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Driving the Shift: Key Factors Influencing Compressed Natural Gas Adoption in Vehicles in Ilala, Dar Es Salaam

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ABSTRACT: This study examines the factors influencing the adoption and usage of compressed natural gas (CNG) in vehicles, focusing on its potential as a cleaner burning hydrocarbon, and the challenges faced by vehicle owners in using CNG. A double hurdle model and descriptive statistics were applied to data collected from 100 randomly selected vehicle owners who visited three major petrol stations in Ilala district, Dar es Salaam, Tanzania. The findings reveal that higher education levels and younger vehicle age positively influence both the decision to adopt CNG and the intensity of its usage. Conversely, older vehicles and higher conversion costs hinder adoption. The study also identifies key challenges such as limited CNG infrastructure, high initial conversion costs, and safety concerns. The research underscores the need for targeted policies that enhance public awareness, expand refueling infrastructure, and provide financial incentives to facilitate the adoption of CNG in Tanzania's transport sector. These measures could significantly contribute to the promotion of cleaner, more sustainable energy alternatives in the automotive industry.

KEYWORDS: Sustainable development, Energy, Clean Energy, Tanzania, Natural gas

INTRODUCTION

Natural gas (NG), a naturally occurring gaseous hydrocarbon mixture, is considered the cleanest fossil fuel and an increasingly vital energy source worldwide (Dimoso & Andrew, 2021). The primary component of NG is methane, and various processing technologies can be used to remove other constituents, making it a safe and efficient energy source when properly transported, stored, and utilized (Faramawy *et al.,* 2016). In recent years, NG has emerged as a key player in the global energy market, representing 23% of the world's primary energy consumption (IEA, 2022). With global reserves estimated at 7,080.3 trillion cubic feet (TCF), NG promises to remain a critical energy source for over 60 years at current consumption rates (Kitole *et al.,* 2023; BP, 2022). The rapid increase in NG production and consumption is driven by the global demand for clean energy and concerns about environmental sustainability (Najibi *et al.,* 2015; Kitole & Genda, 2024).

Natural gas can be utilized in various forms, including compressed natural gas (CNG) and liquefied natural gas (LNG), across multiple transportation modes, such as road, rail, marine, and aviation (Nijboer, 2010). However, due to its gaseous state, NG occupies a larger storage volume compared to liquid fuels like petroleum, which affects vehicle weight and fuel economy (Faramawy *et al.,* 2016). To address this, NG is compressed and stored in high-pressure tanks (cylinders) installed in vehicles to replace traditional fuel tanks, enabling the use of CNG as an alternative to diesel and petroleum (Khan *et al.,* 2015; Kitole & Utouh, 2023). The adoption of NG as a transportation fuel is increasing globally, with governments promoting CNG as a cleaner, cost-effective alternative to traditional fossil fuels (Ogunlowo *et al.,* 2015).

Despite its environmental benefits and cost savings, the use of natural gas in vehicles remains limited in many countries, including Tanzania. The global shift toward NG as a transportation fuel gained momentum during the 1970s energy crisis when petrol and diesel prices soared, prompting governments to promote NG as a cheaper alternative. For example, in Brazil, the government introduced a policy in 2009 that priced NG for vehicles at 50% below gasoline prices to encourage its use (Frick *et al.,* 2007). In Tanzania, the government, through the Tanzania Petroleum Development Corporation (TPDC) and the Energy and Water Utilities Regulatory Authority (EWURA), has set a fixed CNG price to promote its use in vehicles (BP, 2022). However, the diffusion of CNG technology in Tanzania has been slow, with limited refueling stations and only a small number of vehicles converted to CNG since its introduction in 2007 (BP, 2022).

The discovery of 57.54 TCF of natural gas in Tanzania, with 47.08 TCF offshore and 10.96 TCF onshore, presents a significant opportunity for the country to expand its use of natural gas, including in the transportation sector (BP, 2022). The demand for natural gas in Tanzania is growing, driven by rising global petroleum prices and the shift toward cleaner energy sources. Natural gas is not only a more environmentally friendly option compared to conventional fuels, but it also offers cost savings to users, making it an attractive choice for vehicle owners (Curran *et al.,* 2014). However, despite its advantages, the adoption of natural gas as a fuel for vehicles in Tanzania has not reached its full potential, with 81% of the country's natural gas production being used for electricity generation, and only 19% allocated to industries, households, and vehicles (Ishengoma & Gabriel, 2021).

The slow adoption of CNG technology in Tanzania is attributed to several factors, including limited infrastructure, insufficient refueling stations, and low awareness among vehicle owners. Since 2007, only two CNG filling stations have been established in Dar es Salaam, and the number of vehicles using CNG remains relatively low, with around 1,400 vehicles converted to CNG by 2022 (BP, 2022). The potential for CNG usage in Tanzania's transport sector remains largely untapped, despite the clear benefits of reducing emissions, cutting fuel costs, and decreasing reliance on imported oil.

The underutilization of natural gas as a transportation fuel in Tanzania presents a significant challenge, particularly given the country's vast natural gas reserves and the global push toward cleaner energy. While natural gas offers numerous advantages, such as environmental benefits and cost savings, the adoption of CNG in vehicles has not reached its full potential in Tanzania. This research seeks to identify the factors influencing natural gas usage in vehicles, understand the challenges hindering its adoption, and explore strategies to promote the wider use of CNG in Tanzania's transport sector.

THEORETICAL FOUNDATION

This study draws upon the "energy ladder" theory, a commonly used concept in explaining household fuel use in developing countries (Janssen *et al.,* 2006). Developed in the early 2000s by researchers such as Daniel and Pattanayak, alongside scholars at the World Health Organization (WHO) in Sri Lanka, this model illustrates how households move up an energy ladder as their income increases (Muller & Yan, 2016). Specifically, the energy ladder suggests that as household income rises, there is a transition from the use of traditional fuels like biomass, to intermediate fuels such as kerosene and coal, and finally to modern fuels like natural gas and electricity. This progression reflects the economic theory of consumer behavior, where individuals substitute inferior goods for necessary and luxury goods as their purchasing power grows (Moshiri, 2015). The energy ladder, therefore, portrays an evolution in fuel choice linked to technological sophistication, with wealthier households favoring more advanced energy carriers (Janssen *et al.,* 2006).

However, while the energy ladder model is influential in energy policy and research, it has faced several criticisms. One of the major criticisms is its oversimplification of energy-use patterns. Scholars argue that the model assumes a linear progression from traditional fuels to modern energy sources solely based on rising income, ignoring the complex and varied energy-use behaviors found in households, particularly in developing nations. This linear view does not capture the multiple factors that influence household energy choices, which can include access, reliability, and preferences for certain types of energy sources, regardless of income levels. Additionally, the model overlooks important social and cultural factors, assuming that households will automatically switch to modern energy sources once they become affordable and available. In reality, social hierarchies, gender roles, and cultural norms can significantly impact energy choices, influencing whether or not a household adopts modern energy options (Janssen *et al.,* 2006).

Another criticism of the energy ladder theory is its lack of attention to environmental impacts. The model primarily focuses on improving energy access without adequately addressing the environmental consequences of energy use. Critics argue that it does not account for the necessity of developing low-carbon and sustainable energy systems, which is crucial in mitigating climate change. Despite these shortcomings, the energy ladder remains a valuable framework for understanding income-related shifts in energy use, though it needs to be supplemented with a broader consideration of social, cultural, and environmental factors.

The relevance of the energy ladder theory to this study lies in the potential for vehicle owners, as their income increases, to adopt compressed natural gas (CNG) as an alternative to gasoline and diesel in the automotive sector. The researcher observed that as CNG becomes more affordable and accessible, higher-income individuals are more likely to switch from traditional fuels to this cleaner energy source. This income-related shift mirrors the fundamental principles of the energy ladder model, which posits that economic growth can drive the adoption of more sophisticated, environmentally friendly energy options. Consequently, the relationship between income levels and the use of CNG in vehicles offers a practical application of the energy ladder theory in the context of the Tanzanian automotive sector.

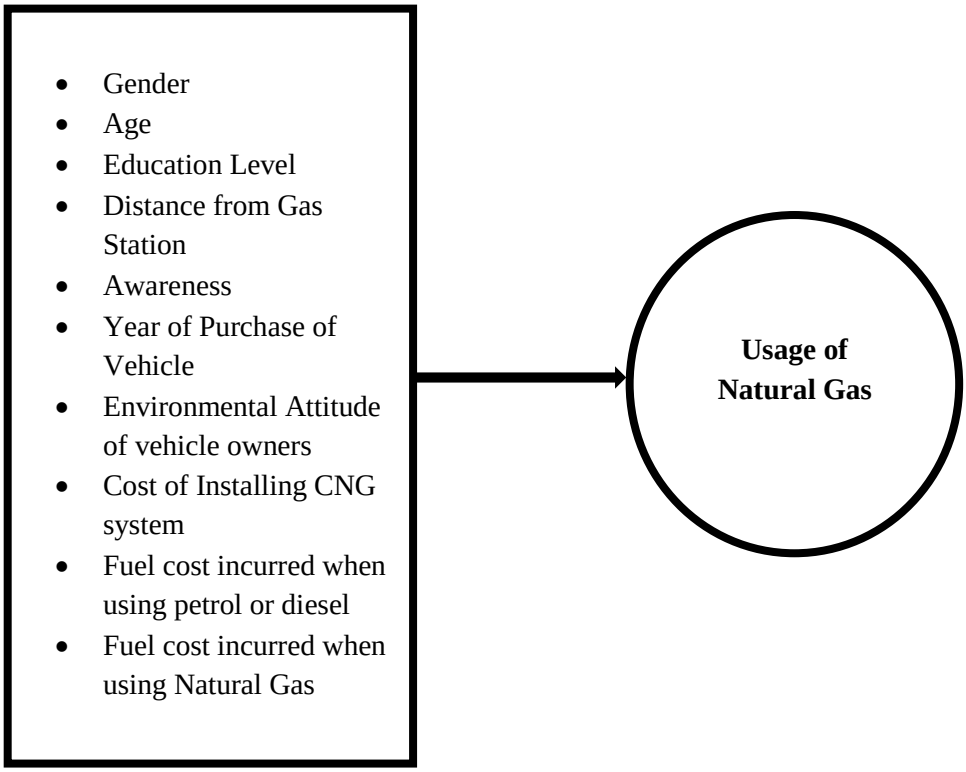

Figure 1: Conceptual framework
Source: Own construct (2023)

RESEARCH METHODOLOGY

This study employed a cross-sectional research design, as data was collected from respondents at a single point in time, allowing for efficient comparisons across multiple variables with minimal additional cost. This design was chosen as it is well-suited to meeting the study's objective of determining the factors influencing the adoption of Compressed Natural Gas (CNG) technology among vehicle owners in Ilala District, Dar es Salaam. The cross-sectional approach provides a snapshot of the current usage of CNG and enables the researcher to gather relevant data for analysis while minimizing costs and time (Asenahabi, 2019).

The research was conducted in Ilala District, one of five districts in Dar es Salaam, Tanzania. The district is subdivided into three administrative areas comprising 26 wards and 159 streets, with a total population of 1,649,912 according to the 2022 population census. Ilala is geographically located at longitude 6.8240S and latitude 39.2490E (Ilala Municipal Council, 2022). The district was selected for the study due to its role as a key transport hub in Dar es Salaam and its hosting of one of the few CNG filling stations in the region, operated by Anriq Gas Company. This location provided the opportunity to interact with a diverse range of vehicle owners from different socio-economic backgrounds, thereby enhancing the quality and reliability of the data collected on the adoption of CNG technology.

The target population for this study consisted of vehicle owners in Ilala District who either had converted their vehicles to use CNG or had not. Due to time and budget constraints, the study focused on a subset of this population: vehicle owners who frequented three petrol stations in Ilala—Big Bon petrol station in Kariakoo, Puma Energy station in Ilala, and Camel Oil in Buguruni. A sample size of 100 vehicle owners was determined using Yamane's formula, ensuring that the sample was representative of the broader population. A cluster sampling method was applied to select three wards (Mnazi Mmoja, Ilala, and Kariakoo) from the 26 wards in Ilala. Systematic random sampling was then used to select vehicle owners visiting the petrol stations, ensuring a fair and unbiased selection process.

Analytical modeling

To analyze the determinants of natural gas usage in vehicles in Dar es Salaam, the double hurdle model was employed. This model is particularly suitable as it accounts for the two-stage decision-making process (Anasel *et al.,* 2024) as vehicle owners undergo: first, the decision to adopt natural gas technology, and second, the extent of its usage. The double hurdle model allows for the separate examination of factors influencing both the adoption and intensity of natural gas use, providing a more nuanced understanding of the variables that drive this behavioral shift.

First hurdle

The probability that vehicle owners in Ilala district to use NG in vehicles is assumed to be determined by an underlying response variable that explains the vehicle owner's demographic, institutional and socio-economic characteristics, thus can be illustrated as:

$D_i^* = x_i'\beta + \varepsilon_i$ ……1

Where D_i^* is a latent (dependent) variable that shows whether vehicle owner use or not use NG in vehicles, β denotes the vector of unobserved served parameters to be estimated, x_i'denote the vector of observed independent covariates explaining the event, lastly ε_i denotes unobserved error term capturing other factors and is assumed to be independent and normally distributed. That is μ_i

N~ (0, 1), and$D_i = 1\ if\ D_i^* > 0$

$$D_i = 1\ if\ \mathrm{D_i^*} \leq 0$$

The variable D_i present the value of 1 if the vehicle owner users NG and the marginal utility over using NG is greater than not using and zero (0) otherwise. The binary variable $\mathrm{D_i}$ is assumed to be a probit model and is specified as:

$Pr(D_i = 1/x_i)' = \phi(\mathrm{x}\beta) + \varepsilon_\mathrm{i}$ ……2

Where Pr presents the probability of NG usage among vehicle owners: $\mathrm{D_i}$ is the binary variable of NG usage: ϕ denotes the cumulative normal distribution: x is the vector of vehicle owner's demographic, socio-economic and institutional characteristics denote the coefficient to be estimated and ε_i denote the random error term distributed normally with zero mean and constant variance.

The second hurdle

The extent to which the vehicle owner use NGD^* is assumed to be truncated normal distribution with parameters to be different from the Probit model that can be estimated as follows:

$\mathrm{D^*} = \mathrm{x_i'}\alpha + \mu_\mathrm{i}$……3

Where $\mathrm{D^*}$is the observed extent of NG usage measured by income of the vehicle owners received in yearly basis from their different income generating activities, $x_i$indicate the vector of covariates that explain the extent, α is a vector of unobserved parameters to be estimated and $\varepsilon_i$is a random variable that denotes all other factors apart from X. Since the assumption of independence of the two error terms, later, it was suggested that the hurdles can be estimated by the maximum likelihood method of Probit and truncated regressions. Moreover, other variables used in the regression have been defined and explained in Table 1.

Table 1: Definition and measurement of variables

Variables	Description	Variable Type	Value
CNG usage	Use of Natural Gas as fuel in Vehicles	Dummy	0 if Vehicle does not use Natural Gas fuel 1 if Vehicle use Natural Gas as fuel
Distance from Gas Stations	Distance from vehicle owner residence to Gas filling stations	Dummy	0 if distant is near $\leq$ 20km 1 if distant is far $>$ 20km
Year of purchase of vehicle	Used years of Vehicle since purchase	Continuous	Measured in years
Income	Income level of individual	Numerical	Measured in amount in Tanzanian shillings
Awareness	Awareness of CNG usage	Dummy	0 if lack of awareness in Natural Gas usage 1 if full informed of Natural Gas usage
Age	Age Groups of Respondents (Years)	Continuous	Measured in years
Cost of CNG system	Perception of vehicle owner on cost of installing CNG system	Dummy	0 if low cost 1ifhigh cost
Gender	Sex of the Respondent	Dummy	1 if Male 0 if Female

Education Level	Level of Education on Respondents	Continuous	Years of schooling
Attitude of vehicle owners	Priority on environmental concerns and cleaner transport fuel options among vehicle owners.	Dummy	0 if vehicle owner does not prioritize environmental concerns in fuel options 1 if vehicle owner take concern on environmental issue on fuel options
Cost incurred when using petrol or diesel	Cost incurred in using petrol/diesel monthly data	Continuous	Measured in amount in Tanzanian shillings
Cost incurred when using natural gas	Cost incurred in using natural gas monthly data	Continuous	Measured in amount in Tanzanian shillings

RESULTS

The sociodemographic characteristics of the respondents in Table 2 indicate a fairly balanced gender distribution, with 55% male and 45% female respondents. In terms of age, the majority of respondents fall within the 25-34 age group, representing 36%, followed by 24% in the 45-54 age range, and 20% in the 35-44 age group. Only a small percentage of respondents are older, with 2% aged between 55-64 and another 2% between 65-74 years. This suggests that the study predominantly reflects the views of younger to middle-aged individuals.

Table 2: Sociodemographic characteristics of respondents

Variables	Category	Frequency	Percent	Cumulative Percent
Gender	Male	55	55%	55
	Female	45	45%	100
	Total	**100**	**100.00**%	
Age levels of respondents	15-24	16	16%	16
	25-34	36	36%	52
	35-44	20	20%	72
	45-54	24	24%	96
	55-64	2	2%	98
	65-74	2	2%	100
	Total	**100**	**100.00**%	
Distance to gas station	Near	44	44%	44
	Far	56	56%	100
	Total	**100**	**100.00**%	
Awareness of CNG	Not Aware	30	30%	30
	Aware	70	70%	100
	Total	**100**	**100.00**%	
Education Level	No formal Education	4	4%	4
	High School or Lower	8	8%	12
	College or Diploma	37	37%	49
	Degree Level	46	46%	95
	Master's or PhD	5	5%	100
	Total	**100**	**100.00**%	
Perception of CNG Cost	Low Cost	43	43%	43
	High Cost	57	57%	100
	Total	**100**	**100.00**%	
Attitude on Environmental Concern	Consider	43	43%	43
	Do Not Consider	57	57%	100
	Total	**100**	**100.00**%	

Regarding the distance to gas stations, 56% of respondents indicated that they live far from a gas station, while 44% reside closer. This distribution highlights a potential challenge in accessing gas refueling stations for many vehicle owners. Moreover, a significant majority (70%) of respondents are aware of compressed natural gas (CNG) technology, while 30% reported not being aware, indicating that while awareness is relatively high, there is still a need for increased information dissemination about CNG. In terms of education level, most respondents have achieved a high level of education, with 46% holding a degree and 37% having a college diploma. Only 4% of the respondents lack formal education. Regarding perceptions of CNG costs, 57% of respondents view the installation of CNG systems as expensive, and similarly, 57% do not consider environmental factors when deciding on fuel options.

Table 3: Determinants of compressed natural gas (CNG)

Variables	Hurdle I			Hurdle II		
	Coefficient	**Std. Err.**	**P>z**	**Coefficient**	**Std. Err.**	**P>z**
Gender	0.6674	0.3244	0.040	0.2598	0.1324	0.053
Age	0.0216	0.0153	0.158	0.0074	0.0056	0.019
Education level	0.1136	0.0431	0.008	0.0577	0.0180	0.002
Distance from the Gas station	-0.0331	0.0376	0.379	-0.0118	0.0129	0.360
Used years of vehicle	-0.3146	0.0917	0.001	-0.1384	0.0363	0.000
Awareness	-0.4147	0.3363	0.218	-0.2155	0.1363	0.117
Cost of Installing CNG	0.1410	0.3262	0.666	0.0335	0.1319	0.800
Attitude of vehicle owner	0.2295	0.3318	0.489	0.0970	0.1314	0.462
Cost incurred when using petrol	0.0573	0.0000	0.569	0.0906	0.0022	0.768
Cost of using natural gas	-0.0347	0.0800	0.916	0.0382	0.0030	0.927
Observation	100					
Pseudo R^2	0.3288					
P value	0.0000					
Log-likelihood	-44.5701					

Source: Research Data (2023)

The results from the double hurdle model in Table 3 reveal several key factors that influence both the adoption and the intensity of compressed natural gas (CNG) usage among vehicle owners. In the first stage of the model (Hurdle I), which examines the decision to adopt CNG, three variables are statistically significant. Gender plays a positive role, with a coefficient of 0.6674 (p = 0.040), indicating that males are more likely to adopt CNG compared to females. Additionally, education level has a positive and significant effect, with a coefficient of 0.1136 (p = 0.008), suggesting that individuals with higher education levels are more inclined to adopt CNG technology. On the other hand, the used years of the vehicle negatively impact the likelihood of CNG adoption, with a coefficient of -0.3146 (p = 0.001), meaning that older vehicles are less likely to be converted to CNG.

In the second stage of the model (Hurdle II), which examines the intensity of CNG usage, several factors remain significant. Age has a positive effect, with a coefficient of 0.0074 (p = 0.019), indicating that older individuals tend to use CNG more intensively. Education level continues to be an important factor, with a coefficient of 0.0577 (p = 0.002), meaning that individuals with higher education are more likely to use CNG more frequently. Similar to Hurdle I, the used years of the vehicle negatively influence the intensity of CNG usage, with a coefficient of -0.1384 (p = 0.000), showing that older vehicles are less likely to be used intensively with CNG.

Other variables, such as distance from the gas station, awareness of CNG, and the cost of installing CNG, are not statistically significant in either hurdle. For example, the coefficient for distance is -0.0331 in Hurdle I and -0.0118 in Hurdle II, but both have p-values greater than 0.3, indicating no significant impact on CNG adoption or usage. Similarly, awareness and installation cost do not significantly affect the decision to adopt or the intensity of CNG usage. Overall, the model has a pseudo-R^2 of 0.3288 and is highly significant with a p-value of 0.0000, meaning it effectively explains a substantial portion of the variation in CNG adoption and usage decisions among vehicle owners.

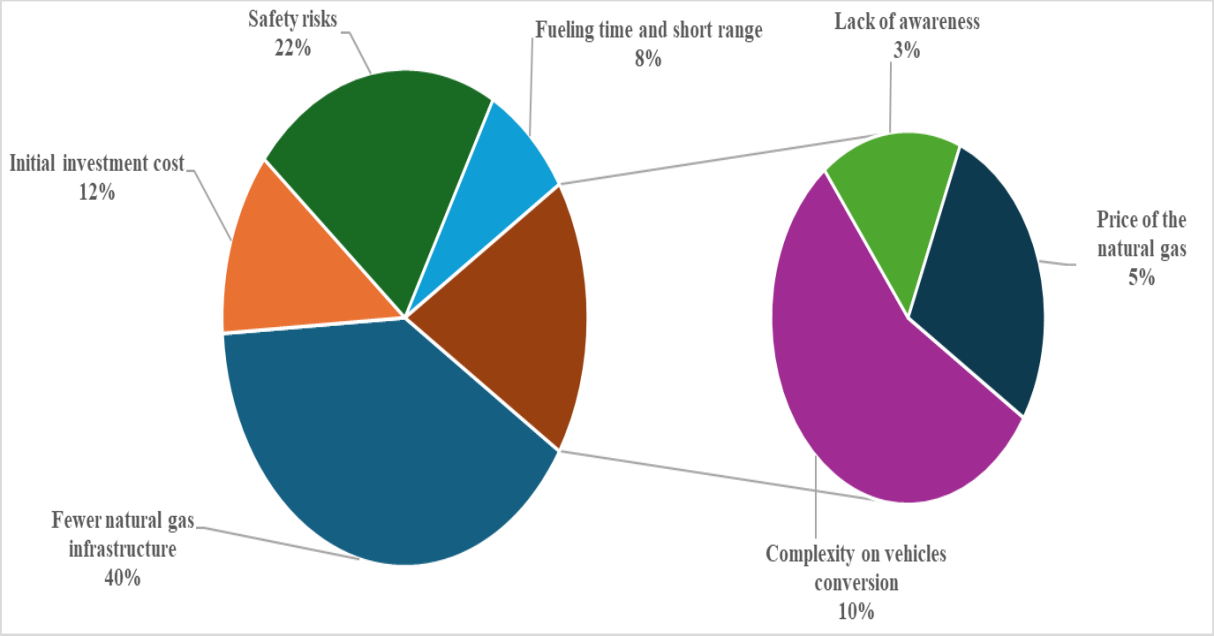

Figure 2: Challenges facing vehicle owners in Natural Gas usage

Source: Source: Research Data (2023)

The challenges faced by vehicle owners in adopting natural gas (CNG) as fuel, as indicated in the chart, highlight several significant barriers that hinder widespread usage. The most prominent challenge is the lack of natural gas infrastructure, which affects 40% of vehicle owners. This suggests that the limited availability of refueling stations is a major deterrent, making it difficult for owners to conveniently access CNG. The scarcity of these stations likely adds logistical challenges, such as the need to travel long distances to refuel, which makes natural gas less attractive compared to traditional fuels like gasoline and diesel, which have a well-established refueling infrastructure.

The second major issue is related to safety risks, which concern 22% of vehicle owners. This reflects apprehension about the perceived dangers associated with using CNG, such as the risk of gas leaks or explosions. While CNG is generally considered safe, the lack of widespread use and misinformation may contribute to these concerns. The fear of safety risks could prevent more vehicle owners from converting to or adopting natural gas, especially if these perceptions are not adequately addressed through public awareness campaigns or improved safety measures.

Other notable barriers include the initial investment cost (12%) and the complexity of vehicle conversion (10%). The cost of converting vehicles to use CNG, including the installation of CNG systems, may be prohibitively high for some vehicle owners. Additionally, the technical complexities involved in converting a vehicle's fuel system to accommodate CNG can be a deterrent, particularly for those who lack access to conversion services or expertise. Furthermore, fueling time and the short driving range of CNG vehicles, which affect 8% of owners, add to the inconvenience factor. Vehicles running on natural gas may require more frequent refueling due to their shorter range, making them less practical for longer journeys or in areas with fewer refueling stations.

Lack of awareness (3%) and the price of natural gas (5%) are less commonly cited concerns, but they still play a role. The low percentage of respondents concerned about awareness suggests that many vehicle owners are already familiar with CNG as a fuel option, though further education on its benefits may still be needed. Meanwhile, the relatively small concern over the price of natural gas could indicate that CNG is seen as an affordable alternative to conventional fuels, but pricing still matters for some consumers, especially if the cost of installing CNG systems is not offset by fuel savings.

DISCUSSION

The adoption of compressed natural gas (CNG) in the transport sector is closely tied to the interplay of various socioeconomic and infrastructural factors. One key element in driving the transition to CNG is education, as individuals with higher education are generally more knowledgeable about the environmental and economic benefits of using cleaner fuels. Educated individuals are better positioned to appreciate the long-term cost savings and environmental advantages associated with CNG, even when faced with higher initial investment costs (Ogunlowo *et al.,* 2015). As seen in other studies, awareness and understanding of new technologies are crucial in fostering acceptance and eventual adoption, especially in the context of promoting sustainable energy alternatives (IEA, 2022; Kitole *et al.,* 2024). Therefore, enhancing public knowledge and providing educational campaigns can

significantly influence the rate of adoption, particularly in emerging markets where environmental concerns are becoming increasingly pressing.

In contrast, the age and condition of vehicles present a significant challenge to CNG adoption. Older vehicles may not be technically or economically viable for conversion to CNG, as retrofitting can be both complex and costly (Khan, 2017). This issue reflects a broader trend observed in markets where used cars dominate, such as Tanzania. Given the prevalence of second-hand vehicles in developing nations, the feasibility of transitioning to CNG is hindered unless supportive policies or financial incentives are introduced (Liu *et al.,* 2012; Utouh & Kitole, 2024). Policymakers must consider creating subsidies or offering financial assistance to help offset conversion costs for vehicle owners. These efforts can help to encourage broader adoption, as the financial burden of vehicle conversion is a major deterrent for many owners (Bishoge *et al.,* 2018).

Infrastructure limitations represent another critical obstacle to CNG adoption. A well-developed refueling infrastructure is essential for ensuring the convenience and reliability of using CNG. Without sufficient CNG refueling stations, vehicle owners may be reluctant to switch to natural gas due to concerns about accessibility (Ishengoma & Gabriel, 2021). This issue is not unique to Tanzania but is a common challenge in many countries transitioning to alternative fuels. A lack of infrastructure can severely undermine efforts to promote cleaner energy in transportation. Consequently, investment in CNG infrastructure must be prioritized to foster widespread adoption. The government and private sector must collaborate to expand refueling networks, which would reduce logistical challenges for vehicle owners and encourage the use of CNG as a viable alternative to traditional fuels (Gerutu & Greyson, 2023).

Furthermore, safety concerns continue to play a significant role in deterring the adoption of CNG. Although CNG is recognized as a safe fuel source, public perception often lags behind technological advancements. Concerns about the potential dangers associated with CNG usage, such as fears of gas leaks or explosions, can hinder its acceptance. Overcoming these concerns requires concerted efforts to improve public awareness and promote safety education regarding the use of CNG. Similar challenges have been observed in other energy transitions, where the public's initial hesitation is gradually overcome through increased visibility of the technology and consistent communication about its safety (BP, 2022). Strengthening public confidence in CNG's safety will be crucial to achieving broader adoption.

Lastly, financial considerations are always at the forefront of decisions regarding fuel adoption. While CNG is generally more cost-effective than gasoline or diesel in the long run, the initial investment required for vehicle conversion remains a barrier for many owners. As seen in other markets, the high upfront costs can outweigh the perceived long-term savings, particularly in low- and middle-income contexts (Igbojionu *et al.,* 2019). To address this, it is essential to develop supportive financial policies, such as tax incentives, subsidies, or low-interest loans, to help reduce the initial burden of CNG conversion (Guma, 2016). These measures could create a more financially accessible pathway for vehicle owners to make the switch, further bolstering the economic viability of CNG as a transportation fuel (Curran *et al.,* 2014). Promoting CNG as a cost-effective and environmentally friendly alternative requires a combination of education, infrastructure investment, and financial support to ensure its success in the broader energy transition (Kitole & Sesabo, 2024; Khan *et al.,* 2015)

CONCLUSION

The adoption of compressed natural gas (CNG) as an alternative fuel in the transport sector presents significant opportunities for reducing both environmental impact and fuel costs. However, the successful transition to CNG depends on overcoming several key challenges, including infrastructure limitations, financial barriers, and public perceptions about safety. Education plays a critical role in influencing the willingness of vehicle owners to adopt CNG, as greater awareness and understanding of its benefits can drive acceptance. Moreover, targeted policies that address the financial burden of vehicle conversion and expand the availability of refueling infrastructure are essential for supporting this transition.

The complexities associated with older vehicles and the initial costs of conversion continue to be significant barriers, particularly in markets dominated by used cars. Addressing these challenges will require concerted efforts from both policymakers and the private sector to develop financial incentives and support systems that make CNG adoption more accessible. Furthermore, public confidence in the safety and reliability of CNG must be strengthened through educational campaigns and transparent communication about the benefits and risks of the technology.

Ultimately, a multi-faceted approach that combines education, infrastructure development, and financial support is necessary to promote the widespread adoption of CNG. By addressing these challenges holistically, CNG can emerge as a viable and sustainable fuel alternative that contributes to cleaner energy use in the transportation sector, supporting broader efforts to mitigate environmental impacts and enhance energy security.

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