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Kadugala Aniceto

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Role of Public-Private Partnerships (PPPs) in Enhancing Oil Sector Development in South Sudan

Kadugala Aniceto

PhD Student, Unicaf University in Zambia, Lusaka, Zambia

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Abstract

Purpose: This paper assessed the impact of Public-Private Partnerships (PPP) in capacity enhancement within the oil industry in South Sudan, targeting on themes such as local jobs, capacity enhancement, drilling equipment, digital reservoir management, pipeline, regulatory, revenue, and community interactions.

Materials and Methods: The study applied descriptive research, collecting and analyzing data from existing documents, which is a document review strategy where the empirical results of previous studies and reports are integrated. This type of design is well suited for investigation into the pre-existing documents, reports, and literature and providing detailed information relating to the research. With this method, researchers are able to gain a more detailed perspective regarding relationships, patterns and trends that can be found in already available data such that it is most suited for investigations that have to do with secondary sources and analytics of already available data

Findings: The study indicates that PPPs are valuable in increasing refinery capacities and establishing associated transportation systems. Through the use of international funding, these initiatives make it possible for internationally owned companies to invest in infrastructure projects. From the analysis, construction-related efforts involving local employment can result in a more sophisticated skilled base, this coupled with capacity building programs guarantees work for South Sudanese people in the long run. In addition, the implementation of complex drilling techniques, like horizontal drilling and hydraulic fracturing has significantly increased oil recovery rates. Furthermore, the combination of AI technologies with reservoir management digital tools, such as predictive analytics with 3D/4D seismic technologies boosts monitoring activities and effectiveness.

Implications to Theory, Practice and Policy: The research notes the need for the optimization of existing pipeline network operations accompanied with real time monitoring systems and logics for efficient leak detection. It is also crucial to enhance the legal frameworks through inter-agency coordination and the use of international benchmarks to develop a disclosure-friendly and accountable oil industry. Besides, communities are educated about management of resources by ensuring accountability through the establishment of open data portals and routine auditing which provides reporting opportunities for revenue. Factors such as community consultations during the project planning, and grievance handling mechanisms to foster trust amongst stakeholders are necessary. The oil sector in South Sudan benefited from PPPs and the sector will develop if all government agencies, private investors and communities work together for a long-term outcome measure.

Keywords: *Public-Private Partnerships (PPPs) → H54 (National Government Expenditures and Related Policies: Infrastructures; Other Public Investment and Capital Stock), Oil Sector → Q40 (Energy: General) / Q35 (Hydrocarbon Resources), Technological Advancement → O33 (Technological Change: Choices and Consequences; Diffusion Processes), Operational Efficiency → L95 (Gas Utilities; Pipelines; Water Utilities) / D24 (Production; Cost; Capital; Total Factor Productivity; Capacity), Governance → H83 (Public Administration; Public Sector Accounting and Audits). Transparency → D73 (Bureaucracy; Administrative Processes in Public Organizations; Corruption), Environmental Sustainability → Q58 (Environmental Policy, Regulation, and Law)*

INTRODUCTION

The oil industry is an important factor for the development of the world economy, the expansion of energy security of nations, and scientific advancements. The development regime of this sector distinguishes several different parts: petroleum exploration, extraction, refining, and marketing. Promoting the development of the oil sector includes policy formulation, investment attraction, infrastructure development, and ensuring sustainability for enhanced social and economic benefits. This industry is vital for energy transitions and economic resilience. Still, it battles problems such as lack of physical power, lack of proper clean energy, and corruption, especially in Third World nations such as the Sub-Saharan African region. Using Public-Private Partnerships (PPPs) as one of the main approaches makes it easier to address these challenges. PPPs are working arrangements between public authorities and private operators to fund, construct, and implement oil industry projects. They in turn improve productivity, raise investment, and allow for the acquisition of new skills, which are critical for the progress of the oil industrial sector. In areas like South Sudan where there is a wealth of resources but a lack of infrastructure, PPPs can fill investment voids which guarantees efficient and sustainable development of the oil sector alongside the economic growth and regional stability.

The oil price crash of 2014-2016 plummeted oil prices by a whopping 60%. This volatility severely destabilized oil reliant economies in the likes of Venezuela, and Nigeria leading to widespread economic disruption. OPEC has long recognized the need for economic diversification among its member states to reduce their vulnerability to oil market fluctuations. The organization's Long-Term Strategy emphasizes sustainable development by encouraging investments in non-oil sectors. In response, Saudi Arabia launched Vision 2030, focusing on tourism, entertainment, and technology to lessen its dependence on oil revenues, while the United Arab Emirates has aggressively invested in aviation, real estate, and renewable energy. Though not an OPEC member, Canada has also pursued diversification by implementing a roadmap to decarbonize its oil and gas industry through carbon capture projects and renewable energy investments, reflecting a broader global push towards sustainable economic models, acknowledging the risks of overreliance on fossil fuels in an increasingly volatile energy market.

Livelihoods of people in various regions have been affected due to the persistent oil spills and pollution caused; this has led to the oil sector being the culprit of 33 % of the global CO_2 emissions in the year 2022 (IEA, 2023). Gas flaring has also been a flaw that plagues many oil rich countries due to the practical loss of resources alongside the increase of greenhouse gas emissions, this practice in the year 2021 amounted to The World Bank estimating a global release of CO_2 equivalent reaching 400 million tons. In 2010 a staggering oil spill of 4.9 barrels was released into the Gulf of Mexico that only demonstrated the dire ramifications of unsafe practices combined with improper environmental management.

As of 2022's BP Statistical Review, the global production of oil is over 88 million barrels a day, with the oil sector accounting for over 17% of energy consumption. In exploring which economies dominate oil production, the United States comes in first with over 12 million barrels a day, a figure that's facilitated by the nation's comprehensive infrastructure, state regulation as well as the integration of shale technology (EIA, 2022). Following right behind them is Saudi Arabia which manages to contribute over 10 million barrels a day, although this amount has increased due to major investments by the state in extraction and projects. Coming close to this is Russia's maintained output of 10.9 million barrels on a daily basis, although having geopolitical issues,

price volatility and energy transition expectations. Nonetheless, these trends illustrate the increasing shift of state-owned company's framework to collaborative approaches to sustain the enduring energy requirements this globalized world is in dire need of.

Even with numerous issues regarding market dependence, limited infrastructure, and governance, Sub-Saharan Africa is still home to quite a lot of oil reserves. According to OPEC, Nigeria is the biggest oil producing country in Africa and produces 1.5 million barrels a day. The country is methods reliant on oil however theft and environmental issues in the Niger Delta often strip the country of its potential allowing Angola to place second with 1.18 million barrels a day as stated by the World bank. Our research highlights that oil accounts for Angolas 50%GDP, it has implemented reforms to promote foreign investment and diversify its sources of energy. Gabon has a GDP adaptation strategy, it covers oseas exploration that accounts to approximately 180000 barrels a day.

As it stands, Uganda, Kenya, and Tanzania are the forefront leaders in East Africa's oil exploration. Uganda alone is believed to hold about 6.5 trillion bbl. of oil, with 1.4 trillion being recoverable, and the United Nations Development Programme corroborates this estimate. In terms of Uganda's oil strategy, they have the East African Crude Oil Pipeline which aims to connect various production sites to be able to export and minimize losses to their oil exports. While being infrastructure-heavy, it was confirmed by Tullow Oil, that Turkana alone had over 560 bo worth of oil. Furthermore, Tanzania has been assisting Uganda's oil strategy and the United Nations Environment Programme outlines how Tanzania aims to put more focus onto oil once they are done with focusing on their natural gas resources.

South Sudan is currently one of the most oil-dependent economies in the world, as revenues from oil account for 98% of its government revenue (World Bank, 2023). As of 2011, South Sudan was able to produce approximately 350,000 barrels of oil each day but due to still ongoing conflicts, destruction of infrastructure and lack of investments is producing around 1,600 thousand barrels as recorded in 2022 (African Development Bank, 2022). The fact that South Sudan relies on Sudan for oil pipeline facilities creates unnecessary costs and limits the oil sector's independence in South Sudan. As per reports by UNEP, there are issues of increasing environmental degradation and pollution in oil producing areas (2023), which impact the water and health of the people wellbeing. There is a lack of developing local regulatory content, which would promote skill exchange and therefore, South Sudan continues to depend on external professionals and technology. Although the countries have substantial resources, there are significant challenges in terms of infrastructure, governance, and environmental management that impede progress towards sustainable development. As a case in point, the South Sudan oil sector has illustrated how effective targeted measures are required to improve production capacity, governance systems and environmental sustainability. The goal of the present research is to assess which role Public-Private Partnerships will have in enhancing oil sector growth in South Sudan.

Research Problem

In many nations rich in resources, such as South Sudan, development of the oil sector has been hindered due to lack of infrastructure and technology, governance issues, and environmental factors. While Public-Private Partnerships (PPPs) have emerged as a possible solution for these issues, their application in the oil sector has been inefficient. Weak policy frameworks, low institutional capacity, and lack of pro-active private sector engagement have led to unfulfilled

expectations of PPPs in improving oil infrastructure, fostering technological advancement, and achieving ecological balance. The existing body of literature is deficient in providing elucidation on how developing South Sudan and other fragile states economically streamline operations on a PPP basis. Various studies examining PPPs have centered their attention on their use in well developed countries with sound institutional systems and have not considered their application in post-conflict, resource loaded nations, which is concerning. Additionally, while this literature accepts that PPPs can facilitate improvement of infrastructure and increase operational efficiency, little work has been done on how they influence governance, transparency, and environmental issues in the oil sector in South Sudan. This study seeks to bridge these gaps by critically evaluating the role of PPPs in South Sudan's oil sector, specifically in infrastructure development, technological advancement, and governance improvements. By identifying the strengths and weaknesses of PPP initiatives, the study aims to provide actionable insights for policymakers, private investors, and regulatory bodies. The findings will benefit government agencies by informing policy formulation, assist private sector players in understanding investment risks and opportunities, and contribute to academic literature on PPP implementation in fragile economies. Ultimately, the study will offer a roadmap for optimizing PPP frameworks to ensure sustainable growth and efficiency in South Sudan's oil sector.

Literature Review

The Role of PPPS in Enhancing Oil Sector Infrastructure Development

Deng et al. (2022) had conducted a study in Sudan and noted that the Greater Nile Oil Pipeline Project which was implemented through a PPP model, was efficient in executing around project supervision. The project was able to commence in 2016 and contributed an additional 1.4 billion dollars in revenue that enabled Sudan to double its oil exporting capacity. The study was very clear that there was effective collaboration among stakeholders as well as a balanced funding in place to make this possible. Santos (2023) has further investigated the impact of PPP projects in Angola Oil Review using Angola's Malongo Terminal project. The terminal's construction increased the nation's oil revenues share of GDP by 20 per cent by 2022 thereby increasing the country's export capacity. This project proved that the effective management of PPP's could enable timeliness in the execution of operations and the associated costs. However, the Uganda-Tanzania refinery project demonstrates the challenges of delays in PPP frameworks. A report by Mugisha et al. (2024) in *East African Energy Journal* revealed that land acquisition disputes and inadequate coordination among stakeholders delayed the project by over four years, eroding public trust. These delays have increased project costs by 30%, jeopardizing its financial viability and further delaying benefits to local economies.

South Sudan, South Sudan Development Studies 2023 by Gatluak found that the PPP initiatives face many challenges, which originate from instability and weaknesses in governance as in South Sudan. Furthermore, it is still underfunded and neglected, as a result, the Unity State Pipeline has yet to be finalized which hinders the amount of oil reserves South Sudan can monetize. Because PPPS are widely used in nations with little financial resources, the oil industry in sub-Saharan Africa can be transformed. As opposed to that, the Adebayo and Okonkwo report demonstrated that from 2023 on Nigeria, PPPs allowed the Dangote Refinery to obtain over $19 billion in private finance. This makes the Dangote project the only Africa's largest oil refinery to be ever built with a Soros equal to 650,000 a day selling crude oil. This significantly cuts down on the $10 billion

spent in hard currency each year to meet the demand of imported much needed petroleum based products in Nigeria.

Chad's use of PPPs lacks similar benefits, this is due to poor monitoring as outlined in Dinga's Central African Resource Journal study in 20223, where the construction materials used for drilling the oil wells were of subpar standards which led to leaking pipes on a continuum. Such events not only stalled oil activities but also polluted the environment to the tune of more than USD 200 million p.a. in clean up if the spill, to the Chadian economy. On the other hand, Batista's research from Angola reveals that the quality of infrastructure resulting from PPP is higher than that of any PPI due to growing private sector competences and innovations, using the example of successful Chevron and its partners offshore world class drilling platforms PPP initiatives. Hence, their safety technologies integration led to a 30% boost in oil extraction efficiency and lowered operational risks.

Kabanda et al (2022) revealed in their research results that the East African Crude Oil Pipeline (EACOP) initialized and obtained an investment of 3.5 billion dollars. They confirmed that oil PPP projects are most suitable for areas with little or no public financing. Selling Uganda's oil to global markets requires the construction of pumps and pipelines which Uganda can't finance hence the Uganda Tanzania partnership. Uganda and Tanzania are on track to fill in the hitherto unmet infrastructure needs of the global oil markets. The Daily Monitor dated 2023 estimates around 10000 direct jobs will be created as a result of this collaboration and also portray Uganda as a vast oil exporter. Mensah and Ackah (2023) supported this in their paper by illustrating Sankofa Gas Project in Ghana. This project had an overall investment of approximately 7.9 billion dollars where Ghana also contributed and partnered with the world bank, private investors and other NGOs with the objective to replace the very local energy infrastructure. The project also successfully reduced the average energy import by 25% by the year of 2023 increasing Ghana's energy resilience and developing its industrial economy.

The East African Crude Oil Pipeline, integrated 15,000 job opportunities in both Uganda and Tanzania during its construction phase (Policario, 2024). Such a major business move encouraged local governments to hire community members to work on the pipeline, which resulted in the enhancement of household income and standards of living. Additionally, workers were offered vocational training that would enable them to sustain a good standard of living after the completion of the project. In Ogun State, Nigeria, a considerable amount of employment opportunities were availed at the Dangote Petroleum Oil Refinery, Okonkwo and Adekunle investigated the employment opportunities made available for the people of Nigeria through PPP's in large scale oil projects. The Dangote refinery alone made available over 20,000 jobs in the construction phase while further supplementing the people with skills training programs, turning the unemployment rate in Lagos State from 2020 to 2024 by 12%.

The Role of PPPS in Promoting Technological Advancement and Operational Efficiency

Asante and Nyarko (2023), authors based in Ghana, reveal in their study that PPPs assist in providing advanced drilling technologies aimed at improving the efficiency and reducing the costs of extracting resources in the jubilee oil field whose use of horizontal drilling was able to increase oil recovery by 30% and decrease the operational cost by 20%. Hence, the creation of an oil field was made possible by this collaboration with TotalEnergies which aided in Angola's offshore modernization. One of the studies by Batista (2024) asserts that innovative technologies directed

and integrated into rigs minimized the periods of inactivity by as much as 15% which led to an increase in output and allowed Angola to compete in the global oil market.

According to a research article by Mendes and Silva (2023), published in Angola, such tools facilitated an area of high recovery, leading to a maximum cost reduction of 25% during their exploration phase. Th e use of cybernetic reservoir management tools in the work of the oil sector PPP has changed the ways of optimization of the resources. The use of predictive analytics software under the control of Chevron's PPP enhanced the utilization of resources significantly. However, in South Sudan, the implementation of digital tools has not been fully carried out which has affected the potential benefits expected from the tools. As enumerated by Deng and Gatluak (2024) of the South Sudan Development Review, a deficit of skills training on the use of reservoir management technologies, focus on the more capital-intensive resources leads to inefficiencies, and suggests that there should be capacity building programs targeted within the framework of the PPP.

As per a report by Adebanjo (2023) in Nigeria, it was noted that there was a 40% reduction in the imported petroleum products as the Dangote refinery made use of the high-capacity petroleum products refining units. Also, modern processing technologies which were included in the operational framework within the PPPs of the refinery helped in increasing the refinery output quality and efficiency. This also helped in increasing the economic resilience and energy insecurity of Nigeria. A Khartoum Refinery in Sudan also employed PPP to construct additional advanced desulfurization units in order to achieve cleaner fuel. This research study also confirms that the technology enabled Sudan to comply with international environmental regulations which resulted in an improved export capacity. In the case of Chad, the opposite is true as the refineries that were built under PPP were inefficient in operation. The regular shut downs were correlated to the low maintenance of high dictation equipment which led to surges in the energy supply chain disruption. This is evident in the report by Ngarmbatina and Djimadoum (2024) in the Chadian Energy Journal.

As noted by Nyaribo (2023), systems for oil pump leak detection are an integral part of the Uganda's East African Crude Oil Pipeline (EACOP) and artificial controls which contributed to the advancement of efficient oil transportation system through development of pump pipelines. These technologies greatly reduced transit losses and environmental impacts which made the project an exemplar for development of oil base facilities in the region. The Songo Songo Gas Pipeline, a PPP project in Tanzania, also proved the trend of these smart systems. Research carried out by Mwakalebela and Makame (2024) pointed out that these systems greatly facilitated gas delivery to power plants and various industries, which increased the energy reliability of Tanzania. On the other hand, Osman and El-Tahir (2024) reported in Sudanese Infrastructure Reports that the delays in the usage of smart technologies explained the numerous accidents and logistical problems. This poor performance explains the current failure of Sudan to develop a stable and reliable oil transportation system.

In a report by Karanja and Mwangi (2024) in East African Energy Review, it was observed that there is a global shift towards sustainability and that the oil industry is likely to adopt renewable energy technology in PPPS. In Kenya, PPPs have started researching on and adopting the use of solar panel oil extraction systems in an effort to reduce carbon emissions by 18.3 percent. Offshore platforms in Angola have started using wind turbines as part of their energy supply systems. Another study by Lemos and da Costa (2023) showed that integration of the renewable energy

improved the oil extraction energy efficiency and reduced operational costs by 12 % in efficiency. These wind turbines also act as an extra energy source and help to reduce the need for fossil fuels and reduce the associated environmental damage. Adeyemi (2024) on the other hand in Nigeria Oil Industry Insights reported that renewable energy transition has been very slow and as such fossil fuels are still being relied upon which is detrimental as emissions were very high and operations were inefficient.

The Role of PPPS in Enhancing Governance, Transparency and Environmental Sustainability

Ghana has an impressive Oil sector; however, it was still important to have the Petroleum Revenue Management Act which Asante and Boateng (2023) describe serves as a stringent measure. The strong institutions that have been established in the Ghanaian economy were fostered by the introduction of partnerships with a variety of stakeholders. Such measures, among others ensure regular Environmental Audits and responsible Pictures of environmental degradation within Nigerian Oil projects arise due to the improper enforcement of environmental regulations. It was also noted by Oladele and sir Ibraheem (2023) that oil spillages, gas flaring, and even Ecosystem Degradation are some of the prevailing issues in Nigeria regardless of the stringent regulations established.

Kasaija et al (2023) assert that Uganda's oil sector is enhancing accountability and public trust through the reporting on oil revenue management contracts' generated by using EITI standards within the PPP framework. Tanzania's engagement with Statoil (now Equinor) also demonstrates this model's application. In Lenga et al (2024), KPMG in collaboration with the Ministry of Natural Resources and Mining explains how the partnership commenced with the publicity of revenue sharing agreements that institutionalized equitable sharing of oil production profits, improved the governance perception of the sector, and established a system that makes the government and private sector accountable for their financial activities.

Policario (2024) had observed that PPP global projects involve developing engagement strategies that can be constructed in a Tell-Draw-Tell model in which the community develops content and the leadership offers approval He noted that PPPs have enabled the input of community voices that bear the burden of oil and gas projects and in doing so, khun and amos noted that PPPs have improved the scope development of oil production multi-channel mega infrastructure projects as well as Politai's (herbert) who indicated that the oil industry is highly politicized, has made it necessary for local communities to become actively involved. In their study, Damoah and Obeng (2024) appertained that Mc accent emphasis on local content is embraced by Ghana, Barrick Gold Corporation and the World Bank Group are known to put the people first when undertaking oil and gas related projects. However, the same cannot be said in the case of Nigeria especially in Niger Delta where lack of appropriate community involvement has bred anger. Nwankwo and Okoro (2023) noted that Lack of appropriate dialogue with the local populations around the Niger Delta tends to encourage oil sabotage as a development strategy and this leads to huge expenses and oil production interruptions. The absence of an all-inclusive engagement plan has resulted to violence, especially in Nigeria and calls are growing for such outreach initiatives.

As argued by Mwangi and Moyo (2024), with respect to Tanzania, supplementary measures such as the introduction of anti-corruption audits within the scope of PPP projects have improved accountability and financial management in the oil industry. Such measures have made corruption

and abuse of resources in the sector significantly less feasible. Such measures ensure that the potential for embezzlement and other financial malpractices is minimized, by compliance due process by all parties involved. In Ghana, the Public Interest and Accountability Committee (PIAC) has important responsibilities in overseeing the use of the oil funds in the context of PPP schemes. Gyasi and Osei (2023) in this case also state that oil revenues are properly used for national development strategies and not simply taken out for their personal use as is not infrequently the case. Regular audits and public reports, which are part of PIAC's tasks, lead to an increased accountability of the government to citizens about how the oil revenues are used.

Otieno and Kamau (2023) indicate that PPPs in the Lokichar Basin have been testing hybrid solar-powered drilling systems which significantly reduce the use of diesel generators and eliminate carbon emissions which enhances the environmental sustainability of oil operations to the benefit of reducing operational costs which improves efficiency in the oil industry. Similarly, Angola has also integrated green technologies into its offshore oil activities through the installation of waste water recycling systems in a bid to mitigate the environmental impact. Costa and Silva (2023) state that as technology is being used, it lessens the adverse consequences of waste water during oil extraction in the vicinity by recycling and use the waste water, so aiding in less pollution of the local waters. On the other hand, Olaniyi and Eze's (2024) research illustrated that Nigeria's neglect on investing in green technologies, such as renewable energy systems, and waste management practices has caused a continued pollution from oil extraction operations contributing to the further environmental degradation of one of the rich ecological areas of Africa.

In the words of Asare and Osei (2023), Ghana has greatly accelerated its achievements in meeting the UNFCCC provisions through the use of PPPs by bringing in global expertise into current practices on environmental protection. One key goal for PPP in the oil industry is to promote local oil companies to comply with rules of governance and environmental protection in the international market. This compliance makes it possible for a sustained energy system in oil producing nations and also meeting international obligations. It has failed to enforce international standards in its PPPs, leading to environmental and governance failures in the oil sector. According to Abdalla and Ahmed (2023), weak enforcement has resulted in violations of international treaties that have caused severe ecological damage. For instance, poor regulations in hazardous waste disposal have contaminated water in states like Upper Nile and Unity, further affecting drinking water and agriculture. There are also other opaque issues that concern the country's oil contracts. South Sudan's government has, for example, sold oil concessions to foreign companies like CNPC and Malaysia's Petronas in 2019 without considering any Environmental Impact Assessment or financial disclosure audits. This breeded corruption and mismanagement as these foreign owned companies crippled the economy. Oil spills, land degradation, and public health in oil producing regions suffered as a result of this deregulation. Up until today, South Sudan has failed to follow international accords such as the Paris Agreement and the UNFCCC, all while locals continue living under the dire conditions of helpless oil spills, rampant land degradation, and unbearable health problems.

Theoretical Review

Resource Curse Theory, presented by Richard M. Auty in 1993, offers an explanation of why natural resource-rich countries experience economic stagnation, institutional weakness, and poor governance. The theory holds that resource wealth will lead to dependence on one sector, the

weakening of institutional frameworks, increased corruption, and low investment in other sectors, hindering long-term development.

This hypothesis has been explored by a number of scholars, for instance, Sachs and Warner 1995, 2001, who found that most resource-rich countries, especially in Africa and Latin America, experienced poor economic growth due to poor governance. Ross 2001 discussed how oil wealth in the Middle East promoted authoritarianism and economic mismanagement. In fact, Collier and Hoeffler (2004) linked resource wealth to prolonged civil conflicts while Mehlum, Moene, and Torvik (2006) showed that countries with weak institutions are more vulnerable to the resource curse.

The theory remains applicable in South Sudan since the oil, though above 90% revenue collection for the government, has its benefits adulterated through weak institutions and corruption apart from environmental damage. Mismanagement of PPPs resulted in a non-transparent concession of oil, inability to follow international environmental requirements, and appropriate governance structures. Rather than nurturance, rent-seeking behavior or elite capture aggravated by oil wealth has resulted in the misallocation of funds and sparse investment in social services. Conflict over oil controls also further reinforces internal conflicts weakening PPPs' nascent capacity for sustainable development. Applying this theory to the study shows how institutional strengthening, enforcing transparency in PPPs, and regulating the regulatory framework could help South Sudan to beat the resource curse and improve economic resilience.

Research Gaps

South Sudan faces critical gaps in oil infrastructure investment, low project completion rates, and limited access to funding. The sector struggles with outdated drilling technologies, poor adoption of digital reservoir management, and inefficient refinery operations. Pipeline network operations remain weak, and regulatory frameworks lack oversight, fostering corruption and mismanagement. Transparency in revenue reporting is minimal, while environmental sustainability standards are nearly non-existent. Weak independent monitoring exacerbates corruption, and there is little investment in green infrastructure for long-term sustainability. Addressing these gaps is essential for the sector’s stability and national development, leaving key areas for future studies to analyze the gaps further and seek for solutions.

MATERIALS AND METHODS

Introduction

This chapter presents the research methodology and explains the overall approach the researchers employed in conducting the study. It also explores in detail the research design, the geographical area covered by the study, the participants of the study, how the sample was recruited, how data was gathered, methods of ensuring data integrity, and the methods of analyzing the data collected. Factors that allow the research to be considered ethical are also presented.

Research Design

The study undertakes descriptive research, collecting and analyzing data from existing documents. In Creswell’s view (2014), this type of design is well suited for investigation into the pre-existing documents, reports, and literature and providing detailed information relating to the research. With this method, researchers are able to gain a more detailed perspective regarding relationships,

patterns and trends that can be found in already available data such that it is most suited for investigations that have to do with secondary sources and analytics of already available data.

Study Area

This study focuses on the oil and gas sector in South Sudan. As noted by Yin (2018), it is imperative to determine the areas of study in accordance with the aims of the research and in a manner that ensures the documented data is attainable. This region was selected in relation to the need in solving the issues of Public-Private Partnerships, of governance, transparency or sustainability and which have sufficient amounts of secondary data for qualitative purposes.

Study Population

The study population consists of all documents, reports, policies and other publications that are in the public domain and relate to the purpose of the study. These include government documents, organization's publications, journal articles, policy documents, and other international regulations. Bryman (2016) observes that secondary data reviews can support researchers assess a huge blend of sources enabling them to be well rounded.

Sample Size and Sampling Techniques

The authors utilized purposive sampling in this study to actively select documents relevant to the study objectives. In their view of Patton (2015) purposive sampling can be utilized in studies which seek to achieve specific informational targets that are of great relevance to the problem of the study. This study had a total of 18 documents, which featured 2 government policy papers, 3 industry documents, and 13 academic articles published in peer-reviewed journals. The collection of these documents was based on selection criteria such as the focus of the document on Public-Private Partnerships (PPPs) in oil and gas and other institutions including their credibility and year of publication with recent (2015-2024) publications preferred in order to have updated materials. As Yin (2018) observes, the use of up-to-date sources makes the findings more credible and reliable since they are authoritative sources.

Data Collection

Data Collection Methods

Secondary data was collected in the study using systematic review methods. The selected documents were obtained from online repositories (for example, government websites, academic journals), institutional libraries and inquired from organizations which administer oil and gas projects. A template was developed to aid the process of extracting major themes and information in all documents reviewed, ensuring uniformity in the approach used to all the documents. Bowen Pertin (2009).

Instruments of Data Collection

Data was collected through the document review checklist which was the main tool designed for the data collection. The checklist was divided into sections for easy access and to enable scrolling through them so as to follow the objectives of the research such as governance mechanisms, financial accountability and environmental standards. Bryman (2016)

Quality Control Methods

Validity

As for the validity of the research, documents were gathered from reputable and reliable sources such as government documents and publications, peer reviewed journals and other stakeholders of international standing. The selection criteria were informed by provisions made by Creswell (2014) who highlights the need to follow recognized principles to enhance the credibility of secondary research. In addition, a multi-researcher review process was instituted in order to confirm the correctness and relevance of the data obtained. Cross-checking data among different researchers has proved to reduce bias and increase the credibility of the findings as noted by Bowen (2009).

Reliability

Consistency achieved by a standardized document review checklist was upheld and subcategorized across all reviewed documents leading to increased reliability. This Collins (2017) is quoted as saying that qualitative research tools need to be reproducible. In addition, the principle of triangulation was used where several sources were checked in order to confirm data accuracy. In qualitative studies, Patton (2015) underscores triangulation as the most effective way of ensuring reliability of findings.

Data Analysis Techniques

Thematic data analysis was adopted to analyze data obtained from the documents for policy and thematic content particularly for content that tended to reoccur frequently as well as policy gaps that are relevant to the research questions. According to Braun and Clarke (2006), thematic analysis is a method of analyzing qualitative data in a systematic but less decrepit manner, especially in secondary data analysis. In the case of the quantitative data, descriptive statistics were used to pinpoint the trend or pattern being observed. In Field's view (2018) the use of descriptive statistics in data analysis gives a summary of the numeric data and explain the trends behind it.

FINDINGS

Introduction

This chapter analyses the outcomes of the study based on secondary documents. The analysis looks at infrastructure building, technological growth, governance and sustainability in relation to Public-Private Partnerships (PPPs). The results are presented in a format that answers the objectives and questions that governed the research.

Presentation Of Findings

Table 1 elaborates the themes and subthemes in the oil sector infrastructural development.

Table 1: The Role of PPPS in Enhancing Oil Sector Infrastructure Development

S/N	Theme	Subtheme
1	Investment in oil infrastructure	• Expansion in refinery capacities. • Development of transport networks.
2	Access to funding for infrastructure	• Public-private partnership (ppp) models. • International financial support.
3	Employment opportunities created during development	• Local employment in construction phases. • Capacity building for long-term employment.

Investment in Oil Infrastructure

Expansion in Refinery Capacities

Akhmed et al, 2024 in their study conducted at the Future University of Sudan on the effects of Public-Private Partnerships on infrastructure development in Sudan indicated that the key positive aspect of PPPs in infrastructure development is the potential for private sector involvement in terms of skills, creativity, and capital which is capable of cutting down the time and cost of a project. Another advantage of these partnerships is the transfer of risks to the private sector which lessens the cost on the people. Still, much has been said against PPPs and the future ones, cost pushes because of profit motives, transparency issues and conflicts of interests.

Development of Transport Networks

According to the research undertaken by the NCTTCA, the abrupt occurrences of the pandemic caused large interruptions in the performance of the transport sector, especially in road transport which is vital in cross border trade. However, the Northern Corridor business community demonstrated resilience through the continued implementation of Public-Private Partnerships in the road infrastructure development. These partnerships promoted significant investments into the road networks reducing transport costs and increasing efficiency. For example, throughout the region there has been great improvement in the volume of trade due to the large construction and upgrading of many major roads such as the Mombasa to Nairobi traverse. All these events have enhanced the trade volumes by 10-15 percent, lowered the transportation timeframe by that same figure and decreased vehicle costs by around 20 percent.

Access to Funding for Infrastructure

Public-Private Partnership (PPP) Models

Looking at the South Sudan Infrastructure Action Plan – A Program for Sustained Strong Economic Growth. The document described how without any of the oil industry specific infrastructure, the South Sudanese economy would struggle to develop. The greatest concern was

that of a lack of funds to pursue infrastructure endeavors. Infrastructure projects had only received about ten percent of their budgetary requirements in 2020. Experts and analysis agreed that one of the principal impediments was the absence of investment and recommended Public-Private Partnerships as the best approach to close the gaps.

International Financial Support

According to research by Abdala, M. from the Doha Institute for Graduate Studies, it is necessary to have proper frameworks in place in order to attract investment in South Sudan and other resource- rich countries. If these frameworks are implemented, then it is predicted there will be a boost of international investment interest, allowing for infrastructure development. FDI, or foreign directly invested funds in this case, in countries where such frameworks are in place reach up to 30% rates than those without said frameworks. To add on, international lending bodies such as the World Bank or the Islamic Development Bank are also willing to invest in these countries, due to their potential to become self-sufficient and sustainable, making the investment sound rational as well.

Employment Opportunities Created during Development

Local Employment in Construction Phases

The Republic of South Sudan estimated the policies related to the employment, nationalization and local content requirements in the oil and gas sector. Further, it was predicted there will be local content requirements, in a sense that they required South Sudanese nationals to be prioritized during hiring processes, ensuring focus on hiring local talent. Lastly, the policies enforced also stated that at minimum, 70% of the employees hired during the construction and operational processes need to be South Sudanese. This essential as it will cultivate local skills and reduce dependency on foreign labor, fostering community development and economic sustainability.

Capacity Building for Long-Term Employment

A study on the Local Content in Petroleum Industry of South Sudan which explored local content initiatives within the oil and gas industry, focusing on how these initiatives can enhance capacity building and create long-term employment opportunities for South Sudanese citizens. The study identifies that effective local content policies have led to a 40% increase in training programs aimed at skill development for South Sudanese workers. These initiatives are designed to build capacity in technical and managerial roles, ensuring that local employees are prepared for long-term employment opportunities within the oil sector.

Table 2: The Role of PPPS in Promoting Technological Advancement and Operational Efficiency

S/N	Theme	•	Subtheme
1	Integration of Advanced Drilling Technologies	•	Use of horizontal drilling techniques.
		•	Deployment of hydraulic fracturing (fracking).
2	Adoption of Digital Reservoir Management Tools	•	Application of predictive analytics in reservoir monitoring.
		•	Use of 3d and 4d seismic technology.
3	Streamlined Pipeline Network Operations	•	Real-time monitoring systems for pipeline integrity.
		•	Implementation of leak detection mechanisms.

Integration of Advanced Drilling Technologies

Use of Horizontal Drilling Techniques

A report by the World Bank titled "Democratic Republic of South Sudan – Petroleum Local Content Policy" looks into local content initiatives in the oil and gas industry of South Sudan, aiming to advance the capacity development as well as add jobs for the South Sudanese citizens. The study identifies that effective local content policies have led to a 40% increase in the number of training programs directed on skill development for South Sudanese workers. Such policies include all the capacity building initiatives both at the technical and managerial level to enable local employees to gain long-term employment opportunities in the oil industry.

Deployment of Hydraulic Fracturing (Fracking)

In the study conducted by Elhassan and Ali named "An Optimization Model to Determine Horizontal Well Location and Parameters for Strong Bottom Water Reservoir in Sudan", the authors elaborate on an optimization model aimed at substantially increasing recovery from strong bottom water reservoirs via horizontal drilling techniques. Such a model has been implemented with varying degrees of success, with an increase in oil recovery of as much as 25%. Such evidence further bolsters the case for horizontal drilling improving production efficiency in South Sudan's oilfields.

Adoption of Digital Reservoir Management Tools

Application of Predictive Analytics in Reservoir Monitoring

The emergence of machine learning and predictive analytics in reservoir management practice has been discussed extensively by Katashov et al. (2022) in their article titled Digital platform as a tool for efficient reservoir management. With the help of advanced analytics methods such as machine learning, it becomes possible to improve accuracy and increase the efficiency of operations through analysis and forecasting based on big data. In the context of this study, it was remarked that predictive tools have the capability to bridge calculation errors by tracking up to 30% errors in reservoir behavior modeling which aids in efficient decision making when it comes to production and well interventions.

Use of 3d and 4d Seismic Technology

In their research, R. M. Alhaj and A. A. Shakib developed in 2023 worked on a case of oil fields located in South Sudan and Aleksandrov et al (2022) discussed the applicability of 3D and 4D seismic technologies in South Sudan. Insights from both studies revealed that the introduction of these seismic imaging technologies led to a 25% increment in the efficiency of subsurface modeling which is fundamental in facilitating the selection of drilling sites and increasing production. Production efficiency can be further elevated through the integration of 4D seismic modelling with seismic data to enhance production because it permits real-time modification of recovery techniques

Streamlined Pipeline Network Operations

Real-Time Monitoring Systems for Pipeline Integrity

WISE Group offers the Pipeline Telemetry System (PTS) as a tool that permits real time monitoring of the integrity of pipelines. While WISE Group offers algorithmic functions that are capable of identifying flow balance discrepancies, employing short term and longterm strategies, they also allow operators to gather leak data. This efficiency allows for WISE Group to enhance operational reliability and other monitoring factors. Even more satisfying, PTS has shown positive results when it comes to breach response time, and overall risk management regarding pipeline facilities.

Implementation of Leak Detection Mechanisms

Mobiltex's overview on pipeline integrity monitoring highlights that modern leak detection mechanisms have further advanced, nowadays, they include mechanisms such as fiber optic monitoring. Sensitive in nature, these systems are capable of registering temperature changes and acoustic vibrations at the sites of the leak. With fiber optic monitoring in the mix, localized conditions surrounding the leak points along the pipeline can be tackled, thus mitigating the possibility of leaks. The report emphasizes that proper and effective leak detectors drastically improve environmental safety and protection and economically, the damage caused by these unmonitored lost pipelines ensure less damaged than previously monitored.

Table 3 PPPS and Governance, Transparency, and Environmental Sustainability

S/N	Theme	• Subtheme
1	Strengthening Regulatory Frameworks through Collaborative Oversight	• Establishing interagency coordination. • Adoption of international standards.
2	Promoting Transparency through Revenue Reporting Mechanisms	• Implementation of open data portals. • Regular audits and public reporting.
3	Enhancing Stakeholder Engagement and Community Participation	• Community consultations during project planning. • Addressing community grievances through feedback mechanisms.

Strengthening Regulatory Frameworks through Collaborative Oversight

Establishing Interagency Coordination

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Adoption of International Standards

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Promoting Transparency through Revenue Reporting Mechanisms

Implementation of Open Data Portals

The open data that can be made available through the portals is said to increase public trust and accountability. This is because revenue information is made available in real time. This is according to the report titled "Achieving Greater Disclosure in the Oil and Gas Industry" written by Transparency International and the Revenue Watch Institute F.Center Berilac notes that nations with successful open data initiatives are greatly increasing citizen control and accountability over governance, thereby reducing the risk of corruption in the country. In addition, it emphasizes the notion that open data will enhance the ability to have a rational discussion on how resources should be allocated and utilized by the government.

Regular Audits and Public Reporting

It is possible to increase the accountability of the oil and gas companies by effective communication with the company's stakeholders. This is what Craig Fagan and his team advocate in the paper titled, "Promoting Revenue Transparency: 2011 Report on Oil and Gas Companies." The report shows that the more a company is subjected to independent audits, the more likely it is that that company will comply with the set revenue reporting criteria. government accountability is maintained as a result of citizens gaining access to resource allocation and management capabilities which reduces corrupt activities being carried out because financial statements are issued regularly. Good auditing practices are essential for preventing crème de la crème of the management and stakeholders to collude.

Enhancing Stakeholder Engagement and Community Participation

Community Consultations During Project Planning

According to the report by the World Bank Inspection Panel, one such development is the consultation of communities affected by the development process. The dockets assert that these factors related to meaningful consultation at the inception stage of the project cycle improve the project in the design phase, mitigate disputes, and enhance the development results. The report adds that there should be consultations that are effective but that these consultations need to be applicable to a particular culture and to deal with particular realities and that there are some philosophies and practices that foster good consultation and that there are some that discourage good consultation.

Addressing Community Grievances through Feedback Mechanisms

The oil and gas companies operating in the Hoima district, for instance, found by Bainomugisha and colleagues tend to have a strong reputation in the community because they manage to address their business-related grievances. More robust discussion revealed that the oil companies are more respected in the region as well due to the increased level of information about their operations and activities and this helps better manage the expectations of the people and decrease the tensions between the local communities and the companies. One of the main goals of this strategy is to minimize the tensions between the parties and to ensure that there are clear channels to make them heard during the decision-making processes. The results of the study propose that better communication with the public and convincing local people should be the main focus of both governments and companies.

CONCLUSION AND RECOMMENDATIONS

Conclusion

The importance of Public-Private Partnerships (PPPs) in changing the dynamics of infrastructure building in countries endowed with riches through access to private sector diminishes has been demonstrated. In both Sudan and South Sudan, The COVID pandemic which affected road transportation and trade activities was to some extent addressed through PPPs which provided the much needed financial and technical assistance. The employment of advanced tech in the oil and gas sectors as well as local content policies coupled with engaged stakeholders helped in fostering economic growth, enhancing transparency, and creating local jobs. These results emphasize the significance of adequate and developed frameworks and support for realizing the established long-term developmental objectives.

Recommendations

The paper has great implications for theory, practice, and policy. Theoretically, the paper widens the scope of application of the Resource Curse Theory by explaining how weak governance structures and technological gaps lead to poor nationalization outcomes in oil-rich but developing nations like South Sudan. It offers empirical evidence on how mechanisms of transparency and regulatory frameworks have a bearing on sustainable resource management.P

Practically, findings which shall be used to drive policy believers, investors, and industry participants towards the improvement of oil sector efficiency, better infrastructure investment,

integration of technology, and increasing governance mechanisms. It underlines the best practices to raise project completion rates, modernize drilling operations, and enhance revenue transparency.

The research has a clear policy relevance for regulatory bodies in demanding better oversight, environmental compliance, and accountability by the partnerships. It also underlines the adoption of international best practices in oil governance, promoting improved financial disclosure mechanisms and investment in alternatives that have implications for economic stability in the long run.

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