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Potentials of GIS-based analyses of Ajaokuta -Kaduna-Kano gas pipeline in Nigeria

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Abstract. Geographic and Information System (GIS) Potentials and emerging technologies in overcoming topographic challenges during construction of Ajaokuta-Kaduna-Kano (AKK) gas pipeline was reviewed. The increasing utilisations of natural gas in Nigeria require development of more gas pipeline systems to increased supply with the existing gas pipeline infrastructures. Hence, in selecting a route for AKK gas pipeline construction project. This paper report on the effects of topography and probable challenges that may arise as a result of Ajaokuta Kaduna –Kano gas pipeline construction activities and solutions so as to reduce the overall rate of adverse natural gas pipeline incidents and effects on environment. The proposed Ajaokuta-Kaduna-Kano (AKK) gas pipeline is a 614km-long being developed by the Nigerian National Petroleum Corporation (NNPC) from Ajaokuta to Kano in Nigeria. Gas pipeline routes are defined by the pipeline size(s), terrain, soil erosion, and engineering analysis requirements. Major challenges and impacts of the AKK gas pipeline includes vegetation clearing; hills and contours; loss of biodiversity; loss of farmlsion, excavation damage and corrosion. GIS Potentials and emerging technologies could address AKK gas pipeline challenges and impact through detection as a higher priority than prevention. These can be addressed through improved technologies by focusing on carrying out topographical study of the area, detection as a higher priority than prevention. Proper selection of gas pipeline routes through GIS could generally reduce potential environmental impacts associated with pipeline construction and typically minimize negative effects on conserving sensitive environments and resources.
KEY WORDS: Topography, Technologies, Gas Pipeline, GIS Challenges, Construction and AKK.

1.0 Introduction

The expansion of current pipeline infrastructure is required for Nigeria's growing demand for natural gas a significant problem for the pipeline sector is maintaining a safe and environmentally responsible natural gas pipeline network in the face of this increasing consumption (Adam and Darma, 2017). Nigeria is a gas-exporting country with estimated gas reserves of 5.748 trillion cubic feet (188tscf) (OPEC, 2021). There are 86tscf of non-related gas and 99tscf of associated gas in the gas reserves (Nigerian Gas Company, 2012). There has been a production of around 23tscf of gas over the previous 40 years, when Nigeria began to engage in active petroleum activity. The annual commercial gas demand is roughly 0.33 tscf of AG. 40% of the volume of liquefied natural gas (LNG) is being exported. Despite its abundance in natural gas, Nigeria has maintained a monocultural economy, relying on the export of crude oil for more than 90% of its export revenues (Globefeed.com ,2020). Due to poor gas infrastructure, inflated and unrealistic gas prices, a lack of industry, and insufficient consumption capacity, the AG and NAG generated in the nation have historically been flared. In a nation where only 40% of Nigerians have access to energy, 60% of the AG is flared, and annual economic growth is reduced by 3% as a result of supply constraints (Nigerian Gas Company, 2012). Despite having significant natural gas and petroleum reserves, Nigeria continues to struggle with a

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steady supply of electricity. With an estimated 182.2 million residents and a $486.60 billion GDP in 2016, Taking into account Nigeria's appalling energy condition and the requirement for the government to make plans to ensure that natural gas significantly contributes to the power sector According to these scenarios, it is clear that Nigeria must make use of its abundant gas resources in order to boost its industries, raise domestic gas use, and enhance gas exports. The proposed construction and operation of the AKK Gas Pipeline Project will assist ensure the supply network in the Northern and Southern portions of the country because natural gas has storage issues and must be transferred to its needed location as soon as it is produced from the reservoir. Additionally, it will lessen the negative effects of gas flaring on the environment (Patrick, 2020).

A pipeline is a network of pipes intended for the long-distance, frequently underground transportation of fluids like oil, water, natural gas, or other petroleum-based goods. It has been utilized for the movement of water for many years and is a crucial component of contemporary civilization. In general, pipelines are more expensive than open channels or roadways. To construct a comprehensive plan that includes the sociological, developmental, environmental, and safety issues essential to build the pipeline, it takes years and the completion of numerous surveys, research, and consistent plans. In contrast to open channels or highways, they might provide cost-based discounts on shorter, more direct routes. Pipeline construction is a significant multi-disciplinary endeavour that involves many different disciplines, particularly for large-scale water supply or petroleum projects. Gas Since trucks and trains are both comparatively more expensive and unsafe than pipeline transportation, pipelines are the only realistic technique for moving natural gas across land. While most distribution lines use flexible plastic pipes that are simple to build and do not corrode, gas collecting and transmission lines are constructed of steel (BP, 2015). A pipeline route and profile survey is also necessary to determine the pipeline's lowest and maximum height, to determine whether it will cross any creeks or rivers, and to comprehend the environmental conditions of the terrain (Michael et al., 2017).

The Ajaokuta-Kaduna-Kano (AKK) gas pipeline is a 614km-long pipeline that originates at the Ajaokuta terminal gas station (TGS) in Kogi state, Nigeria, and travels through Niger, the Federal Capital Territory (FCT), Kaduna, and finally, a gas station in Kano. Along its path, the pipeline will cross 10 important roads and seven significant rivers. There are four sections to the AKK pipeline project. The first leg will cover over 200 kilometres from Ajaokuta to Abuja in the Federal Capital Territory. The second leg of the pipeline will run for 193 kilometres from the Abuja TGS to the Kaduna TGS, the third segment for 97 kilometers from Kaduna to Zaria, and the fourth and last segment for roughly 124 kilometers from Zaria to the TGS in Kano. A pressure of 1,000 pounds per square inch (psig) will be used to operate the pipeline, which consists of 40 in-diameter pipe joints (Shehu, 2020). Up to 3,500 million cubic feet (mcf) of gas per day from several gas collection projects in southern Nigeria will be transported via the Ajaokuta-Kaduna-Kano (AKK) pipeline. Liquefied petroleum gas (LPG) would be created in Ajaokuta by processing hydrocarbon liquids, and the leftover gas will be delivered to Abuja, Kaduna, Kano, and Katsina to serve as feedstock for new power plants and petrochemical facilities. In order to connect the pipeline networks in Nigeria's eastern, western, and northern areas, the AKK gas pipeline was built. The project aims to sustainably supply gas to northern Nigeria by making use of the nation's rich natural gas resources. The change is anticipated to lower the amount of gas flaring in the nation's oil fields, improving air quality (Hydrocarbons Technology, 2020).

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Complete reliance on NEPA combined with the nation's poor/inadequate power generation by businesses and individuals will result in low activity levels and underutilization of facilities (Yar'adua, 2007). Currently, gas, a byproduct of oil production, is being flared. The use of gas by industry to produce electricity is a positive trend. In line with Nigerian Gas Company (2012), Nigeria has around 170 trillion cubic feet (tcf) of recoverable gas reserves, which can be used for commercial purposes. The Ajaokuta-Kaduna-Kano gas pipeline is likely to face unique challenges during construction due to geological variability, such as soils and bedrock, clays to gravels, soft - hard - loose - dense - dry - wet, and a lack of boring data. As a result, it is necessary to conduct a topographic study of the area in question and develop solutions to these issues. Additionally, consideration must be given to environmental effects of building the AKK gas pipeline, pipeline support, slope stability, erosion control, mine subsidence, quarry blasting, active mine crossing, earthquakes, surface water/groundwater drainage control, river crossings, horizontal directional drilling, temporary bridge construction, and pipeline support. The construction of the proposed gas pipeline from Ajaokuta to Kano is being undertaken to take advantage of the abundant natural gas to generate electricity and to provide cheaper, cleaner, and more efficient fuel for the various factories' production lines and operations, lowering the cost of production (NPC, 2011).

Finally, the following factors lead to acceptance of the proposed Ajaokuta-Kaduna-Kano (AKK) gas pipeline route: staying away from settlements, avoiding regions with natural animal migration or movement routes, forest reserves, rock outcroppings, or extremely shallow soils. Avoiding areas containing archaeological sites, notably shrines and cemeteries. In order to overcome and alleviate the topographic obstacles of building the Ajaokuta-Kaduna-Kano gas pipeline, this article explored the potentials of GIS and new technologies.

2.0 Literature

In Arepo, Ogun State, Nigeria, they used remote sensing and geographic information system (GIS) technologies to assess the degree of vulnerability of those residing along the pipeline right-of-way (PROW). Of the 314 buildings identified in the buffered zones, 200 (or 60%) were randomly chosen for the study (Michael et al., 2017). According to Michael et al. (2017), Nigeria, host community encroachment on pipeline right-of-way (PROW) is a significant issue for the oil and gas industry. In the sampled buildings, they gave structured questionnaires to the household heads. In their research, empirical analysis reveals that 140 structures (70%) had a setback from the pipeline of less than 30 meters. Additionally, they claimed in their analysis that incidences of oil spilling benefit locals and that they view this as a way to vandalize the pipeline, making them more vulnerable. More than 30% of responders, according to GIS analysis, are extremely vulnerable to the risk of pipeline explosive accidents. As opposed to a third party's impact on the gas pipeline, a topographic analysis will be conducted in the current work to determine the vegetation and environmental consequences. The Nigerian National Petroleum Corporation is building a 614km natural gas pipeline called the Ajaokuta-Kaduna-Kano (AKK) pipeline (NNPC). Three portions of the 1,300km-long Trans-Nigeria gas pipeline, each with a diameter ranging from 36 to 40 inches, will be constructed. It is planned to be the largest gas pipeline project ever carried out in Nigeria. It will travel through Nigeria from Ajaokuta to Kano (Patrick, 2020).

Phase one of the Trans-Nigeria Gas Pipeline (TNGP) project is the pipeline project. It will have a diameter of 40in and be able to transport 3,500 Mmscfd of dehydrated wet gas per day from numerous gas collection projects in southern Nigeria (Hydrocarbons Technology, 2020). Between Nigeria's eastern, western, and northern areas, a connecting pipeline network will be established as a result of the project. By utilizing Nigeria's abundant gas resources, it also seeks to establish a reliable and secure gas delivery network between its northern and southern regions. Additionally, the development is anticipated to lessen the significant amount of gas flared annually in Nigeria and the ensuing environmental effects (Nigerian Gas Company, 2012). The largest gas reserves in both Africa and the entire world are found in Nigeria. The evidence for natural gas 188 trillion cubic feet (tcf) of gas are present, with 99 tcf of related gas and 89 tcf of non-associated gas (NPC, 2011).

As a part of the Trans Nigeria Gas Pipeline, the Ajaokuta-Kaduna-Kano Natural Gas Pipeline (AKK) is designed to transmit natural gas from Ajaokuta in Kogi State to Kano in Kano State across various states and urban areas (Hydrocarbons Technology ,2020). The pipeline is expected to start in Ajaokuta and travel via Abuja, Kaduna, and Kano before coming to a finish at a terminal gas station. The project will be completed in three phases, the first of which would involve the $855 million construction of a 200 km route between Ajaokuta and Abuja Terminal Gas Station (Olurounbi, 2020). Phase two will include the construction of a 193-kilometer segment between Abuja and Kaduna at a price of about $835 million. Between the Kaduna terminal gas station (TGS) and the Kano TGS, a 221km-long segment will be built as part of phase three. The anticipated cost of finishing this stretch is $1.2 billion. Additionally, a number of linked valve stations, as well as intermediate and terminal facilities, are proposed as part of the development's infrastructure (Alokolaro and Alghali, 2015). It is anticipated that the natural gas pipeline will require the installation of about 51,200 steel pipes with a 40-inch diameter and a combined weight of 240,768 tons. Additionally, the project will make use of 40-inch line break valves and potential tie-in valves, as well as 24-inch steel line pipes for spur lines (Patrick, 2020).

The AKK natural gas pipeline is designed to deliver electricity to the northern region of the country from the south and increase Nigeria's capacity to generate electricity by 3,600MW. Additionally, the industrial sector in the nation's eastern and northern areas will be strengthened. The project is anticipated to considerably reduce gas flaring in the Niger Delta as well as to promote and enhance local domestic gas usage. Additionally, it is projected that the export of natural gas will boost the nation's ability to generate cash (Olurounbi, 2020). Natural gas must be transferred to its required location as soon as it is produced from the reservoir due to storage issues. Transporting natural gas energy from oil and gas sources to markets can be done in a number of ways (PHMSA, 2010). Included are Gas to Solid (GTS), Compressed Natural Gas (CNG), Liquefied Natural Gas (LNG), and Pipeline Natural Gas (PNG) (GTS). Pipelines are connected pipes that are installed to transport gases, liquids, slurries, etc. from supply sources to one or more distribution centres or to one or more large-volume customers. Pipelines can also be installed to connect supply sources to distribution centres or to one or more large-volume customers, a pipe installed to connect supply sources to distribution centres or customers with high volume, or a pipe installed to connect supply sources (Amirat et al., 2006). In order to meet the dimensional specifications for nominal pipe size, pipes are tubes with a round cross section. Over 12,000 miles of new gas pipeline have been installed annually on average over the past few decades, the majority of them

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being international (PIPA, 2021). To construct a suitable gas pipeline, the qualities and compositions of the gas must be ascertained.

To choose the grade of the pipeline, it is necessary to evaluate the parameters of the gas reservoir, including the carbon content, gas specific gravity, compressibility factor, viscosity, critical temperature and pressure, and gas density. To determine the pipeline's minimum and maximum height, to determine whether or not there will be creek or river crossings, and to comprehend the environmental conditions of such terrain, a pipeline route and profile survey is also necessary (Chastain, 2009).

2.1 Related works

Natural gas transmission pipeline was designed by Ugwunna et al. (2019), for a typical marginal oil and gas field in the Niger Delta. They compiled the gas flow rate, pressure, and temperature information and used it to design the gas pipeline while also obtaining secondary data from the field and doing empirical research to ascertain the gas's nature. The pipe diameter, schedule, design pressure, collapse pressure, burst pressure, and hydrotest pressure. Calculations for number, thickness, etc. were made using the proper design formulae. Software Aspen HYSYS version 8.8 (34.0.0.8909) However, they just simulated the gas pipeline's design equation; they did not conduct a feasibility or survey assessment. To identify potential obstacles and potential solutions during the construction of the Ajaokuta Kaduna Kano gas pipeline, a topographic study will be conducted as part of the current operation.

Gas pipelines in Nigeria: a prerequisite for economic growth was addressed by Biose (2019). He describes the strategies required for the establishment of a gas pipeline that will be sustainable and contribute to Nigeria's socioeconomic growth. Based on the current monopoly of the Nigerian Gas Processing and Transportation Company Limited (NGPTC), which currently manages 1,500 to 2,000 km of gas pipeline throughout Nigeria, he came to the conclusion that there is an inefficient framework for the development of gas pipelines in Nigeria. However, this framework is grossly insufficient to meet the domestic supply obligation. Consequently, the need to build additional gas pipelines and increase gas usage in Nigeria (AKK). The private sector should be at the forefront of the proposed strategy to advance the development of Nigeria's gas pipelines, and all current gas pipeline infrastructure should be sold to private investors in order to ensure sustainable management that would boost the nation's Gross Domestic Product (GDP), create jobs, and give people access to relatively clean energy.

The economic analysis of gas pipeline projects in Nigeria is done by Adam and Darma (2017). They said that Nigeria has the greatest gas reserves in Africa, and that a lack of adequate infrastructure for gas development has led to an energy imbalance and a reliance on the country's few pipelines, rendering the sector vulnerable to any shock to these pipelines. As a result, Nigeria needs to expand its gas infrastructure (AKK). They added that there are still potential choices for other gas pipeline lines. They came to the conclusion that new pipelines are crucial because they aid in the better usage of the nation's enormous natural gas reserves and awaken latent energy demand, generating economic benefits and resolving the country's territorial energy demand issues. It is necessary to conduct a topographical assessment of the AKK gas pipeline to determine its viability and economics.

According to Michael et al., (2017) who studied pipeline right-of-way encroachment in Arepo, Nigeria, host community encroachment on pipeline right-of-way (PROW) is a significant issue for the oil and gas industry. They used geographic

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information system (GIS) and remote sensing technology to determine how vulnerable residents of the PROW in Arepo, Ogun State, Nigeria were. Of the 354 buildings found in the buffered zones, 200 (or 60%) were chosen at random for the study. In the sampled buildings, they gave structured questionnaires to the household heads. An empirical investigation reveals that 140 structures (70%) have a setback from the pipeline of less than 30 meters. Additionally, they claimed in their analysis that incidences of oil spilling benefit locals and that they view this as a way to vandalize the pipeline, making them more vulnerable. More than 30% of responders, according to GIS analysis, are extremely vulnerable to the risk of pipeline explosive accidents. Instead of considering the impact of third parties on the gas pipeline, topographic analysis will be conducted in the current work to determine the vegetation and environmental consequences. According to NPC (2011), increasing the use of existing pipeline infrastructure and developing new pipeline systems will be necessary to enhance natural gas usage in the United States. Although industry attention historically has centred on detection as a higher priority than prevention, they claimed that the two main causes of severe pipeline mishaps, excavation damage and corrosion, have been addressed by enhanced technologies in their report. Given the quantity of gas in Nigeria, the gas pipeline needs to be expanded for effective gas usage. As a result, it is necessary to conduct a survey assessment of the AKK gas pipeline to identify potential obstacles that could arise during the construction process.

The Ajaokuta-Obajana Gas Pipeline Project's environmental impact assessment (EIA) is done by the Dangote Group (Dangote group, 2004). They came to the conclusion that the EIA had shown that by implementing all recommended mitigation measures, the overall impacts connected with the Ajaokuta-Obajana Gas Pipeline Project could be managed within reasonable and acceptable bounds. The current work's objectives are to topographically scan the AKK gas pipeline, identify problems, and suggest remedies.

3.0 Methods

The construction of a "614km Ajaokuta-Abuja-Kaduna-Kano 40" natural gas pipeline is the project's approach. The pipeline traverse seven significant rivers and ten significant roadways in the states of Kogi, Niger, Kaduna, Kano, and the Federal Capital Territory (FCT) Abuja. The Obigbo-Umuahia-Ajaokuta and Ajaokuta-Kaduna-Kano and Trans-Nigeria Gas Pipeline Projects are the driving forces behind the construction of the Ajaokuta-Abuja-Kaduna-Kano Gas Pipeline (Phase I) Project, which is the first phase of the Trans-Nigeria Gas Pipeline Project.

The project is being conducted against the backdrop of Nigeria's new domestic supply and gas pricing situation. 3,500 MMscfd of dehydrated wet gas from several Southern gas gathering projects is anticipated to provide the feed gas for the pipeline system. While the remainder will be transported through the pipeline to serve as feed stock for electricity and new petrochemical facilities planned for Abuja, Kaduna, Kano, and Katsina, the hydrocarbon liquids from this process would be further processed in Ajaokuta to make liquefied petroleum gas (LPG). The following considerations can be made during gas pipeline construction: Route analysis, purge the area, excavating a trench or ditch, Bringing the pipes, fittings, and other supplies to the location, Attaching the pipes to the trench's walls, Field bending of steel pipes to accommodate site topography, dressing and encircling steel pipes, connecting pipes before or after they are lowered into the trench, inspecting the pipe for leaks or welding faults at the joints, filling in trenches with soil and restoring the land to its former beauty (TRB, 2004).

For longer pipelines, construction is divided into sections, with each segment being finished before moving on to the next. This reduces the amount of time that construction activities disrupt any one location (PHMSA, 2010).

4.0 Results and Discussions

The following should be done during the building of the AKK gas pipeline project:

4.1. Right-of-way surveying and clearing (ROW): This includes, pipe hauling and stringing, pipe bedding (s), welding, digging a ditch, pipe lowering and backfill. Non-destructive testing, surveying, and ROW preparation, on the other hand, will result in the destruction of vegetation, a decline in biodiversity, the loss of farms, crops, and habitat, as well as the movement of species. By removing the vegetation, the soil will be much more vulnerable to extreme weather and soil erosion. Utilizing existing ROW during construction, using existing routes for surveys, avoiding excessive land taking, enforcing a no-hunting prohibition during bush clean up, and restricting clearance inside ROW habitats are all examples of strategies to lessen the ecological impacts. In order to evaluate the environmental impact assessment, the topographic map of the study area was obtained using a geographic information system (GIS).

4.2 Potentials of GIS with cutting-edge technologies

In general, the use of GIS for map development affects all facets of national affairs. Nearly every aspect of government and many private sector activities, such as defense, upholding the rule of law, emergency services (fire, flood, and disaster), administration, local government, land registration, economic and physical planning regulation, environmental management and pollution control, transportation, utilities (water, drainage, gas, and electric), and utilities (electricity, gas, and water) may require maps to some extent. power, telephone), agriculture, forestry, and fisheries, oil mineral discovery and production, among other things, as well as education, science, and archaeology. Tourism and recreation. Topographic maps are therefore necessary to enable us to become familiar with the area on which development takes place. They are essential study tools due to their wide range of informational capabilities. The topographic map is used for general planning, engineering, and building projects (Adamu and Roddy, 2013). Figure 1 present the topographic map of the whole study area (Ajaokuta to Kano). The study area start from Ajaokuta in Kogi state through FCT Abuja to Kaduna then Zaria and finally Stop at the north western part of Nigeria (Kano).

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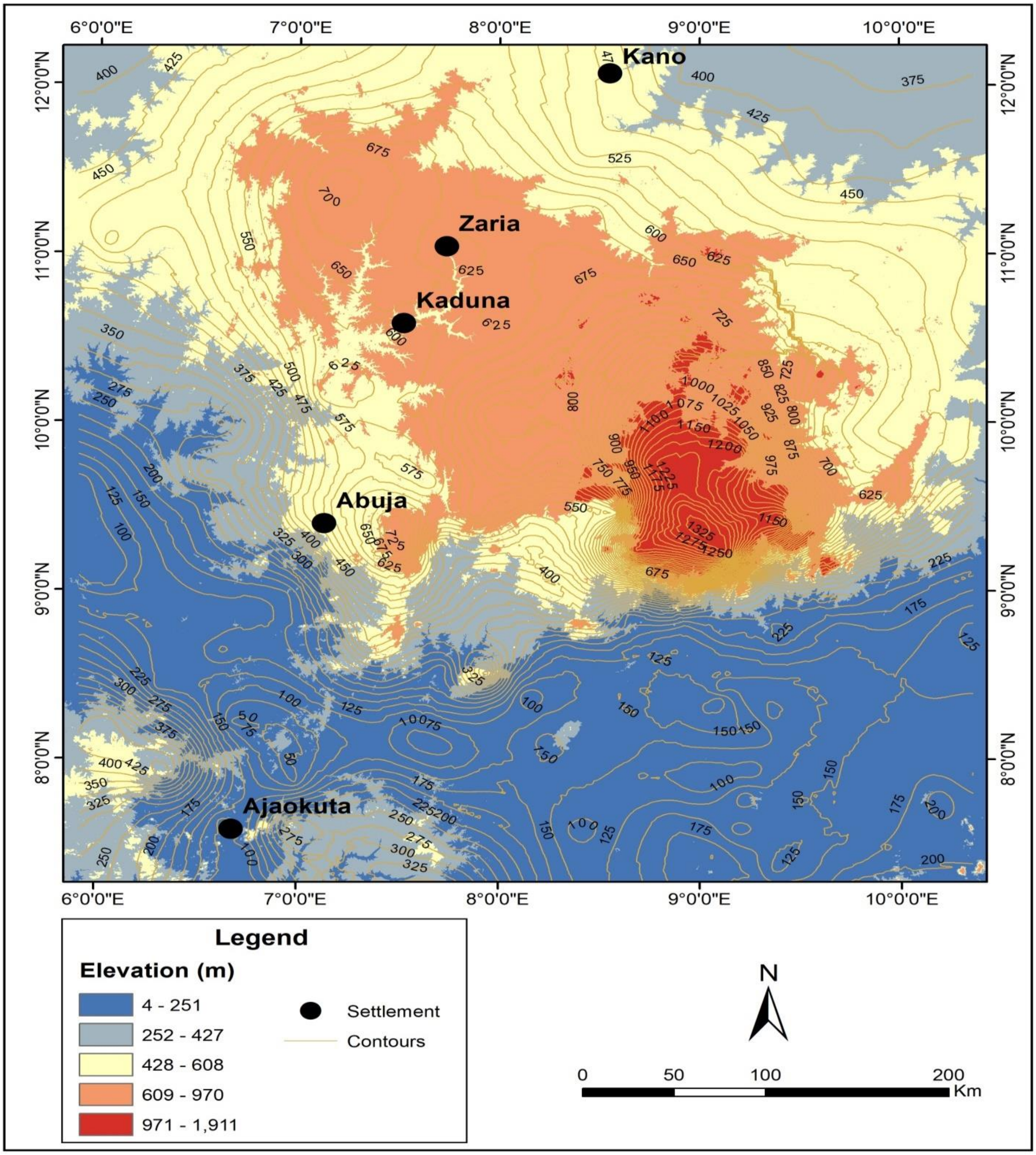

Fig. 1: Topographic map of the whole study area (Ajaokuta to Kano)

Topographic maps are maps of geographical areas with a sequence of curving lines, known as contours that depict the topography of the area, as can be seen in Figure 1 above. A topographic map is one such map. The locus of all points on the map with the same height is represented by a horizontal curve known as a contour. Selecting a sequence of heights and visualizing traveling a similar sequence of horizontal planes over the terrain can help you understand the concept of contours. These planes' intersections with the land's surface produce the contours. Both technical professionals and laypeople can benefit from topographic maps (geologists; environmental engineers). As depicted in Figure 1, toward the south east of Kaduna, we observed the highest elevation of about 970 to 1911 m, this signify that, this region is occupy by fold mountains and highlands. The second higher elevation is Kaduna central, Zaria and north part of Abuja based on the map with an elevation of 609 to 970 m. Although, the low level on the AKK gas mapped area is around Ajaokuta and upper north of Kano with lower elevation height of about 257 to 427 m and 4 to 251 m respectively. Although the low land in Ajaokuta a steep slope and temperate forest with highly dense vegetation of trees and shrubs. Hence, there is likelihood that the there is need for excavation work, clearing and blasting of rocks the area as evidence from the topographical work.

4.3 Relief and other terrain properties

The majority of the study locations' terrain elevations range from 45 to 205 meters. However, some remote places inside these ranges, particularly between the Ajaokuta and Abuja regions, reach up to 400 meters (Turner, 2016). The terrain properties in Ajaokuta to Abuja are mainly highland with temperate forest characterized by economic trees, stunted vegetation. However, from Abuja through Kaduna to Kano, the terrain is dominantly sahel savannah with stunted trees and low land

4.4 Gas pipeline operations control and monitoring

At the pipeline's manifold (valve) end in Ajaokuta, the pressure will be checked, and the flow will be gauged at the terminating locations in Kano. These measurements should serve as additional proof that the integrity of the pipeline is being preserved. Both radio and telephone networks should be used for communication between the activities at the Ajaokuta port and the terminal in Kano.

4.5 Upkeep and inspection

The integrity monitoring system should include routine surveillance of the pipeline route (Turner, 2016).

4.6 Activities relating to wastes and disposal

Key components of an environmental management system include the treatment and disposal of trash in an efficient and responsible manner. Any item (solid, liquid, gaseous, or combination) that is extraneous to needs is referred to as a waste. Tree trunks, stones, and scraps from previous construction projects, wrecked cars, disused pipes, waste oil or grease, unused asbestos, fluorescent tubes, and electrical fittings are some of the trash types that may be found. Wastes produced must be divided into several categories and disposed of in accordance with Nigeria's waste management regulations.

4.7 Vegetation

Savanna woodland makes up the majority of the research area's vegetation. It has both the southern and northern Guinea savanna types of vegetation. This ecological zone typically consists of a combination of trees, shrubs, herbs, and grasses. The vegetation is between 10 and 12 meters high along the pipeline's route from Ajaokuta to Kano. As one travelled north from Ajaokuta to Kano, the number of trees of timber size shrank. These plants have a variety of functions that contribute to their

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economic value, including sponge, fuel, wood, dyes, vegetables, edible fruits, and seed trees (Virginia, 2007). The elevation maps of the research region are shown in Figures 2 to 6 below (Ajaokuta, Kaduna and Kano).

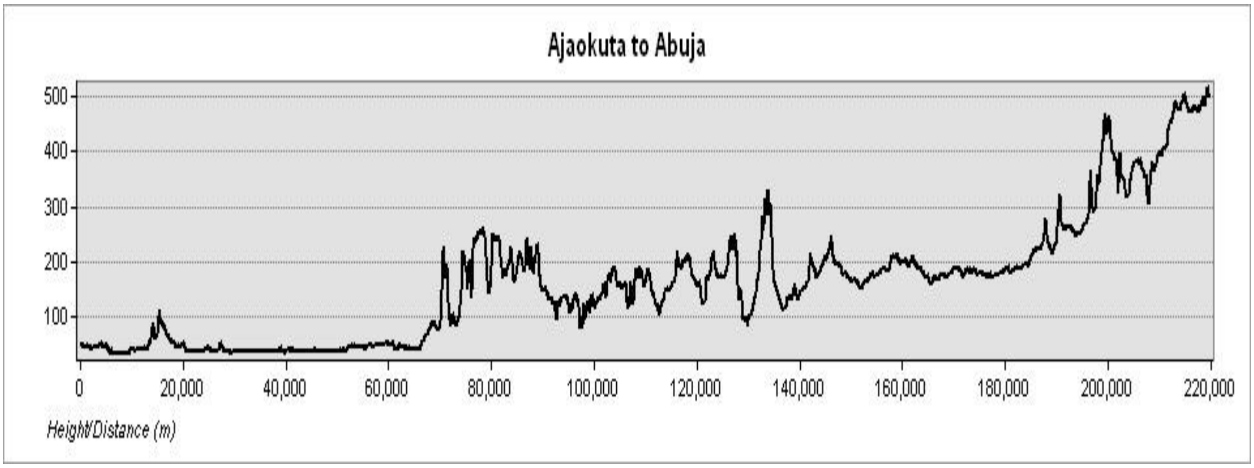

Fig. 2: Elevation map of Ajaokuta to Abuja

The highest elevation between Ajaokuta to Abuja is 500m while the lowest elevation is about 19m with an average elevation of about 211m.

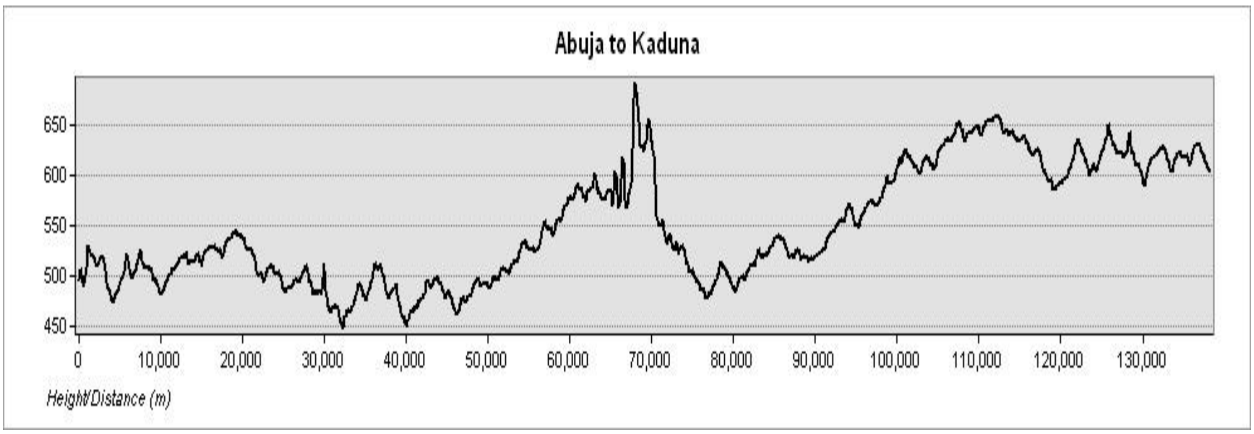

Fig. 3: Elevation map of Abuja to Kaduna

The maximum elevation between Abuja to Kaduna is 700m while the lowest elevation is about 70m with an average elevation of about 515m.

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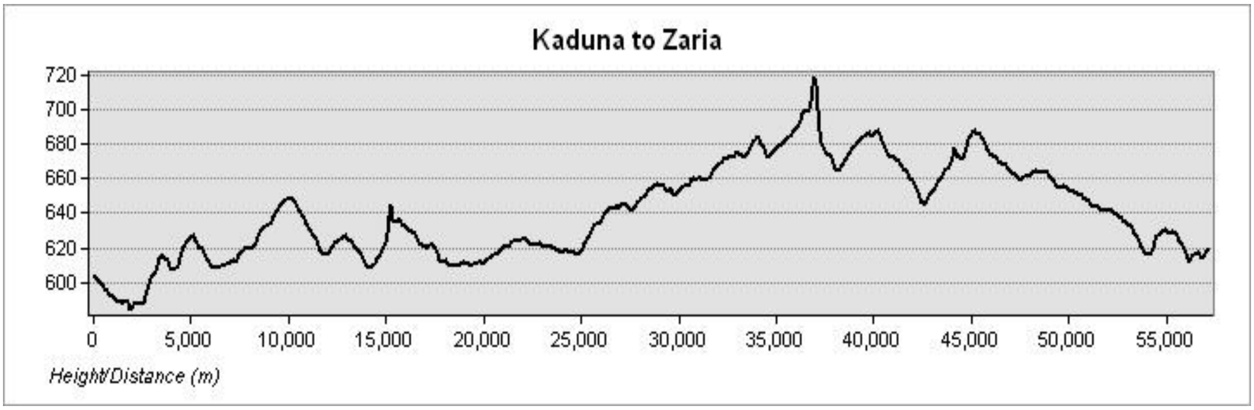

Fig. 4: Elevation map of Kaduna to Zaria

Similarly, the highest elevation between Kaduna to Zaria is 720m while the lowest elevation is about 75m with an average elevation of about 650m.

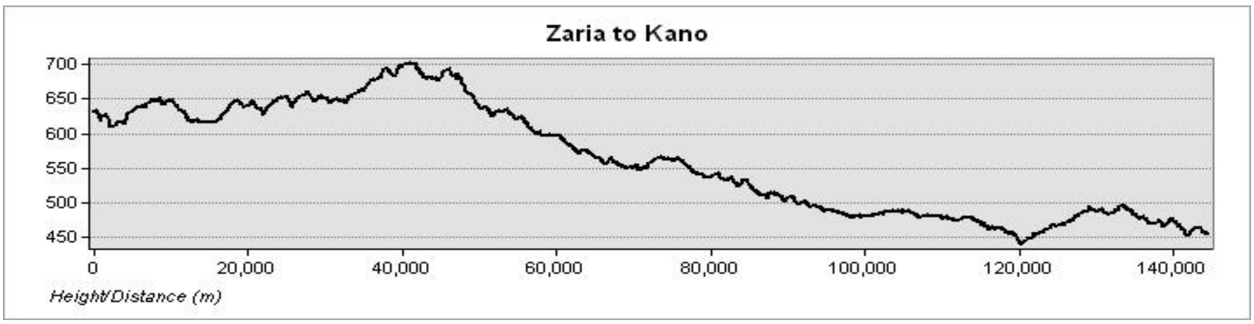

Fig. 5: Elevation map of Zaria to Kano

Also, the highest elevation between Zaria to Kano is 700m while the lowest elevation is about 79m m with an average elevation of about 550 m.

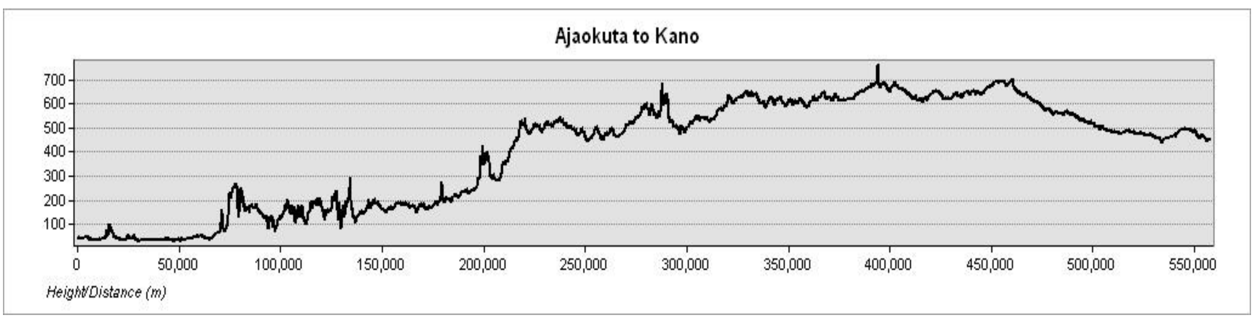

Fig. 6: Elevation map of the whole study area (Ajaokuta to Kano)

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4.8 Usual precautions to avoid excavation damage

In order to preserve soils, aquatic resources, wetlands, native vegetation, wildlife, heritage resources, Aboriginal traditional use sites, and other routing criteria that have a significant impact on the human environment, the following factors should be taken into account when choosing a pipeline route on agricultural lands; reducing the length of the pipeline to lessen possible disruption to the soils, water, wetlands, native plants, wildlife, heritage values, and aboriginal traditional usage sites; use of parallel existing linear projects to reduce overall area of disturbance to soils, aquatics, wetlands, native plants, animals, heritage resources, and Aboriginal traditional use sites (e.g. pipelines, roads, trails, cut lines, seismic lines, power lines, rail lines), avoiding or minimizing crossings of marshes, swamps, bogs, and sloughs where practicable in order to preserve wetlands, native vegetation, wildlife habitat, and aboriginal traditional usage sites; minimizing the number of watercourse crossings and crossing watercourses at right angles; to preserve native flora, wildlife habitat, and aboriginal traditional usage sites, avoid reducing length on sensitive landscapes (such as native prairie, sand dunes, coulee complexes, and steep slopes), avoid or shorten your time in remote bush or woodland regions to protect the local flora and fauna, as well as the habitat for wildlife, and aboriginal traditional use places, strict compliance with setback distances from significant natural features, such as mineral licks and wildlife features including nests, leeks, dens, staging locations, lambing regions, and calving areas, in order to preserve wildlife values, avoiding known archaeological or historical sites, as well as places with a high potential for archaeology or paleontology, when practicable, to protect cultural heritage resources, avoid well-known ceremonial/spiritual locations, habitation sites, and resource collecting areas to protect Aboriginal tribes' traditional use sites, avoid non-compatible land uses (such as aggregate extraction, open pit mines, extensively developed oil or gas fields), where possible, special land use areas (such as golf courses, research farms, certified organic farms, flood irrigated lands, and lands with drainage tiles), and avoid residences, urban areas, parks, and designated natural areas.

In light of the product being transported (such as sour gas, natural gas liquids, and high vapor pipelines), strict adherence to regulatory setbacks and offsets is required (Nigerian Gas Company, 2012). One cannot overstate how crucial it is to choose a pipeline route carefully. The first environmental conservation method utilized when planning new pipelines is to choose a route based on the routing variables and criteria mentioned above in order to minimize environmental damage. By implementing the final two environmental conservation practices, scheduling of construction and construction methods, identified potential impacts of pipeline development for each component of the ecosystem can be further mitigated.

Some of the requirement that must be met by the Ajaokuta-Kaduna-Kano (AKK) gas pipeline includes; the highest permitted operating pressure, public Education, damage Control, line markers, corrosion, internal and external, planning, building, and repair (Act CAP 338 of the Law of the Federation of Nigeria 1990).

4.9 New technology to be applied when building gas pipelines

Electronic white Lining. An excavator would typically outline a projected excavation with white paint, a practice known as "white lining." The excavator often refers to, for example, the closest significant street intersection when notifying the appropriate One-call centre of the location of the proposed dig (PHMSA, 2010). In order to obtain GPS coordinates of subsurface facilities and produce an electronic manifest of the locator's activity, it includes incorporating GPS technology into

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locating instruments. With the use of this technology, the utility should be able to update its mapping and provide the excavator with a "bird's-eye" view of the excavation area with orthophotography of the location superimposed over all indicated facilities. In Phase 3, a GPS monitor should be created and mounted to excavation equipment. This monitor will regularly send data to a fileserver where it should be compared to records from the One-Call location tickets (CGA, 1999).

4.10 Technologies to prevent encroachment: Pipeline operators routinely check the ROWs of their pipelines for signs of impending or ongoing excavation activities and/or actual excavation damage (Chastain, 2009). Effective surveillance strongly depends on patrol frequency. The effectiveness of surveillance may be compromised if the period between patrols is longer than the amount of time needed for a possible excavation contractor to organize and start digging. A pipeline proximity detection system that can identify the presence of excavation equipment nearby and/or detect actual excavation activities can be developed. Although this technique might not always be able to stop actual excavation damage, it could nevertheless be used to warn a pipeline operator that intrusion has taken place. The operator would then be able to inspect the affected section of the line for damage with knowledge of such potential incursion (this technology would be especially helpful for preventing latent defect failures) (Bagajewicz, 1992). Instead, it is likely that many strategies will be needed, depending on the particular situation or environment faced.

The following describes some of the potentials technologies should be deployed to :

4.11. Acoustic surveillance

This makes use of auditory sensors to find intruders. The acoustical sensors are positioned at predefined intervals along the pipeline right of way, and each one needs a power source and a remote transmitter (ROW). The sensors are set up to listen for sound waves and compare them to known threat sound signatures (e.g., excavation equipment). The sensor can then send an alarm to a receiver, who will then alert the operator, if a potential threat is identified (Nigerian Gas Company, 2012).

4.12. Monitoring of earthquakes

Technology for seismic monitoring can be utilized at different stages of development and it uses the identification of auditory traits of prospective equipment risks (e.g., excavators of any known type). An alarm can be sent to a distant receiver to notify the operator if a sound is determined to constitute a danger. This detection method has shown to be incredibly precise, may be deployed above or below ground, and can cover a big region (PHMSA, 2010).

4.13. Monitoring with fiber optics

Fiber-Optic Monitoring makes use of a fiber-optic cable that should be buried close to the pipeline to track different aspects of the light that is carried through it. The cable is sensitive to pressures and vibrations that are conveyed through the ground. Additionally, the loss of the fiber-optic cable acts as an immediate warning of potential incursion in the event that it is severed. This approach is seen as a dependable, low-cost method of delivering real-time encroachment monitoring, albeit it does necessitate some advanced system monitoring and processing equipment (CGA, 1999).

4.14: Monitoring cathodic protection

This makes use of the pipeline's existing external corrosion protection machinery. This monitoring technique measures alterations in the current cathodic protection current flow that could be brought on by outside equipment coming into contact with the pipeline, such as excavation equipment. It is fairly simple to spot sudden changes in current flow that might be brought on by contact with excavation equipment by tracking and graphing the typical flow of electrical current through the pipeline over time.

4.15: Pipeline right-of-way satellite monitoring (ROW)

It is now possible to monitor pipeline ROWs through satellite for encroachment. The "RADARSAT" technology is one illustration of this. This advanced satellite-based radar system may be set up to recognize and detect a variety of tools, including excavators and other known incursion risks. Additionally, the system may be set to concentrate on small areas, like the ROW of a pipeline, which lessens the likelihood of unneeded warnings.

4.16: Robotic aircraft patrols

A novel technology that is now being tested to enable aerial survey of pipeline ROWs is remote-controlled aerial patrols by drones. The drones may be operated remotely and have digital video capabilities and GPS technology. Drones can be routinely deployed from far-off sites. When conducting airborne inspections of existing pipeline ROWs, this technology's main benefit is the low cost and comparatively high level of convenience it offers (Virginia, 2009).

4.17: Laser technology based on the ground

A brand-new technology that might be put along the pipeline ROW is ground-based laser technology. An alarm will sound if a laser beam is interrupted, such as when excavation equipment enters the pipeline ROW, warning the operator of a potential issue.

4.18: Phone prevention technologies

Additionally, excavation damage can be reduced by giving excavation equipment the ability to avoid contact. Currently in testing, onboard excavator technology consists of sensors fitted on excavators that will identify metal items close to the excavator's bucket and issue auditory and/or visual alarms, according to need. GPS technology is used in proximity-based avoidance measures (like the Virginia Pilot's proposed Phase 3) to pinpoint the location of excavation equipment in relation to subsurface utilities. An alarm is set off to alert the operator of the excavation equipment if it is determined that the location of the equipment in relation to the buried utility is critical. A horizontal boring machine's bit is equipped with sensing technology that can be used to find metallic and non-metallic things in its path. This technology is one of the several being tested. The dependability of novel contact-avoidance systems has not yet been shown CGA (1999), despite the fact that they have the potential to significantly increase the safety of excavation operations. Additionally, the future implementation of contact-avoidance technology might call for substantial equipment retrofitting and training of operators.

4.19: Technologies for pipeline location.

As the accuracy of buried pipeline locations improves, the likelihood of avoiding excavation damage decreases. The use of a magnetic gradiometer, which is based on military technology, has some potentials for enhancing line locating accuracy hence it should be provided. Non-metallic pipes have been successfully marked with electronic markers (Nigerian Gas Company, 2012). The waterproof, chemical-resistant housing that houses the electronic marker doesn't need an internal power source to function. However, it does need for the use of a unique location detecting tool created only for this application.

4.20: Daylighting

Daylighting, commonly known as "potholing," is a highly effective way to positively locate buried assets. This should be provided. The method directly confirms the position and depth of the pipeline by removing soil from above it with water and suction technology. With little influence on the environment, this process of removing soil is simple to control, affordable, and gives positive identification.

5.0 Conclusion

The construction of the Ajaokuta-Kaduna-Kano gas pipeline requires the use of geographic information systems (GIS) and other cutting-edge technologies to overcome topographic challenges. The regulator must pay close attention to the implementation of these key steps throughout the construction process. The choice of the pipeline route might be said to be the single most efficient approach for environmental conservation in a pipeline project. As a result, careful GIS route selection for gas pipelines may normally limit negative effects on preserving sensitive habitats and resources while also reducing potential environmental consequences related to pipeline construction. If you are using pipelines to transport oil and gas, then one of the most crucial first steps for your project is going to be route selection. Where you put, your pipelines are going to affect not just how much pipe to buy but have legal and environmental issues as well. The best pipeline transport routes move oil and gas in the safest, most economically efficient way possible and have the least impact to the environment and landowners. The oil and gas pipeline routes are defined by the pipeline size(s), terrain, soils, and engineering analysis requirements. The engineers' assessment based on survey data is essential to the oil and gas pipeline construction project. The most direct route is not always optimal and each solution has an associated cost and schedule increase. Failure to thoroughly investigate all features of the intended route and surrounding lands quickly adds additional time and cost.

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Authors' contributions:

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Maryrita Nnenna AKAH – Report on Literatures, Validation, Writing - Original Draft

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