KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

COLLEGE OF ART AND SOCIAL SCIENCES

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INFORMATION SYSTEMS AND DECISION SCIENCES

ASSESSING THE IMPACT OF EFFICIENT LOGISTICS ON URBAN TRANSPORT ENERGY DEMAND – THE CASE OF KUMASI METROPOLIS

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AUGUST, 2009

ASSESSING THE IMPACT OF EFFICIENT LOGISTICS ON URBAN TRANSPORT ENERGY DEMAND – THE CASE OF KUMASI METROPOLIS

by

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B. A. Publishing Studies (Hons.)

A Thesis submitted to the Department of Information Systems and Decision Sciences, Kwame Nkrumah University of Science and Technology in partial fulfillment of the requirements for the degree

of

MASTER OF BUSINESS ADMINISTRATION

KNUST School of Business

College of Art and Social Sciences

August, 2009

DECLARATION

I hereby declare that, this submission is my own work towards the MBA and that, to the best of my knowledge, it contains no material previously published by another person nor material which has been accepted for the award of any other degree of the University, except where due acknowledgement has been made in the text.

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ACKNOWLEDGEMENT

I am greatly thankful to God, by whose Grace I have been able to complete this work. I wish to express my sincerest gratitude to Mr. Jonathan Annan and Dr. S. K. Amponsah (my supervisor and internal examiner respectively), for their enormous counseling and guidance, constructive comments, useful suggestions, excellent pieces of advice and unlimited help which made it possible for me to complete this work. Many thanks also go to all the drivers and institutions who willingly supplied the needed information to complete this thesis successfully. Finally, I am greatly indebted to all those who helped in any way to make this research work a success, especially Caroline, Fidelia and the rest of my family.

ABSTRACT

The growing energy needs that countries face, especially in the transport sector, present major challenges in terms of energy security and supply. This has mainly been as a result of the lack of efficient logistics in the transport sector, translating into undue congestion, accidents and carbon creation. In this regards, this study was conducted to assess the impact of efficient logistics on urban transport energy demand. This assessment was done with the following specific objectives in mind; Identifying various factors that cause energy demand on urban transport; Investigating the effects the factors identified have on urban transport energy demand; Investigating the relationship between urban transport efficiency and energy demand and; Recommending efficient and effective logistics on urban transport energy demand. After reviewing literature, data for the study were gathered. The data gathering components of the work involved completion of questionnaires by drivers and extraction of secondary data from relevant institutions. Quantitative method of striking percentages and qualitative method were used to analyse the field data to extract the relevant information. Qualitative factors were employed where data could not be quantified. Results of the analysis revealed that the transport system is generally less efficient, constituting the major factor causing severe congestion and high energy consumption. The main criteria for assessing the transport efficiency included: the transport structure, transport infrastructure and traffic management system. The major factors causing energy demand on transport included an unbalanced transport structure with little share of larger buses, poor road utilization, inefficient traffic management system, inefficient vehicles and poor driver skill. The researcher therefore recommends an improvement in the transport structure specifically mass transport, transport infrastructure development such as road link/expansion improvement and traffic management improvement to control traffic flow, etc. These will go a long way to improve the transport efficiency and in effect, transport energy demand will reduce considerably.

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LIST OF ABBREVIATIONS/ACRONYMS

APEC	Asian Pacific Energy Commission
ASME	American Society of Mechanical Engineers
ATS	Average Travel Speed
CBI	Confederation of British Industry
CC	Cubic Capacity
CH_4	Methane
CI	Congestion Index
CLM	Council of Logistics Management
CMV	Commercial Motor Vehicles
CO_2	Carbon Dioxide
DETR	Department of the Environment, Transport and the Regions
DVLA	Driver, Vehicle and Licensing Authority
EEBPP	Energy Efficiency Best Practice Programme
EIA	Energy Information Administration
GEF	Global Environment Faculty
GHG	Greenhouse gas
G8	Group of Eight
HCM	Highway Capacity Manual
HGV	Heavy Goods Vehicle
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
IRR	Internal Rate of Return
JHS	Junior High School
KMA	Kumasi Metropolitan Area

LCA	Life Cycle Analysis
LPG	Liquefied Petroleum Gas
MGI	Mckinsey Global Institute
MMTL	Metro Mass Transit Limited
Mpg	Mile Per Gallon
MSLC	Middle School Level
MtC	Million Tonnes Carbon
MTOE	Million Tons of Oil Equivalent
NMT	Non-motorized Transport
NO_x	Oxides of Nitrogen
NPA	National Petroleum Authority
O-D	Origin to Destination
PMV	Private Motor Vehicles
PRC	People's Republic of China
QBTU	Quadrillion British Thermal Units
T&E	European Federation for Transport and Environment
UK	United Kingdom
UN	United Nations
US	United States
WHO	World Health Organisation
WEC	World Energy Council

CHAPTER ONE

INTRODUCTION

1.0 BACKGROUND OF THE STUDY

In an era of high oil and gas prices, uncertainty about the security of energy supply and concerns about carbon dioxide (CO_2), energy policy has come to dominate political discourse around the world. To date, the energy debate has centered largely on how to secure future energy supply and how to finance research into alternative sources of fuel. While these are important, no energy policy can be complete without a comprehensive understanding of the size of the demand abatement opportunities, and how these can be captured in an economically sound way. After all, what's the point of increasing supplies that are destined to be wasted? (Bressand, *et al.*, 2007).

The impetus for increased interest in energy issues is twofold. First, oil is a prime source of energy, so that high and volatile oil prices and increased dependence on oil imports have strengthened concerns regarding energy security. Long-term projections for oil prices are on the rise. For example, in 2000 the International Energy Agency used a price of $33/barrel for its base line projection for 2030; in 2004 the figure was $40, and in 2005 it had risen to $55, reflecting a concern that higher oil prices are not a transitory phenomenon. The second impetus is a growing consensus that the expected costs of climate change warrant measures to reduce greenhouse gas (GHG) emissions, although just how quickly remains controversial (Arrow, 2007 cited in Small and Dender, 2007).

The growing energy needs that countries face, especially in the transport sector, present major challenges in terms of energy security. According to Brunetti (2006), Transport is responsible for considerable energy loss representing about 20-40% of overall energy consumption, depending on national statistics. This is mainly due to a lack of efficiency in motor vehicles. Engines are really poor in terms of energy efficiency. Traffic and urban planning have considerable political implications and measures to reduce energy loss are difficult to implement. The growth of secondary cities and urban sprawl contribute to the pressure on existing urban transport networks. The trend toward increased motorization, in all forms, leads to longer travel times for surface public transport, which in turn induces more auto and taxi use resulting in poor traffic safety and congestion. All these have resulted in an economic inefficiency of increased fuel use. Energy is not only an expensive and scarce natural resource, transport use also bears environmental concerns related to GHG emissions which contribute to climate change (Reddy and Guttikunda, 2006).

Unless there is a major shift away from current patterns of energy use, total transport energy use and carbon emissions are projected to be about 80% higher than the 2006 levels by 2030 globally, despite urgent calls from the government and international bodies to achieve levels no more than 80% greater than the 1990 base values, in all sectors (Energy White Paper, 2006).

The good news however is that, there is a very large opportunity to contain energy growth in economically attractive ways, and in the process, cut CO_2 emissions. Research by the Mckinsey Global Institute (MGI) and McKinsey's Global Energy and Materials Practice finds that a concerted global effort to boost energy efficiency, or the level of output we achieve from the energy we consume would have spectacular results. By capturing the potential availability from existing technologies with an internal rate of return (IRR) of 10% or more, we could cut global energy demand growth by half a more over the next fifteen years. In other words, more efficient use of energy at all stages of the supply/demand chain could reduce the negative impacts of energy consumption, while still allowing the same economic development (Bressand, *et al., 2007).*

In contrast, the inefficient use of energy generally implies higher than necessary operating costs to the customer/end-user. At the company or enterprise level, higher energy efficiency will reduce operating costs and enhance profitability. At the national level, improved energy efficiency implies reduced energy imports, thus reducing foreign exchange pressures as well as increasing the availability of scarce energy resources for others to utilize, allowing increases in energy-dependent activities to contribute to the economic well-being of the population as a whole. Society as a whole also benefits from increased energy efficiency, principally through reduced adverse environmental impacts of energy usage.

1.1 PROBLEM STATEMENT

News in energy price trends have become topical in recent years and combined with the ongoing crises in the Middle East, a great deal of uncertainty concerning future oil price movements abound. Although Africa is endowed with the widest possible range of energy resources that would far exceed its energy requirements, many African countries are reliant on oil imports and Ghana is one of them. Ghana has made enormous economic progress in the last twenty years, although some years have been very turbulent. In recent years, both political and macroeconomic stability have enabled the country to achieve annual growth rates of over 5%, making it one of the early developing nations to receive debt relief from the international finance institutions. In 2005, oil imports alone accounted for about 20% of the country's merchandise imports. The recent hikes in global oil prices, if sustained, could eventually jeopardize the accumulated economic gains (Jumah and Pastuszyan, 2007).

According to Brunetti (2006), the transportation sector is the largest consumer of oil and often one of the most rapidly growing sectors in the country. Although, almost all countries in the world have experienced significant and sustained increases in passenger travel over the past decades, much of the world is not yet motorized because of income constraints. As the world's economies develop however, energy use for transportation is likely to increase dramatically in the coming decades. If transportation services are not made more efficient, energy use in the sector will continue to grow rapidly in both absolute and percentage terms. Because Ghana is a developing economy and a net importer of petroleum, the growing level of transport energy consumption defines a major area of vulnerability, especially as a tightening oil market prompts global oil prices to rise. The costs of energy consumption in the transport sector are huge, in terms of overall expenditures, oil imports, climate change, and other environmental impacts. The problem of air pollution is particularly relevant to urban transport, considering the high concentrations of urban population, rapid rates of urbanization, and inefficient transport systems in developing countries (Kojima and Lovei, 2001). The large, dense concentration of motorized emissions in relatively small areas means that many, if not most, cities will exceed any reasonable health standard for key air pollutants.

Transport not only plays a key role in the daily functioning of cities, but can also be a tool for managing growth. With more than three hundred (300) cities in Asia expected to have over one billion inhabitants by 2025, and many secondary cities growing rapidly, future economic growth will largely be driven by urban economic activities (GEF, 2006). As urbanization proceeds in Ghana, crises will increasingly arise around the provision of safe, clean and effective transportation. Left unaddressed, this will result in a deteriorating spiral of escalating transport system costs, intolerable congestion, increasing oil dependence, rising air pollution and diminishing capacity of the poor to travel within urban regions, among others. Hence, providing efficient and effective transport logistics is an essential measure to address the problem of **oil price risk**/the transport challenge

1.2 RESEARCH OBJECTIVES

The main objective of this study is to assess the impact of efficient logistics on urban transport energy demand. The study specifically seeks to:

i. Identify various factors that cause energy demand on urban transport;

ii. Investigate the effects the factors identified have on urban transport energy demand;

iii. Investigate the relationship between urban transport efficiency and energy demand and;

iv. Recommend efficient and effective logistics on urban transport energy demand.

1.3 JUSTIFICATION OF THE STUDY

The import of this study is to provide insights into Ghana's transport energy demand, more particularly, urban transport energy demand. The document will go a long way to

i. Provide a critical and analytical perspective for understanding the challenges that the transport sector, particularly urban transport faces in meeting energy consumption targets;

ii. Provide valuable information on the kind of interventions that are required to ensure improved performance in providing the appropriate logistics that will help improve on energy efficiency in the transport sector;

iii. Serve as a frame of reference for application by policy makers and also a resource material for consultation by students and researchers, upon which further studies may be conducted to improve the total transport sector of the economy;

iv. Also, recommendations made by the study will provide benefits at various levels. At the company or enterprise level, higher energy efficiency will reduce operating costs through a reduction in transportation cost which will enhance profitability. At the national level, improved energy efficiency implies reduced energy imports, thus reducing foreign exchange pressures as well as increasing the availability of scarce energy resources for others to utilize, allowing increases in energy-dependent activities to contribute to the economic well-being of the population. Society as a whole also benefits from increased energy efficiency, principally through reduced adverse environmental impacts of energy usage.

v. Notwithstanding, it is required as a partial fulfillment of the requirements for obtaining a degree in a tertiary institution, and therefore, very beneficial to the researcher of the study.

1.4 SCOPE OF THE STUDY

This study was restricted mainly to road transport which continues to be a predominant mode of transport, currently accounting for about 95% of passenger traffic movement in Ghana. The geographical location selected for the study was the Kumasi Metropolitan Area.

1.5 RESEARCH METHODOLOGY

Both primary and secondary data were employed. Primary data were obtained through personal interviews, administration of questionnaires and participant observation. With regard to secondary data, the information gathering techniques that were employed included the extraction of extensive information on the study from relevant books and the internet. Data analysis involved descriptive and statistical analysis to determine the efficiency of the urban transport system, possible factors that cause energy demand on transport and their effects.

1.6 LIMITATION OF THE STUDY

The analysis, conclusion and recommendations of the study relied heavily on both primary and secondary data. As such, errors in these data may reduce the potency of the results/findings to predict perfectly, the true nature of events. Also, a fair representative sample size does not necessarily mean a perfect/a hundred percent representative of the entire population, which also means that any generalization may be subject to some degree of error. It may however be negligible.

1.7 ORGANISATION OF THE STUDY

The research was organized into five chapters. Chapter one provides a background to the study, statement of the problem, research objectives, justification of the study, methodology, scope of the study, limitations and organization of the study. Chapter two reviews the related literature as well as the conceptual framework of the study. The literature covers the definitions and concepts of the components of the study.

Chapter three describes the methodology used for the study. This takes a look at the population, sample and sampling techniques, methods of data collection, method of data analysis, research design, and the profile of the case being studied. Chapter four discusses and analyses the data that were sourced, which are organized and illustrated with the use of appropriate tables, charts and figures. Chapter five summarizes the various findings, gives conclusions to the analyses made and also makes recommendations based on the findings.

CHAPTER TWO

LITERATURE REVIEW

2.0 INTRODUCTION

The literature review looks at existing body of knowledge and researches on efficient logistics and urban transport energy demand. The various aspects are captured in headings that summarize the various aspects of the topic.

2.1 OVERVIEW OF LOGISTICS

Logistics is a broad, far-reaching function which has a major impact on a society's standard of living. In a modern society, we have come to expect excellent logistics services, and tend to notice logistics only when there is a problem. To understand some of the implications to consumers of logistics activity, consider: the difficulty in shopping for food, clothing, and other items if logistical systems do not conveniently bring all of those items together in one place, such as a single store or a shopping mall; the challenge in locating the proper size or style of an item if logistical systems do not provide for a wide mix of products, colours, sizes and styles through the assortment process. This was a continual problem in the former Soviet Union; the frustration of going to a store to purchase an advertised item, only to find out the store's shipment is late in arriving. These are only a few of these issues often taken for granted which illustrate how logistics touches many facets of our daily lives (Lambert, *et al.,* 1998)

2.1.1 DEFINITION OF LOGISTICS

The Council of Logistics Management (CLM) (1991 cited in Lambert, *et al.,* 1998) defines Logistics Management as 'the process of planning, implementing and controlling the efficient, effective flow and storage of goods, services, and related information from point of origin to point of consumption for the purpose of conforming to customer requirements'. Johnson and Wood's definition (cited in Tilanus, 1997) uses 'five important key terms', which are logistics, inbound logistics, materials management, physical distribution and supply-chain management to interpret. Logistics describes the entire process of materials and products moving into, through, and out of the firm. Inbound logistics covers the movement of materials received from suppliers. Materials management describes the movement of materials and components within a firm. Physical distribution refers to the movement of goods outward from the end of the assembly line to the customer.

The commonality of the recent definitions is that logistics is a process of moving and handling goods and materials, from the beginning to the end of production, sale process and waste disposal, to satisfy customers and add business competitiveness. It is 'the process of anticipating customer needs and wants; acquiring the capital, materials, people, technologies and information necessary to meet those needs and wants; optimising the goods or service-producing network to fulfill customer requests; and utilizing the network to fulfill customer requests in a timely way' (Tilanus, 1997).

2.1.2 COMPONENTS OF LOGISTICS SYSTEM

Logistics services, information systems and infrastructure/resources are the three components of logistics system and are closely linked. Logistics services support the movement of materials and products from inputs through production to consumers, as well as associated waste disposal and reverse flows. They include activities undertaken in-house by the users of the services (e.g. storage or inventory control at a manufacturer's plant) and the operations of external service providers (Tseng, *et al.*, 2005). Logistics services comprise physical activities (e.g. transport, storage) as well as non-physical activities (e.g. supply chain design, selection of contractors, freightage negotiations). Most activities of logistics services are bi-direction.

Information systems include modeling and management of decision making, and more important issues are tracking and tracing. It provides essential data and consultation in each step of the interaction among logistics services and the target stations. Infrastructure comprises human resources, financial resources, packaging materials, warehouses, transport and communications. Most fixed capital is for building those infrastructures. They are concrete foundations and basements within logistics systems (Tseng, *et al.*, 2005).

2.1.3 EFFICIENT LOGISTICS

The People's Republic of China (PRC) faces challenges to efficient logistics development. The ratio of total logistics cost to gross domestic product represents the efficiency of logistics operation in the economy, i.e., the lower the ratio, the better the efficiency. Despite the PRC's ratio declining from 21.2% in 1991 to 18.4% in 2007, it is still double that of developed countries. Moreover, the share of logistics cost of finished products in the PRC is much higher than the normal range of 10% – 25% for an efficient operation, particularly in inland regions, further reflecting a needed improvement in its logistics development (Greenwood, *et al*., 2008).

The urban environment is characterized by high settlement and population densities and high consumption of goods and services. In such environments, traffic infrastructure and the possibilities for its extension are both limited and unsustainable. This dichotomy between demand and limitations of the urban environment has resulted in significant problems associated with urban freight transport. The most commonly mentioned are congestion, pollution, safety, noise and carbon creation. In fact, the transportation of goods accounts for 40% of air pollution and noise emissions (COST321, 1998). The combined effects of these problems are both economic and societal, in that they do not only reduce the efficiency and effectiveness of urban freight transport and logistics operations, but also impact on the well-being of a nation by decreasing the quality of life of citizens and through detrimental effects on health (Stantchev and Whiteing, 2006).

Inefficient logistics also results in increased energy consumption and air pollution concerns; unsurprisingly, the PRC is the world's fastest growing oil consumer. From 2000 to 2005, the transport sector's consumption of petroleum increased from 25% to 30% of total use and is projected to reach 50% in 2020. To cope with emerging environmental issues, policies and measures to increase transport energy efficiency are highly desirable, such as raising the quality of transport services, raising vehicle standards (with greater use of containers and larger, multi-axle trucks), and fostering integrated logistics service provider development. Additionally, developing inland waterway transport can also lower environmental impact in terms of high energy efficiency per ton-km. Most importantly, the focus should gradually shift away from the construction of new infrastructure to more effective utilization of existing infrastructure (Greenwood, *et al.,* 2008).

2.2 OVERVIEW OF TRANSPORT

According to Chenoy (2008), transport will primarily be a means for commuting either to office and back or used as a means to earn livelihood or for carrying out essential activities related to daily life. In Operational Management, transport is defined as 'the movement of a product or people from one location to another as it makes it way to the end–use customer' (Russell and Taylor, 2003). Transport is an essential component of life. Positive effects of transport result from providing access to education, employment opportunities, goods/services, leisure activities and other amenities and by contributing to economic development and to the logistics of production and distribution (WHO, 2009).

2.2.1 THE EVOLUTION OF TRANSPORT AND LOGISTICS

According to Sjostedt, *et al.* (1998), three generations of transportation have been well established as an international scientific discipline, at least, since the sixties. As the need to construct highways for the rapidly growing automobile traffic escalated shortly after World War II, this became a natural field of application when the operations research community, which had firmly established itself during the war, was looking for applications in the civilian sector. The growing discipline of transportation found a strong foothold in the civil engineering faculties of many American universities and likewise technical universities in other parts of the world.

In the first generation the original focus was the traffic process. Traffic engineering grew in importance as a profession as most cities found it necessary to employ one or several traffic engineers. Speed-flow relationships are fundamental to understand traffic flow phenomena. In the thirties, Greenfield proposed that speed was a linear function of density, implying a parabolic relation between speed and flow. Theoretically a great step forward was made when the 1965 version of the US Highway Capacity Manual (HCM) was published. The previous concepts of 'possible' and 'practical' capacity were abolished. Instead capacity was defined as the upper bound of the traffic volumes that could be observed in practice. Simultaneously the level of service based on the volume/capacity ratio was introduced as a measure of the extent to which the individual motorist could travel free of disturbances and delays (Sjostedt, *et al.*, 1998).

Second generation, as part of the strong environmental movement and changes of values that swept through universities in 1968, the first strong reactions against unlimited use of the private car in cities appeared. This caused a renewed interest in the role of public transport and partly explains the shift of academic work from traffic to transport that took place in the seventies. The level of service is perceived as a function of the design of the transportation system and the volumes of travelers using the system and serves a similar role as price in ordinary market theory.

Third generation, following the Brundtland report and the UN conference in Riode Janeiro on Sustainable Development, a further shift has taken place from transport to mobility. The increasing use of the term mobility not only reflects attempts to look at the qualitative aspects or utility of transport. It is also closely associated with the ambition to measure consumption of non-renewable resources and energy conversion efficiency as well as emissions of greenhouse gases and substances harmful to living organisms and plants. Techniques such as Life Cycle Analysis (LCA) are increasingly being used to assess transportation systems serving various mobility needs (Sjostedt, *et al.*, 1998).

2.2.2 TRANSPORT EFFICIENCY

Yuan and Lu (2001), defined transportation efficiency as 'the extent to which certain transportation input can meet the travel demand of people in a transportation system'. It is the main factor that determines the scale of transportation supply and the relationship between supply and demand in a transportation system. In a macroscopic point of view, if we take transportation infrastructure as the input element and take transportation mobility/capacity as the output element in transportation systems, then transportation efficiency is the macro parameter influencing the input/output proportion of the system.

2.2.3 URBAN TRANSPORT EFFICIENCY

The efficiency of urban transportation systems is the relationship between the input of an urban transportation system and its capability of satisfying the transportation demand in the system. Generally, the total efficiency of the urban transportation system is scaled by "social benefits/costs". The greater the ratio, the higher the transportation efficiency is. However, social benefits and social costs are both macrocosmic indexes and cannot be quantified and analyzed exactly (Yuan and Lu, 2001).

2.2.4 FACTORS AFFECTING URBAN TRANSPORT EFFICIENCY

Many authors have given varying factors that affect urban transport efficiency. Among such factors include urban land use patterns, urban transport structure, urban transport infrastructure and urban traffic management system.

2.2.4.1 URBAN LAND USE PATTERNS

According to Jones and Collings (1999), changes in land-use planning and travel substitution can have profound effects on transport demand. In terms of land use planning, the relationship between travel demand and population has been observed in many countries, and shows that, as population density increases, demand for travel decreases. In a research on the influence of Development characteristics on the ecological footprint of an urban household, Gilson (2004) explains the relationship between higher population density and road network density that a highly connected transportation network (as indicated by the number and proximity of intersections) reduces the route distance for all modes of travel by increasing the number of route options.

According to Frank (2000 cited in Gilson, 2004), a recent study of the link between land-use patterns and transportation in the Puget Sound region found that as population and transportation network densities increase, the proximity and connectivity of trip ends increase. Higher population and road network densities reduce the distances traveled because route distances are shortened and route options increased by the dense and highly connected road network, just as walking becomes potentially more viable. Yuan and Lu (2001), also add that urban land use pattern means the characteristics and intensity of land-use activities. Transportation demand is derived from the producing and living activities of the human beings. Urban transportation efficiency varies with different land-use patterns greatly. Therefore, in order to improve urban transportation efficiency, it is an essential measure to build a suitable urban land-use pattern, which can decentralize urban functions, balance the distribution of transportation demand, cut down on total traffic volume and relieve traffic congestions in cities.

In an European Commission publication on 'keeping our cities moving', Picque (2004) explains that negative aspects of urban living including traffic congestion, noise, poor public transport, urban sprawl, air pollution, a lack of easily accessible shops and services, and a host of other daily inconveniences are simply the result of bad planning. He traced such problems from the past, where many local and regional decision-makers adopted a 'trial and error' approach to urban development, in which long-term objectives were rarely defined and remedial action taken only when it became absolutely essential. He added that, in some cases, decision-makers did try to plan ahead, but failed to consider the wider impacts of their policies and schemes.

2.2.4.2 URBAN TRANSPORT STRUCTURE

According to Yuan and Lu (2001), under a certain land-use pattern, the total capacity of the urban transportation system is basically determined by the composition of different transport modes in the system. Whether the structure of urban transportation system is harmonized with the land-use pattern, will directly impact the balance between transportation demand and supply. Given the total amount of transportation demand and a certain level of transportation infrastructure in a city, a good transportation structure will most effectively utilize the infrastructure and will help fully realize the functions of urban transportation systems.

Transport projects that promote integration of different transport modes can maximize overall system efficiency. Opportunities for transport demand management are found in integration of different modes of transport and in traffic management. Measures that integrate long-distance freight transport, passenger transportation, and land use planning focusing on housing and employment, along transit hubs have a significant role in transport demand management. In Rio de Janeiro, improved operation of diesel buses has resulted in an annual saving of 40 million liters of fuel (a 12.5% reduction), averting 107,800 tons of CO_2 emissions per year (Reddy and Guttikunda, 2006).

2.2.4.3 URBAN TRANSPORT INFRASTRUCTURE

Urban transportation infrastructure mainly includes roads, parking lots, vehicles and transportation terminals. It is the direct carrier of urban transportation demands and the basic input of the capacity of transportation supply (Yuan and Lu, 2001). Studies on transport infrastructure show that, new roads are often accompanied by new traffic, and generate retail and office development, while local activities such as shopping also promote significant travel (Jones and Collings, 1999).

2.2.4.4 URBAN TRAFFIC MANAGEMENT SYSTEM

Urban traffic management system is an important component which can properly control and guide the distribution of traffic flows on roads, and can help improve the urban environment. Even if urban transportation infrastructure in different cities are at the same level, the capacity of urban road systems may vary greatly with different traffic management systems. For example, according to a survey of some main intersections in Beijing, capital of China, most of them have a queue of more than two hundred meters during the morning and evening peak hours. And the average delay of motor vehicles at these intersections is about two or three minutes. However, the actual highest traffic volume at these intersections is only 60-80% of that at similar intersections in developed countries. Therefore, given a certain land-use pattern and transportation structure in a city, traffic management system then becomes the key factor to determine the level of transportation efficiency and the relationship between transportation demand and supply (Yuan and Lu 2001).

2.2.5 METHODS FOR ASSESSING URBAN TRANSPORT SYSTEM EFFICIENCY

Varying methods for assessing urban transport system efficiency have been propounded by varying authors. These include: the fuzzy theory and fuzzy logic model, road traffic and public assignment models and the stochastic and congestion model.

2.2.5.1 FUZZY THEORY AND FUZZY LOGIC MODEL

Hoogendoor, *et al.* (2000), found that, fuzzy set theory and fuzzy logic are approaches that are much closer to real human observation, reasoning and decision making than other traditional approaches, such as probability theory. These fuzzy approaches have been applied successfully in a wide range of industrial processes (e.g. cement kilns, incineration processes and waste water treatment) and products (e.g. cameras and washing machines). Applications in the field of traffic engineering have only recently emerged in larger numbers, and in many cases seem very promising. Most of these applications have an experimental and preliminary nature, whereas real-life applications of fuzzy sets and fuzzy logic in the field of traffic engineering are rare. However, from a number of applications, the potential of the fuzzy approach becomes already apparent.

Recent research has found that a variety of methods for prediction have been reported in the literature during the last few decades. The regression method is one of the main ways used in Forecasting (Draper and Smith, 1980 cited in Wong, *et al.*, 2003). When conventional regression methods are applied to large scale and complex systems such as transportation problems, the ambiguity or fuzziness of human's subjective judgment usually comes into play. Therefore, exact and accurate modeling of these systems may be very difficult. Alternatively, the concept of the fuzzy set theory seems to be applicable for modeling such systems (Wong, *et al.*, 2003).

2.2.5.2 ROAD TRAFFIC AND PUBLIC TRANSPORT ASSIGNMENT MODELS

According to Shires (2006), a number of assignment models exist and they can be used to model a range of networks from assessments of local junctions to large scale city networks. The basic theory behind assignment models is based upon the actual exchanges of goods and services (supply and demand) and obtaining an equilibrium point where the '*marginal cost of producing and selling the goods equals the marginal revenue obtained from selling them'* (Ortuzara and Willumsen, 2001 cited in Shires, 2006). Placing this into a transport context sees a supply side consisting of a road network and the links and their associated costs (a function of their attributes, e.g. distance and capacity); and a demand side consisting of the number of trips per O-D and the chosen mode for a preferred level of service, i.e. generalised cost elements.

The corresponding equilibrium within a transport system may occur at several points; on the road network equilibrium, thus when car travellers for a fixed trip matrix find routes which minimise their generalised travel costs. With such equilibrium the pattern of travel is such that those travelling are already on the best routes available to them; multi-modal network equilibrium as in road network but now the decisions of car travelers impact upon the journey times of bus users leading them to a change of behaviour in terms of route choice which impacts upon car users choice of route etc; system equilibrium, as in multimodal network, but now the interaction between different modes may lead to travelers to switching between modes, change their destinations, or alter the time of day they travel. This may lead to a re-estimation of the O-D travel matrix and service patterns offered. This process will be iterative until a final equilibrium is reached.

2.2.5.3 STOCHASTIC AND CONGESTION MODEL

Making reference to Public Transport Review 'Stochastic methods of assignment' address some of the shortfalls of the 'all or nothing assignment'. They allow a driver's perceptions of costs to vary as well as the costs of alternative routes. According to Ortuzar and Willumsen (2001 cited in Shires, 2006), this method centres around stochastic (Monte Carlo) simulation and proportional stochastic methods, with the former introducing, *'variability in perceived costs'* and the latter allocating flows via a legit-like algorithm. Whilst these methods are seen as advancement on 'all or nothing assignment' one of the criticisms of the approaches are that they don't make allowances for congestion costs.

One method which addresses this is 'congested assignment' which focuses upon the networks capacity constraints and the relationship between flow and costs on links. The assignment relates to Wardrop's first principle: "*Under equilibrium conditions traffic arranges itself in congested networks such that all used routes between an O-D pair have equal and minimum costs while all unused routes have greater or equal costs*" (Wardrop, 1952).

2.3 OIL/PETROLEUM AS ENERGY

According to The Need Project (2008), Petroleum (sometimes called oil) is a liquid that is found underground. Petroleum can be as thick and black as tar or as thin as water. It has a lot of energy, and can be turned into different fuels like gasoline, kerosene, and heating oil. Most plastics and inks are made from petroleum too. Petroleum is also called a fossil fuel because it is made from the remains of plants and animals. The energy in petroleum came from the energy in plant and animals. That energy came from the sun. Petroleum is nonrenewable. The petroleum we use today was made millions of years ago. It took millions of years to form, and so cannot be made in a short time.

Since World War II, petroleum has replaced coal as the leading source of energy consumed in the United States. Petroleum supplies 38.8% of the total energy demand. Coal supplies 22.6% and natural gas supplies 21.6 % of total energy needs of the United States. America uses almost 20.8 million barrels of oil (more than 915 million gallons) everyday of the year. Most experts say the United States will be using more oil, especially for transportation in the coming years (Need Project Report, 2008).

2.3.1 ENERGY EFFICIENCY

Energy efficiency is understood to mean the utilization of energy in the most cost effective manner to carry out a manufacturing process or provide a service, whereby energy waste is minimized and the overall consumption of primary energy resources is reduced. In other words, energy efficient practices or systems will seek to use less energy while conducting any energy-dependent activity: at the same time, the corresponding (negative) environmental impacts of energy consumption are minimized. Also according to the World Energy Council (WEC), Energy Efficiency encompasses all changes that result in a reduction in the energy used for a given energy service (e.g. heating, lighting, etc.) or level of activity. This reduction in the energy consumption is not necessarily associated with technical changes, since it can also result from a better organization and management or improved economic efficiency in the sector (www.worldenergy.org.).

2.3.2 BENEFITS OF ENERGY EFFICIENCY

According to the Commission on Environment and Energy (2007), energy efficiency makes sense to business in a wide range of sectors for compelling reasons. Efficient energy use reduces costs (energy is an essential input to production, distribution and marketing of products and services); reduces emissions and other environmental impacts; extends the availability of large but non-renewable resources; and makes energy more affordable to consumers, not only by reducing use, but also by reducing the overall need for investments in energy supply. This is particularly important in developing countries where affordability to modern energy services is critical for development. It also improves competitiveness and improves overall productivity.

Given the need to support sustainable global economic development, investments in efficiency offer the most financially favorable returns of any energy policy option. The

Reference Scenario in the IEA's World Energy Outlook (2006c) estimates that investments of US$20 trillion for energy supply will be needed to meet global demand through 2030. This report estimates that an investment of US$3.2 trillion will be required worldwide to double the rate of energy efficiency improvement, US$2.3 trillion of which will be invested by the G8 countries. These efficiency investments avoid new supply investments of US$3 trillion worldwide and US$1.9 trillion in the G8 countries, and result in a net incremental investment of US$200 billion worldwide and US$400 billion in the G8 countries.

These relatively small net efficiency investments generate significant additional benefits in improved business productivity and reduced consumer energy bills worth approximately US$500 billion annually by 2030. This implies an average payback of approximately three to five years for the efficiency investments needed to reach the target suggested in this report. Similarly, the report of IPCC (2007) clearly showed that energy efficiency policies play a critical part in cost-effective strategies for reducing CO_2 emissions in the near term.

2.3.3 ENERGY EFFICIENCY AND ENERGY DEMAND

Most studies conducted by various authors on energy efficiency suggest an inverse relationship between energy efficiency and energy demand, thus as energy efficiency increases, all things being equal, energy consumption reduces. According to the

Commission on Environment and Energy (2007), energy efficiency is a fundamental element in progress towards a sustainable energy future. As global energy demand continues to grow to meet the needs and aspirations of people across the globe, actions to increase energy efficiency will be essential. Also according to Bressand, *et al.* (2007), using energy more productively offers a great opportunity to reduce worldwide energy demand growth to less than 1% annually. Their study identifies a potential to reduce demand of between 125 and 145 QBTUs, the equivalent of 20-24% of projected end-use demand in 2020. Shapiro, *et al.* (2002) also add that greater reliance on more fuel-efficient means of travel, especially use of public transportation is the key to the United States achieving greater energy independence and environmental progress.

2.4 TRANSPORT AND ENERGY USE

According to Jones and Collings (1999), transport currently consumes over 34% of UK's energy demand, and produces 21% of all UK's CO_2 emissions (24% if electricity generation for transport and transport fuel production are included). This share has grown from about 15% over the last twenty years, and is set to grow further. Road transport alone accounts for 80% of all transport-related carbon emissions, which is estimated to have been 33MtC in 1990 and predicted to reach 38MtC by the year 2000. Shapiro, *et al.* (2002), also suggest that the role of transportation in America's energy consumption and environmental quality is immense. Americans use more energy and generate more pollution in their daily lives than they do in the production of all the goods in the economy, the operations of all commercial enterprises, or the running of their homes. As such any serious effort to reduce its dependence on foreign oil and make significant environmental progress must address the way Americans travel.

Transport is forecasted to be the fastest-growing end-use sector in the APEC region, and will account for 72% of incremental oil demand during 1999– 2020. Energy consumption is estimated to reach 1,824 Mtoe by 2020, an increase of 76.1%t or 2.7%t per annum over the 1999 level. This rate is slightly higher than in 1980-99, which reached 2.5% per annum on average. Oil products will continue to account for most of the energy consumed by the transport sector during the forecast period. Their share will fall slightly from 98.5% in 1999 to 98.4% in 2020. This is due to a rising trend of substituting oil products with alternative fuels such as natural gas and ethanol due to environmental and energy security concerns, as well as increase in the use of electricity in railroads and subways (APEC, 2006).

2.5 DRIVERS OF TRANSPORT ENERGY DEMAND

Many factors affect transport energy demand. Notable amongst these, as suggested by many authors, include rising income, motorization, driver skill, vehicle technology, etc.

2.5.1 RISING INCOME

The rising income or wealth of people generally implies a relatively higher ability to pay for transport cost. As a result consumers' desires to own cars increase, which effectively increase the ownership of many small vehicles. This is evident in some APEC cities as the rising income levels have driven substantial growth in gasoline consumption (APEC, 2006). Also in Korea, income growth, improvements in living standards, expansion of residential suburbs and development of vehicle manufacturing industries have all contributed to a thirty-fold increase in the stock of vehicles, which have in turn resulted in a ten-fold increase in gasoline and diesel consumption (APEC, 2006). In California, from 1980 through 2000, due partly to a rising real per-capita income, total on-road travel in the state increased at a significantly higher rate than either population or vehicles; an average of 3.3% annually while, at the same time, gasoline and diesel demand increased by an average of just 1.8% (Kavalec, *et al.,* 2003).

Additionally, Alberta and Saskatchewan (both of Canada) had the highest levels of per-capita travel, with estimated passenger-kilometres per person greater than seventeen thousand kilometers per person in 2007. Over the recent past, Alberta has had one of the highest (if not the highest) level of personal disposable income per capita in the country. This has likely contributed to high transportation demand in the province. On the other hand, Saskatchewan's high transportation demand is likely related to the combination of roughly average personal disposable income per capita in Canada and a lower population density than the Canadian average (National Energy Board, 2009).

2.5.2 MOTORIZATION

Increased motorization contributes significantly to the increased consumption in transport energy. In some cities of APEC, increasing motorization has also contributed to a substantial growth in gasoline consumption (APEC, 2006). In recent years the use of public transport has been very beneficial to the reduction in energy use. In their study, "Conserving Energy and Preserving the Environment", Shapiro, *et al.(*2002), conclude that making much greater use of public transportation may be the most effective strategy to sharply reduce the US's dependence on foreign oil and make historic strides in environmental quality. The study argues that these results can be achieved if America made public transportation a vital part of its nation's energy and environmental policies. Their study revealed that, public transportation was reducing American's energy bills and keeping the air cleaner. As such, energy savings from public transportation contributed to America's national and economic security by making it less dependent on foreign oil or on new sources for drilling.

Their statistical evidence showed that, public transportation saves more than 855 million gallons of gasoline a year, or 45 million barrels of oil. Such savings equal about one month's oil imports from Saudi Arabia and three months of the energy that Americans use to heat, cool and operate their homes, or half the energy used to manufacture all computers and electronic equipment in America. For every passenger mile traveled, public transportation uses about one-half the fuel of private automobiles, sports utility vehicles and light trucks. The study goes further to project that far greater energy and environmental benefits could be derived through increased use of public transportation. The following include the projections made by the study:

If Americans used public transportation at the same rate as Europeans, for roughly 10% of their daily travel needs, the US would reduce its dependence on imported oil by more than 40% or nearly the amount of oil they import from Saudi Arabia each year; save more energy every year than all the energy used by the US petrochemical industry and nearly equal the energy used to produce food in the US; reduce CO_2 emissions by more than 25% of those directed under the Kyoto Agreement; reduce CO_2 pollution by three times the combined levels emitted by four high polluting industries (chemical manufacturing; oil and gas production; metals processing; and industrial use of coal); etc.; If Americans used public transportation at the same rate as Canadians, for roughly 7% of their daily travel needs, the US would reduce its oil dependence by an amount equal to more than a half year's oil imports from Saudi Arabia; save nearly the amount of energy used by the entire petrochemical industry every year; etc. (Shapiro, *et al.,* 2002).

2.5.3 THE ROLE OF THE DRIVER

The driver's behaviour can play a significant role in achieving fuel efficiency, which will translate into a reduced growth in fuel consumption. Jones and Collings (1999), argue that the driver's right foot is a significant factor that must be considered if fuel efficiency is to be improved. According to them, trials on test tracks have shown that a skilled driver can achieve up to 25% better mpg without significantly increasing journey times. An Energy Efficiency Best Practice Programme (EEBPP) case study, *Energy Savings Through Improved Driver Training*, shows that a driver training scheme implemented by a freight operator proved to be highly cost effective in achieving fuel savings of 8% in the first year, while significantly reducing maintenance costs and almost halving the cost of accidents, in addition to cutting annual carbon emissions by an estimated 210 tonnes in the UK.

If a driver's skill can contribute in improving fuel efficiency, then it is logical to conclude that training for car drivers can be of immense help in improving their skills. Consequently, efficiency will be achieved from an improved skill. Monitoring equipment can also play a significant role in checking driver behaviour to promote fuel savings. Once drivers know that their conduct is being checked, it influences their driving behavior in the right direction as the rational driver aims to avoid any legal complications. Results from an EEBPP case study, *Fuel Management for Transport Operators* (which describes the results of a trial of dataloggers to monitor the driver's style and fuel consumption) supports this argument. In such a trial, the recorded data are downloaded into a computer for analysis and can be used to identify good and bad driving practice to support incentives and training. In this study, fuel saving of 6% was achieved, and the accident rate fell by half (Jones and Collings, 1999).

Also according to Jones and Collings (1999), fuel efficiency is also improved if the driver can avoid congested traffic and there is a wide range of computer-based systems to aid route planning. These allow vehicles to take the most fuel-efficient routes, enabling fuel savings in the order of 6%. Driving within speed limits also has a potential of fuel savings. The most recent figures of the Department of the Environment, Transport and Regions (DETR) on vehicle speeds show that 91% of HGVs exceed the speed limit on motorways. Apart from the legal and safety considerations, these lorries are using up to 30% more fuel than they would if they remained within the speed limit. Fuel efficient driving behaviour, correctly done, should also contribute to safe driving. Observing posted speed limits, avoiding aggressive driving behaviours, anticipating traffic situations and avoiding tailgating, all improve fuel economy and traffic safety.

A well-maintained vehicle is a more fuel efficient and safer vehicle. Unfortunately, higher fuel prices have encouraged what has been called "hypermiling" which includes some extreme and unsafe driving practices such as drafting behind other vehicles to reduce aerodynamic drag or coasting with the engine off (in a vehicle not equipped for engine-off-at-idle) (Greene, 2008).

2.5.4 THE ROLE OF THE VEHICLE

The vehicle also plays a significant role in energy consumption. This is affected by such factors as the vehicle technology, the size of the vehicle, the age of the vehicle, among others. Adopting new technologies can play a significant role in improving operational fuel efficiency. This strategy may inlcude the use of low-energy tyres and a range of new, more efficient types of engine. In the UK, the most efficient 1.8 litre cars on the market can achieve 50 mpg, whilst typical cars in this range will actually only achieve about 30 mpg. If all cars were as efficient as these current best models, fuel consumption would fall by around 25% (Jones and Collings, 1999).

The National Energy Board (2009) suggests that continued technological improvement, including aerodynamic and lightweight vehicle body materials, advancements in engine and transmission technologies and other developments, have the potential to significantly improve fuel efficiency. The board also suggests that in addition to improving conventional internal combustion engine technologies, there are also other vehicle technologies available that have the potential to impact future energy demand trends. Examples of other vehicle technologies include hybrid electric vehicles, clean diesel vehicles, flex-fuel vehicles (vehicles designed to run on gasoline or a blend of up to 85% ethanol), alternative fuel vehicles (e.g., ethanol, biodiesel, natural gas, propane, and hydrogen), plug-in hybrids, grid chargeable electric vehicles and fuel cell vehicles.

2.5.5 POPULATION GROWTH

Whilst the population of China is expected to grow from 1.27 billion in year 2000 to 1.44

billion by 2025 (13% growth), its urban population is expected to increase from 35.8% (2000) to 57.2% (and combining the two effects gives an 81% growth in people living in cities). India's total population is expected to grow even more (37% from 1.02 to 1.40 billion) in the same period to almost match China and its urban population is expected to increase from 27.7% (2000) to 37.8% (combined 87% growth in people living in cities). The urban population of the other countries in emerging Asia is expected to double in the same time-span. The future urban population growth in most Asian countries will drive increasing motorization and will have serious consequences for urban road congestion and air pollution as vehicle numbers continue to grow (Rogers, *et al.,* 2006).

2.6 TRANSPORT, SOCIETY AND THE ENVIRONMENT

The rise in road traffic has had a major impact on society, the natural environment and the economy. According to Kockelman (2003), society pays for the congestion created by transport, not just through higher travel times and crash rates, uncertain and missed schedules, additional emissions and personal frustration, but also higher costs for goods and services. After all, commercial delivery services must confront the same traffic delays that personal vehicle occupants face. These delays translate into lowered productivity and more expensive deliveries and commutes, resulting in higher prices for everyone.

In Britain, transport is responsible for nearly 40% of the accidental deaths and, while overall accident rates are declining, casualty rates for pedestrians and cyclists have actually increased. This has made the streets more threatening for pedestrians and cyclists, which further reduces the mobility of those who rely on these modes, especially children. Government travel statistics have revealed a continuing decline in walking and cycling, even for very short trip (Walking in Britain, DETR, 1998; Cycling in Britain, DETR, 1996). For the three in ten households who do not own a car, the increasing dominance of the car has lead to reduced mobility, as alternative methods of transport have declined and reduced availability of local services (Jones and Collings, 1999).

2.7 THE TRANSPORT CHALLENGE FOR INDUSTRY

According to Jones and Collings (1999), as congestion on the UK's road network increases, the damage it causes to the economy is becoming a pressing concern for industry, commerce and government. According to them, the CBI has estimated annual cost of wasted time, fuel and resources to exceed £10 billion. The cost of fuel is set to rise significantly as fuel duty is increased by at least 6% in real terms each year. As a result, the distribution industry must face up to three reasons for change: increased congestion; higher fuel costs; and environmental regulation. These pressures will increase the need to look for ways of improving fuel efficiency and making more efficient use of road space. Also according to Kockelman (2003), automobile congestion has myriad impacts, from wasted fuel and added emissions to frayed nerves, more expensive goods, and elevated crash rates. Its clearest impact is delay, or lost time. Across the US this may average twenty hours per year per person.

2.8 EFFECTS OF CARBON DIOXIDE EMISSION

In today's world, energy problems are becoming an issue of increasing importance. From pollution to the depletion of natural resources, the world must overcome many challenges before the consequences of our energy use become irreversible. For example, if we do not find more environmentally-friendly resources, global temperatures, which have already increased an average of 1.4 degrees Fahrenheit, may continue to rise, melting glaciers and polar ice caps (Stein and Kain, 2009).

Atmospheric levels of CO_2 have increased steadily since the beginning of the industrial revolution and these levels are projected to increase even more rapidly as the global economy grows. Significant climate changes are very likely associated with increased atmospheric concentrations of certain gases, most significantly CO_2. The human and ecological cost of climate changes forecast in the absence of mitigation measures is sufficiently large, and the time scales of both intervention and resultant climate change response are sufficiently long, that prudent action is warranted now (ASME, 2009). Between now and 2050, the global economy is expected to grow by a factor of four and as much as a factor of 10 in developing countries like China and India (IEA 2008). Such growth will inevitably require increased energy use. The International Energy Agency forecasts a 70% increase in oil demand and a 130% increase in CO_2 emissions by 2050. Approximately 65% of global anthropogenic GHG comes from energy-related activities and the remaining 35% comes primarily from agricultural and land-use practices. For most industrial countries, the most significant anthropogenic GHG is CO_2. Most CO_2 is emitted as a result of using fossil fuels. Globally, 89% of primary energy consumed comes from fossil fuels (ASME, 2009).

According to T & E (2008), climate change will have many negative consequences for our environment and society. It will make dry areas drier and increase the risk of flooding in other areas. Among other consequences of a changing climate are droughts, forest fires and health problems due to heat waves. Water availability is projected to decrease in Southern Europe and the Mediterranean especially. Climate change will also lead to widespread biodiversity loss. With a temperature rise of less than 1°C, species such as the Bengal tiger and the mountain gorilla are threatened, while a rise of 1-2°C affects coral reefs, and coastal wetlands. Overall, some 20-30% of plant/animal species will face an increased risk of extinction if the average global temperature increases by more than 1.5 to 2.5°C.

2.9 CONCEPTUAL FRAMEWORK

The writer conducted the research using this conceptual framework. The researcher identified dependent variable and independent variables. The dependent variable was the urban transport energy demand, and the independent variable was efficient logistics.

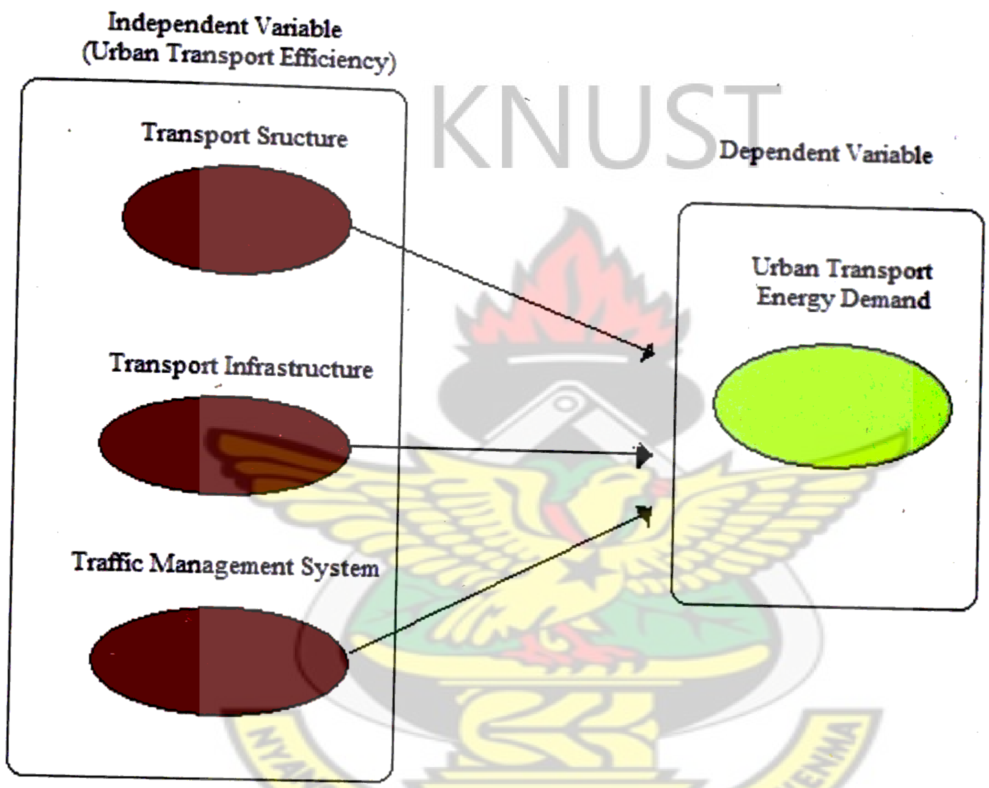
2.9.1 DEPENTDENT VARIABLES

Form the way the topic was framed, urban transport energy demand is dependent on efficient logistics. This makes urban transport energy demand the dependent variable. In this case, the degree of change in logistics efficiency impacts the degree of change in transport energy demand. In other words, a change in logistics efficiency will result in a corresponding change in the demand in urban transport energy, all things being equal.

2.9.2 INDEPENDENT VARIABLES

These are the variables on which urban transport energy demand depends. This is made up of all such factors that affect the efficiency in the transport system. Thus the independent variables have been mainly captured under the heading urban transport efficiency. These include the transport infrastructure, the transport structure and the traffic management system

DIAGRAMMATIC VIEW OF CONCEPTUAL FRAMEWORK



Source: Author's Construct (2009)

Figure 3.1: Diagrammatic View of Conceptual Framework

CHAPTER THREE

METHODOLOGY

3.0 INTRODUCTION

This chapter describes the methodology used for the study. This takes a look at the population, sample and sampling techniques, method of data collection, research design, method of data analysis and the profile of the case being studied.

3.1 POPULATION

The population for the study includes all drivers of different categories commuting along key road links within the city, as well as officials from Urban Roads, National Petroleum Authority, Driver, Vehicle and Licensing Authority (DVLA) and Ghana Statistical Service. According to Urban Roads Report (2004), there are twenty-one key road links in which much congestion levels are recorded. List of these key roads, with their functional class, study length (km) and congestion index are presented in Table 4.1

Table 4.1 KEY ROADS IN ORDER OF CONGESTION LEVEL

Rank	Name of Road	Functional Class	Study Length (km)	Congestion Index (CI)
1	Mampong Road	Principal Arterial	5.0	13.8
2	Suyani Road	Principal Arterial	3.3	8.9
3	Lake Road	Principal Arterial	5.9	7.6
4	Antoa Road	Principal Arterial	5.5	6.0

5	24th February Road	Principal Arterial	5.4	5.8
6	Harper Road	Minor Arterial	2.5	5.6
7	Yaa Asantewaa Road	Collector	1.9	4.9
8	Bantama High Street	Collector	1.4	4.8
9	Offinso Road	Principal Arterial	3.3	4.6
10	Odumasi Road	Collector	1.5	4.5
11	Barekese Road	Principal Arterial	1.2	4.4
12	Southern By-Pass	Principal Arterial	4.2	4.4
13	Western By-Pass	Principal Arterial	5.3	4.0
14	Hudson Road	Minor Arterial	2.3	2.9
15	Maxwell Road	Collector	2.0	2.9
16	New Bekwai Road	Principal Arterial	4.0	2.3
17	Pine Avenue	Minor Arterial	2.3	2.6
18	Kejetia Link (Pinako Road)	Minor Arterial	1.5	2.5
19	Okomfo Anokye Road	Principal Arterial	6.4	2.3
20	Old Bewkai Road	Minor Arterial	1.8	1.9
21	Cedar Avenue	Collector	2.4	1.0
Rank is based on Congestion index (CI). CI represents worst sections of the averages of the peak periods and directions.				

Source: Urban Roads Interim Report, 2004

3.2 SAMPLE AND SAMPLING TECHNIQUE

All the twenty-one key roads had equal chances of being sampled for the study. However, for the purpose of the study, the researcher used a purposive sampling technique to sample the first six roads with the most congestion index, as determined by Department of Urban Roads. These roads consisted of five principal arterial and one minor arterial, in which case, most of the other road links are almost captured by them in terms of geography. Also for the purpose of the study, a convenience sample method was adopted, in which case, a representative sample population of six hundred (600) drivers was employed for this study. For each of the roads understudy, hundred drivers were employed, comprising forty (40) 'trotro' drivers, thirty (30) taxi drivers, twenty-nine (29) private operators and one (1) bus operator.

3.3 METHODS OF DATA COLLECTION

The researcher used both secondary and primary data for the study. The secondary data was collected from the Ghana Statistical Service, the Driver, Vehicle and Licensing Authority (DVLA), the Department of Urban Roads of the Ministry of Roads and Transport, Metro Mass Transit Limited and the Ghana Petroleum Authority, and also other related literature in this field as conducted by other authors. The primary data was obtained from a survey where responses from six hundred drivers that commute on the six sampled key roads were obtained. Also, personal observations were made by the researcher on these roads to study road bottlenecks that cause congestion. Methods used in collecting all these data included personal interviews, administration of questionnaires, and literature searching.

3.3.1 PERSONAL INTERVIEW SURVEY

Interview schedules were used to collect data from some respondents who did not have time to read or incapable of reading through the questions and provide answers accordingly. It gave the researcher the opportunity to react to the respondents' answers or probe for more details or ask personal questions and also encourage effective participation by the respondents. Interviewed respondents like commercial vehicle operators (with very lower level of education) were able to give accurate answers to the questions after explaining the questions to them. The method was however time consuming and costly in terms of money due to much travel which was involved. Again, flexibility could lead to bias in the way questions were asked especially through promptings and the way answers were recorded.

3.3.2 QUESTIONNAIRE

Two sets of questionnaire were prepared. The first set was used to collect information from different kinds of vehicle operators and the second one was used in collecting information from the DVLA.

The questionnaire method is the method of collecting data by the administration of questionnaire through self interpretation of the questions. This is normally done by posting a questionnaire or delivering by hand. Most of the questionnaires administered by the researcher were done by hand. Unlike the interview method, the questionnaire method had no interviewer bias. However, under this method, the respondents need good literacy skills, the absence of which would lead the respondents to seek answers from elsewhere. This particularly posed as a great challenge to the researcher as most drivers had to be interviewed rather than made to fill questions themselves. Again, the possibility of the researcher having less of a feel of respondents was quite imminent.

3.3.3 LITERATURE SEARCHING

Related literature consulted included: published books in the field like Global Logistics and Distribution Planning; Fundamentals of Logistics Management; etc. and articles and journals on energy efficiency; urban transport efficiency; efficient logistics; etc.

3.3.4 THE PARTICIPANT OBSERVATION METHOD

Under this method, the researcher participated in some daily activities in the transport system such as travelling along with some drivers to observe bottlenecks on the roads and also to reconcile some delay causes and their degree of importance as rated by these drivers. In some cases, observations made enabled the researcher to conduct such studies as traffic volume counts, travel time and delay studies, spot speed studies, intersection control studies, vehicle occupancy counts, parking studies, conducts of motorists/pedestrian, among others.

As the researcher participated in these activities, information was recorded in accordance with what was being looked for. The study offered the researcher the opportunity of discovering what was not anticipated like: numerous un-signaled intersection controls at some very critical sections; undue travel times and delays during peak hours on unfamiliar routes; very poor pedestrian controls; etc. There were however, certain inconveniences like boredom resulting from travel delays as experienced in very congested routes; eating the type of food one did not want, etc. One major disadvantage was the high cost involved in terms of time and money.

It was also observed from the study that some of the respondents answered the questionnaires willingly since they felt the importance of the study. There were instances most of the respondents were more than willing to go beyond answering the questionnaires, respond to interviews and give additional information to enrich the researcher's work. Another group of respondents who initially were not willing to grant interview to the researcher, let alone answering the questionnaires, finally gave in when tactfully persuaded. A third group which proved difficult never responded to the questionnaires/interviews. The many 'problems' in the transport system especially undue congestion, higher fuel prices, abuse from police personnel, longer loading time, etc. called for their action, they lamented.

3.4 METHODS OF DATA PRESENTATION AND ANALYSIS

Both quantitative and qualitative methods of data analysis helped the researcher in analyzing the field data collected to extract the relevant information. The quantitative method was used in striking percentages and presenting data in numerical terms where appropriate. The main software used for this included Microsoft Excel and Statistical Package for Social Sciences (SPSS). The qualitative method of analyzing the data was in statement forms. This method was employed where the data could not be quantified.

Also, some aspect of fuzzy set theory was adopted for assessing the efficiency of the transport system. This theory was adopted in order to reduce uncertainty. When using fuzzy evaluation methods, the key step is to build a set of evaluable objects. The outcome of the method depends on the absolute evaluation criteria, which could be obtained by referring to the corresponding optimal figures chosen from the Kumasi city to be evaluated.

3.5 RESEARCH DESIGN

The researcher combined more than a single research design for the conduct of this research. The writer used a cross-sectional design. This is because six different road links were mainly studied in the light of transport efficiency. This made it possible or easier to generalize the findings since the choice of the six road links, being ranked the first six most congested, is quite a representative of the transport situation on the entire road links in the city. The researcher also used longitudinal design in which the trend of petroleum consumption and import growth as well as growth in vehicle in circulation were studied for a period not less than seven years. In which case, a comparative study was made among various years to analyze the trend in congestion levels.

3.6 PROFILE OF THE KUMASI METROPOLITAN AREA (KMA)

The profile of the case under study is presented in three main headings; the regional environment of Kumasi, demographics and socioeconomic recent development and a general description of its economic activities.

3.6.1 THE REGIONAL ENVIRONMENT OF KUMASI

Kumasi as its capital lies between longitude 0° 15' - 2° west and latitude 5° 50' - 7° 40' north and its boundaries are set by the Eastern Region to the east, the Central Region to the south, the Western Region to the southwest, and the Brong Ahafo Region to the west and north. The most significant physical feature is the horse-shoe range of hills running eastward to form part of the main mountain range in the country, i.e. the Koforidua-Kintampo range. The region is drained by the Anum, Pra, Offin and Afram rivers. Lake Bosomtwe, which lies 28km southwest of Kumasi, occupies an area of 48 square kilometers. The mountain range is covered by semi-deciduous forest. Northeast of the region is the guinea savannah woodland. The largest portion of the semi-deciduous forest and the guinea savannah areas are covered by forest and savannah ochrosols. However, along the Afram River, there is a narrow strip of ground water laterite intergrades.

The Ashanti Region has a total population of 3.6 millions (year 2000 census), about one fifth of a total Ghana population of 18.9 millions. The Region is inhabited mainly by Ashantis who speak the Twi Language. Other languages spoken in the Ashanti Region are Ewe, Hausa, Fante, Ga, etc. Kumasi's population consists of about 80 percent Christians and 20% Muslims. The dominant economic activity in the region is agriculture. Cocoa is the most important export crop grown in the region; the heaviest production areas are at Ahafo-Ano and Adansi. Cotton production is concentrated in the savanna and transitional zones mainly around Ejura, Nsuta, Kwamang and Afrancho. Other activities undertaken include mining, timber processing and industry. Gold, which is the next major foreign exchange earner after cocoa, is mined at Obuasi (50km southwest of Kumasi), which is the largest and richest gold mine in the country. Timber processing and industry is centred in Kumasi, with many processing mills located mostly in the Asukwa and Kaasi industrial areas; brewing and bottling enterprises, and vehicle assembly and auto parts. Kumasi, the second most important metropolis of Ghana after Accra, is the main centre of the Ashanti Region with 1,170,270 inhabitants (year 2000 census).

3.6.2 DEMOGRAPHICS AND SOCIOECONOMIC RECENT DEVELOPMENT

Ghana population in March of 2000 was estimated to be 18.9 million inhabitants by the Statistical Services Office (census data). Since 1984, total Ghana population has increased at an annual rate of 2.73%, from 12.3 million inhabitants. Compared with 1970-1984 (2.56%) and 1960-1970 (2.53%) periods, it shows an increase in annual growth rate. However, it should be expected that, as per capita income increases, population growth rates would stabilize and eventually decline.

In recent years, KMA population has increased in proportion to the total Ghana population from 3.24% in 1960 to 61.9% in 2000, but more dramatically to the Ashanti Region population, from 14.72% in 1960 to 32.37% in 2000. Therefore, almost one third of the Ashanti Region population is now located in the Kumasi Metropolitan Area. On the other hand, the proportion of Ashanti Region to total Ghana population has decreased slightly, from 22.03% in 1960 to 19.19% in 2000. These numbers reflect the change in KMA's boundaries between the 1984 and 2000 census, increasing KMA's geographical coverage and, thus its relative population to the Ashanti Region and the nation. According to the housing data, the number of houses has increased in the last forty years at an average annual growth rate of 2.76%, while population has increased at 4.2%. The result has been a sharp increase of the number of persons per house, from 19.34 in 1960 to 34.98 in 2000, an 80% increase in the average occupancy per house.

3.6.3 GENERAL DESCRIPTION OF KMA'S ECONOMIC ACTIVITIES

KMA specializes in a number of activities in agriculture, industry and services. Trade, commerce and farming are leading industries in KMA. By virtue of its geographical position and of its road connections, KMA constitutes probably the most important commercial centre not only in Ghana, but also in West Africa as a whole. Its large markets in fact, constituted the point of arrival and departure of goods produced locally and in neighboring countries. Mining and agricultural production play a major role in the local economy and in the livelihood of large part of the surrounding districts, with wealth derived from substantial gold deposits and agricultural products. Cocoa and high-quality hardwood, are major exports of the Ashanti Region. KMA is also a busy industrial centre with activities in sectors such as wood industry, breweries and vehicle repair small-scale enterprises.

Other major attraction in the city is the National Cultural Centre, west of the Kejetia market. The sprawling complex encompasses a fascinating museum of Ashanti history, a popular library, an excellent crafts shop and an exhibition hall. Classes in traditional dance and drumming are available. One of the centre's more interesting exhibits is the fake golden stool used to trick the British, who had heard that the real Golden Stool held the strength of the Ashanti Empire and demanded it be brought to them.

KMA is also home to numerous educational institutions, including the Kwame Nkrumah University of Science and Technology, one of Ghana's foremost facilities of higher learning, Prempeh College, Wesley College, University College of Education, and Agriculture College, among others.

CHAPTER FOUR

DATA PRESENTATION AND ANALYSIS

4.0 INTRODUCTION

The present chapter attempts to deal mainly with the analysis of the data collected. Data analysis is made up of three sets. The first part analyses secondary data gathered from Ghana Statistical Service, the DVLA, Metro Mass Transit Limited, Ghana Petroleum Authority and the Department of Urban Roads of the Ministry of Road and Transport, to mainly evaluate the transport efficiency of Kumasi and how it relates to energy demand. Evaluation is backed by studies conducted by the researcher on the various roads under study.

The second part analyses data from questionnaires administered to some selected drivers of all categories of vehicles on the six roads. The main purpose of this part of analysis is to identify the role of the driver and vehicle towards the transport efficiency, and also to identify the main factors that cause energy demand on transport.

The third part and the final part of the analysis looks at the trend in oil consumption and imports, which establishes whether transport energy is indeed increasing in part from transport inefficiencies.

4.1 PART 1: EVALUATING THE TRANSPORT EFFICIENCY OF KUMASI

In this section, the transport efficiency of Kumasi is evaluated using three main criteria; transport structure, transport infrastructure and traffic management system.

4.1.1 EFFICIENCY IN THE TRANSPORT STRUCTURE

Under a certain land-use pattern, the total capacity of the urban transportation system is basically determined by the composition of different transport modes in the system. Whether the structure of urban transportation system is harmonized with the land-use pattern, will directly impact the balance between transportation demand and supply. Given the total amount of transportation demand and a certain level of transportation infrastructure in a city, a good transportation structure will most effectively utilize the infrastructure and will help fully realize the functions of urban transportation systems

TABLE 4.1: SUMMARY OF ROADWORTHY VEHICLES IN KUMASI

YR.	MOTOR CYCLE A	PMV UP TO 2000CC 1	CMV UP TO 2000CC 2	PMV ABOVE 2000CC 3	CMV UBOVE 2000CC 4	TOTAL SHARE OF CARS B(1+2+3+)	P/BUS AND COACHS	C/BUS AND COAHES	TOTAL SHARE OF BUSES C	TOTAL A+B+C
2003	1510	5 091	25 361	8457	338	39247	979	9 627	10606	**51 363**
2004	442	16 378	31 315	2 627	7 00	51020	1 034	6818	7852	**59 314**
2005	1828	9729	28773	81 09	621	47232	1062	4303	5365	**54 425**
2006	1324	9888	29991	7564	6	47449	1877	9237	11114	**59887**
2007	1107	12147	35292	5950	6274	59663	2798	7382	10180	**70950**
2008	1703	25284	20826	8675	239	55024	1640	13269	14909	**71636**
2009	817	14089	9717	6233	993	31032	679	5891	6570	**38419**

Source: Modified from Ghana Statistical Service (2009)

a. Motor cycle = Motor cycles of all categories
b. PMV up to 2000 CC = Private motor vehicles up to 2000 cubic capacity
c. CMV up to 2000CC = Commercial motor vehicles up to 2000 cubic capacity
d. PMV above 2000CC = Private motor vehicles above 2000 cubic capacity
e. CMV above 2000CC =Commercial motor vehicle above 2000 cubic capacity
f. P/BUS and Coaches = Private buses and coaches
g. C/BUS and Coaches = Commercial buses and coaches

TABLE 4.2: THE TRANSPORT STRUCTURE OF KUMASI

YEAR	SHARE OF BUSES	SHARE OF CARS	SHARE OF MOTOR CYCLES
2003	20.6%	76.4%	2.9%
2004	13.2%	86.0%	0.7%
2005	9.8%	86.8%	3.4%
2006	18.6%	79.2%	2.2%
2007	14.3%	84.1%	1.6%
2008	20.8%	76.8%	2.4%
2009	17.1%	80.8%	2.1%

Source: Modified from Ghana Statistical Service (2009)

Considering the transportation structure, smaller cars share a large portion representing 76.4%, 86.0% …, and 80.8% of the total amount of vehicles in 2003, 2004,… and 2009 respectively, as shown in Table 4.2. Against this is a relatively smaller share of buses representing 20.6%, 13.2% …, and 17.1% in the various years. Such a situation is not consistent with the land-use pattern in the city and is the main reason for traffic congestion and low transportation efficiency. This has resulted in a high volume of mixed traffic flow. The impetus for the increased interest in such a transportation structure is twofold. First is the relative **load occupancy** of the varying vehicle types, and second is the **traffic length** a particular structure will create on the road. Summary of vehicle occupancy rates are shown in Table 4.3 below:

TABLE 4.3: SUMMARY OF VEHICLE OCCUPANCY RATES IN KUMASI

Road link	Car	Taxi	Pick-up/van	Mini/small bus	Medium large bus	Truck	Motor bike	Bike
Mampong	2.4	3.1	8.4	11.7	23.2	3.7	1.2	1.0
Sunyani	2.3	3.7	3.1	13.7	31.1	3.4	1.5	1.0
Lake	1.8	3.1	3.8	11.5	10.4	2.5	1.3	1.0
Antoa	2.3	3.9	4.2	13.4	20.6	2.7	2.2	1.0
24th Feb.	2.0	3.4	3.3	12.0	21.5	4.0	1.1	1.1
Harper	2.0	3.0	2.4	5.6	8.0	3.5	1.3	1.0
Wtd. Ave.	**2.1**	**3.4**	**4.2**	**11.3**	**19.1**	**3.3**	**1.4**	**1.0**

Source: Modified from Urban Roads Interim Report Vol. 2, 2004

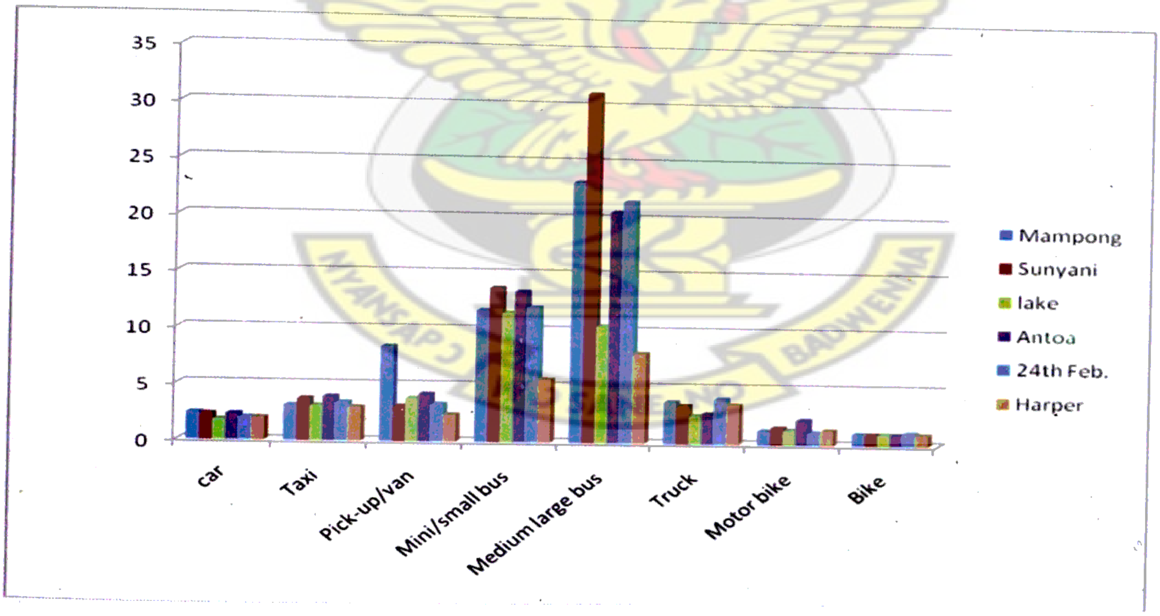


Figure 4.1: Bar Chart Showing Summary of Weighted Average Vehicle Occupancy Rates in Kumasi

The results from Figure 4.1 give comparable values for most of the vehicle types. It is interesting to note that the mini/small bus and taxi vehicle categories that constitute more than 80% of traffic on the various sections have an average of about 2.1 to 11.3 persons in a vehicle for an average day. This situation reflects a study made in 2004, in which case the total number of cars was relatively lower than in very recent years. This means the situation is worse-off, all things being equal, in very recent times. The fact is that, a medium large bus which takes an average of 19.1 persons takes 6 more times than taken by a taxi and even almost twice that of mini/small buses. In other words, about a 100 taxis and 100 mini/small buses could be replaced by nearly 16 and 50 medium buses respectively. This situation indicates that the road space is not being utilized efficiently and calls for congestion-based strategies to be employed to improve the system.

Length of Traffic on Roads

Not only will bigger buses be more efficient in terms of vehicle occupancy rates, but also in terms of traffic length efficiency, since fewer vehicles means relatively shorter traffic length. Though the medium bus is relatively longer than other cars, in relation to the occupancy rate, its length is still much shorter when the total cars that serve the same occupancy rate are put together. Since statistics shows that more than 80% of vehicles are smaller vehicles, the road space is not being efficiently utilized, and these have translated into undue traffic length translating into longer travel time and consequently increased demand for energy.

4.1.2 URBAN TRANSPORT INFRASTRUCTURE

Urban transport infrastructure mainly includes roads, parking lots, vehicles and transportation terminals. It is the direct carrier of urban transportation demand and the basic input of the capacity of transportation supply. Two main criteria form the basis for evaluating the efficiency of the transport infrastructure. These comprise the utilization of the road space/length and the capacity of the road to serve the traffic demand.

4.1.2.1 USAGE OF ROAD INFRASTRUCTURE

Considering the usage of roads, the ratio of the amount of motor vehicles over various lengths of roads in the city is much higher. Though in each day there are more vehicles which are not driven on roads, the load on roads is still very high. This could be explained by the severe congestion and delay levels as have been explained above.

4.1.2.1.1 ROAD CAPACITY

Most of the sections on the roads have reached critical capacity, with volume to capacity ratios above 0.60. Meanwhile, the vehicles on the roads keep on increasing, which means that the road capacity is relatively less efficient to serve the total traffic. This contributes in part to the severe congestion resulting in delay and subsequently poor performance of the road. Summary of results of the capacity analysis is given in Table 4.4 below.

TABLE 4.4: SUMMARY RESULTS OF CAPACITY ANALYSIS FOR ROADS

Road Link	Road Section/Segment	Length (m)	Type of Facility	Vol-to-Capacity (V/C) Ratio
Mampong Road	Tafo Mkt.-Suame New Rd. Int	1625	2-lane 2-way	0.51
	Suame New Rd. Int- Mag. New Rd. Link Int.	375	2-lane 2-way	0.56
	Mag. New Rd. Link Int-Tafo Nhy. Rd. Int.	525	2-lane 2-way	0.87
	Tafo Nhy. Rd. Int-Suame R/A	1075	2-lane 2-way	0.87
	Suame R/A-Kotoko Rd. Int.	300	4-lane 2-way	0.82
	Kotoko Rd. Int-Kejetia Tlite	1050	4-lane 2-way	0.79
	Project road	4950		
Sunyani Road	Siloam Hosp. Jn-Agric Rd. Int.	900	2-lane 2-way	0.72
	Agric RD. Int.-Siloam/2 Brig. Rd. Int.	400	2-lane 2-way	0.63
	Siloam/2 Brig. Rd. Int.-Sofoline R/A	550	2-lane 2-way	1.35
	Sofoline R/A-N. Suntreso Rd. Int.	950	2-lane 2-way	1.14
	N. Suntreso Rd. Intt-Bekwai R/A	500	2-lane 2-way	
	Project road	3300		
Lake Road	Atonsu Terminal-Gyinyase Int	1060	2-lane 2-way	0.54
	Gyinyasi Rd. Int-Kaasi Rd. Int.	1250	2-lane 2-way	0.67
	Kaasi Rd. Int.-Southern BPass Int.	670	2-lane 2-way	0.46
	Southern BPass Int-Hudson Rd. Int	230	2-lane 2-way	0.79
	Hundson Rd. Int-Dadiesoaba Rd. Int.	450	2-lane 2-way	0.63
	Dadiesoaba Rd. Int-Maxwell Rd. Int.	850	2-lane 2-way	0.63
	Maswell Rd. Int.-Prempeh 1 St. Int	1250	2-lane 2-way	
	Prempeh 1 St. Int-Utc Tlite	100	2-lane 2-way	
	Project road	**5860**		
Antoa Road	Dr. Mensah-Odumasi Rd. Int	150	1-lane 1-way	
	Odumasi Rd Int-Kotoko Rd Int	250	2-lane 2-way	
	Kotodo Rd. Int-Manhia R/A	650	2-lane 2-way	
	Manhia R/A-Burma Rd Int	300	2-lane 2-way	0.66
	Burma Rd Int-Dichemso Rd. Int	300	2-lane 2-way	0.66
	Dichemso Rd Int-Airport R/A	1100	2-lane 2-way	0.81
	Airport R/A-Buokrom	2750	2-lane 2-way	0.77
	Project road	**5500**		
24th February Road	KNUST Jn-Bomso Jn	550	4-lane 2-way	0.50
	Bomso Jn-STC Tlite	1500	4-lane 2-way	0.64
	STC Tlite-Anloga Jn	600	4-lane 2-way	0.68
	Anloga Jn-Stadium Jn	950	4-lane 2-way	0.64
	Stadium Jn-Amakom Tlite	350	4-lane 2-way	0.56
	Amakom Tlite-Labour R/A	700	4-lane 2-way	0.56
	LabourR/A-Asafo Market R/Da	450	4-lane 2-way	
	Asafo Market R/A-UTC Tlite	250	2-lane 2-way	
	Project road	**5350**		
Harper Road	Ahodwo R/A-Pine Ave. Int	1425	2-lane 2-way	0.52
	Pine Ave. Int-Prempeh 1 St Int.	800	2-lane 2-way	0.72
	Prempeh 1 St. Int.-Kingsway R/A	300	2-lane 2-way	
	Project road	**2525**		

Source: Urban Roads Interim Report (2004)

4.1.3 TRAFFIC MANAGEMENT EFFICIENCY

Urban traffic management system is an important component which can properly control and guide the distribution of traffic flows on roads. Even if the urban transport infrastructure in different cities are at the same level, the capacity of urban road systems may vary greatly with different traffic management systems. In this analysis therefore, efficiency of the traffic management system is based on three criteria; transport service level, intersection controls and behavior/conducts of motorists/pedestrians.

4.1.3.1 URBAN TRANSPORT SERVICE LEVEL

An efficient traffic management system should necessarily result in the best transport service level such as swiftness, devoid of undue delays. Otherwise, traffic demand volume will increase, which means that a corresponding supply will be required to serve such a demand level. Supply, among other things, includes **energy** which forms the basis for this study. Travel time and delay studies are presented in Table 4.5 below.

TABLE 4.5: WEIGHTED AVERAGE OF TRAVEL TIME /DELAY STUDIES

Road link	Length (m)	Average travel speed, ATS(km/h)	Total Delay (Sec)	Congestion Index (CI)	Level of Service
Manpong road	4950	5.6	3066.0	13.8	F
Sunyani Road	3300	8.4	1315.0	8.9	F
Lake Road	5860	9.8	1995.3	1.6	F
Antoa Road	5500	11.5	1491.0	6.0	F
24th February Road	5350	12.6	1386.0	5.8	F
Harper Road	2525	9.7	850.0	5.6	F
Wtd. Average	**4580.8**	**9.6**	**1683.9**	**7.0**	**F**
Operational values represent worst of the averages of the peak periods and directions.					

Source: Modified from Urban Roads Interim Report, Vol. 2 (2004)

Table 4.5 records very severe travel speed and delay levels for all six roads. The weighted average of these total are 9.6 km/h and 1683.9 seconds (28.1 minutes) respectively. Under very normal conditions, these vehicles could have travelled at least 50 km/h with very little delay. This means that the fuel loss is resulting from the 1683.9 seconds delay spent in traffic, which makes the transport service very less efficient. This loss is relative to each vehicle, which means that, the collective loss from the thousands of vehicle per day can be very threatening and even worse when quantified over a longer period of time. This was even in the case of 2004. Responses from questionnaires administered to the sampled drivers (as shown in Figure 4.6) gave an average of 2.6km/h. This figure predicts a much worse service level, indicating a relatively higher congestion than as recorded in 2004.

TABLE 4. 6 AVERAGE SPEED LEVEL DURING PEAK HOURS

	Response	Frequency	%	Valid %	Cumulative %
Valid	1KM/HR	120	20.0	20.0	20.0
	2KM/HR	117	19.5	19.5	39.5
	3KM/HR	111	18.5	18.5	58.0
	4KH/HR	142	23.7	23.7	81.7
	Zero resp.	110	18.3	18.3	100.0
	Mean	2.6			
	Total	600.0	600.0	600.0	

Source: Field Survey (2009)

Considering the transportation service level in the city, the six roads all have severe traffic congestion . Among the reasons accounting for this, are the high amount of motor vehicles, overload of roads, mixed traffic flow and time distribution of traffic demand.

4.1.3.2 INTERSECTION CONTROLS

The study on the roads reveals a number of un-signaled intersection controls, posing as a major contributor to severe traffic congestions at some critical sections. There are situations where intersection controls are done manually by police personnel. It does help control the situation though, but cannot be effectively and consistently done. Table 4.6 shows examples of un-signaled intersections on some major roads:

TABLE 4.7: UN-SIGNALED INTERSECTIONS ON SOME MAJOR ROADS

Road	Un-signaled Intersections
Mampong road	3-legged intersection with the Suame New road
	5-legged Suame roundabout
	3-legged intersection with Kotoko road
Lake road	3-legged intersection with the Kwadaso Agric road
	4-legged Sofoline roundabout, which is currently under construction
Sunyani road	3-legged intersection with Gyinyase road
	4-legged intersection with Kaasi and Ahinsan roads
Antoa road	4-legged intersection with Southern By-pass/Eastern By-pass
	3-legged intersection with the Dichemso Extension Road
	5-legged Airport roundabout- intersection with the Okomfo Anokye road and the Airport road

Source: Field survey (2009)

The results reveal a collapse or breakdown at the intersections with the situation at Suame Roundabout being the worst on the Mampong road. Capacity at the intersections is woefully inadequate to handle even the existing traffic volumes, much less to handle future traffic demand. The breakdown at these intersections, contribute tremendously to the poor performance of the road. On the Lake Road, the Southern By-pass intersection is the worst that records total collapse or breakdown at intersections. In general, speed drops considerably when approaching the intersections and increases steadily after these control points. On the average, queue build-up is about 900 meters from the Gyinyase road intersection during the morning peak period. Such a traffic system is inefficient, and the major consequence is the many recorded cases of severe congestion and longer travel time/delays.

4.1.3.3 MOTORISTS/PEDESTRIANS' CONDUCT

An efficient traffic management system should effectively control the behavior of motorists/pedestrians to improve traffic flow and performance of roads. On the contrary, observations on the roads reveal many cases of abuse by motorists/pedestrians on the roads, which also contribute quite significantly to the poor performance of the roads, resulting in congestion. This suggests that, the traffic management system that controls motorists and pedestrian conducts are less efficient. Poorly designed and inadequate parking lots/bus stops and pedestrian crossing are major factors that have contributed to this menace. The following are some observed abuses by motorists/pedestrians on the roads:

***Mampong road*:** At the intersection with the Suame New Road, motorists stop and pick passengers illegally, creating safety problems among other things. The activities of mechanics along the route, around the Tafo cemetery area create a lot of hazardous conditions along the road. Broken down trucks were seen parked by the roadside to be repaired by the mechanics whiles others used the roadside as their parking place. The sidewalks, which were in bad condition, were already taken over by the heavy vehicles which were parked on them. Along the road section between Suame Roundabout and Kejetia, the sidewalk has been taken over by traders, thereby forcing pedestrians to walk on the road. Commercial drivers stop at unapproved points to pick and drop passengers.

Sunyani road:At the intersection with the Kwadaso Agric Road, motorists stop and pick passengers close to the intersection. This creates safety problems and congestion on the road. Around the Sofoline roundabout, commercial vehicles have created an illegal station where motorists stop and pick passengers, creating undue congestion along the roads.

Lake road: At the intersection with the Gyinyase road, trucks are usually parked in the lay-by for longer periods of time, creating problems for other motorists to drop and pick passengers. This creates congestion and safety problems. Motorists stop and pick passengers anywhere on the road and pedestrians cross haphazardly within the intersection.

Antoa road: The Antoa road is one of the roads that have few bus stops and pedestrian crossings. Motorists stop and pick passengers anywhere and pedestrians cross anyhow. Quite close to the roundabout, is an illegal taxi rank in which vehicles turning to and from the rank create congestion and safety problems.

All these abuses have had a potential of disrupting traffic flow thereby creating undue congestion. The situation at the central market is worse, as pedestrians and traders have taken over some traffic lanes entirely. The traffic management system has not been efficient enough, meaning that transport resources will continuously be required to service its demands.

4.2 PART 2: RESULTS AND FINDINGS FROM THE PRIMARY DATA

This section presents and analyses data from the questionnaires administered to the vehicle operators. The import is to assess driver skill and vehicle contribution to the transport efficiency, and also to identify some other possible causes of travel delays. These are presented in appropriate tables and/charts and are discussed as follows:

4.2.1 THE ROLE OF THE VEHICLE

Most authors have argued that, the vehicle plays a significant role in optimizing the use of petrol. Such factors often discussed in line with this include the age of the vehicle, quality of oil, maintenance culture, among others.

TABLE 4.8: AGE OF VEHICLE

	Response	Frequency	%	Valid %	Cumulative %
Valid	<5yrs	82	13.7	13.7	13.7
	5-10yrs	150	25.0	25.0	38.7
	10-15yrs	241	40.2	40.2	78.8
	>15yrs	127	21.2	21.2	100.0
	Total	600	100.0	100.0	

Source: Field Survey (2009)

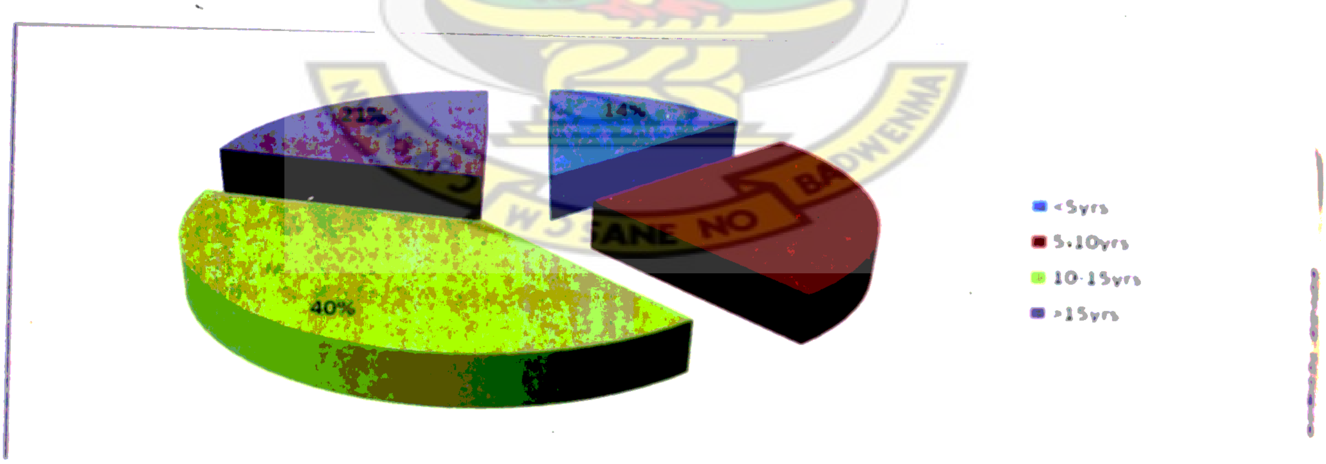


Figure 4.2: Pie Chart Showing Responses on Age of Vehicle

Of the entire 600 responses, 40.2% indicated that their car had spent 10-15 years. 25%, said theirs ranged from 5-10 years. Vehicles indicated as above 15 years constituted 21.2%. Only 13.7% said their cars had spent below 5 years. This clearly shows that most of the vehicles on our roads are quite aged and over-used. The fact is that, though a five-year car might not necessarily be over-aged, most of the vehicles operated on commercial basis however became weak after a period of 2-4 years. This means that in most instances, vehicles especially commercial vehicles that ranged from 5-15 years and more are generally relatively weaker. Weaker vehicles also have the high tendency of consuming more fuel, all things being equal. On the other hand, vehicles that are less than 5 years, have the potency of being relatively strong in every sense, especially the engine which is proven by many authors to have a relatively lower fuel consumption rate. Of the 150 respondents who said their vehicles were less than 5 years, the study unfortunately reveals that more than 90% of them fell into the category of the private vehicle operators.

The import of this is that, commercial vehicles are the most consumers of fuel and if they largely fall into the over-aged range, it means then that one major contributor of high energy demand is over-aged vehicles. Also, the study reveals that about 98% of the vehicles were bought as second–hand vehicles. Of the few that constituted the brand-new model belonged to the category of private vehicle operators. Second-hand in every sense means relatively less efficient vehicles. Such a preponderance of second-hand vehicles in itself makes the transport system less efficient, and thus a contributing factor to increased energy usage/demand.

4.2.1.1 MAINTENANCE CULTURE

Though most cars on our roads are over-aged cars, this might not necessarily mean that they constitute a major contributor to increased fuel consumption, if they are not over-used, or perhaps are well maintained. This means that a badly maintained vehicle which is 4 years or below may consume more fuel than an 8-year old which is well maintained. This assertion means that vehicle maintenance plays a key factor in fuel consumption. Among such determinants of good maintenance culture included the frequency of engine oil change and its source of purchase, kind of tyres normally bought and the frequency of vehicle servicing, etc.

TABLE 4.9: RATE AT WHICH ENGINE OIL IS CHANGED

		Frequency	%	Valid %	Cumulative %
Valid	<1 MONTH	420	70.0	70.0	70.0
	1 MONTHS	4	.7	.7	70.7
	3 MONTHS	176	29.3	29.3	100.0
	Total	600	100.0	100.0	

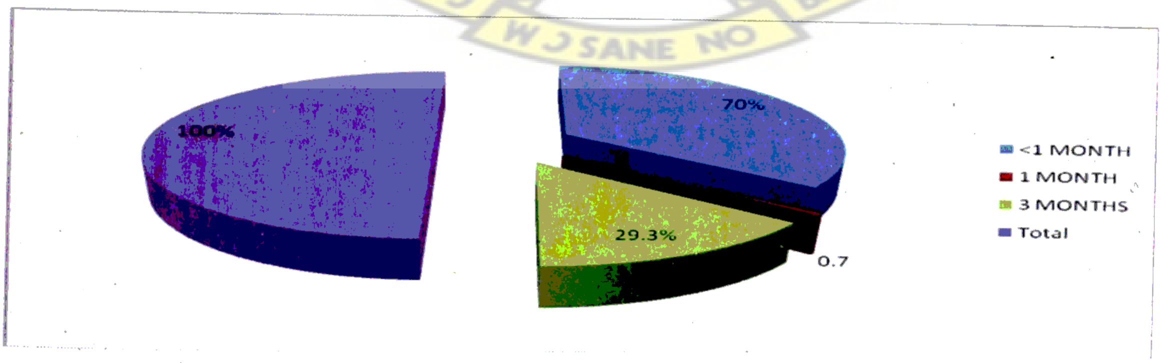


Figure 4.3: Pie Chart Showing Responses on Rate at which Engine Oil is changed

Regarding the rate at which drivers changed their vehicles' engine oil, 70% indicated less than 1 month. 0.7% changed theirs every month whilst 29.3% changed theirs every 3 months as shown in Table 4.9. The 0.7% respondents who changed theirs every month were mainly bus operators, the 70% respondents who indicated 1 month were mostly taxi and 'trotro' operators, whilst private operators mostly indicated 3 months. This practice was fairly good, not conclusively though, and might not be a serious contributor to higher fuel consumption, all things being equal. However, these drivers could not indicate specifically that, the rate of change in engine oil was relative to any specific mile/distance coverage. Irrespective of the mileage, oil change was done mostly according to the various schedules as mentioned earlier. In this sense, such a practice may still affect the engine quality which eventually may result in more fuel consumption, even in insignificant proportion.

TABLE 4.10: SOURCE OF ENGINE OIL

	response	Frequency	%	Valid %	Cumulative %
Valid	CERTIFIED OIL COMPANIES	458	76.3	76.3	76.3
	MECHANICAL SHOPS	124	20.7	20.7	97.0
	INDIVIDUAL SELLERS	18	3.0	3.0	100.0
	Total	600	100.0	100.0	

Source: Field Survey (2009)

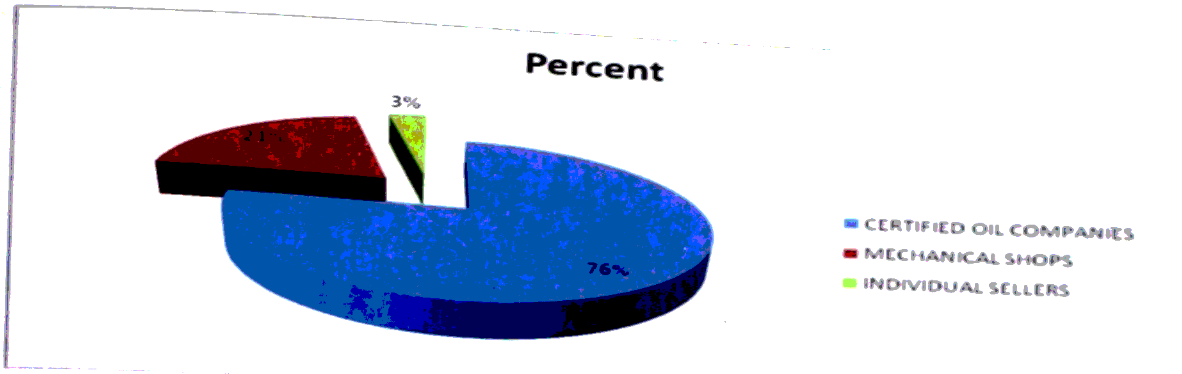


Figure 4.4: Pie Chart Showing Responses on Sources of Engine Oil

The quality of engine oil has a high potency of affecting the quality of the vehicle engine. It has been initially been established that the quality of engine can affect the rate of fuel consumption. This makes the quality of engine oil particularly important. The source from which engine oil is purchased may also determine/affect the quality of engine oil. Referring form Table 4.10, drivers were tested on the sources from which they normally bought their engine oil. 76.3% said they normally bought theirs form certified oil companies such as Shell and Total. Those who indicated they bought theirs from mechanical shops constituted 20.7% and those of individual sellers totaled 3%.

It could be deduced that, most drivers use good quality engine oil, since most of them bought from certified oil companies. Also, most of the mechanical shops are known to be dealers in products from these same companies. However, this generalization could stand if the certified oil companies in deed sell very quality oil. In relative terms, theirs may seem better, but may objectively not be so. This thought is being raised because, most drivers complained that the fuel they bought in recent years was relatively lighter and less quality than those previously bought. However, until proven, the researcher concludes that the source contributes quite less to more petroleum consumption.

TABLE 4.11: KIND OF TYRES NORMALLY PURCHASED

	Response	Frequency	%	Valid %	Cumulative %
Valid	BRAND NEW TYRES	65	10.8	10.8	10.8
	SECOND-HAND TYRES	535	89.2	89.2	100.0
	Total	600	100.0	100.0	

Source: Field Survey (2009)

In as much as the engine plays a significant role in fuel consumption, the quality of tyres used can equally affect the vehicle's fuel consumption. According to Jones and Collings (1999), adoption of new technologies such as low-energy tyres and a range of new, more efficient types of engine have the potency of improving the operational fuel efficiency of vehicles. From Table 4.11 which indicates the type of tyres normally purchased, 89.2% said they normally bought second-hand tyres, whilst only 10.8% bought theirs as brand new. This clearly shows that most of the vehicles on our roads use less efficient tyres since new tyres are most generally efficient than second-hand tyres. Also, of the few 10.8% respondents who usually bought theirs as brand new, more than 90% fall into the category of private vehicle operators. The commercial vehicles which consume more fuel by the nature of their operations are those who buy second-hand tyres, which means that the kind tyres used by vehicle operators contribute to high fuel demand.

TABLE 4.12: FREQUENCY OF VEHICLE SERVICING

	Response	Frequency	%	Valid %	Cumulative %
Valid	ONCE EVERY 3 MONTHS	22	3.7	3.7	3.7
	ONCE EVERY SIX MOTHS	57	9.5	9.5	13.2
	ONCE EVERY YEAR	19	3.2	3.2	16.3
	AS AND WHEN IT BREAKS DOWN	497	82.8	82.8	99.2
	OTHERS	5	.8	.8	100.0
	Total	600	100.0	100.0	

Source: Field Survey (2009)

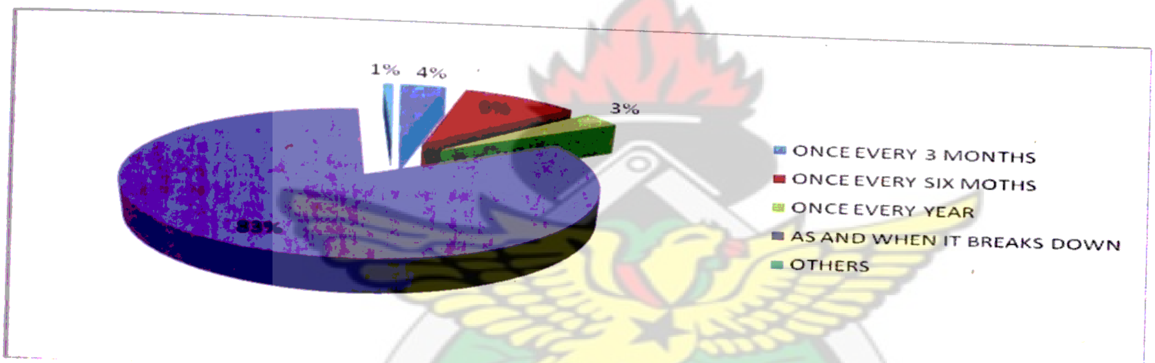


Figure 4.5: Pie Chart Showing Responses on Frequency of Vehicle Servicing

A well-planned vehicle servicing plan if followed plays a key role in improving the efficiency of the vehicle in every essence, particularly efficiency in its fuel consumption. The reverse is very true, thus untimely vehicle servicing can result in inefficiency due to such factors as less efficient engine, increased breakdown and its associated cost such as time waste and total failure of vehicle.

From Table 4.12, 3.7%, 9.5% and 3.2% indicated they serviced their vehicles once every 3 months, 6 months and 1 year respectively. Private car and metro bus operators were the most that fell into these categories of servicing schedules. Majority of vehicle operators however followed no particular scheduled plan for servicing their vehicles. Amongst this group, 82.8% indicated that they only serviced their vehicles as and when the vehicle broke down. Those who fell into the 'others' category totaled 0.8%, giving such reasons as: sometimes servicing is done at the time of engine oil change or when prompted. This means that, bad maintenance culture amongst vehicle operators constitute a significant share of the major factors that account for high energy demand on transport.

TABLE 4.13: SOURCE OF VEHICLE SERVICING

	Response	Frequency	%	Valid %	Cumulative %
Valid	RECOGNISED INSTITUTION	50	8.3	8.3	8.3
	INDIVIDUAL SPECIALISTS	550	91.7	91.7	100.0
	Total	600	100.0	100.0	

Source: Field Survey (2009)

Not only is servicing culture poor amongst vehicle operators, but also the sources from which these vehicles are serviced are generally less efficient. From Table 4.13, 50 of the respondents said they normally had their vehicles serviced at recognized institutions such as Toyota. These represented only 8.3% and were mostly private and company vehicle operators. The rest, representing 91.7%, usually had theirs serviced by individual specialists. This gives a sharp contrast and very bad for the transport system. The problem is that, these individual specialists hardly use machines that detect specific problems and their intensities, and thus operated mostly on 'trial and error' basis, and what they think have worked over a certain period of time, without any specific theory. Most drivers who were interviewed as to why they opted for this choice gave such reasons as: individual sellers charge relatively lower fees; individual sellers are more available; individual sellers do not make us follow any cumbersome procedures to be attended to; individual sellers operate quickly; etc. These drivers did not know the future implications of their choice, especially in terms of fuel efficiency. What mattered most to them was that the car could move, which makes the transport system very inefficient.

TABLE 4.14: VEHICLE SERVICING DECISION

	Response	Frequency	%	Valid %	Cumulative %
Valid	WHEN A FAULT IS DETECTED	497	82.8	82.8	82.8
	ACCORDING TO MY MAINTENANCE PLAN SCHEDULE	98	16.3	16.3	99.2
	OTHERS	5	.8	.8	100.0
	Total	600	100.0	100.0	

Source: Field Survey (2009)

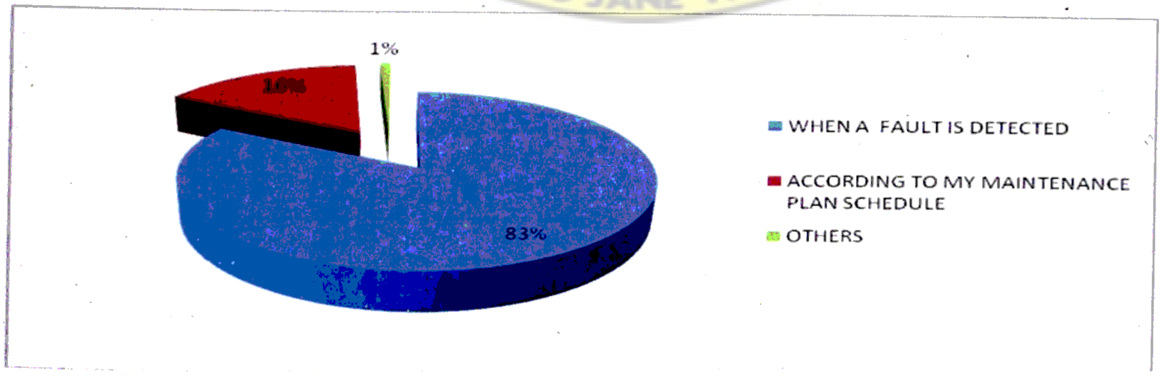


Figure 4.6: Pie Chart Showing Responses on Vehicle Servicing Decision

Table 4.14 shows responses from the study on the vehicle servicing decision of drivers. With a total response of 600, 82.8% said they mostly decided to have their vehicles serviced when a fault is detected. This figure is of course, not surprising as it corresponds to the number of drivers who indicated they had no servicing schedule plan, but only serviced their vehicles as and when it broke down. Notwithstanding, those who indicated they followed a maintenance plan schedule totaled 16.3%, a figure also very similar to those who followed the three different serving frequencies of once every 3 months, 6 months and 1 year. 8% ticked 'others' with such reasons as any time it occurred to them to, especially during oil change or at washing bay.

4.2.2 THE ROLE OF THE DRIVER BEHAVIOUR

The driver's skill, in no doubt, also plays a significant role in achieving fuel efficiency. Such skills include: acceleration control, route planning, and general efficiency practices. Determining factors for good driver behavior in this case included: level of education, training programmes attended and also interviews that tested general driver behavior.

TABLE 4.15: ATTENDENCE OF REFRESHER COURSES

Response		Frequency	%	Valid %	Cumulative %
Valid	YES	25.8	4.3	4.3	4.3
	NO	574.2	95.7	95.7	100.0
	Total	600	100.0	100.0	

Source: Field Survey (2009)

With regard to training, drivers were asked whether they had had any form of refresher courses to improve their driving skills. It is not surprising to know that most of these drivers had not. From Table 4.15, only 4.3% indicated they had had some form of training whilst a majority of them, representing 95.7% indicated they had no training experience. Those in the category of 'YES' were mostly company drivers and a few station drivers.

An interview with some of them revealed that such training programmes occurred once and that they did not see any bearing of that on their driving skills. Regarding how they learnt how to drive, most of the commercial vehicles, especially the 'trotro' operators said they were taught by 'master drivers', during the time they worked as conductors. Majority of those who attended driving school were private vehicle operators. Asked about why the drivers did not attend driving schools, they gave such reasons as: driving school operators charge higher fees; driving school operators focus primary on theory, with little attention to practice; driving school operators will not have patients for people of lower educational levels like we; I just don't like driving school operators; etc.

All these are clear indications of how most drivers lack the right knowledge and skill in driving. They actually do not see the essence in attending training programmes, and regard it as unnecessary cost. This is a major reason for the worse recorded cases in such practices as decision in vehicle servicing, kind of tyres purchased, and the source of engine oil, among others.

TABLE 4.16: EDUCATIONAL LEVEL

		Frequency	%	Valid %	Cumulative %
Valid	MSLC	289	48.2	48.2	48.2
	JHS	107	17.8	17.8	66.0
	SHS	61	10.2	10.2	76.2
	TERTIARY	61	10.2	10.2	86.3
	LITERATE	82	13.7	13.7	100.0
	Total	600	100.0	100.0	

Source: Field Survey (2009)

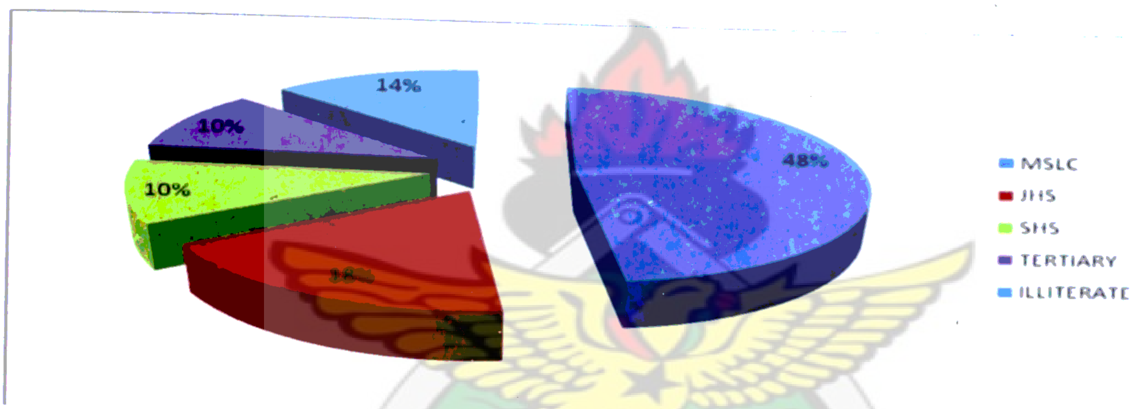


Figure 4.7: Pie Chart Showing Responses on Educational Level

Table 4.16 shows the responses on the study on educational levels of the sampled drivers. Of a total response of 600, 48.2%, 7.8%, and 10.2% indicated they reached MSLC, JHS and SHS levels respectively. 10.2% and 13.7% said they reached tertiary level and are illiterates respectively. Of those in the category of tertiary level, almost all of them fell into the private vehicle category. The rest constitute a mix of commercial operators with majority of illiteracy group being largely 'trotro' operators.

An interview with most of the commercial vehicle drivers on why they chose the driving profession, they gave such reasons as: I was advised by family to go into driving when I could not further my education to higher levels; I was enticed by my mates who were in the driving profession; I learnt driving whilst I was a conductor and so decided to be my own boss; driving takes a relatively lesser time to learn than other professions like carpentry, electricals, etc; driving is the profession I love doing; among others.

These reasons, among others, go to tell that most people do not see driving as a profession for people who have attained higher educational levels, and therefore have relegated it to low level educational holders, school drop outs and illiterates. The ideologies exhibited by these groups are thus translated into the driving profession, and in most cases, done haphazardly. As a result, most of these drivers do not even see the essence in following any maintenance or servicing plan, and in most cases do not view maintenance cost to have any form of future benefit. These reasons have equally translated into careless driving as seen on our roads, with most drivers perceiving smart driving as wrong overtaking, unnecessary crossing, over-speeding, more runs without commensurate attention to machine capacity, etc. The results of these actions have been eminent in the ever increasing rates in road accidents, undue congestion, non-homogenous traffic and the increasing growth in transport energy demand, etc.

4.2.3 CAUSES OF TRAVEL DELAYS

Drivers were equally asked about their knowledge of the possible causes of travel delays. These factors included traffic congestion, poor road network/car condition, road checkpoints, number of traffic lights, pedestrian and trading obstruction, narrow traffic lanes and reserved parking lots. Drivers were asked to rate these factors according to their degree of importance in causing travel delays. The rating ranged from 'not so important', fairly important', 'important', 'very important' and not applicable. The results of these are presented in Tables 4.17 – 4.23, as shown in appendix 2, and are analysed as follows:

Traffic congestion

Traffic congestion received a 100% response of being the major factor causing delays in travel time. A total of 55.7% of respondents rated traffic congestion as a very important cause, whilst the rest, representing 44.3% said it was important.

Pedestrian obstruction

In general, most drivers did not rate pedestrian obstruction as very important cause in travel delays. 22% and 38.2% of them said it was not so important and fairly important respectively. But 16.5% and 14.0% thought it was as much important and very important cause of travel delays. 9.3% of respondents however rated it as not a cause to their travel delays.

Trading obstruction

Trading obstruction was however rated by many as important and very important cause of travel delay, which constituted 16.8% and 31.5% of respondents respectively. 15% and 22.8% however felt it was fairly important and not so important, whilst 13.8% indicated trading does not obstruct their travel time.

Narrow traffic lanes

Majority of respondents said most traffic lanes were narrow and thus rated it as very important cause of travel delays, which were represented by 62.8% of respondents, with 20.5% also rating it as important. The rest were shared across the remaining ratings.

Poor road network

Most drivers explained that most of their destinations were restricted to one or few routes, and thus contributed largely to the delay in travel time. 75.3% rated it as very important, with 9.2% and 15.5% rating it as fairly important and important respectively.

Others:

Other reasons that were rated as causes of travel time delays included longer loading times, unsmooth roads, etc

4.3 PART 3: GROWTH IN PETROLEUM CONSUMPTION AND IMPORTS

TABLE 4.24: NATIONAL PETROLEUM CONSUMPTION

Years	LPG	Premium Gasoline	Gasoil
1999	43502800	605810210	821106489
2000	44999648	707879250	790695840
2001	42519123	722377200	813926690
2002	49954999	769763190	852512318
2003	56707826	647761842	896957186
2004	65666614	777086900	908389400
2005	70460665	726024190	918033600
2006	87956676	691106350	921302668
2007	93286000	734713850	1131544950
2008	117577231	688733170	1073833237

Source: National Petroleum Authority (2009)

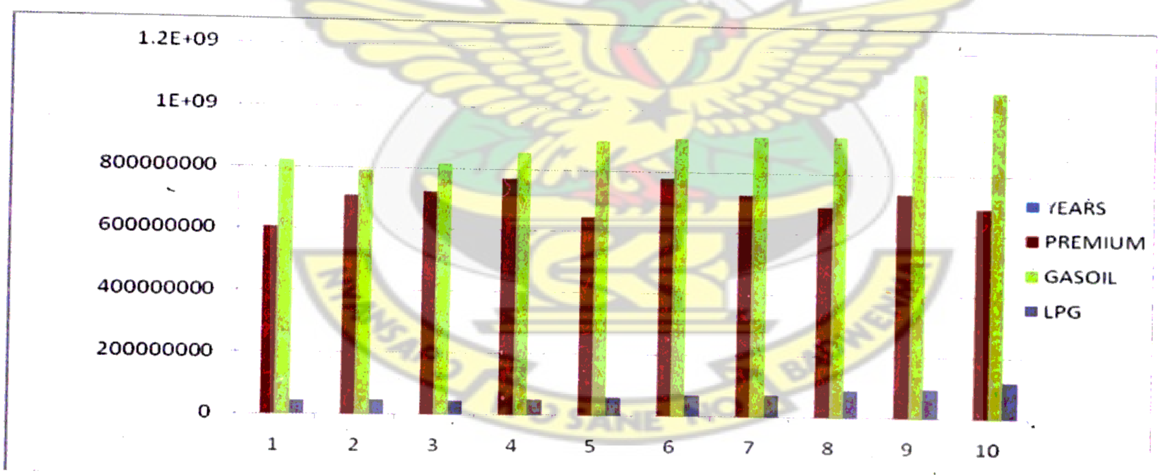


Figure 4.8: National Petroleum Consumption in Various Years

Figure 4.8 illustrates the consumption rates of three different types of petroleum. Of the three types, Gasoil is the most consumed in all the years from the period 1999 to 2008.

This is followed by premium, and the least consumed is LPG (this corresponds with responses on the types of fuel consumed as depicted by Table 4.25 below). The vertical axis represents the consumption rate (in litres), whilst the horizontal axis represents the different years of consumption, given by 1, 2, 3, …, and 10, representing 1999, 2000, …, and 2008. In general, the entire period has seen a continuous growth in petroleum consumption of all the three types, with a few years seeing a decrease in growth in some types. This could mean that such types might have been substituted for other types, since such a decrease did not reflect in all the three. Interviews with some taxi drivers revealed that, they sometimes switched from premium to LPG, in order to reduce cost. This could thus be a possible reason since the years which saw a reduction in premium still saw growth in LPG.

However the case may be, total petroleum consumption increased continuously over the entire period. The concern and interest in the underlying growth call for greater attention. Such a trend is likely to continue in the future if nothing is done about the situation. Though such a growth may be an indication of an increase in productivity, it might as well, and more likely be due to waste in its utilization. The analyses presented previously have revealed the increased waste in fuel/petroleum as a result of inefficiencies in the transport system. This means that, should the transport system be more efficient, relatively lesser consumption rates would be recorded. This is necessary for economic growth and development. Otherwise, the country shall continue to incur so much cost from petroleum imports, not withstanding, increased exposure to oil supply and environmental threats.

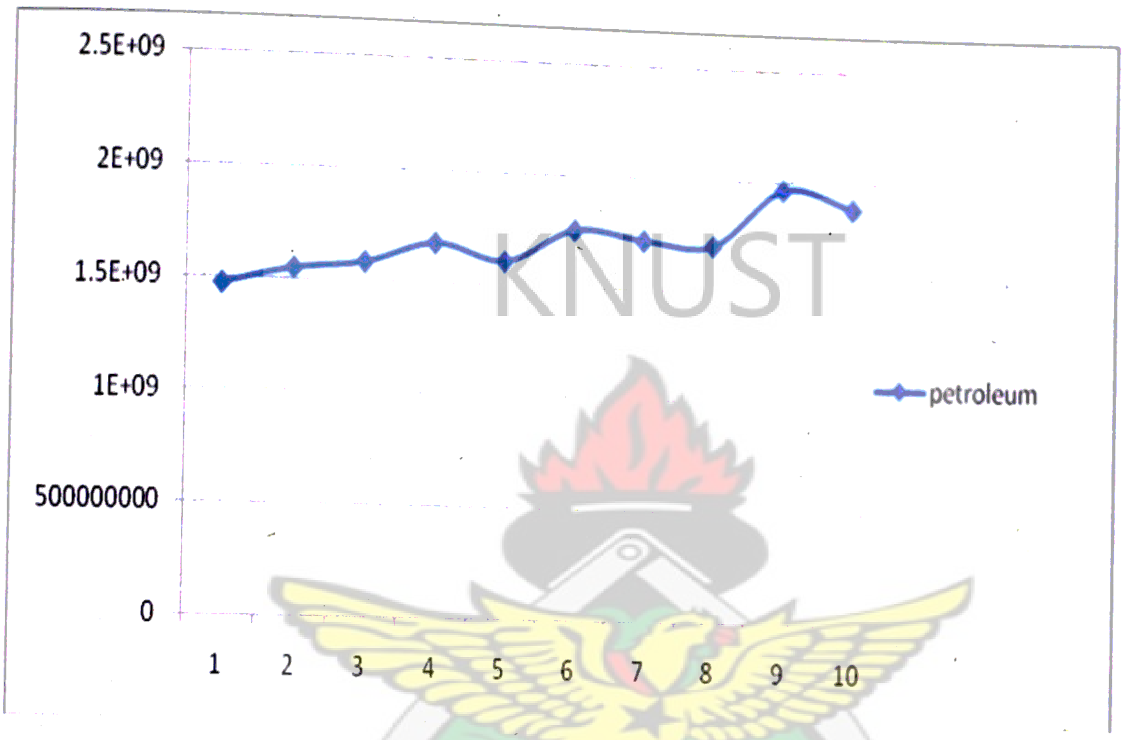


Figure 4.9: Line Chart Showing Trend in National Petroleum Consumption

TABLE 4.25: TYPES OF FUEL USED

	Response	Frequency	%	Valid %	Cumulative %
Valid	Premium	218	36.3	36.3	36.3
	Gasoil	297	49.5	49.5	85.8
	LPG	85	14.2	14.2	100.0
	Total	600	100.0	100.0	

Source: Field Survey, 2009

The increasing growth rate in petroleum consumption has resulted in an equally growth rate in its demand/import. The results of this are presented in Table 4.26.

TABLE 4.26: IMPORTS OF PETROLEUM PRODUCTS

YEARS	LPG	Premium Gasoline	Gasoil
1999	35641	386142	286885
2000	35424	386995	363191
2001	35558	389400	354311
2002	31962	370844	298042
2003	16691	232051	285747
2004	11011	255361	313104
2005	7077	167482	403730
2006	67775	360464	780003
2007	23283	128778	434347
2008	67822	228088	578952

Source: National Petroleum Authority (2009)

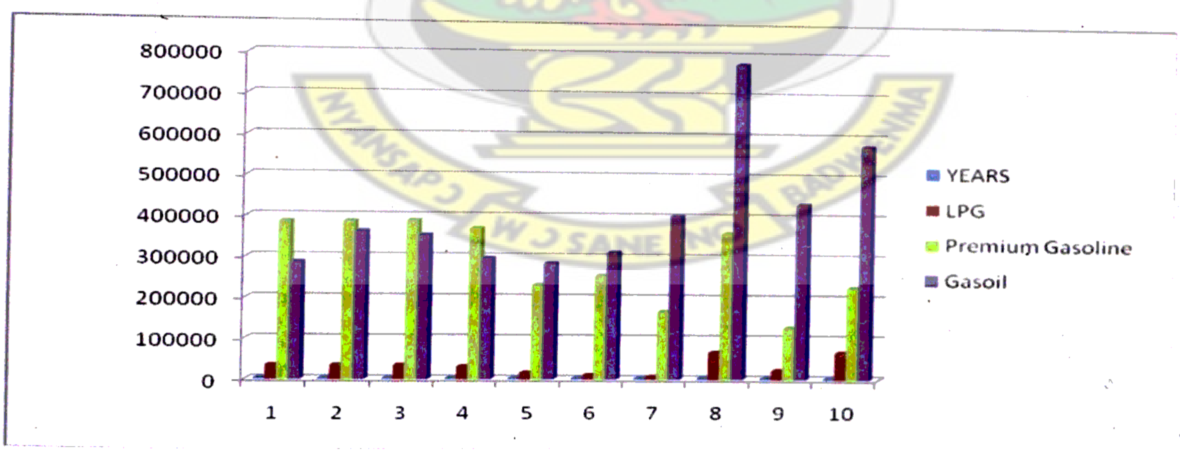


Figure 4.10 Bar Graph Showing Imports of Petroleum Products

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.0 INTRODUCTION

This chapter comprises a brief summary on the content of this study and outlines, conclusions derived from the analysis and also informed recommendations/suggestions based on the analysis of the data, for the improvement of Ghana's transport system.

5.1 SUMMARY

In the introductory chapter of this study, an effort was made to rationalize the need to assess the impact of efficient logistics on urban transport energy demand. The assessment was done in light of efficiency in the transport system comprising transport structure; transport infrastructure; traffic management system; as well as the role of both the driver behaviour and vehicle. The study specifically sought to: identify various factors that cause energy demand on urban transport; investigate the effects the factors identified have on urban transport energy demand; investigate the relationship between urban transport efficiency and energy demand and; recommend efficient and effective logistics on urban transport energy demand.

Methods used in collecting data for the study involved surveys, interviews and participant's observations. Questionnaires were administered to some selected drivers and institution officials. Interview method was also employed to collect data from some respondents who could not have time to read through the questions and provide answers accordingly. It took the form of informed conversation. Data were collected mainly in the following areas: road worthy vehicles in circulation/composition, driver behaviour, efficiency in vehicles, travel delay causes, national petroleum consumption/imports per periods, etc., including definitions and concepts in the field of study as conducted and/ published by other authors.

5.2 CONCLUSIONS

The following Conclusions are drawn from the analysis:

5.2.1 Transport System Efficiency

The efficiency of the transport system of Kumasi was evaluated using three main criteria; the transport structure, transport infrastructure and traffic management system. Also, the evaluation saw the need to assess the role of the vehicle and driver behaviour. Based on these criteria, the transport system was seen to be less efficient, in which case the system records severe congestion levels. There were many cases of longer travel times and undue delays. All these resulted from unbalanced transport structure (not favouring mass transit), over utilization of roads with most roads reaching critical capacity and also poor traffic management systems with very little intersection controls at critical points and less systems to check motorists/pedestrians' conduct. Notwithstanding, the numerous vehicles on roads were less efficient with poor driver behavior worsening the situation.

5.2.2 Major causes of Increased Transport Energy Demand

Among the major causes of high transport energy demand are;

Unbalanced Transport Structure: the transport structure of the city was one of the main causes of the high transport energy demand. The structure consisted of more small vehicles than longer buses, which means that, the occupancy rates of vehicles were less efficient to reduce undue traffic on roads. Also, the high rates in vehicles mean that traffic length on roads is much longer. These resulted in undue congestion, longer travel times and delays, which consumed more fuel than normal.

Poor road infrastructure: considering the usage of roads, the ratio of the mount of motor vehicles over total length of road is much higher than normal. This means that, the road infrastructure was not adequate to serve the many vehicles on the roads. Meanwhile, most of the roads were seen to have reached critical capacity, with very narrow traffic lanes and pot holes.

***Inefficient traffic management systems*:** considering the transport service levels, all the road links have severe traffic congestion, in which case, the traffic management system was less efficient to control traffic flow, aside the problems of poor road infrastructure and unbalanced transport structure. Most critical intersections lacked control signals, with poorly designed and inadequate parking lots/bus stops and pedestrian crossing to control motorists/pedestrians' conducts. These obstructed traffic flows in the corridors.

Inefficient vehicles/ less skilled drivers: most vehicles were seen to be less efficient, with many recorded cases of second-hand vehicles, over-aged vehicles, and poor maintenance culture for these vehicles. In addition, driver behaviour contributed to inefficiencies in the transport system, thereby translating into higher transport energy demand. Most of the drivers had very low level of education with majority of them attaining no training to improve their driving skills. This resulted in poor route planning, and bad driving behavior such as undue crossing and over-taking, wrong parking and picking of passenger practices. All these tendencies obstructed traffic flow, resulting in severe congestion, especially at intersections that lacked control signals.

5.2.3 Growth in Ghana's Transport Energy Demand/Consumption

From the analysis, there has been a continuous growth in National Petroleum Consumption, with few years recording decreases. This growth could be largely attributed to the inefficiencies in the transport system, even though the increase might as well be explained by the increase in production activities. Improving on the transport system will thus, have the capability of reducing the consumption/import rate of petroleum, all things being equal.

5.2.4 Relationship between Urban Transport Efficiency and Energy Demand

Based on the findings and analysis of this study, it was revealed that, in general, inefficiencies in the transport system resulted in the recorded cases of severe congestion, undue travel times/delays and obstructions in the traffic flow. These resulted in increased demand for transportation resources especially energy to achieve a specific transportation function. Hence, the researcher concludes that there exists an inverse relationship between urban transport efficiency and energy demand. Thus, as urban transport efficiency reduces, transport energy demand increases, and as urban transport efficiency increases, transport energy demand reduces, all things being equal.

In conclusion, it must be stated that urban transportation efficiency is the key factor which determines the capacity of urban transportation systems and the balance between transportation demand and supply. The transportation input cannot increase within a short period of time, but the demand of transportation is growing rapidly. Therefore to improve the efficiency of urban transportation systems is the best way to effectively utilize the existing inputs, enhance the capacity of the systems and relieve urban traffic congestion.

5.3 RECOMMENDATIONS

The following recommendations are made for the improvement of Ghana's transport efficiency towards energy efficiency:

5.3.1 Transport Structure Improvement

Public/mass transport improvements will be ideal to increase vehicle occupancy and reduced traffic length, resulting in additive advantage of reduced travel costs.

5.3.2 Transport Infrastructure Improvement

Road link/Expansion improvement: This measure should consider the idealization of the major road links to increase the road capacity. Also, most sections on the roads must be expanded to increase its capacity.

Sidewalk development and improvement: Retrofit sidewalks on the roads and improve the condition of existing ones, and prohibit hawking/trading on sidewalk.

5.3.3 Traffic Management Improvement

Intersection improvements: Intersections must be improved by signaling and improving the capacity at the major intersections in such sections as the Mampong road/Suame new road intersection, Suame roundabout, etc.

Crosswalk improvements: This may involve repainting and signalizing all crosswalks to control pedestrian movements.

Road furniture/Traffic Control Devices: faded road markings must be repainted, new ones must be installed at the appropriate places, bad road signs should be replaced, and also, streetlights should be provided especially at intersections.

Restrictions on roads: There should be restrictive delivery time bans which will significantly reduce city centre congestion. There should however not be very restrictive delivery time windows as it can lead to serious bunching of delivery vehicles immediately before and after restricted periods, possibly with the queuing for access to premises that can cause traffic congestion. It can as well reduce the likelihood that suitable vehicles will be dedicated to city centre work. In some cases, restrictions must be eased allowing delivery over longer periods, but avoiding peak times of shopping activities. Also restrictions in neighbouring towns must be co-ordinated, particularly in metropolitan areas, to assist operators in planning their delivery rounds across the area as a whole. Time-of-day or vehicle size restrictions will also help in congestion reduction.

There should be careful design of pedestrianization and traffic calming schemes. Selling on the street and in pedestrian path should be abolished. Enforcement of existing parking regulations to keep delivery bays free of parked cars and to prevent disruption to deliveries through illegal car parking, especially at the central business units in the city.

The promotion of consolidated freight movements in urban areas, possibly involving co-operation between different retailers and/or different transport operators will efficiently utilize resources. There should also be urban collection and delivery at night and review of delivery frequencies, thus larger loads to shops but less frequently. This should however not cause a counter to the recent trend towards inventory reduction and just-in-time logistics, but a balance must be created.

5.3.4 The Vehicle

The use of appropriate sized vehicles for urban logistics work must be promoted as well as alternative vehicle fuels and quieter vehicles. There should also be a tax variation that favours the importation of efficient vehicles, such as low fuel consumption cars.

Notwithstanding, there should be a complete banning of over-used and over-aged cars importation. Road worthy inspections must be strict to prevent inefficient vehicles from operating on roads.

5.3.5 The Driver

The metropolitan assembly, in collaboration with the DVLA and appropriate bodies may enforce training programmes to improve driver skills, especially in route planning and acceleration control, which will equally promote good maintenance culture among vehicle operators.

5.3.6 Recommendation for further studies

Transport demand - Even if there are major improvements in fuel efficiency through improvement in vehicle efficiency, increased use of public transport, road infrastructure, etc, energy and CO_2 reduction targets are unlikely to be achieved if the total demand for transport is not reduced, or at least the rate of growth reduced. Transport demand is affected by such factors like socio economic and population growth, etc. These and such other factors were not tackled sufficiently by the researcher, and so further studies will be required to improve transport energy efficiency as a whole.

Land-use pattern in the city

Aside road infrastructure, traffic management system, composition of the transport system, etc, one major determinant of any urban transport efficiency is its land-use pattern. As such, further studies in this area will be necessary to effectively evaluate the efficiency of the transport system.

Transport mode composition

This study mainly focused on road transport and so conclusions and recommendations by this study does not reflect directly, issues in other transport modes. Hence research in such areas will be very beneficial to unearth transport problems in totality, so that recommendations can have a holistic approach towards improving the total transport sector.

Transport efficiency of other cities in the country

Even though the findings, conclusions and recommendations of this study may reflect the transport system of other cities in Ghana, there may be instances where some generalizations may be very unique to Kumasi. As such, solving the transport problem of Ghana will require that other cities be studied.

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APPENDIX 1A

QUESTIONNAIRE ON ASSESSING THE IMPACT OF EFFICIENT LOGISTICS ON URBAN TRANSPORT ENERGY DEMAND

DRIVERS WITHIN THE KUMASI CITY

PART 1: Personal background data

1. What is your age?
   ☐ < =20 years ☐ 21–30 years ☐ 31–40 ☐ 41–50 ☐ >50

2. Your gender? ☐ Female ☐ Male

3. What is your level of education?
   ☐ MSLC ☐ JHS ☐ SHS ☐ Tertiary ☐ Illiterate

3. What category of car do you drive? (Please tick the appropriate box)
   ☐ Taxi ☐ 'Trotro' ☐ Private ☐ Bus
   ☐ other, please specify ________________

4. Which of the following routes do you drive along?
   ☐ Kejetia to Tech
   ☐ Kejetia to Tafo
   ☐ Kejetia to Atonso
   ☐ Kejetia to Abuakwa
   ☐ Kejetia to Buokrom
   ☐ Kejetia to Santasi

5. How long have you been driving along this
   ☐ < = 1 year ☐ 1 – 2 years ☐ 2 – 3 ☐ 3 – 4 ☐ > 4

PART 2: Energy efficiency through the vehicle

6. How old is the vehicle you are driving?
   - ☐ < 5 years ☐ 5 – 10 years ☐ 10 – 15 years
   - ☐ >15 years Other, please specify ____________

7. What type of vehicle do you drive? ☐ Heavy duty ☐ Light duty

8. Was your vehicle bought as a ☐ brand new or ☐ a second-hand?

9. What type of fuel do you use?
   - ☐ Petrol ☐ Diesel ☐ Gas
   - ☐ Other(s), please specify ____________

10. What is the vehicle's fuel consumption rate? ____________

11. What average amount of fuel does your car consume per day?
    - ☐ < 1 gallon ☐ 1–3 gallons ☐ 3- 6 gallons ☐ 6–9 gallons
    - ☐ Other(s), please specify ____________

12. Do you use fuel additives for your engine? ☐ Yes ☐ No
    If yes, how frequent? ____________

13. How often do you change the vehicle's engine oil?
    - ☐ >2000 miles covered ☐ 2000 – 4000 ☐ > 4000
    - ☐ Other, specify ____________

14. What are the criteria for oil change?
    - ☐ Too much friction
    - ☐ Engine breakdown
    - ☐ When oil is dirty
    - ☐ When oil is exhausted
    - ☐ When prompted
    - ☐ Other(s), please specify ____________

15. What type of engine oil do you use?
    - ☐ Extra ☐ Super ☐ Extra super

16. Which source do you buy your engine oil from?
   - ☐ Certified oil companies
   - ☐ Individual sellers
   - ☐ Mechanic shops
   - ☐ other(S), specify ____________________

17. What is the tank capacity of the vehicle?
   - ☐ 1.6 litres ☐ 1.8 litres ☐ 2.0 litres ☐ 2.5 litres
   - ☐ other, please specify ____________________

18. What kind of tyres do you normally buy?
   - ☐ Brand new tyres ☐ Second-hand tyres ☐ Repaired tyres

19. What are the criteria for changing the vehicle tyres?
   - ☐ When it bursts
   - ☐ When prompted
   - ☐ When there is a flat tyre
   - ☐ When it loses its threads
   - ☐ According to plan schedule
   - ☐ Other(s), please specify ____________________

20. Is your engine model the same as your car model? ☐ Yes ☐ No

21. Is your vehicle currently using the originally manufactured engine? ☐ Yes ☐ No
   If no, was the engine bought as a,
   - ☐ Brand new model? ☐ Second-hand model? ☐ Locally manufactured model?

22. What is/are your peak traffic period(s)
   - ☐ Morning ☐ Afternoon ☐ Evening

23. What average time does it take you to cover the distance (ticked in question 2) under no traffic condition?
   - ☐ Morning ____________
   - ☐ Afternoon ____________
   - ☐ Evening ____________

24. What average time does it take you to cover the distance (ticked in question 2) above under traffic condition?

☐ Morning ____________

☐ Afternoon ____________

☐ Evening ____________

PART 3: Energy efficiency through the driver behavior

25. Have you attended any refresher course(s) in driving? ☐ Yes ☐ No

If yes, how many times? ____________________

26. Do you have a driver's license? ☐ Yes ☐ No

If yes, which category?

☐ A ☐ B ☐ C ☐ D ☐ E ☐ F

27. Under no traffic condition, what is your average speed level? ____________________ ☐

28. Where do you usually pick passengers?

☐ Only at a bus stop ☐ Anywhere along the road

☐ Within the traffic ☐ Other(s), please specify? ____________________

29. To what extent do you follow road signs?

☐ Poor ☐ Good ☐ Very good ☐ Excellent

PART 4: Energy efficiency through maintenance culture

30. How often do you service your vehicle?

☐ Once every 3 months ☐ Once every 6 months

☐ Once every year ☐ As and when it breaks down

☐ Other(s), specify ____________________

31. Where do you service your vehicle?

☐ Recognized institutions ☐ Individual specialists

☐ Self servicing ☐ Others, please specify ____________________

32. What informs your decision to service the vehicle?
- ☐ When a fault is detected
- ☐ According to my maintenance plan schedule
- ☐ When there is a total breakdown
- ☐ Others, please specify ______________________________

33. Do you usually have the entire vehicle serviced? ☐ Yes ☐ No
If no, which part(s) are your main focus?
☐ Engine ☐ Tyres ☐ Tank ☐ Body
☐ Others, please specify ______________________________

PART 5: Energy efficiency through other factors

34. To what extent do these factors delay your distance coverage on this route?

1 – not important – 7 very important; N/A – don't know/not applicable

	1	2	3	4	5	6	7	N/A
Traffic congestion	☐	☐	☐	☐	☐	☐	☐	☐
Poor road network	☐	☐	☐	☐	☐	☐	☐	☐
Poor car condition	☐	☐	☐	☐	☐	☐	☐	☐
Road checkpoints	☐	☐	☐	☐	☐	☐	☐	☐
No. of traffic lights	☐	☐	☐	☐	☐	☐	☐	☐
Pedestrian obstruction	☐	☐	☐	☐	☐	☐	☐	☐
Trading obstruction	☐	☐	☐	☐	☐	☐	☐	☐
Narrow traffic lanes	☐	☐	☐	☐	☐	☐	☐	☐
Reserved parking lots	☐	☐	☐	☐	☐	☐	☐	☐
Other(s), specify ______________	☐	☐	☐	☐	☐	☐	☐	☐

35. In your own opinion, what do you suggest for the improvement of the transport system along the following areas:

Road ______________________________

Traffic management system ______________________________

Number of vehicles ______________________________

Fuel ______________________________

Other(S) ______________________________

APPENDIX 1B

THESIS QUESTIONNAIRE - ASSESSING THE IMPACT OF EFFICIENT LOGISTICS ON URBAN TRANSPORT ENERGY DEMAND

Driver, Vehicle and Licensing Authority

PART 1: Personal background data

1. Name of department
- ☐ Licensing
- ☐ Registry
- ☐ Road-worthy

2. What does your department primarily focus on?

____

____

____

3. For how long has this department been working in this field?
☐ <=2 years ☐ 2-5 years ☐ 6-9 years ☐ =>10 years

PART 4: Testing efficiency – Licensing Department

1. What criteria are used in the issuance of license and how important are these to the decision?

1 – not important – 7 very important; N/A – don't know/not applicable

	1	2	3	4	5	6	7	N/A
Age	☐	☐	☐	☐	☐	☐	☐	☐
Educational level	☐	☐	☐	☐	☐	☐	☐	☐
Fitness	☐	☐	☐	☐	☐	☐	☐	☐
Examination test	☐	☐	☐	☐	☐	☐	☐	☐
Other(s): ____________	☐	☐	☐	☐	☐	☐	☐	☐
____________	☐	☐	☐	☐	☐	☐	☐	☐

4. What minimum age qualifies the issuance of a license? ___________________

5. What minimum level of education qualifies the issuance of a license?
☐ MSLC ☐ JHS ☐ SHS ☐ Tertiary ☐ Illiterate

6. What are the criteria for checking the fitness level?
☐ Visual ☐ Mental ☐ other(s) ___________________

7. What assessment criteria are used for the examination test?
☐ Knowledge of road signs ☐ Knowledge of vehicle function
☐ Fuel efficiency ☐ Practical driving
☐ Other(s) ___________________

8. Is there a provision for the renewal of a license? ☐ Yes ☐ No
If yes, how often?
☐ Every 6months ☐ 1 year ☐ 2years
☐ 5 years ☐ others, please specify ___________________

PART 3: Vehicle Registration

9. What is the total number of registered vehicles for the city in the following years?

Category	2008	2007	2006	2005	2004	2003	2002	2001	2000	1999
private	___	___	___	___	___	___	___	___	___	___
taxi	___	___	___	___	___	___	___	___	___	___
trotro	___	___	___	___	___	___	___	___	___	___
bus	___	___	___	___	___	___	___	___	___	___
truck	___	___	___	___	___	___	___	___	___	___
other, (spec)	___	___	___	___	___	___	___	___	___	___
Total	___	___	___	___	___	___	___	___	___	___

1. Are you limited to specific number of vehicles per period per area? ☐ Yes ☐ No
If yes, what are the limits for each category for the city?

	Limited number per period
Private	________
taxi	________
trotro	________
bus	________
truck	________
other, specify	________

2. How important are these factors in vehicle registration?

1 – not important – 7 very important; N/A – don't know/not applicable

	1	2	3	4	5	6	7	N/A
Age of vehicle	☐	☐	☐	☐	☐	☐	☐	☐
Model of vehicle	☐	☐	☐	☐	☐	☐	☐	☐
Inherent technology	☐	☐	☐	☐	☐	☐	☐	☐
Fuel consumption rate	☐	☐	☐	☐	☐	☐	☐	☐
Size of vehicle	☐	☐	☐	☐	☐	☐	☐	☐
Weight of vehicle	☐	☐	☐	☐	☐	☐	☐	☐
Passenger capacity	☐	☐	☐	☐	☐	☐	☐	☐
Condition of vehicle	☐	☐	☐	☐	☐	☐	☐	☐
Availability of spare parts	☐	☐	☐	☐	☐	☐	☐	☐
Other(s), specify ________	☐	☐	☐	☐	☐	☐	☐	☐

PART 3: Road worthiness

1. What criteria are used in the issuance and how are they important are they:

1 – not important – 7 very important; N/A – don't know/not applicable

	1	2	3	4	5	6	7	N/A
a. ________	☐	☐	☐	☐	☐	☐	☐	☐
b. ________	☐	☐	☐	☐	☐	☐	☐	☐
c. ________	☐	☐	☐	☐	☐	☐	☐	☐
d. ________	☐	☐	☐	☐	☐	☐	☐	☐
e. ________	☐	☐	☐	☐	☐	☐	☐	☐
f. ________	☐	☐	☐	☐	☐	☐	☐	☐
e. ________	☐	☐	☐	☐	☐	☐	☐	☐

2. Is the certificate renewable? ☐ Yes ☐ No
If yes, how frequently?
☐ => 6 month ☐ 1 year ☐ 1 1/2 years ☐ < =2 years

APPENDIX 2

RESULTS OF TRAVEL DELAY FACTORS

TABLE 4.17 **TRAFFIC CONGESTION**

Response	Frequency	Percent	Valid Percent	Cumulative Percent
Valid IMPORTANT	266	44.3	44.3	44.3
VERY IMPORTANT	334	55.7	55.7	100.0
Total	600	100.0	100.0	

Source: Field Survey (2009)

TABLE 4.18 **POOR ROAD NETWORK**

Response	Frequency	Percent	Valid Percent	Cumulative Percent
Valid FAIRLY IMPORTANT	55	9.2	9.2	9.2
IMPORTANT	93	15.5	15.5	24.7
VERY IMPOTANT	452	75.3	75.3	100.0
Total	600	100.0	100.0	

Source: Field Survey (2009)

TABLE 4.19 **NARROW TRAFFIC LANES**

Response	Frequency	Percent	Valid Percent	Cumulative Percent
Valid NOT VERY IMPORTANT	25	4.2	4.2	4.2
IMPORTANT	123	20.5	20.5	24.7
VERY IMPORTANT	377	62.8	62.8	87.5
N/A	75	12.5	12.5	100.0
Total	600	100.0	100.0	

Source: Field Survey (2009)

TABLE 4.20 **RESERVED PARKING LOTS**

Response	Frequency	Percent	Valid Percent	Cumulative Percent
Valid NOT VERY IMPORTANT	89	14.8	14.8	14.8
FAIRLY IMPORTANT	128	21.3	21.3	36.2
IMPORTANT	161	26.8	26.8	63.0
VERY IMPORTANT	150	25.0	25.0	88.0
N/A	72	12.0	12.0	100.0
Total	**600**	**100.0**	**100.0**	

Source: Field Survey (2009)

TABLE 4.21

PEDESTRIAN OBSTRUCTION

	Response	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	NOT VERY IMPORTANT	132	22.0	22.0	22.0
	FAIRY IMPORTANT	229	38.2	38.2	60.2
	IMPORTANT	99	16.5	16.5	76.7
	VERY IMPORTANT	84	14.0	14.0	90.7
	N/A	56	9.3	9.3	100.0
	Total	600	100.0	100.0	

Source: Field Survey (2009)

TABLE 4.22

TRADING OBSTRUCTION

	Response	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	NOT VERY IMPORTANT	137	22.8	22.8	22.8
	FAIRLY IMPORTANT	90	15.0	15.0	37.8
	IMPORTANT	101	16.8	16.8	54.7
	VERY IMPORTANT	189	31.5	31.5	86.2
	N/A	83	13.8	13.8	100.0
	Total	600	100.0	100.0	

Source: Field Survey (2009)

TABLE 4.23

OTHER(S)

	Response	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	FAIRLY IMPORTANT	73	12.2	12.2	12.2
	IMPORTANT	278	46.3	46.3	58.5
	VERY IMPORTANT	249	41.5	41.5	100.0
	Total	600	100.0	100.0	

Source: Field Survey (2009)