

Assessment of Compressed Natural Gas (CNG) Facilities in Kogi State: Socioeconomic Gains and Drawbacks

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ARTICLE INFO

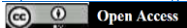
Keywords:

compressed natural gas (cng),
socio-economic benefit,
sustainable energy transition,
alternative fuel, energy security

Vol.01, No.03, 2026

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ABSTRACT

Nigeria's vast natural gas reserves, estimated at over 209 trillion cubic feet, represent a largely untapped engine for economic and industrial growth. Despite this abundance, the nation remains tethered to a volatile, import-dependent petroleum market that depletes foreign exchange and exposes citizens to frequent fuel shortages. This study evaluates the transition to Compressed Natural Gas (CNG) as a strategic alternative, focusing on Kogi State as a critical development hub. Positioned along the Ajaokuta-Kaduna-Kano (AKK) pipeline, Kogi State is central to the Presidential CNG Initiative (P-CNGI), which seeks to diversify the transport sector and mitigate the environmental menace of gas flaring. The research identifies a significant gap between federal policy goals and the local reality in the Kogi Central Senatorial District. While the socio-economic benefits of CNG including a potential 73% reduction in carbon emissions and substantially lower fueling costs are clear, widespread adoption is stalled by inadequate infrastructure. The study highlights that the scarcity of refueling stations, high upfront vehicle conversion costs, and a lack of technical expertise create a "barrier to entry" that restricts benefits to large-scale fleet operators while leaving average households and small businesses stranded. Utilizing a mixed-methods approach and anchored in the Diffusion of Innovation (DOI) theory, the study employs regression models to analyze how infrastructure, government support, and user demographics influence the success of this energy shift. The findings suggest that while the economic impacts of government policy are often immediate, the social and environmental gains depend on long-term investments in accessibility. Ultimately, the work concludes that for Kogi State to realize its potential as a model for sustainable energy, the government must move beyond policy rhetoric toward concrete investments in refueling networks, technician training, and financial incentives to lower the cost of conversion for the public.

Introduction

Nigeria possesses one of the world's largest natural gas reserves, with approximately 187 trillion cubic feet (TCF) of proven high-quality gas reserves, nearly half of which is associated gas (AG). For many years, a significant proportion of the associated gas was flared; however, government initiatives introduced to reduce gas flaring have begun to yield positive results. One of such initiatives is the Presidential Compressed Natural Gas Initiative (P-CNGI), which was introduced to mitigate the menace of gas flaring and diversify the nation's transportation sector from its heavy dependence on petrol.

The value chain of the Presidential Compressed Natural Gas Initiative (P-CNGI) involved the upstream sourcing and processing of natural gas, followed by its compression and storage at mother stations in the midstream sector. The downstream segment comprised the distribution of compressed natural gas (CNG) to daughter stations and refueling stations for end users. The value chain also included essential support activities such as vehicle conversion at designated conversion centres, the training of technicians, and the development of CNG-powered mass transit systems.

In addition, the Ajaokuta-Kaduna-Kano (AKK) Gas Pipeline Project was planned to transport natural gas from Ajaokuta in Kogi State to Kano in Kano State through several states and urban centres as part of the Trans-Nigeria Gas Pipeline project (Lin, 2021). The project was expected to improve gas supply across the country and stimulate industrial development. Previous studies have also indicated that

for Nigeria to achieve the objectives of Vision 20:2020, natural gas should serve as a primary driver of industrial and domestic economic growth (Ugolo et al., 2024).

Given its strategic location and abundant natural gas resources, Kogi State was identified as a suitable hub for the expansion and adoption of Compressed Natural Gas (CNG), making it one of the leading states for implementing the Presidential CNG Initiative (Kogi State Government, 2024). In Kogi Central Senatorial District, access to CNG was promoted through initiatives such as the Presidential CNG Initiative and the establishment of CNG parks. This transition to CNG as an alternative fuel was considered an effective strategy for reducing the rising cost of petrol and minimizing dependence on imported refined petroleum products.

Nigeria had experienced recurrent shortages of premium motor spirit (PMS) and diesel due to the poor performance of domestic refineries. These shortages significantly increased fuel prices and placed considerable financial pressure on motorists and businesses. The emergence of compressed natural gas provided a viable alternative capable of reducing this burden. The country's heavy dependence on imported petroleum products further depleted its foreign exchange reserves, thereby creating additional economic challenges. Conversely, Nigeria possessed abundant natural gas reserves estimated at about 209 trillion cubic feet (NUPRC, 2023). Although the country ranked among the leading nations globally in terms of natural gas reserves, these resources remained largely underutilized. At the prevailing rate of utilization, Nigeria's natural gas reserves were projected to last for more than one hundred years (Ikechukwu & Joshua, 2020).

Furthermore, gas flaring had contributed significantly to environmental pollution, community displacement, public health challenges, safety concerns, and substantial economic losses. Consequently, the commercialization and effective utilization of natural gas were widely regarded as the most sustainable approach for achieving both economic development and environmental protection.

The global transition from fossil fuels to Compressed Natural Gas (CNG) has been driven by the need to mitigate climate change and promote energy diversification. Countries such as the United States, China, Iran, Brazil, and India have played significant roles in the adoption and utilization of CNG as an alternative transportation fuel. In many developing countries, the transition from conventional fossil fuels to CNG in vehicular and industrial operations has been recognized as an urgent priority for achieving economic stability and environmental sustainability (International Energy Agency, 2020; Dadras, 2021).

Dependence on fossil fuels has been identified as a major driver of economic vulnerability, particularly in countries that import substantial quantities of refined petroleum products (Konrad Adenauer Stiftung, 2024). Nigeria, despite being Africa's largest economy and one of the continent's major crude oil producers, has continued to experience the paradox of heavy dependence on imported petroleum products. This situation, often described as the "resource curse," has had significant implications for the country's economic stability and sustainable development. Fluctuations in global crude oil prices have exposed the economy to financial shocks, resulting in budget deficits, inflationary pressures, and currency depreciation.

The adoption of Compressed Natural Gas (CNG), which is relatively cheaper and more price-stable than conventional petroleum fuels, has been considered a viable strategy for reducing the adverse effects of fuel price volatility. The use of CNG has the potential to reduce the financial burden on government expenditure, particularly in relation to fuel subsidies and foreign exchange requirements, while simultaneously lowering transportation costs for households and businesses (Ahmed, 2024). Such stability enhances long-term economic planning and strengthens the government's capacity to invest in critical sectors of the economy (World Bank, 2021). Consequently, the utilization of CNG as a transportation fuel presents a dual opportunity to reduce dependence on imported petroleum products and improve national economic resilience.

Despite these prospects, one of the major obstacles to the widespread adoption of CNG-powered transportation in Nigeria has been the inadequate state of the country's natural gas infrastructure. Nigeria has continued to rank relatively low in terms of the availability of CNG refueling stations, storage facilities, compression systems, and other supporting infrastructure required for efficient distribution and utilization of CNG. Consequently, only a limited number of CNG refueling stations have been operational, with most of them located in Abuja, Lagos, and Benin City through the efforts of the

Nigerian National Petroleum Company Limited (NNPCL) and NIPCO Gas Limited (Anyadiegwu & Muonagor, 2017).

Until recently, there were very few CNG refueling stations within Kogi Central Senatorial District. Nevertheless, growing demand among fleet operators and commercial transport providers for CNG as an alternative to premium motor spirit and diesel has demonstrated the considerable market potential of the technology. To effectively harness this opportunity, the establishment and expansion of CNG refueling facilities should be guided by comprehensive needs assessments, strategic planning, and accurate demand forecasting capable of supporting future energy requirements.

In recent years, the Federal Government of Nigeria implemented several policies and programmes aimed at harnessing the country's abundant natural gas resources. However, regulatory constraints, policy inconsistencies, inadequate implementation strategies, and technical limitations continued to impede the successful expansion of CNG-powered transportation across the country. Although a number of studies have examined CNG utilization in Nigeria, empirical evidence on its socio-economic implications, particularly within Kogi State and Kogi Central Senatorial District, has remained limited. This gap in knowledge underscored the need for further investigation into the availability of CNG infrastructure and its socio-economic benefits and challenges.

Over time, Nigeria experienced periodic shortages of refined petroleum products, especially petrol and diesel. Although these shortages were not continuous, they resulted in persistent increases in fuel prices, thereby imposing additional financial burdens on motorists and businesses that depended on conventional fuels. These recurring challenges strengthened the demand for alternative energy sources such as Compressed Natural Gas (CNG).

Despite its numerous economic and environmental advantages, the adoption of CNG has been constrained by several factors. These include the limited availability of CNG-compatible vehicles, inadequate refueling infrastructure, and the relatively high cost of converting conventional petrol-powered vehicles to CNG-powered systems. These challenges have slowed the widespread adoption of CNG among private vehicle owners. Consequently, public transportation operators and government-owned vehicle fleets emerged as the earliest adopters because they were better positioned to recover the initial investment required for vehicle conversion through lower operating costs over time (Kaur et al., 2020).

Statement of the Problem

Despite Nigeria's vast natural gas reserves and the Federal Government's sustained efforts to diversify the nation's energy mix through initiatives such as the Presidential Compressed Natural Gas Initiative (P-CNGI), the adoption of Compressed Natural Gas (CNG) as an alternative transportation fuel remained limited in several parts of the country, including Kogi State. In the face of recurrent fuel shortages, rising petrol and diesel prices, and the nation's heavy dependence on imported refined petroleum products, CNG offered a promising alternative for improving energy security, reducing foreign exchange depletion, and promoting environmental sustainability.

However, the development and accessibility of CNG infrastructure within Kogi Central Senatorial District were found to be inadequate to meet the growing demand for the product. The limited number of CNG refueling stations, inadequate distribution networks, high vehicle conversion costs, and low public awareness significantly hindered the widespread adoption of CNG across the study area. These infrastructural and socio-economic constraints reduced the effectiveness of government initiatives aimed at promoting cleaner and more affordable energy alternatives.

Furthermore, empirical evidence on the socio-economic implications of CNG adoption within Kogi Central Senatorial District remained limited. Existing studies largely focused on the technical and environmental aspects of natural gas utilization, while relatively little attention had been given to assessing its effects on transportation stakeholders, household expenditure, employment generation, local business activities, and environmental quality within the study area. This lack of localized evidence created a significant knowledge gap that limited informed policy formulation and investment decisions regarding CNG infrastructure development.

Consequently, this study assessed the availability and adequacy of existing CNG facilities in Kogi State, particularly within Kogi Central Senatorial District, and examined the socio-economic benefits and challenges associated with their development and utilization. The findings of the study were

intended to provide empirical evidence that could guide government agencies, investors, policymakers, and other stakeholders in designing appropriate policies and infrastructure strategies for promoting sustainable energy transition and enhancing the adoption of Compressed Natural Gas in Nigeria.

Purpose of the Study

The purpose of this study was to assess the current state of Compressed Natural Gas (CNG) facilities in Kogi State, with particular emphasis on identifying the socio-economic benefits and challenges associated with their development and utilization. The study was undertaken to provide empirical evidence that could inform policy formulation, investment decisions, and infrastructure planning aimed at promoting a sustainable energy transition in the region. Specifically, the study sought to:

- i. Evaluate the availability, accessibility, and functionality of existing Compressed Natural Gas (CNG) infrastructure in Kogi State.
- ii. Examine the economic and social impacts of CNG adoption on households, businesses, and transportation operators within the study area.
- iii. Identify the technical, economic, and regulatory barriers that hindered the widespread adoption of Compressed Natural Gas (CNG) as an alternative transportation fuel in Kogi State.
- iv. Provide evidence-based recommendations for optimizing the socio-economic benefits of Compressed Natural Gas (CNG) facilities while minimizing the associated challenges and promoting sustainable energy development in the study area.

Research Questions:

Here are four research questions formulated from the Statement of the Problem:

1. What is the current adequacy and accessibility of Compressed Natural Gas (CNG) infrastructure, including refueling stations and conversion centers, within the Kogi Central Senatorial District?
2. What are the primary socio-economic benefits and drawbacks experienced by transportation stakeholders, households, and local businesses due to the current level of CNG adoption in Kogi State?
3. To what extent do conversion costs, distribution challenges, and a lack of public awareness contribute to the limited adoption of CNG as an alternative fuel in Kogi State?
4. How can policy interventions, investment strategies, and infrastructural planning effectively enhance the adoption of CNG and maximize its socio-economic and environmental benefits for sustainable energy transitions in Kogi State?

Literature Review

This chapter reviewed relevant conceptual and empirical literature related to the adoption of Compressed Natural Gas (CNG), its socio-economic benefits, associated challenges, and the development of CNG infrastructure. The review provided the theoretical and empirical foundation for understanding the role of CNG as an alternative energy source within Nigeria's transportation sector, with particular emphasis on Kogi State. The chapter was divided into conceptual literature review and empirical literature review, highlighting existing knowledge, research findings, and gaps that this study addressed.

Conceptual Literature Review

The Global and National Imperative for CNG Adoption

The global energy landscape is undergoing significant transformation due to increasing concerns about climate change, energy security, environmental sustainability, and fluctuations in fossil fuel prices (International Energy Agency, 2020). Developing countries are particularly vulnerable because of their dependence on imported petroleum products, which often place pressure on foreign exchange reserves and expose their economies to international market instability (Konrad Adenauer Stiftung, 2024; Ahmed, 2024).

Within this context, Compressed Natural Gas (CNG) has emerged as a viable alternative fuel due to its economic advantages, lower environmental impact, and potential contribution to energy security (Dadras, 2021). Several countries, including the United States, China, Iran, Brazil, and India, have made significant progress in CNG adoption, demonstrating its suitability for transportation and industrial applications.

Nigeria, despite being Africa's largest economy and possessing one of the world's largest natural gas reserves, estimated at approximately 209 trillion cubic feet (NUPRC, 2023), presents a paradoxical case of energy vulnerability. The country possesses substantial proven gas reserves, with a significant proportion occurring as associated gas, yet these resources remain largely underutilized while the nation continues to experience shortages and rising costs of refined petroleum products (Ugolo, Iwegbu & Onwuche, 2024; Ikechukwu & Joshua, 2020).

This situation represents a resource utilization challenge, where abundant natural resources exist alongside energy insecurity and economic difficulties. The continued dependence on imported petroleum products has contributed to foreign exchange pressure, fuel price instability, and increased transportation costs. The availability of extensive natural gas reserves, which could last for more than 100 years at the current utilization rate, emphasizes the strategic importance of transitioning towards gas-based energy solutions (Ikechukwu & Joshua, 2020).

Furthermore, gas flaring remains a significant environmental and economic challenge in Nigeria. The practice has contributed to air pollution, ecosystem degradation, health risks among host communities, displacement of communities, and loss of potential economic value from natural gas resources (Ikechukwu & Joshua, 2020). Consequently, the commercialization of natural gas through initiatives such as Compressed Natural Gas adoption provides a dual advantage by reducing environmental degradation and promoting economic development.

The adoption of CNG therefore aligns with global efforts toward sustainable energy transition by providing an alternative to conventional petroleum fuels while supporting national energy security, economic diversification, and environmental protection.

Economic Benefits of Compressed Natural Gas Adoption

The adoption of Compressed Natural Gas (CNG) provides several economic benefits that contribute to household welfare, business sustainability, and national economic development. These benefits have been associated with reduced energy costs, improved price stability, foreign exchange conservation, employment generation, and increased investment opportunities within the energy sector.

Cost Savings and Price Stability

One of the major economic advantages of CNG adoption is its potential to reduce fuel expenditure for transportation operators, businesses, and individual consumers. CNG is generally considered less expensive than petrol and diesel, thereby providing users with significant cost savings (Ahmed, 2024). The relatively stable pricing structure of natural gas compared with conventional petroleum products reduces the impact of fluctuations in international crude oil prices and allows households, businesses, and government institutions to undertake more reliable long-term financial planning (World Bank, 2021).

In Nigeria, where transportation costs are strongly influenced by fluctuations in petroleum product prices, increased utilization of CNG has the potential to reduce the financial pressure experienced by transport operators and passengers. Furthermore, reduced dependence on imported petroleum products may decrease government expenditure associated with fuel subsidies and foreign exchange allocation for petroleum imports.

Reduced Import Dependency and Foreign Exchange Conservation

Nigeria's dependence on imported refined petroleum products has continued to place significant pressure on the country's foreign exchange reserves. The utilization of domestically available natural gas as a transportation fuel provides an opportunity to reduce this dependence and conserve foreign exchange resources.

By replacing a proportion of imported petrol and diesel consumption with locally available CNG, Nigeria could redirect foreign exchange savings towards other critical sectors of the economy, including infrastructure development, healthcare, education, and industrial expansion (Ahmed, 2024). This approach would contribute to macroeconomic stability by reducing exposure to international petroleum market volatility and strengthening national economic resilience.

Employment Generation

The development of CNG infrastructure has the potential to create direct and indirect employment opportunities across various sectors of the economy. The establishment of CNG refueling stations, gas

processing facilities, vehicle conversion centres, maintenance workshops, and distribution networks requires skilled and semi-skilled labour.

Employment opportunities may emerge in areas such as construction, engineering services, vehicle conversion, equipment maintenance, transportation logistics, and technical training. Consequently, the expansion of the CNG value chain can contribute to poverty reduction, skills development, and improved livelihoods among individuals involved in the sector.

Investment and Industrial Growth

A well-developed CNG ecosystem can encourage investment and promote industrial diversification within Nigeria's energy sector. Increased investment in gas compression, storage facilities, distribution networks, and vehicle conversion technologies can stimulate economic activities and attract both domestic and foreign investors.

Furthermore, the growth of the CNG industry can support the development of related industries, including manufacturing of conversion equipment, production of gas-related technologies, and expansion of transportation services. Such industrial development can contribute to economic diversification by reducing excessive dependence on crude oil revenue and strengthening the role of natural gas in Nigeria's economic development.

Social Benefits of Compressed Natural Gas Adoption

The adoption of Compressed Natural Gas (CNG) provides several social benefits that extend beyond economic considerations. These benefits include improved environmental quality, enhanced public health outcomes, increased energy security, affordable transportation services, and community development. The transition towards CNG-based transportation has therefore been recognized as an important component of sustainable energy development.

Improved Air Quality and Public Health

One of the major social advantages of CNG adoption is its contribution to improved air quality and public health. Compared with conventional petroleum fuels such as petrol and diesel, CNG combustion produces lower levels of harmful emissions, including particulate matter, carbon monoxide, nitrogen oxides, and other pollutants associated with respiratory and environmental health problems (Kaur, Sidhu & Ravindra, 2020; International Energy Agency, 2020).

The reduction in harmful emissions associated with CNG utilization contributes to cleaner urban environments, particularly in densely populated areas where transportation-related emissions constitute a significant source of air pollution. Improved air quality reduces the risk of respiratory illnesses and other pollution-related health challenges, thereby contributing to better public health outcomes and improved quality of life.

Enhanced Energy Security

The utilization of CNG as an alternative transportation fuel strengthens national energy security by reducing excessive dependence on imported petroleum products. Countries that rely heavily on imported fuels are often vulnerable to external factors such as geopolitical tensions, international price fluctuations, and supply disruptions.

For Nigeria, which possesses abundant natural gas resources, increased adoption of CNG provides an opportunity to utilize domestic energy resources for transportation purposes. This reduces dependence on imported refined fuels and promotes a more stable and self-reliant energy system.

Increased Accessibility to Affordable Transportation

The adoption of CNG has the potential to reduce transportation costs due to the relatively lower price of natural gas compared with conventional petroleum fuels. Lower operational costs for transport operators may translate into reduced transportation fares and improved affordability for commuters.

Affordable transportation enhances access to employment opportunities, education, healthcare services, and other essential social activities. In this regard, CNG adoption contributes not only to energy transition but also to improved social welfare and economic inclusion.

Community Development

The establishment of CNG facilities and related businesses can stimulate local economic development within host communities. The construction and operation of refueling stations, conversion centres, maintenance facilities, and other supporting infrastructure can promote infrastructure development, skill acquisition, and employment opportunities.

Additionally, communities involved in the CNG value chain may benefit from increased commercial activities and improved access to energy services. Therefore, the development of CNG infrastructure can contribute to broader community development objectives and support sustainable economic growth at the local level.

Drawbacks and Challenges to Compressed Natural Gas Adoption

Despite the numerous economic, social, and environmental benefits associated with Compressed Natural Gas (CNG), its widespread adoption in Nigeria, particularly in Kogi State, has been constrained by several technical, economic, infrastructural, and institutional challenges. These challenges have limited the ability of CNG to achieve its full potential as an alternative transportation fuel.

Limited Refueling Station Network

One of the major challenges affecting CNG adoption in Nigeria is the inadequate availability of refueling stations. The country has continued to experience a shortage of CNG refueling facilities, with most existing stations concentrated in major urban centres such as Abuja, Lagos, and Benin City. Many of these facilities were established through the initiatives of organizations such as the Nigerian National Petroleum Company Limited (NNPCL) and NIPCO Gas Limited (Anyadiiegwu & Muonagor, 2017).

The limited distribution of CNG refueling stations has created accessibility challenges for vehicle owners and transportation operators who intend to adopt CNG technology. In areas such as Kogi Central Senatorial District, where CNG infrastructure has only recently begun to develop, inadequate refueling facilities have discouraged potential users due to concerns about fuel availability and convenience.

The availability of reliable refueling infrastructure is critical for the successful diffusion of CNG technology. Without adequate station coverage, users may perceive CNG adoption as risky due to the possibility of fuel shortages or difficulty accessing refueling points.

Storage and Distribution Challenges

The storage and distribution of natural gas present significant technical challenges due to the physical properties of the fuel. Unlike liquid petroleum products, natural gas requires specialized compression systems, high-pressure storage facilities, and carefully managed transportation networks.

The establishment of CNG infrastructure therefore requires substantial investment in compression equipment, storage facilities, transportation systems, and safety mechanisms. These requirements increase the cost and complexity of developing a widespread CNG distribution network (Anyadiiegwu & Muonagor, 2017).

Inadequate storage and distribution infrastructure can affect the reliability of CNG supply, thereby limiting consumer confidence and reducing the rate of adoption among transportation operators and other potential users.

Vehicle Conversion Costs

The high initial cost of converting conventional petrol and diesel vehicles to operate on CNG remains one of the major barriers to adoption. Although CNG provides long-term savings through lower fuel costs, the upfront investment required for vehicle conversion can be financially challenging, particularly for low-income vehicle owners and small-scale transport operators (Kaur, Sidhu & Ravindra, 2020).

The cost of conversion equipment, installation services, and technical maintenance may discourage potential users from adopting CNG technology. This explains why early adoption has largely been observed among government-owned fleets, municipal transportation systems, and large commercial operators that possess greater financial capacity to recover conversion costs through long-term fuel savings.

Technical and Maintenance Challenges

The successful operation of CNG-powered vehicles requires specialized technical knowledge and skilled personnel capable of carrying out proper installation, maintenance, and safety inspections. A shortage of trained technicians and conversion specialists may affect the quality and reliability of CNG vehicle conversions.

Poorly executed conversions may result in operational problems, safety concerns, and reduced confidence among potential users. Therefore, the availability of technical training programmes and qualified personnel remains essential for ensuring the safe and sustainable growth of the CNG sector.

Public Acceptance and Safety Concerns

Public perception and awareness also influence the adoption of CNG technology. Although CNG is considered safe when properly handled and managed, limited awareness and misinformation regarding its operation and safety characteristics may create resistance among potential users.

Concerns about vehicle performance, storage safety, availability of emergency services, and reliability of supply may discourage individuals and businesses from transitioning from conventional fuels to CNG. Addressing these concerns through effective public education, awareness campaigns, and stakeholder engagement is necessary to improve acceptance and confidence in CNG technology.

Policy and Regulatory Gaps

The development and widespread adoption of Compressed Natural Gas (CNG) in Nigeria have been influenced significantly by the effectiveness of government policies, regulatory frameworks, and institutional support systems. Although the Nigerian government has introduced various initiatives aimed at promoting natural gas utilization and reducing dependence on conventional petroleum fuels, several policy and regulatory challenges have continued to limit the effective implementation of CNG programmes.

Inadequate Regulatory Framework

A major challenge affecting CNG adoption in Nigeria is the absence of a fully developed and coordinated regulatory framework that supports long-term investment and sustainable growth of the CNG sector. Previous studies have indicated that regulatory inconsistencies, unclear implementation strategies, and institutional limitations have constrained the expansion of CNG-powered transportation (Anyadiegwu & Muonagor, 2017).

A well-defined regulatory environment is essential for providing confidence to investors, ensuring safety standards, regulating conversion practices, and establishing clear operational guidelines for CNG infrastructure development. The absence of consistent policies may increase investment risks and discourage private sector participation in the development of refueling stations, conversion centres, and distribution networks.

The successful expansion of CNG adoption requires effective coordination among government agencies, energy regulators, transportation authorities, and private sector stakeholders. Strong institutional collaboration is necessary to ensure that policies are properly implemented and that infrastructure development aligns with national energy transition objectives.

Limited Government Incentives and Support Mechanisms

The availability of government incentives plays an important role in encouraging the adoption of alternative energy technologies. However, limited financial support mechanisms have remained a challenge to the expansion of CNG utilization in Nigeria.

Incentives such as tax reductions, subsidies for vehicle conversion kits, low-interest financing options, and preferential policies for CNG-powered vehicles can reduce the financial burden associated with adoption. Without such incentives, many individuals and small-scale transportation operators may find the initial cost of transitioning to CNG unaffordable.

Although recent government interventions, including the Presidential Compressed Natural Gas Initiative (P-CNGI), have demonstrated increased commitment towards promoting CNG adoption, sustained policy support and effective implementation mechanisms remain essential for achieving widespread adoption.

Infrastructure Planning and Policy Implementation Challenges

Effective CNG adoption requires proper integration between energy policy, transportation planning, and infrastructure development. Inadequate coordination between these areas may result in slow infrastructure expansion, inefficient resource allocation, and limited accessibility for end users.

Furthermore, delays in policy implementation and insufficient monitoring mechanisms may reduce the effectiveness of government initiatives. Therefore, continuous evaluation of CNG programmes and stakeholder engagement are necessary to ensure that policy objectives translate into practical improvements in infrastructure availability and user adoption.

Overall, addressing policy and regulatory gaps is critical for creating an enabling environment that supports investment, improves public confidence, and accelerates the transition towards CNG-based transportation in Nigeria.

Awareness and Perception

Public awareness and perception are important factors influencing the acceptance and adoption of Compressed Natural Gas (CNG) as an alternative transportation fuel. Although CNG provides several economic and environmental advantages, limited knowledge, misconceptions, and uncertainty regarding its operation and safety characteristics may affect users' willingness to adopt the technology.

Limited Public Awareness

A major barrier to CNG adoption in Nigeria has been inadequate public awareness regarding the benefits, availability, and operational requirements of CNG-powered vehicles. Many potential users remain unfamiliar with the economic advantages of CNG, including reduced fuel costs, improved energy security, and environmental benefits.

Limited awareness may also affect users' understanding of vehicle conversion processes, maintenance requirements, and the availability of CNG facilities. As a result, some vehicle owners and transportation operators may hesitate to adopt CNG due to uncertainty about its reliability, affordability, and long-term benefits.

Effective awareness campaigns, stakeholder engagement, and public education programmes are therefore necessary to improve understanding and increase confidence among potential users. Such initiatives can enhance the diffusion of CNG technology by addressing information gaps and encouraging informed decision-making.

Safety Concerns: Perceived Versus Actual Risks

Safety perception represents another important factor influencing public acceptance of CNG. Although CNG is considered a relatively safe fuel when properly stored, transported, and utilized according to established safety standards, public perception may sometimes be influenced by misinformation, inadequate knowledge, or concerns regarding high-pressure storage systems.

Some potential users associate compressed gas storage with increased risks, including leakage, explosion, or vehicle damage. However, properly designed CNG systems incorporate safety mechanisms such as pressure control devices, protective storage cylinders, and regulated installation procedures to minimize these risks.

The difference between perceived safety risks and actual safety performance can significantly influence adoption decisions. Therefore, improving public education on CNG safety standards, strengthening regulatory oversight, and ensuring proper installation and maintenance practices are essential for building user confidence.

Influence of Awareness on Technology Adoption

The level of awareness among users is closely linked to the diffusion and acceptance of innovative technologies. According to the Diffusion of Innovation Theory, individuals are more likely to adopt an innovation when they understand its advantages, compatibility, and practical applications.

In the context of CNG adoption in Kogi State, increased awareness among transportation operators, households, and businesses could contribute to greater acceptance and utilization of CNG facilities. Conversely, inadequate information dissemination may slow the adoption process despite the economic and environmental benefits associated with CNG.

Therefore, improving awareness and addressing negative perceptions remain critical components of strategies aimed at promoting sustainable CNG adoption in Nigeria

Vehicle Availability and Technical Limitations

The availability of suitable vehicles and the presence of adequate technical capacity are important factors that influence the successful adoption of Compressed Natural Gas (CNG) as an alternative transportation fuel. Although CNG technology has gained acceptance in several countries, its expansion in Nigeria has been constrained by limited vehicle availability, dependence on aftermarket conversions, and shortages of skilled technical personnel.

Limited Availability of CNG-Compatible Vehicles

One of the major challenges affecting CNG adoption in Nigeria is the limited availability of factory-fitted CNG vehicles. Unlike countries with established CNG markets where vehicles are manufactured with integrated CNG systems, many Nigerian users rely primarily on converting existing petrol-powered vehicles to operate on CNG.

The dependence on aftermarket conversion creates several concerns, including vehicle performance, durability, safety, warranty limitations, and maintenance requirements. Some vehicle

owners may be reluctant to convert their vehicles due to uncertainty regarding the long-term effects of conversion on engine efficiency and resale value (Kaur, Sidhu & Ravindra, 2020).

The limited supply of original equipment manufacturer (OEM) CNG vehicles also restricts consumer choice and slows the rate of adoption. Expanding access to CNG-compatible vehicles through local assembly, importation incentives, and partnerships with vehicle manufacturers could improve adoption rates and strengthen the CNG market in Nigeria.

Technical Skills Gap

The operation and maintenance of CNG-powered vehicles require specialized technical knowledge and expertise. However, the availability of adequately trained technicians capable of installing, servicing, and maintaining CNG systems remains limited in many parts of Nigeria.

A shortage of skilled personnel may affect the quality of vehicle conversions and increase safety risks associated with improper installation or maintenance. Poor conversion practices can reduce vehicle efficiency, increase operational challenges, and negatively influence public confidence in CNG technology.

The development of structured training programmes for technicians, certification standards for conversion centres, and continuous professional development initiatives are necessary to ensure the reliability and safety of CNG systems.

Maintenance and Operational Challenges

CNG-powered vehicles require specialized maintenance procedures, including regular inspection of storage cylinders, fuel systems, pressure regulators, and conversion components. Limited access to maintenance facilities and spare parts can create additional challenges for users, particularly in areas where CNG infrastructure is still developing.

In regions such as Kogi Central Senatorial District, the availability of competent service providers and technical support networks is essential for sustaining user confidence and encouraging long-term adoption.

Therefore, addressing vehicle availability constraints and strengthening technical capacity are important requirements for achieving a successful transition from conventional petroleum fuels to CNG-based transportation in Nigeria.

Kogi State in the CNG Landscape

Kogi State occupies a strategic position in Nigeria's emerging Compressed Natural Gas (CNG) landscape due to its geographical location, abundant natural gas resources, and its connection to major national gas infrastructure projects. The state's location along the Ajaokuta–Kaduna–Kano (AKK) Gas Pipeline corridor places it at the centre of the Federal Government's efforts to expand domestic gas utilization and promote cleaner transportation alternatives (Kogi State Government, 2024).

The Presidential Compressed Natural Gas Initiative (P-CNGI) has identified Kogi State as one of the strategic locations for expanding CNG infrastructure through the establishment of refueling stations, vehicle conversion centres, and CNG parks. These initiatives are intended to improve access to affordable transportation fuel, stimulate investment in the gas sector, create employment opportunities, and reduce dependence on conventional petroleum products.

Despite these strategic advantages, the level of CNG infrastructure development in Kogi State remains relatively low compared to the increasing demand for alternative transportation fuels. The limited number of operational refueling stations and conversion centres has constrained the widespread adoption of CNG among commercial transport operators, private vehicle owners, and businesses within the state. Consequently, many potential users continue to rely on petrol and diesel despite the increasing cost of these conventional fuels.

The inadequate availability of CNG infrastructure has also affected accessibility, convenience, and public confidence in the technology. In many parts of Kogi Central Senatorial District, prospective users face difficulties accessing reliable refueling services, while concerns regarding conversion costs and maintenance further discourage adoption.

Although government initiatives have created opportunities for expanding the CNG value chain within the state, significant investments in infrastructure, technical capacity, public awareness, and policy implementation remain necessary to achieve the desired level of adoption. Strengthening these

components would enhance the socio-economic benefits associated with CNG utilization while supporting Nigeria's broader energy transition agenda.

Furthermore, existing literature reveals that relatively few empirical studies have examined the socio-economic implications of CNG adoption specifically within Kogi State. Most available studies focus on national trends or broader discussions of natural gas utilization, with limited attention given to the availability of CNG facilities, users' experiences, accessibility challenges, and localized socio-economic outcomes within the state.

This gap in the literature justified the present study, which assessed the availability of Compressed Natural Gas facilities in Kogi State and examined their socio-economic gains and potential drawbacks. The findings of the study contributed to the existing body of knowledge by providing location-specific evidence that could guide policymakers, investors, and other stakeholders in planning and implementing sustainable CNG development strategies within Kogi State and Nigeria as a whole.

Empirical Literature Review

The empirical literature reviewed previous studies that investigated the socio-economic implications, infrastructure development, environmental impacts, and adoption of Compressed Natural Gas (CNG) in Nigeria and other developing countries. The review examined the methodologies, findings, and conclusions of these studies with the aim of identifying areas of convergence, divergence, and existing knowledge gaps that justified the present study.

Empirical Evidence on CNG Adoption and Economic Security in Nigeria

Several empirical studies have investigated the economic implications of Compressed Natural Gas (CNG) adoption in Nigeria, particularly following the removal of fuel subsidies and the increasing emphasis on domestic gas utilization. The findings of these studies generally indicate that CNG adoption has the potential to improve economic security through lower fuel costs, increased availability of domestic energy resources, and significant savings in foreign exchange expenditure.

Daser and Adams (2025) examined the implications of CNG adoption for Nigeria's economic stability and reported that CNG provides a more affordable and relatively stable alternative to petrol and diesel. Their study found that increased utilization of CNG could reduce household transportation costs, lessen government expenditure on fuel subsidies, and improve overall economic resilience against fluctuations in global crude oil prices. The study concluded that wider adoption of CNG could contribute significantly to sustainable economic development in Nigeria.

Similarly, empirical findings have shown that replacing a substantial proportion of imported petroleum products with domestically available natural gas could generate considerable foreign exchange savings. These savings would strengthen Nigeria's foreign reserve position, reduce pressure on the national currency, and improve macroeconomic stability. Such findings support the argument that the commercialization of Nigeria's abundant natural gas resources can enhance national economic performance while reducing dependence on imported refined petroleum products.

Ibeneme and Ighalo (2020) investigated the economic effects of developing Nigeria's domestic gas industry and found that investment in CNG infrastructure stimulated industrial activities and created employment opportunities across several sectors, including construction, engineering services, transportation, and automotive conversion. Their study concluded that the expansion of CNG infrastructure could promote industrial diversification while contributing to employment generation and poverty reduction.

Despite these positive findings, several empirical studies have also identified factors that continue to hinder the successful adoption of CNG in Nigeria. Energy for Growth Hub (2025) reported that inadequate public sensitization, limited awareness of CNG benefits, and weak coordination among government institutions have slowed the diffusion of CNG technology. The study emphasized that successful implementation requires a coordinated national strategy involving government agencies, private investors, and other stakeholders.

These empirical findings support the proposition of the Diffusion of Innovation Theory, which explains that the successful adoption of an innovation depends largely on awareness, communication, perceived benefits, and accessibility. The studies reviewed demonstrate that while CNG possesses significant economic advantages, its widespread adoption in Nigeria remains constrained by infrastructural deficiencies, institutional challenges, and inadequate public awareness.

Although previous empirical studies have examined the economic benefits of CNG at the national level, relatively few have focused specifically on assessing the availability of CNG facilities and their socio-economic implications within Kogi State. This limitation provided the basis for the present study, which generated location-specific empirical evidence on the socio-economic gains and challenges associated with the adoption of Compressed Natural Gas in Kogi Central Senatorial District.

Empirical Assessments of CNG Infrastructure Development in Nigeria

The development of adequate Compressed Natural Gas (CNG) infrastructure is a critical requirement for the successful adoption of CNG as an alternative transportation fuel. Several empirical studies have assessed the availability of CNG refueling stations, conversion centres, storage facilities, and distribution networks in Nigeria. The findings consistently indicate that inadequate infrastructure remains one of the greatest barriers to widespread CNG adoption.

Empirical evidence suggests that although the Federal Government of Nigeria has introduced several initiatives to promote domestic gas utilization, the pace of CNG infrastructure development has remained relatively slow. Government programmes such as the Presidential Compressed Natural Gas Initiative (P-CNGI) have focused on increasing investment in refueling stations, vehicle conversion centres, and gas distribution facilities across the country. However, available empirical reports indicate that the number of operational CNG stations remains insufficient to meet the growing demand for alternative transportation fuels.

According to Punch Newspapers (2025), fewer than sixty operational CNG refueling stations had been established nationwide despite increasing public interest in CNG following the removal of fuel subsidies. The study observed that the limited availability of refueling facilities had reduced accessibility for vehicle owners and commercial transport operators, thereby slowing the adoption of CNG technology across the country.

Similarly, empirical reports by Vanguard (2025) highlighted that although Nigeria possesses abundant natural gas reserves capable of supporting large-scale CNG utilization, inadequate infrastructure development continues to hinder effective commercialization of these resources. The report identified limited investment in gas compression facilities, storage infrastructure, and distribution networks as major factors constraining the expansion of CNG services.

With respect to Kogi State, empirical evidence indicates that the state has received increasing attention because of its strategic location along the Ajaokuta–Kaduna–Kano (AKK) Gas Pipeline corridor. The Kogi State Government, in collaboration with Automotive Gas Nigeria Service Limited and other stakeholders, has initiated projects aimed at establishing CNG refueling stations and vehicle conversion centres within the state (Kogi State Government, 2024). These initiatives are expected to improve access to cleaner and more affordable transportation fuel while promoting local economic development.

Despite these efforts, available empirical evidence suggests that the existing CNG infrastructure within Kogi State remains inadequate relative to the growing demand for alternative fuels. The limited number of operational refueling stations and conversion centres has continued to restrict accessibility, particularly for commercial transport operators and private vehicle owners residing outside major urban centres.

Furthermore, Punch Newspapers (2025) reported that many Nigerians remain reluctant to convert their vehicles to CNG because of concerns regarding the availability of refueling stations. This finding demonstrates that infrastructure availability directly influences consumer confidence and adoption behaviour. Even where government policies encourage vehicle conversion, inadequate supporting infrastructure reduces the willingness of potential users to invest in CNG technology.

The empirical studies reviewed therefore establish that infrastructure development remains a fundamental determinant of CNG adoption in Nigeria. While government initiatives have created opportunities for expanding CNG facilities, greater investment in refueling stations, distribution networks, storage facilities, and technical support services is required to achieve widespread utilization. These findings further justified the present study, which assessed the adequacy, accessibility, and functionality of existing CNG facilities within Kogi Central Senatorial District and examined their socio-economic implications.

Case Studies and Empirical Findings on Challenges of CNG Adoption in Developing Countries

Empirical evidence from several developing countries provides valuable insights into the opportunities and challenges associated with the adoption of Compressed Natural Gas (CNG) as an alternative transportation fuel. Although many countries have successfully integrated CNG into their transportation systems, the process has often been constrained by infrastructural, financial, institutional, and technical challenges. These international experiences provide useful lessons for Nigeria in its efforts to expand domestic CNG utilization.

Daser and Adams (2025) examined the adoption of CNG in selected developing countries and found that inadequate infrastructure, limited financing, competing demands for natural gas resources, and inconsistent government policies were among the major constraints to successful implementation. The study observed that while CNG possesses significant economic and environmental advantages, sustainable adoption depends on adequate investment in production, distribution, and refueling infrastructure.

A notable example is Pakistan, which has one of the largest CNG vehicle fleets in the world. Empirical findings revealed that although the country initially recorded remarkable success in promoting CNG-powered transportation, increasing domestic demand eventually exceeded available natural gas supply. This imbalance resulted in periodic fuel rationing, supply shortages, and increased dependence on imported energy resources. The experience demonstrates the importance of maintaining a sustainable supply chain capable of meeting future demand as CNG adoption expands.

Similarly, empirical studies conducted in countries such as India and Iran indicate that strong government commitment, supportive regulatory policies, and continuous investment in infrastructure played significant roles in accelerating CNG adoption. These countries successfully expanded their refueling station networks, introduced fiscal incentives, and promoted public awareness programmes that encouraged vehicle owners to transition from conventional petroleum fuels to CNG.

However, evidence from several developing economies also indicates that the high cost of vehicle conversion remains a major obstacle to widespread adoption. Consumers who recently purchased petrol or diesel vehicles often lack sufficient financial resources to retrofit their vehicles, particularly where government subsidies or affordable financing mechanisms are unavailable. Consequently, the economic benefits of CNG may not be immediately realized despite its lower operating costs.

Adams and Jauro (2024) further argued that the successful adoption of CNG requires careful evaluation of local economic conditions, existing transportation systems, and long-term infrastructure costs. Their study concluded that although CNG provides substantial environmental and economic benefits, its viability depends largely on the availability of reliable gas supplies, adequate infrastructure, supportive government policies, and sustained public acceptance.

The empirical evidence reviewed demonstrates that the challenges associated with CNG adoption are not unique to Nigeria. Many developing countries have experienced similar constraints relating to infrastructure development, financing, technical capacity, policy implementation, and consumer acceptance. Nevertheless, countries that adopted comprehensive implementation strategies combining infrastructure investment, government incentives, technical training, and public awareness campaigns recorded greater success in expanding CNG utilization.

These international experiences provide useful lessons for Nigeria and reinforce the need for coordinated policy implementation, strategic infrastructure investment, and continuous stakeholder engagement. They also underscore the relevance of the present study, which examined how similar challenges influenced the adoption of Compressed Natural Gas within Kogi Central Senatorial District and assessed their socio-economic implications.

Empirical Evidence on Environmental Impacts of Compressed Natural Gas Adoption

Several empirical studies have established that Compressed Natural Gas (CNG) is a cleaner and more environmentally sustainable alternative to conventional petroleum fuels. Research conducted within Nigeria indicates that the adoption of CNG contributes significantly to the reduction of greenhouse gas emissions and other harmful pollutants associated with transportation activities.

Ogbonnaya and Eji (2025) reported that the widespread adoption of CNG in Nigeria's transportation sector could reduce daily carbon dioxide (CO₂) emissions by approximately 73 percent.

Their findings demonstrated that CNG combustion produces substantially lower emissions of carbon dioxide, particulate matter, sulphur oxides (SO_x), nitrogen oxides (NO_x), and carbon monoxide compared with petrol and diesel. These pollutants have been identified as major contributors to environmental degradation and public health challenges in urban areas.

Similarly, empirical evidence has shown that CNG-powered vehicles emit lower quantities of hydrocarbons (HC), carbon monoxide (CO), and other toxic substances than conventional internal combustion engines operating on petrol or diesel. These environmental advantages contribute to improved air quality, reduced atmospheric pollution, and enhanced public health outcomes.

The reviewed studies further indicate that increased utilization of CNG supports Nigeria's commitment to climate change mitigation by reducing greenhouse gas emissions from the transportation sector. Consequently, the adoption of CNG has been recognized as an important strategy for achieving sustainable environmental management while promoting cleaner energy utilization.

The empirical findings reviewed therefore provide substantial evidence supporting the environmental benefits of CNG adoption and reinforce the argument that greater investment in CNG infrastructure can contribute to environmental sustainability and improved quality of life.

Empirical Studies on Consumer Behaviour towards Alternative Fuels in Nigeria

Consumer behaviour plays a significant role in determining the adoption and utilization of alternative energy technologies. Several empirical studies have examined the factors influencing household and commercial decisions regarding alternative fuels in Nigeria, revealing that adoption behaviour is influenced by a combination of economic, social, demographic, cultural, and psychological factors.

Adeniran (2023) investigated consumers' attitudes towards environmentally sustainable products in Nigeria and found that although awareness of environmental sustainability has increased, the willingness to adopt alternative energy products remains dependent on affordability, accessibility, educational level, and perceived benefits. The study concluded that increased public education and improved access to sustainable energy technologies are necessary to encourage wider adoption.

Similarly, Kiyawa and Yakubu (2017) found that household fuel choices are determined by several socio-economic variables, including income level, educational attainment, household size, occupation, cultural preferences, and accessibility to energy sources. Their findings indicate that households with higher educational attainment and greater awareness are more likely to adopt cleaner and more sustainable energy alternatives.

Onuche and Oladipo (2021) also reported that fuel availability, household income, accessibility, and infrastructure significantly influence consumer decisions regarding alternative energy utilization. Their study emphasized that economic considerations alone are insufficient to explain adoption behaviour, as social and demographic characteristics equally influence consumer preferences.

Furthermore, Egwuogu (2025) examined the socio-economic effects of fuel subsidy removal in Nigeria and reported that rising transportation costs and declining household purchasing power have increased public interest in cheaper alternative fuels such as CNG. However, the study also observed that inadequate refueling infrastructure, high vehicle conversion costs, and limited public awareness have continued to restrict widespread adoption.

The empirical studies reviewed demonstrate that successful CNG adoption depends not only on economic advantages but also on consumers' perceptions, awareness, accessibility to infrastructure, and socio-economic characteristics. These findings support the application of the Diffusion of Innovation Theory, which emphasizes the importance of awareness, communication, and perceived relative advantage in influencing technology adoption.

Gaps in Empirical Literature and Contribution of the Study

The empirical literature reviewed provides substantial evidence regarding the economic, environmental, and social benefits of Compressed Natural Gas adoption, as well as the challenges associated with infrastructure development, policy implementation, and consumer acceptance. However, several important gaps remain within the existing body of knowledge.

First, most empirical studies have concentrated on national-level analyses of CNG adoption, with limited attention given to state-specific or senatorial district-level assessments. Consequently, there is

limited empirical evidence regarding the availability, accessibility, and functionality of CNG facilities within Kogi State, particularly Kogi Central Senatorial District.

Second, although previous studies have examined individual aspects of CNG adoption, relatively few have undertaken a comprehensive assessment that simultaneously evaluates the socio-economic benefits, environmental advantages, infrastructure adequacy, accessibility, and operational challenges associated with CNG utilization within a specific geographical area.

Third, existing empirical studies have rarely examined the relationship between CNG infrastructure availability, users' demographic characteristics, government support, and the socio-economic outcomes of CNG adoption using an integrated analytical framework. Consequently, limited empirical evidence exists regarding how these variables collectively influence the adoption of CNG within developing economies.

Furthermore, only a few empirical studies have applied the Diffusion of Innovation Theory to explain the adoption behaviour of CNG users within the Nigerian context, particularly following the implementation of major policy reforms such as fuel subsidy removal and the Presidential Compressed Natural Gas Initiative (P-CNGI).

To address these identified gaps, the present study employed a mixed-method research design to collect and analyse both quantitative and qualitative data relating to the availability of CNG facilities, accessibility, socio-economic benefits, and the challenges associated with CNG adoption in Kogi Central Senatorial District. The study generated location-specific empirical evidence capable of informing policy formulation, infrastructure development, investment decisions, and sustainable energy planning within Kogi State and Nigeria generally.

Theoretical Framework

This study was anchored on the **Diffusion of Innovation (DOI) Theory** developed by Rogers (1962). The theory explains how, why, and at what rate new ideas, technologies, or innovations spread within a particular population or social system. According to Rogers (1962), the successful diffusion of an innovation depends on the communication channels through which information is transmitted, the characteristics of the innovation, the time required for adoption, and the nature of the social system in which the innovation is introduced.

The theory further posits that the adoption of an innovation occurs through interaction among individuals within interpersonal and social networks. Adoption implies that individuals modify their previous behaviour by accepting and using a new product, technology, or practice. For an innovation to be adopted, potential users must perceive it as new, useful, and capable of providing relative advantages over existing alternatives.

Rogers also identified five categories of adopters based on their willingness to embrace innovation: innovators, early adopters, early majority, late majority, and laggards. The rate of adoption is influenced by several factors, including the innovation's relative advantage, compatibility with existing practices, complexity, trialability, and observability. These characteristics determine the extent to which an innovation is accepted within a given society.

The Diffusion of Innovation Theory was considered appropriate for this study because the adoption of Compressed Natural Gas (CNG) in Kogi State represented the introduction of a relatively new energy technology within the transportation sector. The study examined how factors such as the availability of CNG infrastructure, accessibility of refueling stations, government support, public awareness, and users' socio-economic characteristics influenced the acceptance and utilization of CNG among households, commercial transport operators, and other stakeholders.

The theory also provided a useful framework for explaining why the adoption of CNG differed among various categories of users within Kogi Central Senatorial District. While some transport operators readily embraced the innovation because of its perceived economic and environmental benefits, others remained reluctant due to high vehicle conversion costs, inadequate refueling infrastructure, safety concerns, and limited awareness. Consequently, the Diffusion of Innovation Theory provided a suitable theoretical foundation for examining the socio-economic benefits and challenges associated with the development and utilization of Compressed Natural Gas (CNG) facilities in Kogi State.

Summary of Literature Review

The literature reviewed established that Compressed Natural Gas has emerged as a viable alternative transportation fuel capable of addressing many of Nigeria's energy, economic, and environmental challenges. Both conceptual and empirical studies demonstrate that CNG offers numerous socio-economic advantages, including reduced transportation costs, improved energy security, employment generation, foreign exchange conservation, environmental sustainability, and enhanced public health.

The review further revealed that despite these considerable benefits, the adoption of CNG in Nigeria remains constrained by several challenges, including inadequate refueling infrastructure, high vehicle conversion costs, limited technical capacity, weak policy implementation, insufficient public awareness, and regulatory limitations. These challenges have slowed the diffusion of CNG technology despite increasing government commitment through initiatives such as the Presidential Compressed Natural Gas Initiative (P-CNGI).

The empirical literature also revealed that while considerable research has been conducted on CNG adoption at the national level, limited empirical evidence exists regarding the adequacy of CNG facilities and their socio-economic implications within Kogi State, particularly Kogi Central Senatorial District. This identified gap justified the conduct of the present study.

Overall, the literature provided a strong conceptual and empirical foundation for the study by identifying the major determinants of CNG adoption, highlighting existing knowledge gaps, and supporting the selection of the Diffusion of Innovation Theory as the theoretical framework. The reviewed literature also informed the research objectives, research questions, methodology, and interpretation of findings presented in subsequent chapters of this study.

Research Design

This study adopted a descriptive survey research design using a mixed-methods approach. According to Ehinmetalor and Nwandiani (2002), a descriptive survey design is used to describe, analyse, and interpret existing conditions or situations as they occur. This design was considered appropriate because it enabled the researcher to gather relevant information from respondents on the availability, accessibility, utilization, socioeconomic benefits, and challenges associated with Compressed Natural Gas (CNG) facilities in Kogi State.

The quantitative aspect of the study involved the use of a structured questionnaire to collect measurable data from respondents. This made it possible to analyse the extent of CNG infrastructure availability, its level of utilization, and its perceived socioeconomic benefits and drawbacks. On the other hand, the qualitative aspect relied on interviews with selected key stakeholders to obtain detailed insights into policy issues, infrastructure development, operational challenges, and other factors influencing the adoption of CNG in the study area.

By combining quantitative and qualitative methods, the study was able to capture both statistical evidence and the practical experiences of stakeholders. This integration provided a more complete understanding of the issues under investigation and improved the credibility, validity, and reliability of the findings through the triangulation of data from different sources.

Population of the Study

The population for this study comprised stakeholders who were directly involved in or affected by the adoption and utilization of Compressed Natural Gas (CNG) facilities in Kogi Central Senatorial District of Kogi State. These stakeholders included commercial transport operators currently using or intending to use CNG-powered vehicles, private vehicle owners who had converted or planned to convert their vehicles to CNG, operators and staff of CNG refuelling stations and vehicle conversion centres, officials of relevant government agencies responsible for transportation and energy, as well as representatives of transport unions operating within the study area.

Sample Size and Sampling Procedure

Sample Size

The sample size for this study comprised all 110 commercial transport operators identified within the study area. Since the accessible population was relatively small and manageable, the researcher adopted a census (total enumeration) approach, whereby every member of the accessible population was included in the study. This approach eliminated sampling error associated with selecting only a portion of the population and ensured that the views of all identified respondents were adequately represented.

The decision to use the entire accessible population was based on the recommendation of Creswell and Creswell, (2018). who noted that when the population is small and manageable, it is more appropriate to study the whole population rather than draw a sample. Consequently, all 110 commercial transport operators participated in the quantitative aspect of the study.

For the qualitative aspect, 10 key informants were selected to participate in the interview. These comprised CNG refuelling station operators, vehicle conversion centre operators, officials from relevant government agencies, and representatives of transport unions. Their inclusion provided detailed information that complemented the quantitative findings.

Sampling Procedure

The study employed two sampling techniques. For the quantitative component, total enumeration (census sampling) was adopted. This technique involved including all 110 commercial transport operators in the study because the accessible population was small and could be effectively managed. The use of total enumeration ensured comprehensive coverage of the target respondents and enhanced the reliability of the findings.

For the qualitative component, purposive sampling was used to select the key informants. This technique was considered appropriate because it enabled the researcher to deliberately select individuals who possessed relevant knowledge, experience, and direct involvement in the development, operation, regulation, and utilization of Compressed Natural Gas (CNG) facilities in Kogi State. The selected participants were therefore able to provide rich and detailed information on the socioeconomic benefits, operational challenges, policy issues, and future prospects of CNG adoption within the study area.

The combination of total enumeration and purposive sampling ensured that the study obtained both comprehensive quantitative data and in-depth qualitative information necessary to achieve the objectives of the research.

For the quantitative phase of the study, the accessible population consisted of 110 commercial transport operators. This group formed the basis for the administration of the questionnaire and subsequent statistical analysis. Commercial transport operators were selected because they represent the largest category of CNG users and are among those most directly affected by the availability of CNG infrastructure, fuel accessibility, conversion costs, and the economic and operational benefits associated with CNG adoption.

For the qualitative phase, a small number of key informants were purposively selected from CNG facility operators, government agencies, and transport unions. Their participation provided valuable insights into policy implementation, infrastructure development, operational experiences, and the challenges and opportunities associated with expanding CNG adoption in Kogi State.

The selected population was considered appropriate because it included the major stakeholders whose knowledge, experiences, and opinions were essential for achieving the objectives of the study and for providing a balanced assessment of the socioeconomic gains and drawbacks of Compressed Natural Gas facilities in the study area

Instrument for Data Collection

The primary instrument used for data collection in this study was a structured questionnaire supported by an interview guide. The questionnaire was designed by the researcher based on the objectives of the study, research questions, and relevant literature on Compressed Natural Gas (CNG) adoption and infrastructure.

The questionnaire consisted of two sections. Section A elicited information on the demographic characteristics of the respondents, such as age, occupation, and CNG usage status. Section B contained items relating to the availability and accessibility of CNG facilities, the socioeconomic benefits of CNG adoption, and the challenges associated with its utilization in Kogi State. The items were structured on a four-point Likert scale of Strongly Agree (SA), Agree (A), Disagree (D), and Strongly Disagree (SD).

An interview guide was also developed for selected key informants, including operators of CNG facilities, officials of relevant government agencies, and representatives of transport unions. The interview focused on issues relating to policy implementation, infrastructure development, operational challenges, and strategies for improving the adoption of CNG within the study area.

Validation of the Instrument

To ensure the validity of the research instruments, the questionnaire and interview guide were subjected to face and content validation. Copies of the instruments were presented to experts in Economics Education, Research Measurement and Evaluation, and Energy Policy for critical examination.

The validators assessed the clarity, relevance, appropriateness, and adequacy of the items in relation to the objectives and research questions of the study. Their observations and recommendations were carefully considered, and the necessary corrections were made before the final copies of the instruments were administered. This process ensured that the instruments adequately measured the variables they were intended to measure.

Reliability of the Instrument

The reliability of the questionnaire was established through a pilot study conducted among commercial transport operators in a neighbouring area with characteristics similar to those of the study area but not included in the main study. The responses obtained from the pilot test were analysed using Cronbach's Alpha reliability technique to determine the internal consistency of the instrument.

A reliability coefficient of 0.70 or above was considered acceptable, in line with the recommendation of Nunnally (1978), indicating that the instrument was reliable and suitable for data collection.

Method of Data Collection

The researcher personally administered the questionnaires to the respondents with the assistance of trained research assistants where necessary. Before administering the instruments, the respondents were informed of the purpose of the study and assured that the information provided would be treated with strict confidentiality and used solely for academic purposes.

The completed questionnaires were retrieved immediately after completion or collected at an agreed time to ensure a high response rate. In addition, interviews were conducted with the selected key informants at locations convenient to them. Their responses were recorded through note-taking and, where permission was granted, audio recording to ensure accuracy during data analysis.

Method of Data Analysis

The data collected through the questionnaire were coded and analysed using the Statistical Package for the Social Sciences (SPSS). Descriptive statistics, including frequencies, percentages, mean scores, and standard deviations, were used to answer the research questions. A criterion mean of 2.50 was adopted for decision-making. Mean scores of 2.50 and above were regarded as Agree, while mean scores below 2.50 were regarded as Disagree.

The qualitative data obtained through interviews were analysed using thematic analysis. Responses from the participants were organised into themes based on the objectives of the study and used to complement and explain the quantitative findings. The integration of quantitative and qualitative results provided a richer understanding of the socioeconomic gains and drawbacks associated with Compressed Natural Gas (CNG) facilities in Kogi State.

Method of Data Analysis

The data collected through the questionnaire were coded, entered into Microsoft Excel for proper organization and cleaning, and subsequently exported to the Statistical Package for the Social Sciences (SPSS) version 26.0 for analysis. SPSS was used due to its robust and efficient capabilities for analysing quantitative data and generating reliable statistical outputs.

Descriptive statistics, including frequencies, percentages, mean scores, and standard deviations, were employed to summarize the demographic characteristics of respondents and address the research questions. A criterion mean of 2.50 was adopted for decision-making. Mean scores of 2.50 and above were interpreted as Agree, while mean scores below 2.50 were interpreted as Disagree.

The qualitative data obtained through interviews were analysed using thematic analysis. Responses from interview participants were organized into relevant themes and interpreted alongside the quantitative findings to provide a comprehensive understanding of the availability of Compressed Natural Gas (CNG) facilities, their socioeconomic benefits, and the challenges associated with their adoption in Kogi State.

Data Presentation, Analysis and Discussion of Findings

This section presents the analysis of data collected from 110 respondents on the assessment of the adoption of Compressed Natural Gas (CNG) among commercial transport operators. The data were analyzed using descriptive statistics, including frequencies, percentages, means, and standard deviations. The results are presented according to the research questions.

Note that lower mean score indicates agree, while higher mean score indicates disagree.

Research Question One

What is the level of infrastructure and accessibility of CNG facilities among commercial transport operators?

Table 1 Mean Ratings on Infrastructure and Accessibility

S/N	Statement	Mean	SD	Decision
1	CNG refueling stations are easily accessible in my locality	2.78	0.75	Agree
2	The waiting time at CNG stations is reasonable	3.72	0.58	Agree
3	Conversion centres are readily available to users	1.78	0.58	Disagree
4	Existing CNG infrastructure meets current local demand	2.77	0.88	Agree
	Grand Mean	2.76		Agree

Source: SPSS Output (2026).

Table 4.1 presents respondents' opinions regarding infrastructure and accessibility of CNG facilities. The highest mean score (Mean = 3.72) was recorded for the statement that the waiting time at CNG stations is reasonable, indicating strong agreement among respondents. Conversely, the statement that conversion centres are readily available recorded the lowest mean score (Mean = 1.78), suggesting that respondents generally disagreed with this statement. The overall grand mean of 2.76 indicates that respondents generally agreed that infrastructure and accessibility influence CNG utilization.

The findings imply that although respondents perceive some aspects of CNG infrastructure positively, the limited availability of conversion centres remains a major obstacle to wider adoption. Government agencies and private investors should therefore establish more conversion centres to improve accessibility.

Research Question Two

What is the socio-economic impact of CNG adoption among commercial transport operators?

Table 4.2 Mean Ratings on Socio-Economic Impact

S/N	Statement	Mean	SD	Decision
1	Switching to CNG has significantly reduced my fuel costs	1.33	0.53	Strongly Agree
2	CNG usage has improved business planning	1.65	0.57	Strongly Agree
3	CNG is safer for the environment than petrol/diesel	1.56	0.55	Strongly Agree
4	CNG adoption has created new job opportunities	1.69	0.48	Strongly Agree
	Grand Mean	1.56		Strongly Agree

Source: SPSS Output (2026).

Table 4.2 shows that respondents strongly agreed that CNG adoption has generated positive socio-economic benefits. The lowest mean value (1.33), corresponding to reduced fuel costs, reflects the strongest level of agreement. The grand mean of 1.56 indicates an overall positive perception of the socio-economic benefits of CNG adoption.

This finding suggests that CNG adoption contributes to lower operating costs, improved business sustainability, environmental protection, and employment creation. Policymakers should continue to encourage CNG adoption through incentives and awareness programmes.

Research Question Three

What are the barriers to CNG adoption among commercial transport operators?

Table 3 Mean Ratings on Barriers to Adoption

S/N	Statement	Mean	SD	Decision
1	Vehicle conversion cost is too high	1.15	0.38	Strongly Agree
2	I lack adequate information on safe CNG operation	2.33	0.85	Agree
3	I am concerned about the safety of CNG cylinders	1.46	0.52	Strongly Agree
4	Frequent scarcity of CNG discourages me	1.55	0.82	Strongly Agree
	Grand Mean	1.62		Strongly Agree

Source: SPSS Output (2026).

The results in Table 4.3 indicate that respondents perceived several significant barriers to CNG adoption. The high cost of vehicle conversion recorded the strongest agreement (Mean = 1.15), while inadequate information on safe operation recorded the highest mean score (2.33), though respondents still generally agreed that it was a barrier. The grand mean of 1.62 indicates that respondents strongly agreed that these factors hinder the adoption of CNG technology.

The findings imply that reducing conversion costs, increasing public education on CNG technology, ensuring adequate safety standards, and improving fuel availability are essential to encourage wider adoption of CNG among commercial transport operators.

Summary of Findings

The study found that:

Respondents generally agreed that infrastructure and accessibility influence the adoption of CNG, although conversion centres were considered inadequate.

Respondents strongly agreed that CNG adoption reduces fuel costs, improves business planning, protects the environment, and creates employment opportunities.

The major barriers to CNG adoption were the high cost of vehicle conversion, inadequate information, concerns about cylinder safety, and the frequent scarcity of CNG supply.

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
Ages of respondents	106	1	3	1.97	.577
Valid N (listwise)	106				

Fig 1: Local Government area of respondents

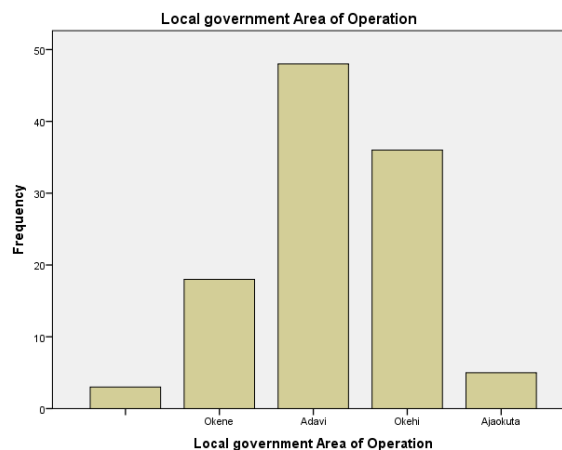


Fig 2: Occupation of Respondents

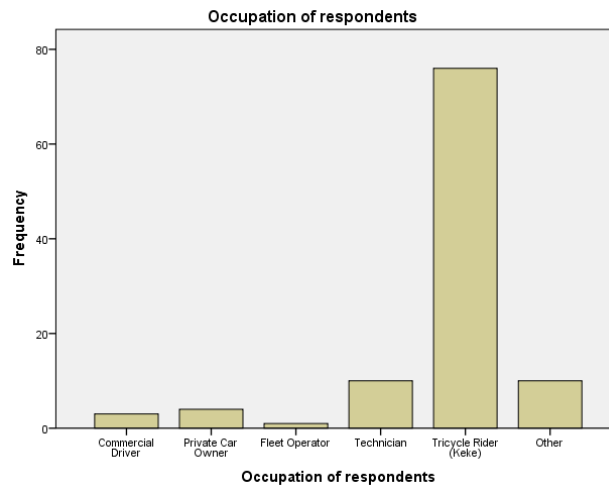
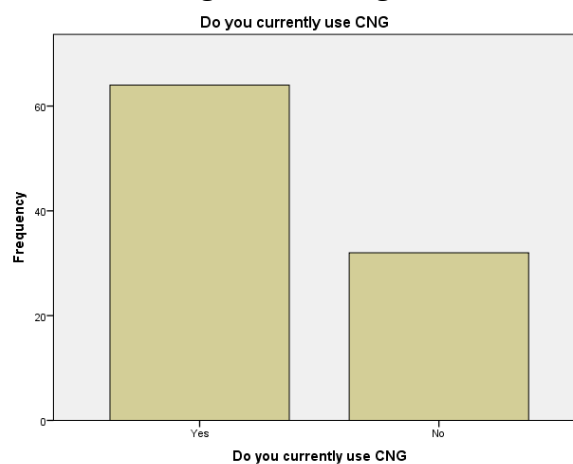


Fig 3: CNG usage



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 /STATISTICS=STDDEV MEAN
 /BARCHART FREQ
 /ORDER=ANALYSIS.

Frequencies

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	Cases Used	Statistics are based on all cases with valid data.
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Statistics													
		Infrastructure and Accessibility: CNG refueling stations are easily accessible in my locality	The waiting time at CNG Stations is reasonable	Conversion centres are readily available to users	Existing CNG infrastructure meets current local demand	Socio-Economic Impact: Switching to CNG has significantly reduced my fuel costs	CNG usage has led to better stability in my businesses planning	I feel that CNG is safer for the environment than petrol/diesel	Adoption of CNG has created new job opportunities in my area	Barriers to Adoption: The cost of Vehicle conversion is too high for the average user	I lack enough information on how to safely operate a CNG Vehicle	I am concerned about the safety/maintenance of CNG Cylinders	Frequent scarcity of CNG supply discourages me from using it
N	Valid	110	110	110	110	110	110	109	107	110	109	110	110
	Missing	0	0	0	0	0	0	1	3	0	1	0	0
Mean		2.7818	3.7182	1.7818	2.7727	1.3273	1.6545	1.5596	1.6916	1.1455	2.3303	1.4636	1.5545
Std. Deviation		.74664	.57680	.58076	.88472	.52653	.56563	.55162	.48392	.37919	.85044	.51895	.81933

Frequency Table

Infrastructure and Accessibility: CNG refueling stations are easily accessible in my locality					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Agree	8	7.3	7.3	7.3
	Agree	21	19.1	19.1	26.4
	Disagree	68	61.8	61.8	88.2
	Strongly Disagree	13	11.8	11.8	100.0
	Total	110	100.0	100.0	

The waiting time at CNG Stations is reasonable					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Agree	1	.9	.9	.9
	Agree	4	3.6	3.6	4.5
	Disagree	20	18.2	18.2	22.7
	Strongly Disagree	85	77.3	77.3	100.0
	Total	110	100.0	100.0	

Conversion centres are readily available to users					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Agree	31	28.2	28.2	28.2
	Agree	74	67.3	67.3	95.5
	Disagree	3	2.7	2.7	98.2
	Strongly Disagree	2	1.8	1.8	100.0
	Total	110	100.0	100.0	

**Existing CNG infrastructure meets current local demand**

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Agree	14	12.7	12.7	12.7
	Agree	16	14.5	14.5	27.3
	Disagree	61	55.5	55.5	82.7
	Strongly Disagree	19	17.3	17.3	100.0
	Total	110	100.0	100.0	

Socio-Economic Impact: Switching to CNG has significantly reduced my fuel costs

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Agree	76	69.1	69.1	69.1
	Agree	33	30.0	30.0	99.1
	Strongly Disagree	1	.9	.9	100.0
	Total	110	100.0	100.0	

CNG usage has led to better stability in my business planning

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Agree	42	38.2	38.2	38.2
	Agree	65	59.1	59.1	97.3
	Disagree	2	1.8	1.8	99.1
	Strongly Disagree	1	.9	.9	100.0
	Total	110	100.0	100.0	

I feel that CNG is safer for the environment than petrol/dissel

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Agree	50	45.5	45.9	45.9
	Agree	58	52.7	53.2	99.1
	Strongly Disagree	1	.9	.9	100.0
	Total	109	99.1	100.0	
Missing	System	1	.9		
Total		110	100.0		

Adoption of CNG has created new job opportunities in my area

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Agree	34	30.9	31.8	31.8
	Agree	72	65.5	67.3	99.1
	Disagree	1	.9	.9	100.0
	Total	107	97.3	100.0	
Missing	System	3	2.7		
Total		110	100.0		

Barriers to Adoption: The cost of Vehicle conversion is too high for the average user

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Agree	95	86.4	86.4	86.4
	Agree	14	12.7	12.7	99.1
	Disagree	1	.9	.9	100.0



	Total	110	100.0	100.0	
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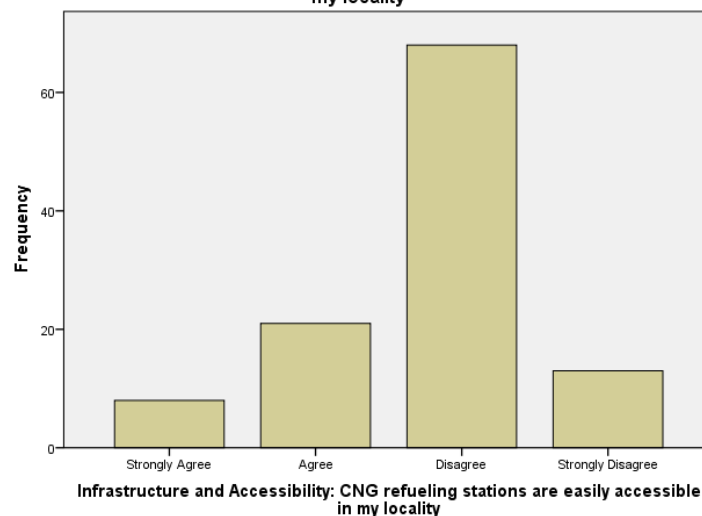
I lack enough information on how to safely operate a CNG Vehicle					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Agree	19	17.3	17.4	17.4
	Agree	43	39.1	39.4	56.9
	Disagree	39	35.5	35.8	92.7
	Strongly Disagree	8	7.3	7.3	100.0
	Total	109	99.1	100.0	
Missing	System	1	.9		
Total		110	100.0		

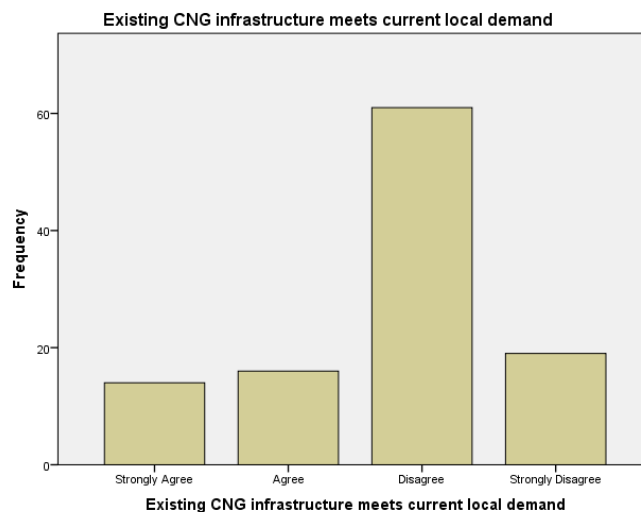
I am concerned about the safety/maintenance of CNG Cylinders					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Agree	60	54.5	54.5	54.5
	Agree	49	44.5	44.5	99.1
	Disagree	1	.9	.9	100.0
	Total	110	100.0	100.0	

Frequent scarcity of CNG supply discourages me from using it					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Agree	67	60.9	60.9	60.9
	Agree	30	27.3	27.3	88.2
	Disagree	8	7.3	7.3	95.5
	Strongly Disagree	5	4.5	4.5	100.0
	Total	110	100.0	100.0	

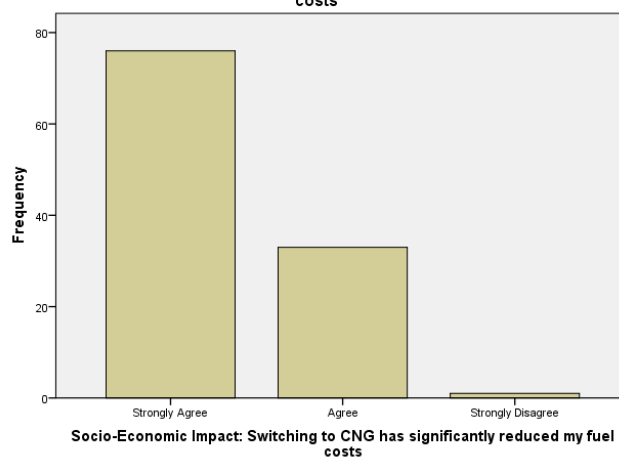
Bar Chart

Infrastructure and Accessibility: CNG refueling stations are easily accessible in my locality

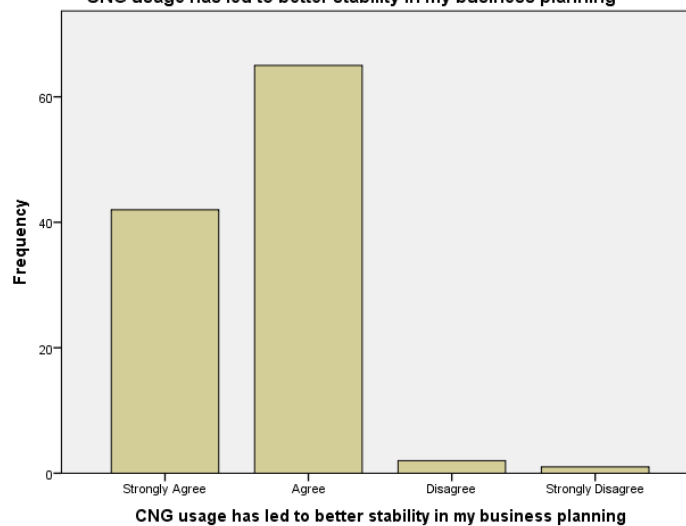


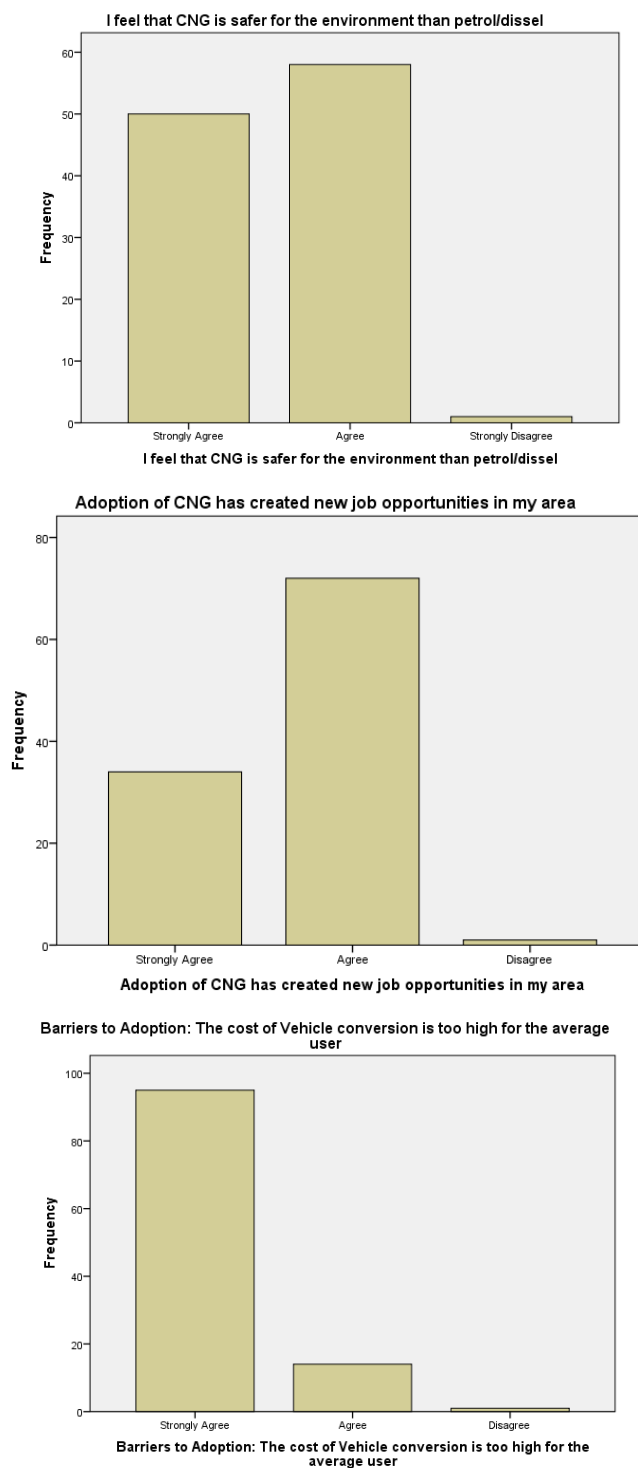


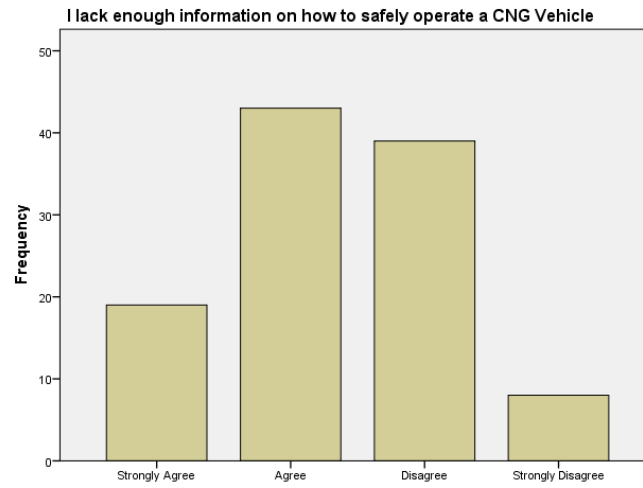
Socio-Economic Impact: Switching to CNG has significantly reduced my fuel costs



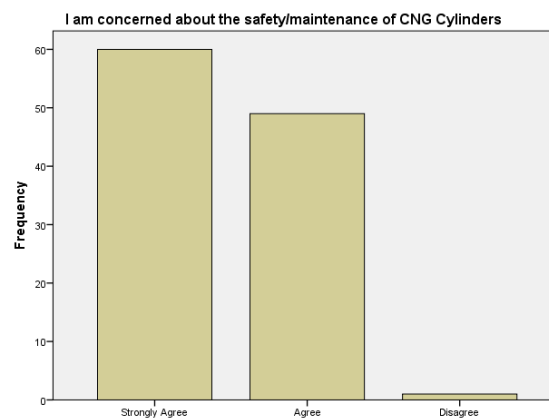
CNG usage has led to better stability in my business planning



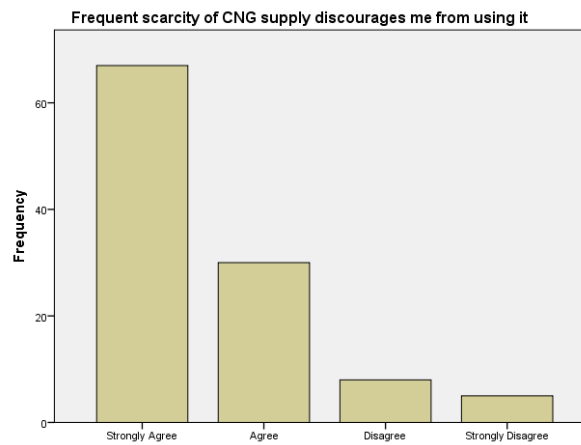




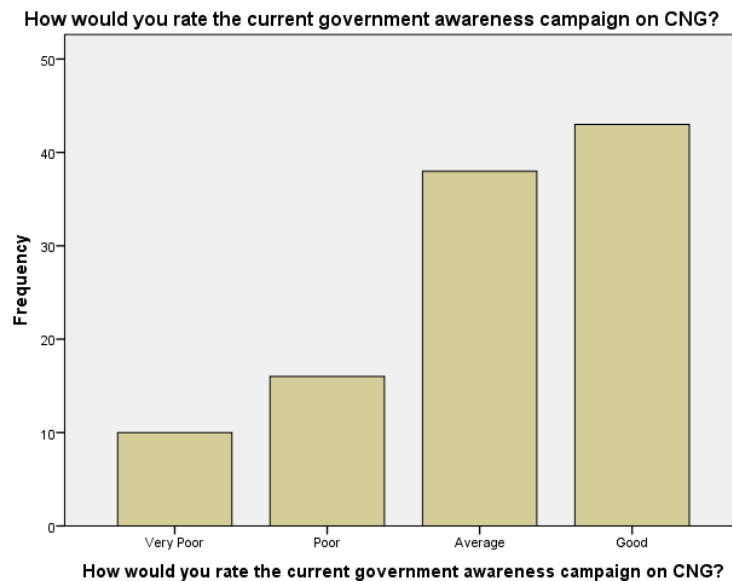
I lack enough information on how to safely operate a CNG Vehicle



I am concerned about the safety/maintenance of CNG Cylinders



Frequent scarcity of CNG supply discourages me from using it



Summary of Findings

The study assessed the availability of Compressed Natural Gas (CNG) facilities in Kogi State with particular emphasis on their socio-economic gains and drawbacks among commercial transport operators. The findings were summarized according to the research questions as follows:

1. **Infrastructure and Accessibility of CNG Facilities:** The study found that respondents generally agreed that CNG infrastructure is gradually becoming available within the study area. Existing refueling stations were considered reasonably accessible, and waiting time at the stations was viewed as satisfactory. However, respondents indicated that the availability of vehicle conversion centres remains inadequate, suggesting that the existing infrastructure is still insufficient to support large-scale adoption of CNG.

2. **Socio-economic Benefits of CNG Adoption:** The findings revealed that CNG adoption provides significant socio-economic benefits. Respondents agreed that the use of CNG reduces fuel expenditure, lowers transportation operating costs, improves business profitability, creates employment opportunities, and contributes to environmental sustainability through cleaner energy use. These benefits indicate that CNG has considerable potential to improve the welfare of transport operators and support economic development in Kogi State.

3. **Challenges Hindering CNG Adoption:** The study identified several major challenges affecting the adoption of CNG. These include the high cost of converting petrol-powered vehicles to CNG, inadequate public awareness, limited availability of refueling and conversion facilities, concerns about safety, and irregular gas supply. Among these, the high cost of vehicle conversion emerged as the most significant obstacle discouraging many transport operators from embracing the technology.

4. **Strategies for Enhancing CNG Adoption:** The findings further showed that respondents believed the adoption of CNG could be significantly improved through increased government investment in CNG infrastructure, provision of subsidies or financial incentives for vehicle conversion, expansion of refueling stations and conversion centres, implementation of effective awareness campaigns, and the formulation of supportive government policies. Respondents also emphasized the importance of collaboration between government and private investors in expanding CNG facilities across the state.

Discussion of Findings

Discussion of Findings Based on Research Question One

The study found that respondents generally agreed that the availability and accessibility of CNG infrastructure influence the adoption of Compressed Natural Gas among commercial transport operators in Kogi State. Although respondents acknowledged that existing CNG refueling stations provide reasonable service, they expressed dissatisfaction with the limited availability of vehicle conversion centres. This suggests that while some progress has been made in developing CNG infrastructure, the facilities are still inadequate to support widespread adoption.

This finding is consistent with the study by Punch Newspapers (2025), which reported that the limited number of CNG refueling stations in Nigeria continues to discourage potential users despite

growing public interest in CNG. It also supports the findings of Anyadiegwu and Muonagor (2017), who identified inadequate refueling stations and weak distribution networks as major barriers to CNG utilization. The result further aligns with the Diffusion of Innovation Theory, which argues that the availability and accessibility of supporting infrastructure significantly influence the rate at which new technologies are adopted. Therefore, expanding refueling stations and conversion centres across Kogi State would improve accessibility and encourage greater acceptance of CNG technology.

Discussion of Findings Based on Research Question Two

The study revealed that commercial transport operators strongly perceived CNG adoption as having significant socio-economic benefits. Respondents agreed that CNG reduces fuel expenditure, improves business profitability, creates employment opportunities, and contributes to environmental sustainability through cleaner fuel utilization. The reduction in fuel costs emerged as the most important benefit identified by respondents.

These findings agree with Daser and Adams (2025), who reported that CNG provides a more affordable and stable alternative to petrol and diesel, thereby improving household welfare and reducing transportation costs. Similarly, Ibeneme and Ighalo (2020) found that investment in CNG infrastructure stimulates employment generation and industrial development. The findings also support the conceptual literature, which identified reduced transportation costs, foreign exchange savings, improved energy security, and environmental protection as major benefits of CNG adoption. The implication is that wider adoption of CNG can contribute significantly to economic development and sustainable transportation in Kogi State and Nigeria as a whole.

Discussion of Findings Based on Research Question Three

The findings showed that the major barriers to CNG adoption include the high cost of vehicle conversion, inadequate public awareness, concerns about safety, and the irregular availability of CNG supply. Among these factors, the cost of converting conventional vehicles to CNG was identified as the greatest challenge.

This result corroborates the findings of Kaur, Sidhu and Ravindra (2020), who observed that the high initial cost of vehicle conversion discourages many transport operators from adopting CNG despite its long-term economic benefits. It also agrees with Energy for Growth Hub (2025), which identified inadequate public awareness and weak institutional coordination as major obstacles to CNG diffusion in Nigeria. Furthermore, the finding supports Rogers' Diffusion of Innovation Theory, which explains that innovations spread more slowly when potential adopters perceive them as costly, complex, or difficult to access. Consequently, reducing conversion costs through subsidies, expanding public awareness campaigns, and ensuring reliable gas supply would accelerate the adoption of CNG in Kogi State.

Conclusion

This study assessed the availability of Compressed Natural Gas (CNG) facilities in Kogi State with particular emphasis on their socioeconomic gains and associated drawbacks. The findings demonstrate that although the state has made appreciable progress through the Presidential CNG Initiative and increasing investment in gas infrastructure, significant gaps remain in terms of infrastructure adequacy, accessibility, and service coverage.

The study found that commercial transport operators strongly acknowledged the socioeconomic benefits of CNG adoption. Respondents reported substantial reductions in fuel expenditure, improved business planning, environmental sustainability through cleaner energy utilization, and increased employment opportunities associated with the expanding CNG value chain. These findings are consistent with the Diffusion of Innovation Theory, which posits that innovations perceived as economically advantageous are more likely to gain acceptance and wider adoption.

Despite these positive outcomes, the study equally identified critical challenges limiting the widespread adoption of CNG in Kogi State. Chief among these are the high cost of vehicle conversion, inadequate availability of conversion centres, irregular CNG supply, insufficient technical infrastructure, and limited public awareness regarding safe operation and maintenance. These constraints continue to slow the diffusion of CNG technology despite its demonstrated economic and environmental advantages.

Overall, the study concludes that Compressed Natural Gas represents a viable and sustainable alternative to conventional petroleum fuels in Nigeria. If adequately supported through expanded infrastructure, effective government policies, financial incentives, strengthened regulatory frameworks,

and continuous public sensitization, CNG has considerable potential to enhance transportation efficiency, improve household welfare, stimulate employment generation, reduce greenhouse gas emissions, conserve foreign exchange, and strengthen Nigeria's long-term energy security.

The study therefore contributes to the growing body of literature on sustainable energy transition in Nigeria by providing empirical evidence from Kogi State. It also offers practical policy insights that can guide governments, investors, development partners, and other stakeholders in maximizing the socioeconomic benefits of CNG while minimizing the constraints associated with its adoption. Consequently, accelerating CNG development should remain a strategic priority in Nigeria's pursuit of sustainable economic growth, environmental sustainability, and energy transition.

Recommendations

Based on the findings of this study, the following recommendations are made:

1. The Federal Government, through the Presidential Compressed Natural Gas Initiative (P-CNGI), Nigerian Midstream and Downstream Petroleum Regulatory Authority (NMDPRA), and the Kogi State Government, should prioritize the establishment of additional CNG refueling stations and certified conversion centres across all three senatorial districts of Kogi State. Improved infrastructure will reduce travel distance, waiting time, and accessibility constraints, thereby encouraging wider adoption of CNG.
2. The study established that the high cost of vehicle conversion is the greatest barrier to CNG adoption. Government should therefore introduce targeted financial support such as conversion grants, tax incentives, subsidized conversion kits, and low-interest credit facilities for commercial transport operators and small businesses. Such interventions will accelerate the transition from petrol and diesel to CNG.
3. Relevant agencies, including the Presidential CNG Initiative, Nigerian National Petroleum Company Limited (NNPCL), National Orientation Agency (NOA), transport unions, and civil society organizations, should intensify awareness campaigns on the economic, environmental, and safety benefits of CNG. Public enlightenment programmes should address misconceptions regarding cylinder safety and promote proper operational practices.
4. Government should collaborate with tertiary institutions, technical colleges, the National Board for Technical Education (NBTE), and private-sector organizations to train and certify CNG conversion technicians, maintenance personnel, and safety inspectors. Increased technical capacity will improve service quality, create employment opportunities, and ensure compliance with international safety standards.
5. The study revealed that frequent scarcity of CNG discourages users. Therefore, government and private investors should strengthen the gas supply chain by expanding mother stations, daughter stations, storage facilities, and distribution networks. Improved supply reliability will increase user confidence and sustain demand.
6. Government should create an enabling regulatory and investment environment that encourages private investment in CNG infrastructure through public-private partnerships (PPPs), tax holidays, import duty waivers on CNG equipment, and simplified licensing procedures. Increased private-sector participation will accelerate infrastructure development and reduce the financial burden on government.
7. The findings support the inclusion of CNG within Nigeria's broader energy transition agenda. Policymakers should integrate CNG development into national and state transport policies while promoting gradual replacement of conventional public transport fleets with CNG-powered vehicles. This will contribute to reduced greenhouse gas emissions, improved air quality, and enhanced energy security.
8. The Nigerian Midstream and Downstream Petroleum Regulatory Authority (NMDPRA) should strengthen routine inspection, certification, and monitoring of CNG refueling stations, conversion centres, and storage facilities to ensure strict adherence to safety regulations. Effective regulation will increase public confidence in CNG technology.
9. Government agencies should establish a monitoring and evaluation framework for CNG projects to periodically assess infrastructure utilization, socioeconomic outcomes,

environmental impacts, and user satisfaction. Continuous evaluation will provide reliable evidence for future policy adjustments and investment decisions.

10. Future studies should employ larger sample sizes covering all geopolitical zones of Nigeria and utilize advanced econometric techniques such as Structural Equation Modelling (SEM), Panel Data Analysis, or Logistic Regression to examine determinants of CNG adoption. Comparative studies between CNG, Liquefied Petroleum Gas (LPG), electric vehicles, and hybrid transportation systems are also recommended.

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