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PHYSICAL PLANNING AND ENVIRONMENTAL SAFETY CHALLENGES OF PIPELINE TRANSPORTATION IN NIGER-DELTA REGION, NIGERIA

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Abstract
This paper examines the safety and land use planning aspects of pipeline transportation in Nigeria. Pipelines as a mode of transportation crisscross various parts of the country mainly because oil became the major source of revenue to the country. A mixed research design involving direct field observation and desk research method was utilized in this study. An overview of the situation shows that the physical planning and safety aspects of this mode of transportation have come under serious attacks. There is incessant attack on this mode by vandals and other criminal acts, natural disasters, accidents, and equipment failure in most cases causing pipeline explosions leading to the loss of lives. The safety guidelines and good practices for pipelines established by the United Nations Economic Commission for Europe were never considered in Nigeria as many are ignorant of the dangers of livelihood activities on pipeline right-of-way. The situation is exacerbated by lack of enforcement of the laws. Stringent measures should be put in place to avoid pipeline explosions and insist that multinational oil companies obey the rules of engagement.

Key Words: *Pipeline Transportation, Physical Planning, Safety, Mixed Research Design, Nigeria*

Introduction

The first pipeline for the transportation of crude oil was constructed in 1955 and in 1958 crude oil was first lifted from Nigeria (Arosanyin, 2005). The exploration of crude oil in the Niger Delta region of Nigeria signalled the start of pipeline transportation, another method of moving freight. Arosanyin (2005) discussed extensively the history, operation, economic benefits, challenges, opportunities, and the construction of pipeline networks in Nigeria. However, much needs to be learnt in the provisions of pipelines, safety, and settlement planning. Therefore, it is imperative to examine the physical planning and environmental safety challenges of oil and gas pipeline transportation in the Niger-Delta region of Nigeria. Moreover, National Bureau of Statistics (NBS, 2022) reported that the nation recorded an average daily oil production of 1.49 million barrels per day (mbpd), lower than

the daily average production of 1.72 million barrels per day recorded for the same quarter of 2021 by 0.23 mbpd, and lower than the fourth quarter production volume of 1.50 mbpd by 0.01mbpd. However, there is a dearth of research on the overview of the safety and integration of physical development planning with pipelines as a mode of transportation of gas and oil in Nigeria.

Literature Review

Pipelines as Essential Infrastructure

According to Wang *et al*. (2022), pipelines are the essential transportation infrastructure of the energy system, undertaking most transportation tasks of oil and gas on land. Arosanyin (2005) stated that pipeline transportation as a mode is crucial to the distribution of petroleum products in Nigeria. The mode has contributed immensely to the movement of crude oil and refined products across the country and for export. Bazyar *et al*. (2021) posited that as pipeline transport remains the most economical and widespread mode for inland and near-shore oil and natural gas transportation, pipeline networks in China have expanded rapidly. Shaikh *et al*. (2017) stated that pipelines are the link infrastructure of the integrated oil and natural gas market, connecting extraction areas to refineries, depots, factories and residents.

According to Downy (2009), pipelines play a very critical role in the transportation process because most of the oil moves through pipelines for at least part of the route. After the crude oil is separated from natural gas, pipelines transport the oil to another carrier or directly to a refinery. Petroleum products then travel from the refinery to market by tanker, truck, railroad tank car, or pipeline.

Since pipelines are a safer means of moving oil and gas than vehicles or trains, military attacks on them frequently occur during times of conflict (HDPE, 2021). It has also helped in transporting the raw materials far away from the resource base for manufacturing the end product and distribution to consumers. Thus, for strategic reasons, it helps a country to maintain a supply of petroleum products even if the resource base is attacked.

Pipeline routes are practically unlimited as they can be laid on land or underwater (Rodrigue, 2020), and are comparatively more economically viable in terms of accessibility to remote locations, distance coverage, speed and efficiency with the fluids that are transported, such as slurry, gas, oil, water, and other liquids (Lawler *et al*., 1996, Fricker and Whitford 2001, Degermenci, 2001, Oni, 2002). Moreover, 70% of crude oil and petroleum products are transported by pipeline in USA, with the remaining 23% transported by ship, 4% by truck, and 3% by rail. About 97% of the natural gas and petroleum products shipped from Canada are transported via pipeline (James, 2014).

Steiner (2010) and Mohamed *et al*. (2012) stated that in many parts of the world, accidental third-party damages of crude oil pipelines have become increasingly common especially during excavations, but recently, pipeline interdiction and oil bunkering have been reported in countries like Columbia, Mexico, Middle East as well as Asia and Africa. Alawode and Ogunleye, (2011), and Anifowose *et al*. (2012) posited that interdiction is a term used to describe a hostile situation whereby a certain commodity or goods is prevented from movement from one place to another by certain aggrieved individuals. As such it is

an international act of sabotage, vandalism or attack.

The Economic Commission for Europe (2008) established the following standards for pipeline safety and best practices:

1. Governments should exercise leadership, establish and manage administrative structures to facilitate the development of a safe and environmentally sound transportation infrastructure, including pipelines.
2. Throughout the complete lifespan of the pipeline's system, the operator and owner of pipelines has basic responsibility of maintaining safety, and to prevent accidents, and minimizing the effects those accidents may have on the environment and public health. Additionally, in the event of an accident, every precaution should be made to minimize any negative effects.
3. Hazardous material transportation pipelines ought to be built and run to avoid any unintentional releases into the environment.
4. Especially, in locations that are heavily populated or environmentally sensitive, leaks containing hazardous substances from any part of a facility or pipeline should be quickly and reliably recognized.
5. A management system should be put in place by the pipeline operator to create and preserve pipeline integrity. Sound management, together with proper design, construction, maintenance, inspection, and monitoring, are essential to ensuring the integrity of pipelines.
6. When assessing pipeline integrity and its effects on the environment and public health, deterministic and/or probabilistic methods should be employed.
7. If there are mishaps, the proper action should be taken. Both the authorities and pipeline operators should create emergency plans (external emergency plans) and (internal emergency plans), which should be tested and updated regularly. The steps required preventing accidents and lessening their negative effects on the environment, and public health should be outlined in these plans.
8. Land-use planning should be considered when routing new pipelines to limit proximity to highly populated areas and water catchment areas to the extent feasible, and in making decisions about proposals for new developments/constructions near existing pipelines.
9. There should be a review by pipeline operators and authorities responsible for pipelines and if necessary, develop an implementation system to reduce third-party interference, which is the principal cause of accidents, including trans boundary implications.
10. Information about pipeline safety, the location of pipelines, safety protocols and necessary steps to take in the event of an accident should be provided to individuals who may be affected by pipeline accident. General information should be accessible to the public.
11. Regular exchange of information between pipeline operators and

authorities regarding best practices, improving pipeline safety, and previous accidents and near-miss cases should be considered.

The listed pipeline guidelines have been useful, perhaps may be the reason for low pipeline transport-related accidents in Europe compared to the high incidence of pipeline-related accidents, explosions and deaths in Nigeria.

Pipeline Development in Nigeria

Pipeline transportation gained recognition in Nigeria after the 1975–1980 Third National Development Plan (NDP). Apart from Arosanyi (2005), the history, length, motivations, economic benefits, and challenges of pipeline gas and oil transportation in Nigeria have also been discussed in FRN (1975), FRN (1981), Onakomaiya (1983), Osayimwese (1986), FRN (1987) and David (1995). Despite measures put in place, there seems not to be an orderly planning of pipelines in Nigeria.

Consequently, it is not possible to comprehend the environmental crises plaguing the region without paying special attention to the multinational oil companies' phenomenon, because it is particularly salient to the long and terrible record of environmental degradation which has gone on unchecked for over fifty years. The degradation of the environment from pollution of running waters to rivers and destruction of farmlands is monumental and catastrophic. It is therefore not a surprise that the youths in the Niger Delta region of Nigeria engage in artisanal refineries. That is seen by the youths as a reaction to the severe environmental pollution, unemployment, and excruciating extreme poverty experienced in the oil producing region of Nigeria.

The main risk of pipeline breakage/vandalism is that it has an adverse effect on the environment from product spills. This eventually compromise pipeline product safety. Under the issues facing the mining and quarrying industry, the Fourth National Development Plan (1981–1985) duly recognized these dangers, stating:

"The events of the past years both at the domestic and international levels have demonstrated the extent to which mining activities, particularly in the area of petroleum production, processing, and transportation could be susceptible to such dangers as accidental spillage, pollution, and wilful damage to installations" (FRN, 1981).

Nigeria's oil and gas pipeline networks are aging and vulnerable to natural breaks as a result of improper maintenance schedules and the growing instances of intentional damage or blowouts of pipelines intended to disrupt supplies or pilfer goods.

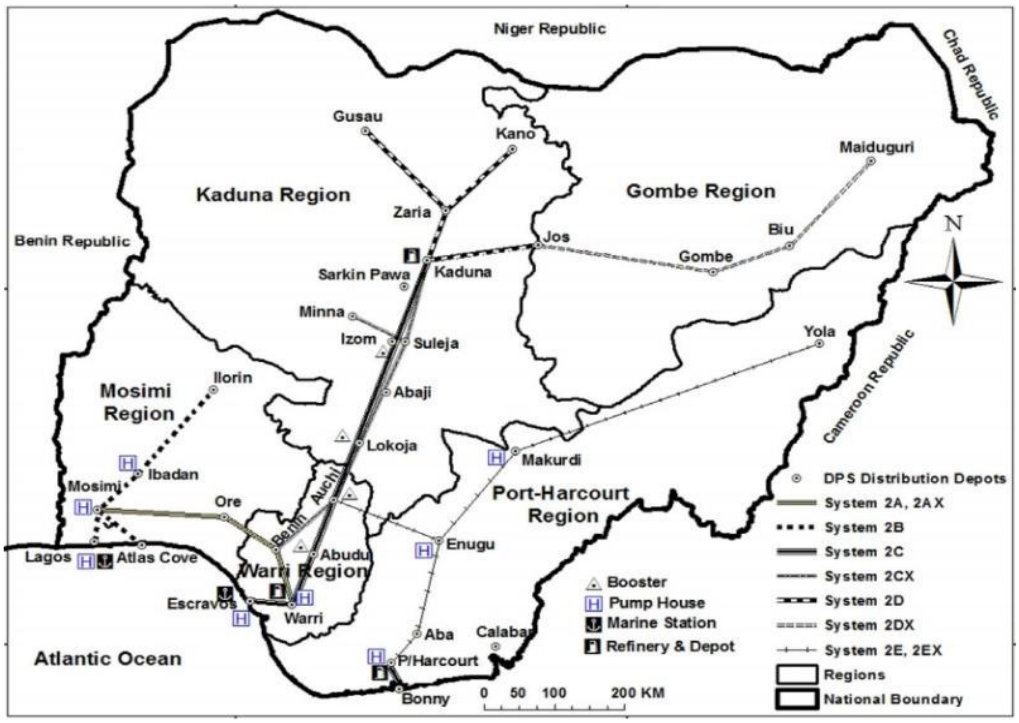

Fig. 1: Pipeline network and facilities in Nigeria
Source: https://www.researchgate.net/figure/Map-of-Nigerian-showing-pipeline-network-and-facilities-4_fig1_276058686

Methodology

A mixed research design which involved direct-field observations (primary data) and desk research method (secondary data) was utilized in this study. The primary data sought information on the personal experiences of physical development planners and professionals involved in the oil and gas sector of the region and Nigeria by extension. The secondary data (desk research) on pipeline transportation and pipeline vandalisation in Nigeria between (2000 -2020) were derived from the National Bureau of Statistics and other relevant literature (journals, textbooks and periodicals).

According to Nooraini (2013) and Gandhi *et al*. (2018), desk research consists of the analysis of available data sources, including their compilation, mutual verification, and processing. In addition, Nooraini, (2013), Rahman *et al*. (2014) and Gandhi *et al*. (2018) stated that desk research involves collection of data from existing resources, hence it is often considered a low-cost technique. The desk research method consists of five consecutive stages spanning from the identification of the research topic, statement of objectives to performing the discourse analysis. This desk research method provided a synthesis and extensive review of literature on transportation of oil and gas via pipelines, pipeline vandalism, corporate social responsibilities of multinational companies, and the responsibilities of Physical Planning and Development Board.

Results and Discussion

Nigeria has a high rate of pipeline right-of-way encroachment especially in the Niger-Delta, most likely as a result of

the absence of pipeline markers in most places, which indicate the pipeline's presence. The Etegwe/Tombia market was on multiple pipes for gas and oil that are not more than a meter deep from the earth surface for more than a decade. In this market, there were areas where cow skin locally called kpomo considered a delicacy was roasted and processed. This area was a time bomb waiting to explode as no safety measures were put in place. The market was relocated to an open site without accommodation and infrastructure shortly before the inauguration of a new government in February, 2024. Respondents have suggested that the market was relocated because it was causing traffic congestion and an eyesore as it was located on the road leading to the airport. However, the pipeline right-of-way is still being used for livelihood activities as seen in Plates 1 and 2.

Plate 1: Residents of Scavengers on Pipeline Right-of-way

Plate 2: Operational Park for Trucks on Pipeline right-of-way

Naturally, abiding by the principles of corporate social responsibility, the multinational oil companies should provide necessary and relevant information and steps to guarantee the safety of people that may choose to engage in livelihood activities within the pipeline right – of – way. Even if it is visible some persons do not care about the pending danger. There are pipeline explosions due to the aging of pipes and others due to vandalization or the inability of pipeline companies to provide maps of their critical infrastructure to the authorities in charge of urban planning and development. Table 1 presents major pipeline explosions in Nigeria.

Nigeria National Petroleum Corporation (NNPC) in May 2021 reported that 54 petroleum pipeline points were vandalized in February 2021. It said the number represented 50% increase from a total of 27 points reported in January of the same year; 50% of the vandalized points were in the Warri Area, 39% in the Mosimi Area, and 4% in the Kaduna and Port Harcourt Areas. (vanguardngr.com, 2021). Oil pipeline incidences in Bayelsa State alone as compiled from reports of environmental activists in Yenagoa office are alarming (Table 2).

Table 1: The Major pipeline explosions in Nigeria from (2000-2020)

S/No	Dates	Location	Cause	Casualties
1.	10th July, 2000	Jesse, Delta State.	Pipeline explosion.	250 persons died.
2.	9th June, 2003	Umuahia, Abia State	Punctured pipeline by thieves.	125 persons lost their lives.
3.	17th Sept., 2004	Lagos State	Pipeline vandalization by thieves.	Over 20 people died
4.	26th Dec., 2006	Abule-Egba, Lagos State	Pipeline vandalization by thieves.	About 500 people died
5.	26th Dec., 2007	Lagos State	Pipeline explosion.	More than 45 persons were burnt to death.
6.	15th May, 2008	Ijegun Area, Lagos State	The explosion from a bulldozer that struck a petroleum pipeline.	About 100 persons died.
7.	12th Jan., 2013	Arepo, Ogun State	Pipeline gutted by fire.	3 people died
8.	18th May, 2014	Okrika Jetty, Rivers State	Pipeline explosion.	About 7 persons died and scores were injured.
9.	2nd March 2016	-	Blast at a repair work. (Environmental Rights Action).	3 deaths with many injured.
10.	12th Oct., 2018	Umueze community, Abia State	Vandalization of pipeline.	19 people died in an attempt to scoop from a vandalized pipeline.
11.	4th July, 2019	Ijegun area, Lagos State	Vandalization of pipeline.	About 30 people died and over 30 cars burnt.
12.	19th Jan. 2020	AbuleEgba, Lagos State	Pipeline explosion	5 people died

Table 2: The list of oil pipeline incidences in Bayelsa State, Nigeria

SN	Title	Location	Year
1.	Six fresh spill points spewing Crude oil along Agip Pipeline in Kalaba community.	Kalaba community, Okordia Clan, Yenagoa Local Government Area, Bayelsa State	2013
2.	Major spill raging at Shell's Okordia Manifold; spraying high into the air and spreading.	Okordia Manifold at Ikarama community, Yenagoa Local Government Area, Bayelsa State.	2014
3.	The spill from Shell facility spread from Odau to Oruma/Yibama community environment	Oruma/Yibama Community Environment	2015
4.	Agip pipeline explosion at Olugboboro community: three lives lost	Olugboboro community environment, Southern Ijaw LGA, Bayelsa State.	2016
5.	Oil Spill along Nigerian Agip Oil Company [NAOC] Pipeline.	Kalaba /Ayamabele and Akumoni environment	2018
6.	Two Equipment Failure Spills from Agip pipelines confirmed	Okpoama/Ewoama and Olugbobiri environment.	2020
7.	Fourth Oil Spill Recorded from Agip'sOgoda/Brass Pipeline	Etieama Community, Nembe LGA, Bayelsa State.	2022
8.	Agip's Riser 15a Lingering Oil Spill at Fantuo; a case of negative environmental practice.	Fantuo community	2023

The Nigerian Institute of Town Planners (NITP, 2014) and Gunn (2022) highlighted the challenges involved in the preparation and implementation of Physical Development Plans in Nigeria, and Bayelsa State respectively. The protection of the nation's oil and gas pipelines has become more challenging due to these issues. Among the difficulties are:

The Physical Planning Institutional Framework

Three tiers of planning activities are specified by the Nigerian Urban and Regional Planning Law (1992): the National Urban and Regional Planning Commission, State Planning Boards, and Local Planning Authorities. The States and Local Governments are to prepare plans within the framework of the National Physical Development Plan. But it is sad to note that the National Planning Commission has not been established since 1992 when the Nigerian Urban and Regional Planning Law came into existence. States are therefore left to prepare their physical development plans and in most cases without consideration for inter–state physical development issues such as oil and gas pipelines.

Political Commitment and Public Perception

Since urban and regional planning and development is essentially a government-regulated activity, its effectiveness and efficiency are dependent on the amount of political commitment which the government in power is prepared to give. Urban planning and development score a high mark when the political authority accords it the expected priority. On the contrary, governments do little or nothing to ensure that the citizenry is protected from pending dangers of likely explosions from oil and gas pipelines. Plates 1and 2 says it all as functional livelihood activities are taking place on multiple oil and gas pipelines in Yenagoa, Bayelsa State, Nigeria.

Urban and Regional Plans Implementation/Monitoring

The aspect of monitoring of physical development plan implementation is yet to be made visible in some states. Monitoring is a process that aids the effective implementation of urban and regional plans. The importance of implementation and monitoring of Physical Development Plans has made some persons suggest that implementation and monitoring be designated a specialization subject area in the curriculum of Urban and Regional Planning programs in Nigeria (NITP, 2014).

Field Reports on Pipeline Incidents

A non-governmental organization known as Environmental Rights Action (ERA) is primarily responsible for the environmental field monitoring and reporting, with particular emphasis on pollution caused by oil industries, such as gas flaring, gas leaks, explosions, and oil spills. From the reports on pipeline incidences, it was discovered that most of the incidents happened on pipelines while very few of the incidents occurred on wellheads and manifolds. These incidents are primarily caused by pipeline sabotage, equipment failure, operational failure, and meddling from third parties. In most cases when these incidents take place the companies who are the pipeline owners do not respond immediately, not until when the media publicize it that they swing into action. Some of these incidents have been documented in Ogoda-Brass trunk line in Okpoama. Leaks at the bottom or under the pipe are designated as occurring at 6:00 am, and are primarily caused by

equipment failure; leaks on either side of the pipe are designated as occurring at 9:00 am and 3:00 pm, and leaks on top of the pipeline are designated as occurring at noon, which is the suspect leak (Plates 3a and 3b).

Plates 3a and 3b: 6'O Clock rupture of 24" Ogoda-Brass trunk line at Okpoama Spill point from pipeline
Source: Environmental Rights Action/Friends of the Earth, Yenagoa office (2023)

Conclusion and Recommendations

In the absence of a National Physical Development Plan that would have formed the basis of preparing Physical Development Plans, the Government should ensure the preparation of an operative state physical development plan and plans for all urban settlements in all the Niger Delta states. The Federal Government through the Federal Ministry of Housing and Urban Development has commissioned consultants to prepare Strategic Regional Development Plans for a few geopolitical zones in Nigeria, which could mean that the National Physical Development Plan could soon come to pass. These plans will form the basis of preparing the National Physical Development Plan.

The need to urgently review the existing master plan and regional development plans of cities and regions in Nigeria to accommodate critical oil and gas infrastructure is very necessary. This will guide developers to maintain the required setbacks in their physical developments. The government is to give priority to plan preparation, implementation and monitoring in the annual budgetary allocations. Ministries, Departments and Agencies (MDAs) are to be enlightened on the need to give relevant data to researchers for plan preparation. There should be regular meetings with Community-Based Organizations (CBOs), community youths and Community Development Committees (CDCs) to assist in requesting developers to do the needful as regards planning permits as they pay their development levy. These organizations and individuals are to be educated on the need to safeguard oil and gas infrastructure and the dangers of encroachment.

The combined negligence of owners/operators of pipeline facilities in the proper management of pipelines as well as other stakeholders such as

regulating agencies in the enforcement of safety guidelines has led to loss of lives, and properties, denial of means of livelihood and even the destruction of the environment. The utilization of barges and trucks for the transportation of petroleum products also poses severe danger on marine source of livelihood. It is therefore important that the existing pipeline safety measures/policies be reviewed in line with world physical planning standards and best practices.

References

Alagoa, M. (2023). Environmental Rights Action/Friends of Earth, Yenagoa office, Nigeria. Niger Delta Resource Centre.

Alawode, A.J., Ogunleye, I.O. (2011). Maintenance, security, and environmental implications of pipeline damage and ruptures in the Niger delta region. *Pac. J. Sci. Technol.,* 12: 565–573.

Arosanyin, G.T. (2005). Pipeline Transportation of Petroleum Products in Nigeria: Threats, Challenges and Prospects; Central Bank of Nigeria. *Economic and Financial Review,* 43(2): 1 - 36.

Anifowose, B., Lawler, D.M., Van Der Horst, D. and Chapman, L. (2012). Attacks on oil transport pipelines in Nigeria: a quantitative exploration and possible explanation of observed pattern. *Appl. Geogr.,* 32: 636–651.

Bazyar, A., Zarrinpoor, N. and Safavian, A. (2021). Optimal design of a sustainable natural gas supply chain network under uncertainty. *Chem. Eng. Res. Des*., 176(2021): 60-88

David T. (1995). "Niger Delta Oil Production, Reserves, Field Sizes Assessed". *Industry Briefs. Oil and Gas Journal. (13 November 1995).*

Degermenci, O. (2001): An EU study of the Caspian area oil and gas pipelines, comparing routes and costs. *Pipes and Pipelines International,* 46(6): 5-18.

Downy, M. (2009). *Oil 101* (Wooden Table Press, 2009), 242.

Federal Republic of Nigeria (FRN) (1975). Third National Development Plan: 1975-1980 Vol. I Lagos: Federal Ministry of Economic Development, 135-146 and 199-228.

Federal Republic of Nigeria (FRN), (1981) Fourth National Development Plan (1981-1985) Vol. I Lagos: Federal Ministry of National Planning, P.127-135 and 215-248.

Federal Republic of Nigeria (FRN), (1987) "Report of the Committee of Experts on National Transport Policy for Nigeria". Lagos: Federal Ministry of Transport and Aviation: 109-118.

Federal Republic of Nigeria (1992) Nigerian Urban and Regional Planning Law, Decree No. 88 of 1992 (now CAP N138 LFN 2004), Federal Government Printer, Lagos

Fricker, J.D. and Whitford, R.K. (2001) Fundamentals of Transportation Engineering – A Multimodal Systems Approach, New Jersey, Pearson Prentice Hall,

Gandhi, A., Sucahyo, Y.G. and Ruldeviyani, Y. (2018). Investigating the Protection of Customers Personal Data in the Ridesharing Applications: A Desk Research in Indonesia. *In Proceedings of the 15th International Conference on*

Electrical Engineering/Electronics, Computer, Telecommunications and Information Technology (ECTI-CON), Chiang Rai, Thailand, 18–21 July 2018; pp. 118–121

Gunn, E.O. (2022). Challenges in the preparation and implementation of physical development plans in Bayelsa State, Nigeria. A paper presented at the Bayelsa State Physical Planning and Development Summit, Banquet Hall, Yenagoa. December 13th – 15th 2022.

HDPE (2021). *"HDPE Pipes and Poly Pipe Fittings Polyethylene Pipe Systems". All Plastic Pipe Here Hdpe Pipe, Corrugated Pipe Systems (in Turkish). Retrieved 2021-12-15.*

James, C. (2014). Pick Your Poison For Crude -- Pipeline, Rail, Truck Or Boat. *Forbes*. 26 April 2014.

Lawler, D.M., Sljivic, S. and Caplat, M. (1996). *Assessing the environmental impact of the Birmingham Airport Link pipeline,* In: Gerrard, A.J.G. and Slater, T.R.S. (Eds.), Managing a Conurbation: Birmingham and its Region, British Association for the Advancement of Science volume, Brewin Books, Studley, UK, 75-89.

Mohamed Y., Werr P. and Cooney P. (2012). Blast rocks Egypt's gas pipeline to Israel, Jordan. Reuters. Available: http://www.reuters.com /article/2012/07/22/us-egypt-pipeline-idUSBRE86L00T20120722

NITP (2014). *The State of Urban and Regional Planning in Nigeria,* A Publication of the Nigerian Institute of Town Planners (NITP).

Nooraini, R. (2013). Algorithm analysis of definite integration by using desk check method. *J. Inform. Bisnis* 2013(1): 50–55. 33.

Nwilo, P.C. and Badejo, O.T. (2004). *Management of oil spill dispersal along the Nigerian Coastal Areas.* Presented at the Geo-Imagery Bridging Continents XXth ISPRS Congress, 12-23 July Istanbul, Turkey

Onakomaiya, S.O. (1983). *'Overland Transport'.* In Oguntoyinbo, I.S., Areola, O.O. and Filani, M. (eds). A Geography of Nigerian Development. Ibadan: Heinemann: 3 5 0-3 71.

Oni, S.I. (2002). Effective Pipeline Management and operations. Paper presented at the 2nd international seminar on Shipping, Transport and Export, held in Lagos, Nigeria. pp 2-6

Osayimwese, I.Z. (1986). "*Pipeline Transportation*", in Falola, T. and Olanrewaju S.A. (ed) Transport Systems in Nigeria New York: Syracuse University: 107-124.

Rahman, R., Alarifi, A.H.E., Eden, R. and Sedera, D. (2014). *Archival analysis of service desk research: New perspectives on design and delivery.* In Proceedings of the 25th Australasian Conference on Information Systems, Auckland, New Zealand, 8–10 December 2014; Wang, W., Pauleen, D., Eds.; ACIS: Auckland, New Zealand; Auckland University of Technology: Auckland, New Zealand, 2014; pp. 1–10.

Rodrigue, J. (2020), The *geography of transport systems*; Fifth Edition, New York, Routledge

Shaikh, F., Q. Ji, P.H. Shaikh, N.H. Mirjat and Uqaili, M.A. (2017). Forecasting China's natural gas

demand based on optimised nonlinear grey models. *Energy,* 140: 941-951.

Steiner, R. (2010). Double standard: Shell practices in Nigeria compared with international standards to prevent and control pipeline oil spills and the Deepwater Horizon oil spill. *Milieudefensie, Amsterdam*, 11-15.

United Nations Economic Commission for Europe (2008). Safety Guidelines and Good Practices for Pipelines, United Nations, New York and Geneva.

Wang, G., Cheng, Q., Zhao, W., Liao, Q. and Zhang, H. (2022). Review on the transport capacity management of oil and gas pipeline network: Challenges and opportunities of future pipeline transport. Energy Strategy Review, Vol. 43. ScienceDirect.

Worldwide Pipeline Construction Report (2012). Archived 2013-03-25 at the Wayback Machine," *Pipeline and Gas Journal,* 239 (1).

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