# Determinants of Passenger Transport Choices in Ghana: Evidence from Household Data

## C.K.K. Sekyere[1], F. Davis[2], R. Opoku[3], T. S. Oko[4]

[1, 2, 3]Department of Mechanical Engineering, KNUST, Kumasi, Ghana

[4]National Film and Television Institute (NAFTI)

**Abstract:** *The study applies a data-driven statistical tool called Probit Econometric Model to household data to explain the factors that influence the choice of road transport modes in Ghana. The data used for the study was extracted from the 7th round of the Ghana Living Standards Survey. Core living standard indicator variables employed include travel choice, household income, employment status, number of years spent in education, location of the household and car ownership. The study finds that household income, location, employment and educational status significantly induce the usage of private cars for commuting. This requires that effective economic and transport policies be designed to optimize citizens travel comfort, reduce congestion on the roads, increase productivity and reduce emission of harmful gases in the atmosphere for green economy. The study further established that larger households patronize commercial travelling choices than smaller households.*

**Keywords:** Transport choice, Probit Econometric model, Living Standard Survey, green economy, household

## Acronyms

| | |
|---|---|
| APPA | American Private Transport Association |
| FAA | Federal Aviation Administration |
| GDP | Gross Domestic Product |
| GIPC | Ghana Investment Promotion Council |
| GLSS | Ghana Living Standard Survey |
| KIA | Kotoka International Airport |
| LPM | Linear Probability Model |
| MMT | Metro Mass Transit |
| OLS | Ordinary Least Squares |
| SDGs | Sustainable Development Goals |
| STC | State Transport Company |
| US | United States |
| VLTC | Volta Lake Transport Company |

## 1. Introduction

The importance of transportation to the growth and development of economies cannot be overemphasized. The relationship between the transport sector and the economy is multidimensional with noteworthy direct and indirect impacts on the growth of economies. Transportation enhances efficiency in supply chain and productivity, improves access to labour markets, supports agglomerations and facilitates market openings for business activities [1,2]. Transportation is also directly linked to environmental pollution. For instance, a surge in transportation demand leads to increased traffic congestion and atmospheric air pollution arising from engine emissions which subsequently affects human health. Annual passenger traffic in 2015 amounted to 54 trillion passenger-kilometres and is estimated to exceed 80 trillion passengers before 2030 [3]. This projection poses serious threats to human health and living standards globally (particularly, in large urban cities around the world) and requires extensive research and careful planning in order to improve the quality of life in the future.

Increasing demand for transportation services have been triggered by world developmental goals captured in the Sustainable Development Goals (SDGs). Essentially, these goals seek to ensure the provision of access to safe, sustainable and affordable transport, whiles expanding public transport systems to meet the requirements of the economically vulnerable in the society. As a result of rising global income levels and socioeconomic characteristics, it is estimated that 1.2 billion more people will demand new transport solutions with digital technology spearheading this revolution (World Bank, 2017).

Transportation has immense direct and indirect benefits to stakeholders. American Private Transport Association (APTA, 2007) [4] estimates that, for every $10 million allocated to capital and operational investment in transportation, a corresponding return of US$30 million and US$32 million will be realized in increased business sales respectively. Thus, investments in transportation is seen as a critical ingredient in economic growth [5, 6]. Furthermore, World Bank [3] provides estimates to show that, an annual expenditure of 15% to 25% is expended on transport systems by cities in developing economies. Also, an average annual income of 15% is spent by urban households on transportation in developing economies.

## 2. Literature Survey

In Ghana, the transport sub-sector which falls under the services sector has contributed significantly to Gross Domestic Product (GDP). The transport sub-sector has contributed an average of 11.7% to the GDP of Ghana's economy between 2008 and 2017 (see Fig.1). The sector continues to attract investments aimed at developing sustainable transportation systems. As a major producer and exporter of raw materials, Ghana has prioritized the development of road and rail infrastructure [7]. The transport industry is made up of five (5) distinct sub-sectors in Ghana. These include road transport, railway transport, air transport, maritime transport and inland transport services.

The mode of transport plays a significant role within transport systems by providing alternative mobility options for different socioeconomic characteristics of people as well

as business activities [7,8]. According to Littman [6], the various modes of transport are either operated in private or public circles. Public transport is seen as a mode of transport accessible for use by the general public [9]. Hensher [10] observed that the share of passenger transport mode in developed economies are predominantly by private transport whereas, public transportation is primary used in developing economies. Thus, the identification of the choice of transport mode forms an integral part for the effective management of public transport systems.
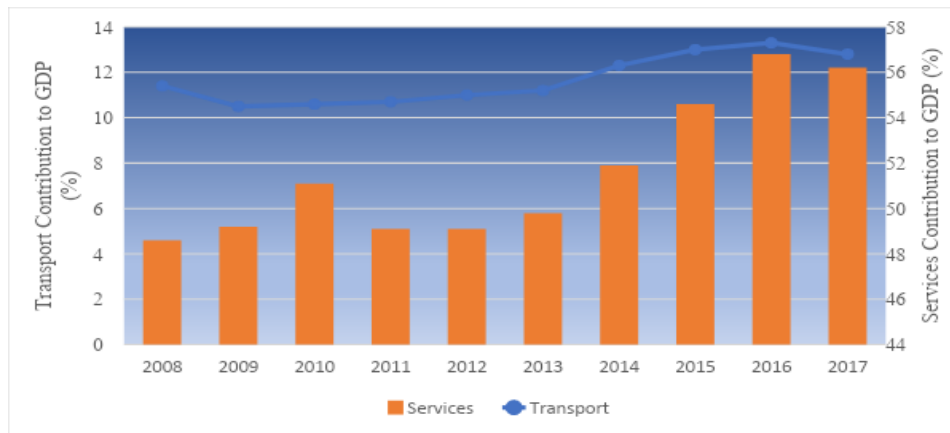


**Figure 1:** Transport Contribution to GDP (2008-2017)
Source: [11]

Moreover, Ojo et al. [8] emphasized that studies on the assessment of travel behaviour and modal choice have largely focused on urban dynamics as well as socio-demographic, economic and lifestyle related factors. Eriksson [12] held that people choose their mode of transport based on the purpose of the trip. With the availability of different travel models, people now choose the mode by considering comfort, safety, reliability, trip distance and the cost of the trip. Also, the choice of transport further depends on the type of passengers (e.g. workers, students, leisure travellers). Thus, the patronage and demand for transport choice is dynamic and volatile due to the vast array of factors that affect it [13]. Polat [13] further suggested that commuters are considered as rational beings, and are likely to choose transport modes that will give them the maximum utility based on their income constraints. This makes income of passengers a major determinant of transport choice. Crotte [14] showed that an inverse relationship exists between transport fares and the patronage of public transport. Thus, higher transport fares are associated with low patronage and vice-versa.

## 3. Problem Definition

In Ghana, studies on the road transportation sector have focused on public transportation dynamics, demand capacity and traffic congestion in peri-urban centres [15, 16, 17, 18]. Furthermore, studies conducted on mode of transport choice were limited to government employees in designated public organizations of major cities of Accra, Kumasi and Takoradi [19, 20]. These studies essentially focus on road transportation and the various vehicular types and transport operators available for commuters. Specifically, these studies examined the factors that influence the choice of private, taxi, 'trotro', and bus transportation. A study of transport choice that is representative of the Ghanaian population is still missing in the literature. With the focus of earlier studies on road transport, a huge literature gap exists for the determinants of transport choice for private and commercial vehicles. In spite of the insightful results of previous studies on transport choices, household analysis provides richer source of information to deepen the understanding of the factors that influence the mode of transport choice in Ghana [8, 13] . For example, household level data can unearth issues of rising income on transport choices.

This study, therefore, employs household data obtained from the Ghana Statistical Service on the Ghana Living Standards Survey round 7 (GLSS 7), to explain the factors that influence the choice of transport modes in Ghana as well as type and profile of transport modes used by households.

## 4. Methodology

### 4.1 Theoretical framework

Following [21, 22, 23] the theoretical framework underpinning the study is espoused as follows:

$$T_i = f\left(X_{ij}\right) + \delta_{ij} \qquad (1)$$

Where:
$T_i$ = Road Vehicle travel choice and i runs from 0 to 1. That is whether the individual used private or commercial vehicle in his/her road transport.

$X_{ij}$ = Driving factor i for household j.

$\delta_{ij}$ = Stochastic error term for household j

A number of researchers [21, 22, 23] found variously that the individuals transport modes and travel choice are driven by income, age, employment status, level of education, population, location (i.e. rural or urban) and occupation. This study, therefore, builds on these factors to espouse the empirical model.

## 4.2 The Probit Econometric Model

The motivation for the probit model is due to the dichotomous nature of the dependent variable [24 – 26], where road commuters either use private or commercial cars. Among the class of choice models, the probit model is superior to the Linear Probability Model (LPM) [27]. The justification is that the probabilities of the LPM does not lie between zero and one [24-27]. The LPM thus violates the principles of probability theory [25].

A major competitor in the field of dichotomous choice modelling is the logit model. Johnston & DiNardo [27] maintain that there is no significant difference between the two models because they produce similar results. Whiles the logit model is estimated through a logistic distribution, the probit model is operationalized with a normal distribution [24-25]. Therefore, the choice of a probit model over the logit model is strictly due to preference and convenience [24].

In the parlance of [24-27] the probit model is espoused as follows, beginning with the implicit econometric model relating the decision to use a private or commercial car to the control variables:

$$T = \beta X + \varepsilon \qquad (2)$$

Where:
T = Desire outcome which is unobserved
X = The independent or control variables
β = Coefficient of the explanatory variables
ε = The error term which is normally distributed with a mean zero and unit variance.

With this model, the observed dummy variable, T, is whether or not the individual uses private or commercial cars to his/her destination. While T* is the tendency for a person to use private or commercial vehicles. This implies that when (T* > 0) the person uses a private car. Given the normality of the probit distribution, the probability that T* is less than or equal to T can be computed as follows:

$$P_i = P(T = 1/X) = P(T^* \leq Y_i) =$$
$$P(Z_i \leq \beta X) = F(\beta X) \qquad (3)$$

Where:
P = the probability that an event will occur

$P(T = 1|X)=$ the probability that the individual uses a private car.
$Z_i$ = the standard normal distribution variable
F = the standard normal cumulative distribution function. Specifically, F is represented as:

$$F(T_i) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{Y_i} e^{-z/2} dz \qquad (4)$$

$$F(T_i) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\beta X_i} e^{-z/2} dz \qquad (5)$$

To obtain information on T*, and, the inverse of equation (2) is taken. This is espoused as:

$$T_i = F^{-1}(T_i) = F^{-1}(P_i) \qquad (6)$$
$$= \beta X_i \qquad (7)$$

Unlike the linear models, estimates of non-linear models such as the probit model in equation (6) cannot be interpreted as effects of the control variables on the dependent [24]. Thus, to obtain one-unit change interpretation for the estimates of equation (6), the marginal effects are estimated. Gujarati [24] and Hill et al. [28] specify the marginal effects functions as:

$$\frac{dP(X)}{dX_i} = F(\beta X)\beta_i \qquad (8)$$

Based on the forgoing, the empirical model that underpins the study is espoused as follows:

$$T = \beta_0 + \beta_1 \ln INCOM + \beta_2 EMP +$$
$$\beta_3 LOCATE + \beta_4 \ln AGE + \beta_5 \ln EDU +$$
$$\beta_6 CARW + \beta_7 HHS + \varphi \qquad (9)$$

Where:
INCOM = Income of the individual
EMP = The employment status of the individual
LOCATE = Location of the household
AGE = Age in years of the individual
EDU = Educational attainment of the individual
CARW = Car ownership status of the individual
HHS = The household size
$\beta_0$, $\beta_1$, $\beta_2$, $\beta_3$, $\beta_4$, $\beta_5$, $\beta_6$, and $\beta_7$ are the coefficients of the variables captured in equ. (7).
Table 1 shows description of variables utilised in the analysis and expected signs.

**Table 1:** Classification, description of variables and Expected signs

| Variable | Description | Expected Sign |
|---|---|---|
| Income level | Monthly income of the individual | - |
| Age | Age of the individual measured in years | - |
| Educational attainment | Educational attainment of the individual measured in years | - |
| Employment status | Employment status of the individual is measured as dummy. Coded 1 if the individual is employed and 0 otherwise. The unemployed therefore represent the reference category | - |
| Household size | Household size is the number of people dwelling in the household. | + |
| Location | Location of the individual. measured as dummy. It is coded 1 if the individual lives in the urban area and 0 if otherwise. Rural denote the reference category | +/- |
| Car Ownership | Car Ownership is measured as a dummy. It coded 1 if the individual owns a car and 0 if he/she does not. The reference category is those who do not own cars | +/- |

### 4.3 Data Type and Source

This study utilised data from the GLSS core 7 which was collected during the years 2016 and 2017. The Ghana Living Standards Survey is regularly compiled by the Ghana Statistical Service to make micro level data available on key variables such as consumption, employment, health, education, labour force participation and time use, housing, transportation and finances of households in Ghana, for informed decision making and policy formulation. The data was obtained from the Data Service Unit of the Ghana Statistical service and used for this research.

## 5. Results and Discussions

### 5.1 GLSS 7 Statistics Summary

The GLSS core 7 data used for the study revealed that 15,000 households where interviewed out of which 14,009 households responded. This resulted into an accumulated individual response of 59,864 household members. Out of the 14,009 households that were asked from the GLSS 7 survey whether they commute by private or commercial cars, majority (95.42%) responded that they do not own their personal vehicles and thus, commute via commercial cars. Nonetheless, 97.01 percent of the respondents indicated that they travel via commercial vehicles. This implies that households who own their private cars sometimes commute via commercial means (see Fig. 2).
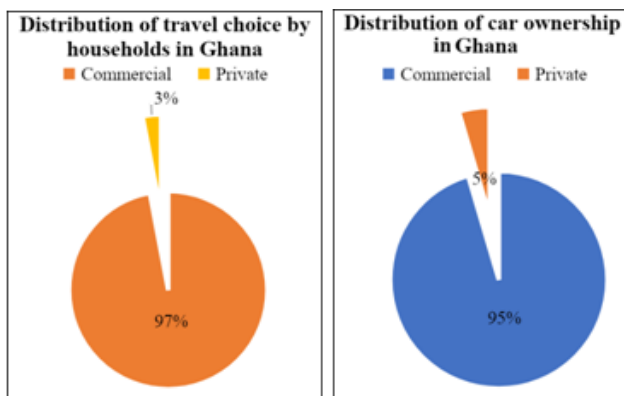


**Figure 2:** Distribution of car ownership and travel choice of households in Ghana
Source: Author's Estimation from GLSS Dataset

Table 2 presents the summary statistics of the continuous variables for the respondent household members. The table shows that the average household income in Ghana is GH₵7791.10 ($1,420.62) with a standard deviation of GH₵641.52 ($116.85). On the average, a respective household member is 39.21 years old. This has a standard deviation of 11.25. The household size is 4.54, with a standard deviation of 3.58.

**Table 2:** Summary statistics for the continuous variables

| Variables | Mean | Standard Deviation |
|---|---|---|
| Household Income | 7791.10 | 641.52 |
| Age | 39.21 | 11.25 |
| Years of education | 12.10 | 14.15 |
| Household Size | 4.54 | 3.58 |

Source: Author's Estimation from GLSS Datasets

The summary statistics for the dummy variables are presented in Table 3. The study found that 89.59 percent of the respondents are employed. These are either wage or non-wage employed. Specifically, 66.39 are involved in non-wage employment whiles 23.20 percent of them are in wage-employment. The unemployed respondents were estimated at 10.41 percent. The responding households that live in the urban areas were also estimated at 39 percent, whiles 61 percent lived in the rural areas. This reveals that majority of Ghanaians live in the urban areas (See GLSS Report, 2014).

**Table 3:** Summary statistics from dummy variables

| Variables | Proportion of households involved |
|---|---|
| Employment status | |
| Employed | 89.59 |
| Unemployed | 23.20 |
| Location | |
| Urban | 39 |
| Rural | 61 |

Source: Author's Estimation from GLSS Datasets

### 5.2 Interpretation of Results

This section presents the results of the probit model which addresses the objectives of the study. The results of the marginal effects are presented. As indicated in session 2, the marginal effects enable the interpretation of the coefficients of the model.

**Table 4:** Marginal Effects of Probit Model

| Variables | Estimates |
|---|---|
| Household Income | 0.392*** (0.0911) |
| Age | 0.057*** (0.0065) |
| Education | 0.050* (0.0097) |
| Car ownership | 0.030** (0.0835) |
| Household Size | -0.030** (0.0876) |
| Employed | 0.541* (0.0876) |
| Urban dummy | 0.094** (0.0813) |
| Observations | 14,009 |

*Robust standard errors in parentheses*
**\*\*\* p<0.01, \*\* p<0.05, \* p<0.1**
Source: Author's Estimations, 2019

#### 5.2.1 Effect of income, employment status, education and location on travel choice in Ghana

Table 4 presents the marginal effects estimate of the probit model. Observations show that all the variables employed in the model statistically drive the choice of travel in Ghana. The study reveals that income is a major driver of the travel choice of household members in Ghana. The study shows that a percentage increase in household income increases the likelihood of commuting with private cars by 0.39 percent. This is statistically significant at all levels.

The finding agrees with the results of [21, 22, 23, 30]. For instance, De Jong & de Riet [30] found that a 10 percent increase in income increases motorization by 6.35 percent. The probable explanation for this result is that higher income enables households to purchase more luxurious or normal goods, including private cars to facilitate their travels.

In addition, the results indicate that household members who are employed are more likely to choose private modes of travel compared to the unemployed. Specifically, people who are employed are 0.54 percent more likely to resort to private means of travel compared to the unemployed (see Table 4). Statistically, this finding is significant at 10 percent and consistent with the results of [6, 31]. This can be explained from the angle that the employed are more likely to have more income that the unemployed.

Urban dwellers are more likely to choose private means of transport compared to their rural counterparts in Ghana. This corroborates the results Mensah [7]. Specifically, urban folks are 0.094 percent more likely to use private means of transport compared to rural dwellers. The result is statistically significant at 5 percent.

Also, the educational status of the household head was also found to impact the choice of travel. The study found that an additional year of education impacts choice of travel positively at 0.05 percent, with a significance level of 1 percent. This implies that a general improvement in the educational level of Ghanaians will significantly help in driving people's interest in using private means of transport [32].

### 5.2.2 Effect of Car ownership, Household size and Age on travel choice in Ghana

The results indicate that private car owners are more likely to commute with their cars compared to households who do not own cars. Specifically, private car owners are 0.03 percent more likely to drive their cars than commute via commercial means (see Table 4). The result is statistically significant at 5 percent. The probable reason for private car owners not joining commercial vehicles could be due to the fact that the commercial transport system of Ghana is fraught with professionalism challenges. The finding is consistent with [7, 33].

Household size is negatively signed, indicating that the larger the household, the more likely members of the households will use commercial means of transport. This could be to the heavy financial burden additional member in household imposes on the household budget. Given the average income of the household, as indicated in Table 3, a highly populated household is more likely to face financial constraints; and therefore, commute via commercial means [6, 22, 31].

In terms of statistics, an additional member in the household increases the likelihood of commercial travel means by 0.03 percent. This is statistically significant at 5 percent. Also, an additional age of a household member increases the likelihood of a person using private means of travel. One additional year increases the likelihood of using private means of travel by 0.05. This is statistically significant at all levels.

### 6. Conclusions

This study analyses household data using Probit Econometric Model to explain the factors that influence the choice of road transport modes in Ghana as well as type and profile of transport modes used by households. Following the results of GLSS Core 7 data analysis, the following conclusions are dawn:

- Income is a significant driver of the travel choice of households in Ghana. Specifically, a percentage increase in household income increases the likelihood of the household commuting with private cars by 0.39 percent. This is statistically significant at all levels.
- Household members who are employed are 0.54 percent more likely to resort to private means of transport compared with the unemployed.
- Urban dwellers are more likely to choose private means of transport compared to their rural counterparts in Ghana. Specifically, urban folks are 0.094 percent more likely to use private means of transport compared to rural dwellers.
- Educational status of household heads was also found to impact the choice of travel. The study found that an additional year of educational impacts choice of travel positively at 0.05 percent, with a significance level of 1 percent.
- In terms of the impact of car ownership on the travel choice of people, the results indicate that private car owners are more likely to commute with their cars compared to households who do not own cars. Specifically, private car owners are 0.03 percent more likely to drive their cars than commute via commercial means. The result is statistically significant at 5 percent.
- The study found an inverse relationship between household size and travel choice. An additional member in the household increases the likelihood of commercial travel means by 0.03 percent. This is statistically significant at 5 percent. An additional age in years of a household member also increases the likelihood of a person using private means of travel. In terms of statistics, one additional year increases the likelihood of using private means of travel by 0.05. This is statistically significant at all levels.

The study concludes that household income, location, employment and educational status significantly induce the usage of private cars for commuting. This requires that effective economic and transport policies be designed to optimise citizens travel comfort, reduce congestion on the roads, increase productivity and reduce emission of harmful gases in the atmosphere for green economy. The study further concludes that larger households use more of commercial travelling channels. Since most households in Ghana have larger members, government should endeavour to implement efficient transport systems to enhance the lives of the many large households in Ghana.

### 7. Future Scope

In order to do an exhaustive study in relation to determinants of passenger transport choices in Ghana, the authors have outlined the following topics for further studies:
1) An extension of this study to cover all sixteen regional capital cities/towns in Ghana in order to facilitate planning of intracity/intracity road transport infrastructure and the improvement of public sector transport by the Ministry of transport.

2) Investigation of the effectiveness/adequacy of current government policies being deployed at the public transport sector and the possibility of framing more policies to facilitate passenger vehicle access

3) An investigation of the perception of Ghanaian road users about the use of electric vehicles and vehicles and the preparedness of Ghana to adopt greener technologies as the number of vehicles imported into the country increases

## 8. Acknowledgement

## 9. Declaration of interest

None

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## Author Profile

**Dr. Sekyere** is currently a lecturer at the Department of Mechanical Engineering at KNUST, Kumasi and a research fellow of the Brew-Hammond Energy Center. Dr. Sekyere has accumulated over eleven (11) years of experience in teaching and research. He spent the first eight (8) years of his academic career at the Mechanical Engineering Department of the Kumasi Technical University (formerly known as Kumasi Polytechnic) and about two (2) years at the University of Energy and Natural Resources (UENR), Sunyani. His research interests are modelling and experimental studies on clean energy systems, gas turbines, fuels and combustion, energy efficiency in buildings, residential cooling and climate change. He is currently the Coordinator for the ECREEE Regional Certification Scheme (RCS) examination for off-grid Solar Photovoltaic Technicians at KNUST. Charles received his BSc., MSc. And PhD degrees in Mechanical Engineering in 2004 and 2008 and 2012 respectively, specialising in Thermo-fluids and Energy Systems Engineering from the Kwame Nkrumah University of Science and Technology (KNUST), Kumasi. For his PhD studies, Charles looked at modelling and experimental studies on a mixed-mode solar dryer with backup heating. Charles has worked as a regular consultant and trainer for food processing industries in Ghana.

**Dr. Francis Davis** is a Senior Lecturer in Design and Manufacturing at the Department of Mechanical Engineering, Kwame Nkrumah University of Science and Technology (KNUST), Kumasi. He holds a PhD in Mechanical Engineering from North Carolina Agriculture & Technical State University, Greensboro, USA, and a MPhil in Mechanical Engineering, and a BSc (Hons) Degree in Mechanical Engineering, each from the Kwame Nkrumah University of Science and Technology, Kumasi, Ghana. His research interests are: design of experiment and modeling; design, analysis, and manufacturing of engineering product; monitoring of machining operations; maintenance and production engineering. About twenty-five (25) journal and conference publications have been developed and published out of the research areas. Frequently taught subjects include engineering drawing, machine design, machine tool design, manufacturing processes, manufacturing technology, design optimization, and principles of production systems. He has coordinated several academic related programs including Student and Staff Exchange Program with North Carolina Agricultural and Technical State University, Online Programs with Institute of Distance Learning, KNUST, Professional Master's in Engineering - Industrial Operations Program, and Top Up Program in Mechanical Engineering. He has also been involved in a number of technical activities and training at the local, national and international levels. He is currently managing KNUST fleet of vehicles as Transport Engineer and also the Principal Investigator for the International Accelerated Degree Program (3+1+1) between Arizona State University and Kwame Nkrumah University of Science and Technology sponsored by Mastercard Foundation.

**Richard Opoku** is a lecturer at the Department of Mechanical Engineering, Kwame Nkrumah University of Science and Technology, Kumasi-Ghana, and also a research fellow at The Brew-Hammond Energy Center at the same University. He holds a PhD in Mechanical Engineering from North Carolina Agriculture & Technical State University, Greensboro, USA, and a MSc. and a BSc (Hons) Degree in Mechanical Engineering, each from the Kwame Nkrumah University of Science and Technology, Kumasi, Ghana. Richard Opoku has over 10 years of post-BSc and 7 years of post-MSc experience as mechanical engineer, engineering systems analyst, energy auditor, energy efficiency advisor and solar PV design and installation advisor. He has a lot of experience in research and development (R&D) of energy systems including renewable energy (solar energy) for irrigation, solar energy for cooling applications and food preservation, solar crop drying and solar water pumping. Additionally, he has expertise in computer modeling and analysis of engineering systems and is currently the Director of EYAT Engineering Solutions, a company that provides consultancy services and training in engineering,

procurement and construction of engineering processes and systems.

**Mr. Samuel Oko Tetteh** obtained his bachelor's degree in Mechanical Engineering at the Kaaf University College in the Central Region of Ghana in the year. He currently works with the National Film and Television Institute (NAFTI) as Head of the Transport Department. Mr Oko has accumulated twenty-one (21) years of experience as Transport Manager at NFI. Because of his diligent and hard work, he was adjudged the best worker at NAFTI in the years 2012, 2013 and 2014 consecutively. His interest and goals are to creates and enforce Transport policies for a safe, sustainable and efficient green economy.