that make gas injection, especially hydrocarbon gas injection, more effective. Fields like Bonga and Agbami have used gas injection as part of their reservoir management strategy, thereby taking advantage of associated gas produced alongside oil rather than letting it go to waste (Afolabi and Okon, 2026). This approach makes financial and environmental sense because with offshore operations, strict flaring restrictions and the high cost of gas infrastructure make reinjection an attractive option. It also helps maintain reservoir pressure, supports oil recovery, and gives operators a productive use for gas that would otherwise need separate handling (Biu et al, 2019).

Nigeria's Associated Gas as a Potential EOR Resource

Nigeria produces a large amount of associated gas i.e. gas that comes up alongside oil during production. For years, a lot of this gas was flared simply because there was no infrastructure to capture and use it. But now, it is changing, partly due to regulatory pressure and a growing recognition that this gas has real value. Using associated gas for EOR hence gives Nigeria a way to solve this problem as well as another. It reduces the amount of gas flared, which supports the country's flaring reduction targets, and provides a cheap and readily available resource operators can reinject to support oil recovery instead of importing gas or sourcing it from elsewhere. And as Nigeria continues building out gas infrastructure, associated gas could become a more central part of the country's EOR strategy, particularly for offshore and gas-rich fields where reinjection is already part of normal operations.

CHALLENGES FACING EOR AND RESERVOIR MANAGEMENT IN NIGERIA

EOR and good reservoir management sound straightforward on paper, but in practice, particularly in Nigeria's petroleum sector, Nigeria's operators run into real obstacles that slow down or limit how much field development and recovery work gets done (Biu et al, 2019). This section looks at the main financial, technical, and operational hurdles holding back widespread adoption.

1. High Cost of EOR Implementation

EOR requires a massive upfront financial commitment before a single barrel of extra oil is produced. Thermal, chemical, and gas injection methods all need specialised equipment, materials, and expertise, and that adds up fast (Agbon, 2025). Chemical EOR, for instance, needs a steady supply of polymers or surfactants. This supply often has to be imported at high exchange rates, and for most oil and gas industries, the high shipping and customs costs make projects unprofitable. Thermal EOR, on the other hand, needs equipment to generate and inject steam, or the infrastructure to manage in-situ combustion safely (Agbon, 2025). Without reliable power generation and heavy surface facilities, steam injection becomes impossible. And for a lot of Nigerian operators, especially smaller indigenous firms, these costs are hard to justify unless the expected return is clear and significant. Even when a field would technically benefit from EOR, the upfront investment can be enough to keep companies focused on cheaper alternatives instead, even if those alternatives leave more oil behind in the long run.

2. Data Scarcity and Poor Reservoir Characterization

EOR planning depends on knowing exactly what a reservoir looks like underground, its rock properties, fluid behaviour, and pressure history. In Nigeria, this kind of detailed data is not always available. Some fields have incomplete production records, while others were developed decades ago, before modern data collection standards, and the information gathered back then does not always meet today's needs. Without solid data, choosing the right EOR method becomes a risky gamble (Joel and Oguanobi, 2025). A method that works well in one reservoir can fail completely in another with different rock and fluid properties. Poor characterisation increases the risk of picking the wrong method, thereby wasting money on a project that was never suited to the reservoir in the first place.

3. Technical Capacity Gaps Among Nigerian Operators

EOR is not a routine operation an operator can learn overnight. It takes engineers with specific training in chemical processes, thermal operations, or gas injection design, depending on the method being used. Nigeria has skilled reservoir engineers, but the pool of people with hands-on EOR experience, particularly with chemical and thermal methods, is still limited. This gap therefore affects indigenous operators more than international companies, since IOCs often bring in specialists or draw on experience from operations in other countries. Smaller Nigerian firms however do not always have that option, which leaves them more dependent on external consultants and less able to build in-house expertise over time.

4. Regulatory and Investment Barriers

Getting an EOR project approved and funded in Nigeria is not always a fast process. Regulatory approval can take time, particularly when a project involves new methods or techniques that have not been widely tested in the country before. This adds delays and uncertainty for operators trying to plan EOR investments.

5. Security Challenges in the Niger Delta Affecting Field Operations

The Niger Delta has dealt with security issues for years, including pipeline vandalism, community tensions, and restricted access to certain fields. These problems create real complications for EOR projects in active land and swamp areas, which often require sustained access to injection and production wells over long periods to work properly. If access to a field is disrupted, whether by security incidents or community disputes, EOR operations can be delayed, paused, or abandoned altogether. This adds an added burden of risk on top of the technical and financial challenges already involved, which makes some operators hesitant to commit to long-term EOR projects in areas where security is not guaranteed.

Summary of the Findings

This paper examined Enhanced Oil Recovery and reservoir management, with a clear focus on Nigeria's oil and gas sector. The study finds out that:

1. Reservoir management is the practice of planning, monitoring, and controlling how a reservoir is developed and produced over its entire life (Oyedeko and Susu, 2015). It involves collecting data, adjusting production rates, and making sure a field is developed in a way that petroleum industries get the most value out of it. The study noted that, reservoirs are classified into two types which are onshore and offshore reservoirs.
2. The principles and classifications of EOR methods are relevant to Nigeria oil and gas sectors as EOR changes the physical or chemical conditions inside the reservoir, making the remaining oil easier to move and produce because without it, a lot of oil will stay trapped underground permanently. Enhanced oil recovery methods can be classified into: Thermal Methods, Chemical Methods, and Miscible Gas Injection.
3. Conversely, the study found out that, thermal EOR methods are applicable to Nigerian reservoirs management as it is built for heavy oil. The process of heating makes heavy or condensed oil to move freely or flow well without help. Thermal EOR method application in Nigeria comes with practical concerns. The Niger Delta's swampy terrain and environmental sensitivity make large-scale steam operations more complicated than they would be in a drier, more open setting. In-situ

community concerns around oil operations.

4. In addition, the study found out that chemical EOR works by changing how oil, water, and rock interact underground to release trapped hydrocarbons (Ogolo et al, 2015). The study observed that, chemical EOR has not been widely adopted in Nigeria's oil fields at full field scale, but it has shown real promise in controlled field trials.
5. Similarly, the study found out the types of gas injection to include: carbon dioxide (CO2) injection, hydrocarbon gas injection, and nitrogen injection. For instance, the avered that, fields like Bonga and Agbami have used gas injection as part of their reservoir management strategy, thereby taking advantage of associated gas produced alongside oil rather than letting it go to waste (Afolabi and Okon, 2026).
6. Conclusively, the study found out the challenges facing EOR and reservoir management in Nigeria to include: high cost of EOR implementation, data scarcity and poor reservoir characterization, chnical capacity gaps among Nigerian operators, regulatory and investment barriers, and security challenges in the Niger Delta affecting field operations.

The central finding of this research is that Nigeria's fields, especially across the Niger Delta, are aging. Primary recovery only gets a fraction of the oil out of any reservoir, and secondary recovery methods like water and gas injection, while useful, still leave a lot behind. This is exactly why EOR matters so much for Nigeria right now.

CONCLUSION

Thermal, chemical, and gas injection methods each offer a way to recover oil that older methods cannot reach, though each comes with its own conditions for where it works best. Thermal methods, on one hand, suit heavy oil but are rarely applied in Nigerian fields today due to high operational costs and complex terrain.

Chemical methods, on the other hand, have shown promise in pilot projects but encounter real limits from reservoir temperature, water salinity, and cost. For gas injection, particularly associated gas, is most widely used in offshore operations, where it also supports Nigeria's push to cut down on flaring. However, none of this happens without good reservoir management guiding it. The need to understand a reservoir properly, stay flexible as new data comes in, and plan with the long term in mind therefore determines whether EOR succeeds or fails once it's applied.

The study shows that technical capability and data availability are just as important as the technology itself for Nigerian field operators. And Nigeria's long-term energy security will depend on how effectively industry regulators and oil companies address these technical and financial obstacles to unlock mature fields.

RECOMMENDATIONS

To move from basic recovery to widespread Enhanced Oil Recovery, Nigeria needs a clear strategy that connects government policy, technical training, and data collection. The following recommendations can help operators unlock the remaining potential in mature fields:

1. Policy and Fiscal Recommendations for EOR Adoption: Nigeria's government has a real role to play in making EOR more attractive to operators. Right now, the upfront cost of EOR projects is one of the biggest things holding companies back. Tax incentives or fiscal terms designed specifically for EOR investments, similar to how some countries structure their oil and gas tax codes, could help shift that calculation for operators weighing whether a project is worth it. And when regulators like the NUPRC align fiscal policies under the Petroleum Industry Act (PIA) with EOR goals, operators will feel more confident committing long-term capital to mature fields.
2. Investment and Technology Priorities: Nigeria needs to be strategic about where EOR investment goes first. Gas injection, particularly using associated gas, already has a foothold offshore and

lines up well with Nigeria's flaring reduction goals. This makes it a sensible area to prioritise for further investment, since the infrastructure and experience already exist to build on. As for chemical EOR, it deserves continued investment too, but in a more careful, phased way. Given the mixed results from pilot projects so far, operators should keep testing and refining chemical methods in Nigerian conditions before committing to large-scale rollouts. This step-by-step approach will prevent costly project failures while building a reliable database of local technical successes.

3. Capacity Building for Reservoir Engineers and EOR Specialists: Nigeria's petroleum industry needs more engineers who understand EOR beyond the theory i.e. people who've actually worked on chemical, thermal, or gas injection projects in real field scenarios. This starts with stronger partnerships between universities and oil companies, where joint research projects and practical internships give students real exposure to EOR planning and execution during their studies. This will build a sustainable pipeline of local technical talent and reduce dependence on expensive foreign consultants.
4. Data Management and Reservoir Characterization Improvements: Better EOR decisions start with better data. Companies and regulators need proper systems for storing and maintaining production records, well test data, and reservoir data, so this information doesn't get lost or scattered when fields change hands or companies restructure. Besides, reservoir characterisation also needs more investment, especially for older fields being considered for EOR. Updated well tests and reservoir studies would give engineers a solid view of what a field can actually support, which thereby reduces the risk of choosing an EOR method that doesn't suit the reservoir's real conditions.

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