INTERNATIONAL JOURNAL OF LATEST TECHNOLOGY IN ENGINEERING, MANAGEMENT & APPLIED SCIENCE (IJLTEMAS)

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XIV, Issue IV, April 2025

Horizontal Directional Drilling: A Solution to Oil and Gas Pipeline Vandalism and Theft in Nigeria

Ogunweolu Oluseyi Emmanuel

API 570 certified inspector, NNPC Gas Infrastructure Company Limited

DOI: https://doi.org/10.51583/IJLTEMAS.2025.140400127

Received: 20 April 2025; Accepted: 30 April 2025; Published: 26 May 2025

Abstract: Nigeria, a major oil-producing country in Africa, has long been plagued by the persistent problem of oil pipeline vandalism. Sabotage and illegal tapping of oil pipelines have resulted in significant economic losses, environmental damage, and disruptions to the country's energy supply. This study explores the potential utilization of horizontal directional drilling (HDD) as a viable solution to help eliminate oil pipeline vandalism in Nigeria. The objective of this literature review is to showcase the effectiveness of HDD technology in preventing or reducing incidents of pipeline vandalism as compared to conventional methods of pipeline installation. By examining case studies and scholarly literature, this paper will analyze the advantages, challenges, and economic feasibility of implementing HDD techniques to mitigate oil and gas pipeline vandalism in Nigeria. Firstly, the study will explore the advantages of HDD technology, including its ability to install oil pipelines underground and mitigate accessibility to potential vandals, enabling the creation of subsurface pathways, reducing the visibility and potential vulnerability of infrastructure. In addition, this literature review will shed light on the challenges associated with implementing HDD in Nigeria. The economic feasibility of implementing HDD technology in Nigeria's oil and gas sector will be assessed. A cost-benefit analysis will be conducted, comparing HDD with traditional methods of oil pipeline installation. The findings of this study will contribute to the existing body of knowledge regarding methods to combating oil and gas pipeline vandalism in Nigeria, thereby providing useful insights to policymakers, infrastructure developers and relevant stakeholders, encouraging them to consider HDD as a potent solution to mitigate oil and gas pipeline vandalism.

Keywords: Horizontal Directional Drilling (HDD), Oil and Gas pipeline vandalism, Nigeria, mitigate, Niger Delta, Crude Oil

Introduction

Nigeria's expansive oil and gas pipeline network traverses diverse terrains, including densely populated urban areas and remote rural regions. Traditional above-ground pipeline installations have made them vulnerable to vandalism, with criminal groups frequently targeting these critical energy assets. The resulting spills and explosions have devastated local communities and ecosystems, while costing the Nigerian government and oil companies billions of dollars in lost revenue and cleanup efforts.

In recent years, Nigeria has faced numerous counts of oil thefts and pipeline vandalism, such incidents, resulting in a monthly loss of about $700m[1]. Subsequently, Nigeria reached its lowest daily average output since 1997, resulting in the country slipping behind Angola as Africa's largest exporter in July 2022 [1].

Fig 1 showing a tap of point on a crude line made by vandals [8]

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XIV, Issue IV, April 2025

Fig 2 showing pipeline explosion as a result of bunkering activities in Niger Delta [9]

Fig 3. A crude oil line punctured by vandals [10]

This has resulted in major international oil and gas companies planning to exit the country such as Shell which announced its plan to sell its Nigerian onshore subsidiary, Shell Petroleum Development Company of Nigeria, to Renaissance, also , Italian energy giant Eni agreeing to sell its Nigerian subsidiary, Nigerian Agip Oil Company, to Oando[2].

Conventional methods of protecting pipelines, such as increased security patrols and the use of above-ground infrastructure, have had limited success in deterring vandalism. The accessibility of pipelines, often traversing remote and hard-to-reach areas, makes them vulnerable to persistent attacks. Consequently, there is a pressing need to explore alternative solutions that can effectively mitigate the threat of pipeline vandalism in Nigeria

All this and more are the problems bedeviling the Nigerian oil and gas sector, however, one promising solution may be found in the use of horizontal directional drilling (HDD) technology. HDD offers the ability to install pipelines and other critical infrastructure underground, significantly reducing their visibility and accessibility to potential vandals. By placing pipelines beneath the surface, HDD can create a physical barrier that hinders unauthorized access and tampering, potentially curbing the frequency and impact of vandalism incidents.

This review delves into the potentials of HDD as a strategic tool to combat pipeline vandalism in Nigeria. It examines the technical aspects of HDD, its advantages over conventional pipeline installation methods, and the feasibility of implementing this technology within the Nigerian context[14]. The literature review also addresses the potential challenges and barriers to the widespread adoption of HDD, as well as the economic considerations that may influence its viability as an anti-vandalism measure.

By exploring the application of HDD technology, this article aims to contribute to the ongoing dialogue on enhancing the security and resilience of Nigeria's critical energy infrastructure. The findings presented here could inform policymakers, infrastructure

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XIV, Issue IV, April 2025

operators, and stakeholders, guiding them towards more effective strategies to mitigate the devastating consequences of pipeline vandalism and secure the nation's energy future.

Methodology

This study employs a qualitative research methodology anchored in a comprehensive literature review and comparative analysis to evaluate the viability of Horizontal Directional Drilling (HDD) as a solution to oil and gas pipeline vandalism in Nigeria. The methodology is structured around the following key phases:

Research Design

The study adopts a descriptive and exploratory design utilizing secondary data sources to analyze the technological, economic, environmental, and socio-political implications of implementing HDD for oil pipeline infrastructure in Nigeria. The goal is to draw connections between HDD application and its potential to reduce pipeline vandalism.

Data Collection

Data was sourced through desk-based research, including:

Academic publications, peer-reviewed journals, and technical reports on HDD, trenchless technology, and pipeline security.

Industry case studies and white papers that document the application of HDD in oil and gas projects both within and outside Nigeria.

Government reports and datasets from Nigerian regulatory bodies such as the Nigerian National Petroleum Corporation (NNPC), the Nigeria Extractive Industries Transparency Initiative (NEITI), and the Department of Petroleum Resources (DPR).

News archives and NGO publications on pipeline vandalism incidents, economic losses, and security interventions.

These sources provided insight into the scale of pipeline sabotage, HDD technological applications, and the socioeconomic and environmental context of Nigeria’s oil-producing regions.

Comparative Analysis

A comparative framework was developed to contrast HDD and conventional open-trench pipeline installation methods. This involved:

Analyzing technical specifications (e.g., depth, alignment flexibility, disruption footprint).

Evaluating security implications, including accessibility to potential vandals.

Conducting a cost-benefit assessment of initial investment, maintenance, and long-term operational costs.

Reviewing environmental and social impacts based on documented HDD projects and modeling potential applications in Nigeria.

Case Study Review

The methodology incorporated review of select HDD implementation case studies, including:

HDD applications in the Niger Delta (e.g., Fenog Nigeria Ltd’s river crossing project).

International HDD projects (e.g., Saudi Arabia, Trinidad & Tobago) with similar geotechnical or sociopolitical characteristics.

These case studies helped in evaluating the technical feasibility and scalability of HDD in Nigeria’s terrain and socio-political context.

Technical and Economic Feasibility Assessment

To examine economic viability, the study reviewed:

HDD operational cost data (mobilization, drilling, and material costs).

Long-term savings related to reduced repair costs, security expenses, and environmental remediation.

Pipeline lifecycle economics, factoring in reduced sabotage incidents and extended asset lifespan.

Where quantitative data were available, economic modeling and comparative cost analyses were referenced from existing pipeline engineering literature.

Risk and Barrier Identification

A barrier analysis was conducted to identify potential challenges in HDD implementation, such as:

Geological and environmental constraints.

Regulatory and policy bottlenecks.

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XIV, Issue IV, April 2025

Socio-cultural resistance and community engagement issues.

Technical capacity and workforce availability.

These were examined in the context of Nigeria's oil-producing regions, particularly the Niger Delta, using data from environmental impact assessments, oilfield operation reports, and stakeholder interviews from secondary sources.

Limitations

The study relies exclusively on secondary data due to the absence of field-based experimentation or site visits.

Certain cost estimations and economic projections are derived from international case studies and may not fully reflect local Nigerian market dynamics.

The analysis does not incorporate real-time monitoring data or direct stakeholder surveys, which could enhance the reliability of threat estimation and community perceptions.

Ethical Considerations

All referenced materials were properly cited and drawn from publicly available, credible sources. The study-maintained objectivity by presenting both the advantages and challenges of HDD adoption, avoiding bias toward a singular outcome.

This methodology provides a robust framework for evaluating HDD as a transformative technology in combating pipeline vandalism in Nigeria, offering a basis for evidence-informed decision-making by policymakers, energy stakeholders, and infrastructure developers.

Some cases of pipeline vandalism in Nigeria and their economic implications

According to data from the Nigeria Extractive Industries Transparency Initiative (NEITI), Nigeria recorded a cumulative loss of approximately **619.7 million barrels of crude oil** to various forms of theft between **2007 and 2020**. The estimated market value of the lost crude oil amounts to **$46.16 billion** over the period under review [19].

When converted using an exchange rate of **₦769.24 per US dollar** (as of August 10, 2023), this loss equates to approximately **₦35.51 trillion** in revenue forgone due to crude oil theft and related illicit activities.

Year	Volume of Losses ('million barrels)	Value of Losses ($) 'billion
2009	69.49	4.31
2010	28.31	2.29
2011	38.61	4.39
2012	51.58	5.82
2013	78.30	8.55
2014	40.17	4.14
2015	27.12	1.43
2016	101.05	4.42
2017	36.46	1.99
2018	53.28	3.38
2019	42.25	2.77
2020	53.06	2.21
TOTAL	**619.70**	**46.16**

Table 1. Total losses from crude oil theft and sabotage in volume and value between 2009 and 2020 [19]

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XIV, Issue IV, April 2025

Also in 2022, a total of **572 oil spill incidents** were recorded based on reported causes. Of these, **480 cases (approximately 83.9%)** were attributed to **oil theft and acts of sabotage**, while **92 incidents (approximately 16.1%)** resulted from **operational failures**.

The estimated **volume of crude oil spilled due to sabotage** amounted to **16,135 barrels**, whereas **operational-related spills** accounted for approximately **2,599 barrels**.

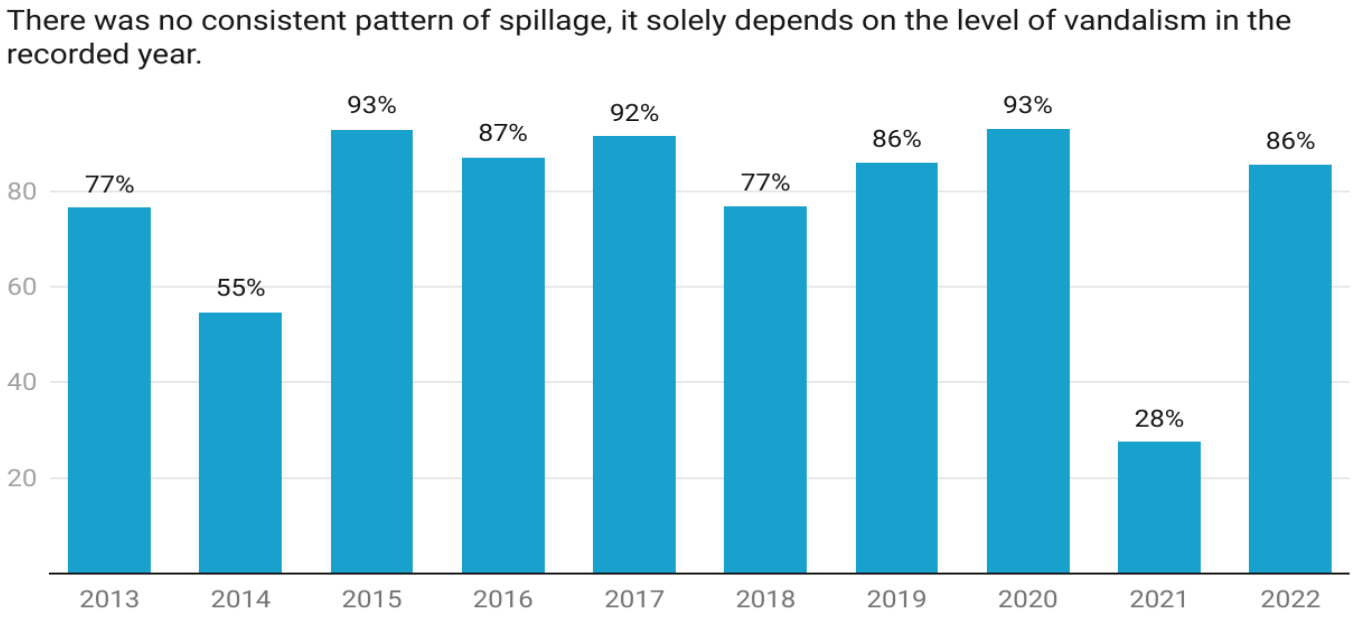

Fig 4. Percentage of oil spilled through oil theft between 2013 and 2022 [19]

Between **January 2019 and September 2020**, a total of **1,161 pipeline vandalism incidents** were recorded across Nigeria. These incidents occurred along **five major pipeline corridors** nationwide.

The **Port Harcourt pipeline corridor** experienced the highest frequency of attacks, accounting for **538 vandalized points**. This was closely followed by the **Mosimi–Ibadan corridor**, which recorded **535 damaged points** during the same period.

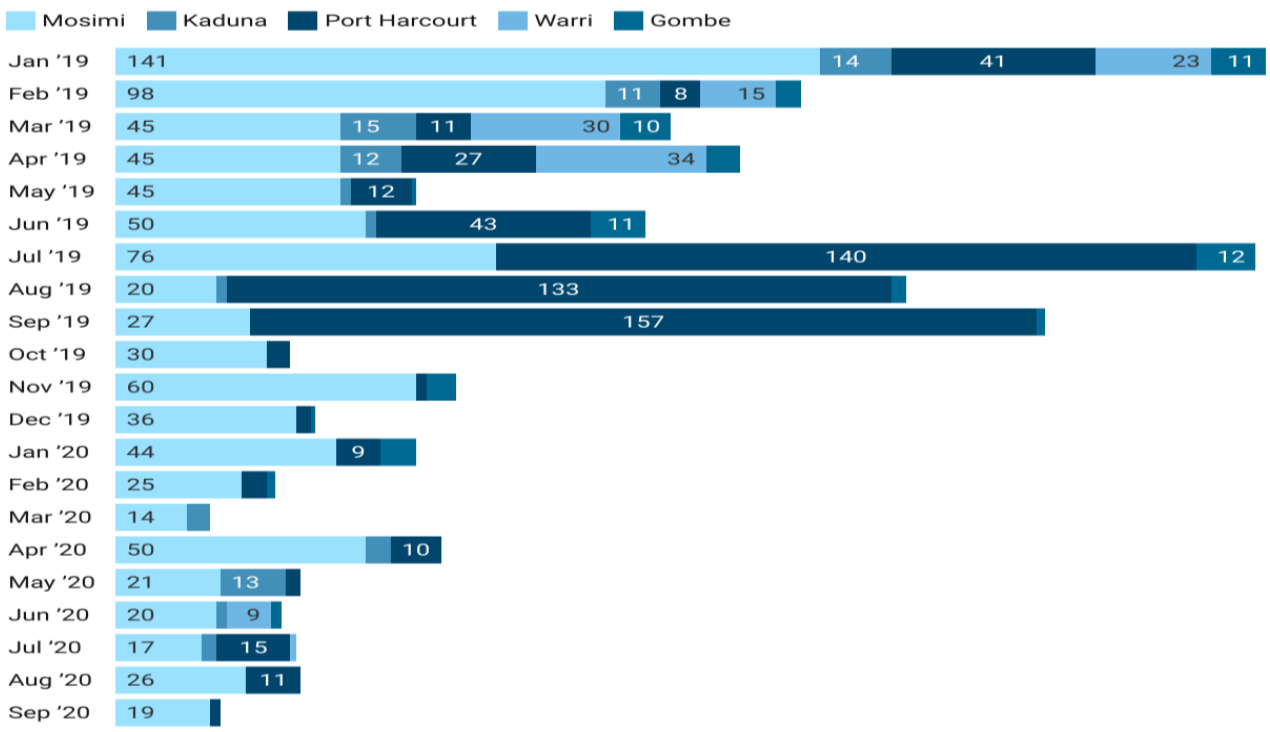

Fig 5. Number of pipeline points vandalized within two years [20]

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XIV, Issue IV, April 2025

According to the Nigerian National Petroleum Corporation's (NNPC) monthly Federation Account Allocation Committee (FAAC) reports covering the period from December 2019 to January 2021, a total of ₦59.1 billion was expended on pipeline repair and management over the course of one year.

The expenditure was distributed across key operational areas as follows:

Strategic holding operations accounted for the largest share at ₦19.1 billion,

Pipeline and facility repairs amounted to ₦15 billion,

Marine distribution incurred ₦10.9 billion,

Security and maintenance costs totaled ₦8.9 billion, and

Pipeline management expenses stood at ₦5.1 billion.

Spending peaked between March and May 2019, with ₦8 billion disbursed in May, ₦7.8 billion in April, and ₦7.7 billion in March.

The Rise of Horizontal Directional Drilling

Horizontal Directional Drilling (HDD) has emerged as a game-changer in the field of underground infrastructure development, offering a versatile and efficient method for installing utilities without disrupting the surface. The HDD market has experienced significant growth in recent years, driven by increasing demand for cost-effective, environmentally friendly, and minimally invasive solutions in various industries.

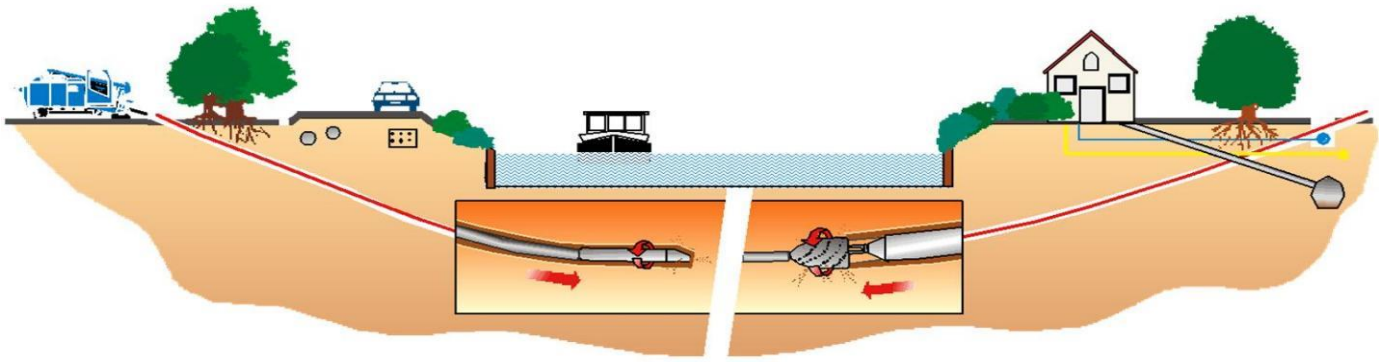

Fig 6. HDD Process [11]

Fig 7. Arial view of HDD Process [21]

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XIV, Issue IV, April 2025

As shown in Figures above, horizontal directional drilling (HDD) is a trenchless method of installing underground pipelines in a shallow arc along a prescribed path by using surface-launching drilling rig, with minimal impact on the surrounding area. HDD is also used when trenching or excavating is not possible. The tools and techniques used in HDD process are an outgrowth of the oil well drilling industry.

Horizontal directional drilling offers a viable alternative to conventional pipeline construction. This technique involves drilling a pilot hole beneath the surface, followed by pulling the pipeline through the pre-drilled path. By burying the pipelines deep underground, often at depths of 10 to 15 meters, HDD significantly reduces the risk of sabotage and unauthorized access[2].

Reported Industry use of HDD techniques

In August 2010, Fenog Nigeria Limited (FNL) successfully laid gas pipes across the 1.7km Escravos River in Warri Southwest Local Government Area of Delta State[7].

In 2004, Cross Island Pipeline Project for The National Gas Company of Trinidad and Tobago installed 56-inch diameter pipeline which has three HDD sections in lengths of 2,230 feet (680 meters), 2517 feet(767 meters), and 2415 feet (736 meters)[7].

Two parallel 24-inch and 30-inch steel pipelines of length 10,000 ft (3050 meters) were completed on the Arabian Gulf Coast in Saudi Arabia in January of 2009 using the capabilities of the drilled intersect method[7].

Recent Advancements in Pipeline Protection Technologies Focusing on Enhancing Security Against Vandalism and Environmental Threats

Distributed Acoustic Sensing (DAS) with Machine Learning

Description: DAS utilizes fibre optic cables to detect vibrations along pipelines. Machine learning algorithms analyse these vibrations to identify potential threats such as unauthorized digging or tampering [16].

Advantages: DAS provides real-time monitoring over long distances, enhancing the ability to detect and respond to security threats promptly. This will go a long way in providing additional security alertness against pipeline vandalism in Nigeria

Limitations: The effectiveness of DAS can be influenced by environmental factors such as temperature fluctuations and ground movement, which may affect the accuracy of vibration detection [17].

AI-Based Threat Estimation Systems

Description: Recent studies have proposed AI-based systems that integrate intelligent sensors to detect external vibrations and estimate the spatial location of threats to pipelines. These systems utilize deep learning techniques to improve recognition accuracy and reduce false alarms [18].

Advantages: AI-based systems offer enhanced accuracy in threat detection and localization, facilitating timely and appropriate responses to potential security breaches.

Limitations: The deployment of AI-based systems requires significant investment in infrastructure and technology. Additionally, these systems may require continuous updates and maintenance to adapt to evolving threats. Nigeria being a developing country may not be able to sustain this type of technology for its pipeline.

Advantages of HDD for Pipeline Security and Transportation

The underground installation of pipelines through HDD provides several key benefits for enhancing oil pipeline security and economic benefits in Nigeria:

Reduced Visibility and Accessibility: Placing pipelines deep beneath the surface makes them much less visible and physically inaccessible to would-be vandals, deterring potential attacks. HDD can be used to bury pipes as deep as 10 to 15 meters which will make it very difficult for vandals to access [2,3].

Reduced traffic and road accidents: Since the increase of pipeline vandalism, transportation of petroleum products had been majorly by road with the use of tankers of various sizes to transport petroleum products across all the Nigerian states from the refineries and depots. The inherent use of pipelines can help reduce the rate of fuel tanker accidents and explosions on the highway which has led to the loss of lives and properties worth millions of dollars over the years, thereby making our highways safer[2].

Increased Resilience: The protected, subterranean positioning of pipelines installed via HDD makes them less susceptible to damage from external factors, such as heavy machinery, construction activities, or natural disasters[3].

Improved Leak Detection: Advanced monitoring systems can be integrated with HDD-installed pipelines, enabling early detection and rapid response to any potential leaks or ruptures [3].

Cost-effectiveness: While HDD technology requires significant initial investment, the long-term cost savings can be substantial. Reduced surface restoration costs minimized traffic disruptions, and the ability to drill longer and larger-diameter bores contribute

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XIV, Issue IV, April 2025

to the cost-effectiveness of HDD compared to traditional methods [3]. Also pipeline transportation reduces cost reason being that its operational and running expenses are low compared to road transport[2]. Additionally, it requires less energy consumption to transport oil from production point to consumers.

Minimized Environmental Impact: By avoiding surface-level disturbances, HDD can help mitigate the environmental consequences of oil spills and reduce the impact on local communities [3].

Table 1 below further shows the advantages of HDD versus conventional trench type of pipeline installation

S/N	HDD Method	Traditional Open Cut
1.	• Rapid Deployment Easy setup & minimum Machineries. Open trench only at launching and receiving pits	Slow Deployment Involve a lot of machineries for excavation & import/ export materials Open Excavation all the way
2.	• Flexible Installation Drill from surface Can re-engineer the alignment vertically/horizontally to avoid utilities/obstacles Installation not necessary straight	• Rigid Installation Open Excavation all the way Difficult to change direction once meet utilities and obstacles. Difficult to change alignment
3.	• Environmental Friendly Process Minimum open excavation Less noise and dust. Fewer amounts of debris & waste generation. Reduce construction materials (For road repairs). Bentonite can be recycle and chemically not harmful	• Non-environmental Friendly Process 100% open excavation Large dumping of excavated materials, import/export at site, large noise and dust pollution. Huge quantity of waste, required heavy machinery to export/import materials A lot import/export sand, crusher run requires for road repairs
4.	• Better Quality reinstatement Less excavation easier to repair and control reinstatement quality	• Poor Quality reinstatement 100% Open excavation difficult to repair and control reinstatement quality
5.	• Avoid Traffic Congestion No road closure Less construction machineries Less import/export construction material	• Causes Traffic Congestion Road closure Many Construction machineries Major import/export construction mater

Table 2 [3]

Embracing HDD for Nigeria's Oil and Gas Infrastructure

Adopting horizontal directional drilling as a preferred method for new pipeline installations and the rehabilitation of existing pipelines can be a game-changer in the fight against oil pipeline vandalism in Nigeria. This trenchless technology not only enhances the security of critical energy infrastructure but also promotes sustainable development and environmental protection.

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XIV, Issue IV, April 2025

To fully realize the benefits of HDD, Nigeria must invest in the necessary skills, equipment, and regulatory frameworks to support its widespread implementation. Collaboration between the government, oil companies, and engineering firms will be crucial in driving this transformation and securing the country's energy future.

Challenges and Barriers

Implementing Horizontal Directional Drilling (HDD) for oil and gas pipelines in Nigeria presents unique challenges due to the nature of the industry and the specific conditions in the country:

Geological Complexity: Nigeria's diverse geological formations, including hard rock, soft soils, and challenging terrain such as swamps and mangroves in the Niger Delta, can complicate HDD operations. Adapting drilling techniques to varying soil conditions and avoiding geological hazards like faults and unstable formations are critical[4, 5].

Environmental Sensitivities: The Niger Delta region is ecologically sensitive, with diverse flora and fauna, as well as fragile ecosystems. HDD projects must adhere to strict environmental regulations to minimize disruption to habitats, water bodies, and biodiversity. Spill prevention measures and restoration of affected areas are also essential[5].

Pipeline Integrity and Safety: Ensuring the integrity and safety of oil and gas pipelines is paramount. HDD projects must meet rigorous standards for pipeline design, construction, and operation to prevent leaks, corrosion, and other potential hazards. Comprehensive risk assessments and monitoring systems are necessary to detect and mitigate threats to pipeline integrity[5].

Community Engagement and Social License: Local communities in the Niger Delta often have deep-seated grievances related to land rights, environmental degradation, and economic marginalization. Government and stakeholders alike must engage with communities early and transparently, addressing concerns about land acquisition, compensation, employment opportunities, and the potential impacts of drilling activities on livelihoods and cultural heritage.

Security Risks: The Niger Delta has a history of social unrest, militancy, and sabotage targeting oil and gas infrastructure. HDD projects are vulnerable to security threats such as vandalism, theft, and attacks on personnel and equipment. Implementing robust security measures, including collaboration with local authorities and communities, is essential to safeguard project assets and personnel.

Regulatory Compliance: HDD projects for oil and gas pipelines in Nigeria are subject to a complex regulatory framework that includes environmental laws, safety regulations, and industry standards[6]. Ensuring compliance with relevant regulations and obtaining permits and approvals from regulatory authorities can be time-consuming and bureaucratic.

Logistical and Infrastructure Challenges: Nigeria's inadequate infrastructure, including poor road networks, limited port facilities, and unreliable power supply, can pose logistical challenges for HDD projects. Accessing remote project sites, transporting heavy equipment and materials, and mobilizing skilled personnel may require careful planning and coordination.

Technical Expertise and Capacity Building: HDD operations require specialized skills and expertise in drilling engineering, geotechnical analysis, and pipeline construction. Building local capacity through training programs, technology transfer, and collaboration with international partners is essential to ensure the success and sustainability of HDD projects in Nigeria[5].

Several socio-cultural factors may also hinder the adoption and expansion of Horizontal Directional Drilling (HDD) as an anti-vandalism measure in Nigeria:

Resistance to Change: In many communities, there may be resistance to adopting new technologies, particularly if they are perceived as unfamiliar or disruptive. HDD may be viewed with skepticism or mistrust, especially if community members are unfamiliar with its benefits or have concerns about its potential impact on their livelihoods or environment.

Cultural Beliefs and Practices: Socio-cultural norms and beliefs can influence perceptions of technology and innovation. Traditional beliefs about land use, ownership, and spiritual significance may conflict with the implementation of HDD projects, particularly if they involve disturbance of sacred sites or ancestral lands[6].

Communication Barriers: Effective communication and engagement with local communities are essential for gaining acceptance and support for HDD projects. Language barriers, literacy levels, and communication styles may pose challenges to effective dialogue and information dissemination, leading to misunderstandings or mistrust[5,6].

Perceptions of Government and Industry: Distrust of government authorities and oil and gas companies is prevalent in many communities affected by pipeline vandalism. Past experiences of exploitation, corruption, and environmental degradation may fuel skepticism about the motives and intentions behind HDD projects, hindering community buy-in and cooperation.

Economic Factors: Socio-economic disparities and inequalities can exacerbate tensions between communities and the oil and gas industry. Perceptions of unfair distribution of wealth and benefits from resource extraction may undermine support for HDD projects, particularly if local communities feel excluded from decision-making processes or see limited economic opportunities arising from the projects[13].

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XIV, Issue IV, April 2025

Security Concerns: In regions affected by insecurity and criminal activities such as pipeline vandalism, communities may prioritize short-term survival strategies over long-term development initiatives like HDD[14]. Fear of reprisals from criminal groups or armed conflict with security forces can deter community members from supporting anti-vandalism measures that may disrupt the status quo.

Historical Trauma and Conflict: Many communities in Nigeria have experienced historical trauma and conflict related to resource extraction, land dispossession, and environmental degradation. Past grievances and unresolved disputes may shape community attitudes toward HDD projects, with some viewing them as extensions of colonial or neo-colonial exploitation.

Addressing these challenges requires a collaborative effort involving government agencies, oil and gas companies, local communities, civil society organizations, and other stakeholders[13,15]. Adopting best practices in project management, environmental stewardship, community engagement, and risk management can help mitigate risks and ensure the safe and responsible implementation of HDD for oil and gas pipelines in Nigeria[14].

Economic feasibility of implementing HDD technology in Nigeria

Improved Security of Pipeline:

HDD: HDD provides better protection from vandals due to the fact that it is buried very deep into the ground, thereby reducing accessibility to vandalism.

Traditional Method: Open-cut methods provide easy access to vandals as the pipes are buried at a depth not too deep and may be more exposed as erosion wear away the top soils thereby giving more access to vandals.

Installation Costs:

HDD: HDD typically involves higher upfront costs due to the specialized equipment, skilled labor, and advanced technology required for drilling horizontally underground. The cost of HDD can vary depending on factors such as soil conditions, length of the pipeline, and environmental considerations.

Traditional Methods: Traditional open-cut methods, such as trenching, are generally cheaper upfront because they involve simpler equipment and labor-intensive processes. However, costs can escalate if the terrain is challenging, requiring extensive excavation, rock blasting, or environmental mitigation measures.

Operational and maintenance costs:

HDD: Once installed, pipelines laid using HDD tend to have lower operational costs and require less maintenance compared to pipelines installed via traditional methods[2]. HDD pipelines are less susceptible to external damage and corrosion since they are buried deeper underground and are not exposed to surface disturbances.

Traditional Methods: Pipelines installed using open-cut methods may require more frequent maintenance and repairs due to exposure to environmental elements, soil movement, and potential damage from human activities. Regular inspections, corrosion protection, and integrity management are essential to ensure safe and reliable pipeline operation.

Risk Management:

HDD: HDD offers better risk management by minimizing the risk of accidental damage to pipelines during installation[4]. It reduces the likelihood of surface disruptions, utility conflicts, and construction-related incidents, thereby enhancing safety for workers, communities, and the environment.

Traditional Methods: Open-cut methods entail higher risks of accidents, such as trench collapses, equipment failures, and utility strikes[7]. These risks can result in injuries, property damage, and environmental contamination, leading to project delays, litigation, and reputational damage for project sponsors.

Potential Financial Advantages of Implementing HDD

Reduced Vulnerability to Vandalism: HDD can bury pipelines deeper underground, making them less accessible to vandals and reducing the frequency and cost of repairs[2,3]

Reduced Surface Disruption: HDD minimizes the need for surface disruption, leading to lower costs for land acquisition, environmental restoration, and community disruption[2].

Environmental Compliance: HDD is often more environmentally friendly, reducing the risk of regulatory fines and expediting the permitting process.

Flexibility and Adaptability: HDD is better suited for difficult terrains and urban areas, where traditional trenching would be cost-prohibitive or impractical.

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XIV, Issue IV, April 2025

Long-Term Cost Savings: Despite higher initial costs, the reduced need for frequent maintenance and repairs due to vandalism can lead to significant long-term savings.

Safety and Risk Management: HDD reduces the risk of accidents and environmental damage during installation, potentially lowering insurance and contingency costs[2,3,7].

Shorter Project Timelines: Faster installation times can lead to quicker project completion, reducing the time-related costs such as labor and equipment rentals, and enabling faster commencement of pipeline operations and revenue generation [2,7].

Conclusion

As Nigeria navigates the challenges of pipeline security, the strategic use of horizontal directional drilling emerges as a promising solution to combat the scourge of oil pipeline vandalism and ensure the reliable and safe transportation of its valuable natural resources.

Additionally, Nigeria where pipeline vandalism is a significant issue, HDD offers substantial financial advantages over traditional trenching methods. The initial higher investment in equipment and specialized labor is offset by the long-term savings from reduced vandalism-related repairs, lower maintenance costs, and enhanced security. HDD's ability to minimize environmental impact and expedite project timelines further enhances its cost-effectiveness and sustainability for oil pipeline installations in Nigeria. It offers significant benefits in terms of environmental protection, operational efficiency, security and risk management.

References

1. NNPC Seeks Help for Oil Theft and Pipeline Vandalism in Nigeria. (2024). Retrieved March 18, 2024, from https://www.offshore-technology.com.
2. Benefits of Transporting Crude Oil Through Pipelines.(2024). In Tank Farm Nigeria. Retrieved June 6, 2024 , from https://www.tankfarmnigeria.com
3. Mohd Norizam, Nuzul Azam, Helmi Zulhaidi, Abdul Aziz;Nadzrol Fadzilah (2017). Literature review of the benefits and obstacles of horizontal directional drilling. IOPScience, 271,4-6.
4. Kai Zang, Liqiong Chen, Tin He, Duo Xu, Weihe Huang, Song Yang, Zhiqiang Zeng (2024). Dynamic response of buried natural gas pipelines under horizontal directional drilling loads. International journal of structural Stability and Dynamics, 25(01),25-27.
5. Emmaanuel Ayodele, Amuah Freda (2019). Asset Security: Curbing Oil Theft and Pipeline Vandalism Using Effective Data Analysis Approach. Research gate, x vol,
6. Eberechi Nwagu Iheanyi, Chukwuma Chinedu Ukachukwu (2023). Impact of Oil Pipeline Transportation and Vandalism on Economic Development in Ikwere Local Government Area, Rivers State, Nigeria Journal AJEBA, 23(13), 88-95.
7. Ibeh, S.U, Nwakaihe, S.E (2016). Challenges and Prospects of the Use of Horizontal Drilling Drilling Techniques for Laying Oil and Gas Pipelines in Nigeria. Society of Petroleum Engineers, SPE-184315-MS, 11-12.
8. NNPC Uncovers 240 Illegal Oil Refineries Pipeline Connections in One Week (2023). Retrieved July 27, 2023, from https://www.thecable.ng/.
9. Pipeline Vandalism worsens up 94 in November (2020). Retrieved February 10, 2020, from https://dailytrust.com/.
10. Pipeline vandalism Nigeria Defers 700000bpd of crude oil (2017). Retrieved September 21, 2024, from https://punchng.com/.
11. Horizontal Directional Drilling Good Practices Guidelines (2017), Retrieved July 10, 2017, from https://www.slideserve.com/.
12. Onuoha FC (2008). Oil pipeline sabotage in Nigeria: Dimensions actors and implications for national security. African Security Review.17(3):99-105.
13. Emelu V.O, Oyegun C.U, Eludoyin O.S (2021). Causes of Oil and Gas Pipeline Vandalism in the Niger Delta Region of Nigeria. Journal of Research in Humanities and Social Science, 9(9), 01-07.
14. A.I, Chukwuma Okoli, S, Orinya (2013). Oil Pipeline Vandalism and Nigeria's National Security. Global Jounals. 13(5), 3-7.
15. Francis I. Johnson, Richard Laing, Bassam Bjeirmi, Marianthi Leon (2022). Examining The Causes and Impacts of Pipeline Disasters in Nigeria. AIMS Environmental Sciences. 9(5), 637-642.
16. Mugdim Bublin, FH Kaernten (2019). Machine Learning For Distributed Acoustic Sensors Classic versus Image and Deep Neural Networks Approach. 1, 2-4.
17. Horizontal Directional Drilling vs. Trenching: Which Is Right for Your Project?(2024), Retrieved April 24, 2024, from https://scanningwise.co.za/ .
18. Chengyuan Zhu, Yiyuan Yang, Kaixiang Yang et al (2023). AI-Based Energy Transportation Safety: Pipeline Radial Threat Estimation Using Intelligent Sensing System. 2, 3-7.
19. Oil thieves rob Nigeria of $46 billion in 14 years (2023). Retrieved August 12, 2023, from https://archive.dataphyte.com/.

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XIV, Issue IV, April 2025

20. ANALYSIS: Nigeria spends billions on pipeline maintenance as hundreds are vandalised annually (2025). Retrieved May 9, 2025, from https://www.premiumtimesng.com/.
21. A guide to Horizontal Directional Drilling (2025). Retrieved May 19, 2025 from https://outsideplantcabling.com/.