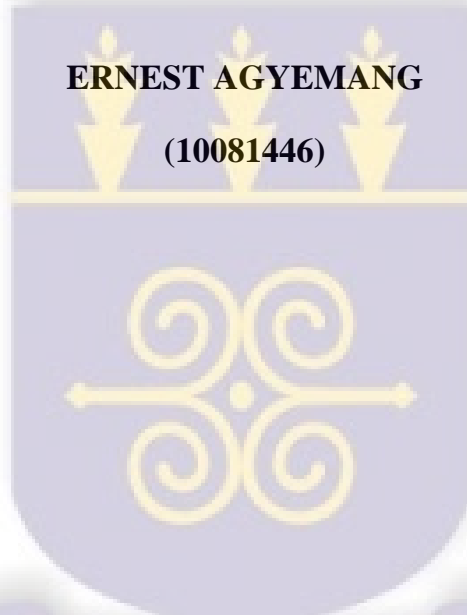


**TRANSPORTATION SYSTEM AS A
CLIMATE MITIGATION STRATEGY FOR
THE GREATER ACCRA METROPOLITAN AREA (GAMA)**

BY

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**THIS THESIS IS SUBMITTED TO THE UNIVERSITY OF GHANA, LEGON IN
PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF A
PHD DEGREE IN GEOGRAPHY & RESOURCE DEVELOPMENT.**

JULY, 2015.

DECLARATION

This thesis entitled “**Transportation System as a Climate Mitigation Strategy for the Greater Accra Metropolitan Area (GAMA)**” is an original end product of a study I personally conducted. With the exception of existing relevant literature that were used, for which due acknowledgement has been made, the thesis has not been submitted anywhere in part or whole for the award of any degree.

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INTEGRI PROCEDAMUS

DEDICATION

Yaa Serwaa, Afia Serwaa, Kwadwo & Kwabena Abora-Agyemang,

I dedicate this work to you for your kind understanding, support and prayers.



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“Give thanks to the Lord, for HE is good. His love endures forever” (Psalm 136:1).

But for your protection, love and care during my entire study period, this thesis would never have seen the light of day. Thank you, Jesus.

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ABSTRACT

In many cities across the globe, transportation has been a major catalyst for economic growth and for the progress of human societies. However, as an activity that is largely dependent on the combustion of fossil fuels, on-road urban transportation has fast become one of the most important sources of anthropogenic-induced Greenhouse gases (GHGs) which are known to contribute to climate change. The causes and effects as well as adaptation and mitigation strategies for climate change have received global attention from policy and non-policy actors, including the scientific and academic community. Three broad climate mitigation strategies –efficiency in vehicle technologies, use of alternative fuel sources and travel reduction through land use and transport integration –have been proposed for the transport sector. Climate mitigation policy for the transport sector in Ghana has generally favoured the first two strategies. Thus, notwithstanding the burgeoning scientific evidence that has shown that developing countries have greater opportunities to significantly mitigate climate change through an integrated land use and transport system, the third strategy has not received the needed academic and policy attention. In the context of urban sprawl and long commuting distances between residential areas and locations of activity points in some major Ghanaian cities, this present study explores the ramifications of present land use and transportation systems on energy use and climate mitigation, using the Greater Accra Metropolitan Area (GAMA) as a case study.

Inspired by the philosophical worldview of pragmatism, the study adopted a complementary mixed methods design involving quantitative surveys of trip makers and qualitative interviews with relevant stakeholders, including public transport suppliers, government officials and social scientists, together with participant observations. Secondary data sources, including policy documents and existing literature were also used in the study. The Systems conceptual framework of land use and transport system was developed as an interpretative guide in analysing the symbiotic relationship between spatial and transportation

patterns and the extent to which this relationship has impacted on energy use and GHG emissions in GAMA.

While GAMA continues to sprawl, the functional interactions between Accra Central and its peri-urban localities with respect to work, shop and accessing government services trip patterns are characterised by extensive use of low occupancy motorised transport modes over long commuting distances. This has adverse implications for per capita energy use and GHG emissions. In contrast, relative short distance trips to nearby activity points are accompanied by a significant use of non-motorised transport modes by trip makers with its associated reduction in fossil energy use and subsequent emissions. Long distance trip makers surveyed expressed high preference for mass transit, with its climate mitigation co-benefits.

In the light of the above, it is recommended that in order to promote climate mitigation, there is the need for planners and city authorities to re-organise GAMA's spatial patterns through the densification of land use in and around Accra Central to properly integrate land use and transportation systems. Alternatively, the virtual monopoly of Accra Central with respect to the concentration of activity points must be addressed through effective decentralisation policies. Also, non-motorised transport modes use must be encouraged particularly for short distance trips while mass transit must be prioritized for long distance trips.

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CHAPTER ONE: GENERAL INTRODUCTION

1.1. Introduction

The indispensable role of transportation towards socio-economic development is now widely acknowledged. Transportation does not only ensure access to amenities and services such as employment, education, health and leisure but it also facilitates family life and helps in creating social networks (Ahmed, Lu & Ye, 2008). However, urban transport, especially those that are based on the combustion of fossil fuels, is a primary emitter of anthropogenic-induced Greenhouse gases (GHG), besides other carbon sources such as energy supply for electricity generation, energy use in buildings, industrial production and waste. Transport is said to be a major sector of the economy where emissions continue to grow, as the increased demand for travel outweighs the technological gains (Banister, Schwanen & Anable, 2012). An International Energy Agency (IEA, 2011) report shows that transport was responsible for about 23% of global CO₂ emissions in 2009. An earlier IEA (2010) report had projected that the demand for global transport fuel will grow by about 40% by 2035. The excessive oil consumption in transport may greatly add to global warming and climate change. According to the UN-Habitat (2011), some of the effects of global climate change includes rising air and ocean temperatures, droughts and sea-level rise which threatens coastal zones with inundation, saltwater intrusion and the reduction of liveable land space

It is important to note that the degree of energy consumption and the resulting GHG emissions per passenger or tonne (freight) per kilometres vary among the various modes of transport. Road transport, including cars, buses or coaches and motorcycles have a relatively high energy intensity, accounting for 80% of worldwide total energy demand by the transport sector (Grazi, Jeroen & van den Bergh, 2008; IEA, 2006). In Europe, a European Environment Agency (2007) report notes that road transport accounts for 93% of total GHG emissions and 92% of total CO₂ emissions in the transport sector.

The United States Environmental Protection Agency (USEPA, 2006) also reports that road transport is responsible for 86% of total GHG and 84% of total CO₂ emissions in the transport sector of the country. Although of a lesser proportion, GHG emissions from road transport in developing countries continue to rise due to rapid urbanisation and population growth, economic boom with a consequent rise in levels of motorisation and high energy demand. Various studies conducted on road transport in China and India show that developing countries could potentially be a major source of carbon emissions in the not-too-distant future. According to the World Bank (2007), China's road transport sector's use of petroleum increased from 24.6% to 29.8% of total use between 2001 and 2005. Consequently, Li (2011) and an earlier study by Huang (2009) estimate road transport-related air pollution in China to be around 23% of total air pollution, close behind industrial pollution. Similarly, Li (2011) notes that road transport in India consumed approximately 17% of the country's total energy of about 217 Million Tonnes of Oil Equivalent (Mtoe) between 2005 and 2006. In a business-as-usual scenario, Singh (2006) estimates a 5-fold increase in energy demand and carbon emissions in India's road transport sector by 2020, relative to 2000. Studies conducted in African countries, including South Africa and Lesotho (Tongwane, Piketh, Stevens & Ramotubei, 2015; Thambiran & Diab, 2011) and Tunisia (Shahbaz, Khraief & Jemaa, 2015) have provided evidence to show that increasing use of road transport fuel has had adverse implications for GHG emissions on the continent. GHG emissions from the transport sector in many African countries have been compounded by poor road transport infrastructure and the use of ageing vehicles which are seldom maintained (Zachariadis, Ntziachristos & Samaras, 2001).

The aviation sector –which is the most energy-intensive transport mode – now accounts for about 3.5% of total anthropogenic GHG emissions (UN-Habitat, 2011). Its rapid growth combined with the fact that it emits GHG directly into the high atmosphere has

aroused academic concern. This is because the emissions from high-flying aircraft cause a greater amount of warming than the same volume of emissions would do at ground level. Again, it is estimated that emissions from aviation is growing at 2.1% per year and is likely to exceed all national climate targets by 2030 (UN-Habitat, 2011; Grazi et al., 2008; Kahn Ribeiro et al., 2007; Bows, Upham & Anderson, 2005). This notwithstanding, it is problematic to include emissions from the aviation sector in national GHG inventories due to the lack of consensus to which country or legal actor that GHG emitted in international airspace should be allocated in a system of global governance, where the legal parties to treaties are nation states. The shipping sector is another important transport mode that accounts for about 10% of transportation energy use (UN-Habitat, 2011; Kahn Ribeiro et al., 2007) but emissions from international maritime transportation are also not included within national GHG inventories for similar reasons.

In the light of the above, recent climate mitigation strategies in the transport sector have focused primarily on road transport. From a theoretical perspective, strategies for mitigating road transport emissions have emphasised vehicle technological efficiency (Stanley, Hensher & Loader, 2011; Kromer, Bandivadekar & Evans, 2010; Bristow, Tight, Pridmore & May, 2008); low carbon fuel-alternatives (Schipper, 2011; Johansson, 2009; Kahn Ribeiro et al., 2007) and travel reduction (Akerman, 2011; Heres-del-Valle & Niemeier, 2011; Tiwari, Cervero & Schipper, 2011). All of the above strategies have potential climate mitigation benefits. However, the degree of appropriateness, effectiveness and permanency of these strategies vary significantly between developed and developing countries. From a policy response perspective, while admitting that the problems with growing emissions in transportation remain largely unsolved, most European countries have adopted policy measures and strategies that have resulted in considerable mitigation gains.

These include improvements in car engines leading to improved fuel economy, fleet renewal and strict fuel emission regulations. For example, even though there was a 7% increase in the number of vehicles, with total mileage growing at a faster rate (approximately 22%) in Genoa, Italy, between 1992 and 2010, total emissions decreased considerably, primarily due to improvements in vehicle and fuel technologies (Dulal, Brodnig & Onoriose, 2011; Zamboni, Capobianco & Daminelli, 2009).

Similarly, the land use and spatial planning policies in some major cities in Western Europe have resulted in substantial climate mitigation benefits. The policy of integrating land use with the mobility needs of urban dwellers through, for instance, densification of land use and mixed development have promoted shorter trip distances from homes to activity points¹. For instance, Cirilli and Veneri (2014), has found that the siting of activity points closer to residential locations of Italian urban dwellers often resulted in the high use of non-motorised transport modes² such as walking and cycling. Also, the large concentration of human and activity point locations creates the necessary conditions for mass transiting, usually by bus and light rail. All of the above, coupled with some restrictions on car use, particularly in city centres, have resulted in less fossil-fuel energy use and lower per capita emission of GHGs. In the U.S., however, studies have shown that emission levels continue to rise due to the consistent increase in car weights and power during the last 15 years (UN-Habitat, 2011; Ewing, Bartholomew, Winkelman, Walters & Chen, 2008). This may also be due to the fact that America has a large land size, and that citizens could travel longer and more often, compared to Europe.

¹ Activity points, as used in this study, refer to various locations where urban residents go to work, shop, school or organise their socio-cultural and recreational activities.

² Non-motorised transport modes in urban areas generally include walking, bicycles, push carts, wheel barrows and animal drawn carts. In the context of this present study, the focus is on NMTs that are used for passenger mobility (i.e. walking and bicycle) as opposed to the remaining NMTs that are used principally for freight movements.

On the other hand, policy makers in most developing countries have promoted mass transport through the organisation of an efficient urban public transport system that emphasises fleet renewal and the use of new, high occupancy and fuel efficient vehicles. These policies are primarily meant to ensure efficiency and the sustainability of urban transport for the movement of passengers and freight. Mass transport also has immediate and substantial climate mitigating co-benefits for poor cities in developing countries. For instance, in Bogota (Colombia), a high capacity and high-quality busway system known as ‘TransMilenio’ – together with private car-restriction measures resulted in a decline in air pollutants by 40% within the first 12 months of operation (Ardila & Gerhard, 2002). So substantial was the emission gains that the ‘TransMilenio’ project was recognised by the United Nations in 2006 to generate and sell carbon credits under the Kyoto Protocol. The Brazilian city of Curitiba, touted as ‘the world’s cradle for bus rapid transit (BRT) and one of the most successful bus transit systems in the Western Hemisphere’ (Lindau, Hidalgo & Facchini, 2010, p.17), has made giant mitigation strides through the proper integration of land use and mass transportation.

Das and Parikh (2004) also claim that Mumbai’s greater share of a public bus transport and a sub-urban railway system will result in an estimated 60% less fuel consumption for transport by 2020 compared to Delhi which greatly depends on car use. In Lagos (Nigeria), less fuel consumption among ‘BRT-Lite’ vehicles is estimated to have led to a 32% reduction of fuel use, resulting in 25,000 tonnes of CO₂ per year being mitigated (Trans-Africa Consortium, 2010). Similarly, the ‘Rea Vaya’ bus rapid transit system in Johannesburg (South Africa) also removed the need for at least 1,100 minibus-taxi operations and the pollution associated with these vehicles (Trans-Africa Consortium, 2010). In Dakar, an ambitious policy to formalise and professionalise the informal sector through a bus renewal scheme has improved the attractiveness of public transport and customer satisfaction,

besides the obvious climate mitigation benefits. Unfortunately, in many cities of the developing world, vehicle and fuel technology improvements have not been able to hold overall ambient air pollution levels steady or to reduce them (Li, 2011; Newman & Kenworthy, 2006). This may be attributed to increased vehicle ownership, non-decommissioning of old polluting vehicles, use of substandard fuel and lack of proper maintenance of vehicles. Generally, motorised transport modes in cities of the developing world have low carrying capacity, averaging four to thirty seats maximum, and most of them are old and polluting due to poor maintenance culture. For instance, in Delhi (India), it is estimated that over 50% of cars and taxis are between 10 and 20 years old (Dulal et al., 2011; Sen, Tiwari & Upadhyay, 2010). The crowding of the road space with low occupancy cars has resulted in chaotic traffic congestion with its attendant socio-economic costs including traffic accidents, usually involving vulnerable road users, and loss of productive hours.

The scenario described is worsened by the fact that most developing world cities lack an integrated land use and transportation master plan. This has often resulted in the uncontrolled spatial expansion of the cities without due consideration for the transportation needs of residents. The sprawl of cities has often resulted in longer travel distances and the increased use of motorised transport (Boapeah, 2005; Abane, 1993), as opposed to non-motorised transport modes. The apparent lack of policy attention to the land use-transport system and its ramifications have led some scholars to call for developing countries to pay particular attention to the integration of land use and transport system as a major step towards a sustainable and permanent climate mitigation (Cervero, 2013; Abane, 2011; Zegras, 2012; Zhao, 2010; Lin & Yang, 2009; Zhang, 2004). In contrast with most cities of the developed world, the general lack of an integrated land use and transportation system appear to make conventional climate mitigation strategies of improvements in vehicle and fuel technology as well as travel reduction difficult to achieve in cities of the developing world.

In recent times, however, there has been a growing number of developing country cities that have made significant mitigation gains through the promotion of low-carbon mass public transport and proper land use planning. The experiences of these cities could benefit the rest of the developing world, including Accra, Ghana's capital.

1.2. Statement of Research Problem

Academic interest in the interaction between transport, land use and climate change has proliferated recently due to the growing awareness in the realms of public policy, industry, popular media and beyond about the challenges climate change poses to society and the concern that transport is the sector where reductions in GHG emissions are particularly difficult to achieve (Schwanen, Banister & Anable, 2011; Kahn Ribeiro et al., 2007; Stern, 2007). In the late 1980s and early 1990s when climate change assumed global attention, a lot of studies were conducted, particularly on the costs of climate change mitigation in the Organisation for Economic Co-operation and Development (OECD) countries (United Nations Environment Programme (UNEP), 1992). Thus, as noted by Naess (2012), it is not uncommon to find that the majority of the scientific publications on climate change mitigation, particularly from the transport sector, are found in the American and European countries. This may be due to the realisation that 'the largest share of historical and current global emissions of greenhouse gases had originated in developed countries' (United Nations Framework Convention on Climate Change (UNFCCC), 1992, p.85).

However, a strong argument has been made for developing countries to be involved in studies on climate change mitigation. Such participation, according to Rowlands (1998, p.7-8), will among other benefits enhance 'developing countries own environmental, social and economic goals' and will also contribute to a 'broader capacity building on climate change issues'.

Thus, a number of developing countries, including Zimbabwe, Botswana, Tanzania and Zambia, have undertaken climate change investigations (Rowlands, 1998; UNEP, 1995; 1993).

Ghana's present Greenhouse gas contribution is estimated at 24 million metric tonnes of Carbon Dioxide equivalent (MtCO₂e) (GoG, 2011a). This may appear insignificant compared to emissions from other large countries of the world. However, as in other developing countries, Ghana has the potential to make a very significant contribution in the near future in a business-as-usual development pathway. According to Ghana's Energy Commission (2006), the road transport sector accounts for 99.7% of gasoline use leading to over 60% of non-biomass Carbon Dioxides (CO₂) and over 50% of Nitrogen Oxides (N₂O) emissions respectively. Also, there is evidence to show that in Ghana, on-road transport is responsible for about 70% of all GHG emissions (EPA-Ghana, 2007). Emissions from the transport sector are likely to worsen given the cause and effect relationship involved in the present land use and transportation patterns in major Ghanaian cities, including the Greater Accra Metropolitan Area (GAMA). This is because earlier studies (Cobbinah & Amoako, 2014; Owusu, 2013; Doan & Oduro, 2012) have found that GAMA's present land use pattern is characterised by a high concentration of activity points for work, shopping, recreation, among others, at the city centre while the majority of the residential locations are found at distant locations, due to urban sprawl. This notwithstanding, earlier studies in GAMA confirmed the existence of a functional link between the city centres and their peri-urban localities with respect to work and shopping-related trips (Yeboah, 2003; Abane, 1993).

Earlier studies conducted elsewhere (Naess, 2012; Boarnet & Crane, 2001; van Acker et al., 2007) have found that the location of activity points vis-à-vis residential locations, or urban land use in general, directly influences transportation behaviour of urban dwellers. For instance, the urban form can promote or constrain the use of motorised or non-motorised

transport modes, as well as determine the cost and consumption of travel. In view of the long commuting distances and time associated with the observed functional linkages in GAMA, it is reasonable to expect that the majority of intra-urban trips are carried out using one form of motorised transport or the other, as has been found in earlier studies (Yeboah, 2003; Abane, 1993).

Motorised transport in GAMA, as in most cities of the developing world, are generally characterised by a high use of low occupancy, old and poorly-maintained vehicles. This is further exacerbated by the fact that the price for using GHG-efficient fuel to power motor vehicles is usually higher than the average fuel sold on the market. Thus, the majority of motorists in GAMA are less likely to opt for the former. Consequently, motorised transport in GAMA often results in high fossil energy use and GHG emissions, which ultimately contributes to global warming and climate change (Armah et al., 2010, Nerquaye-Tetteh, 2009). Strategies proposed in earlier studies to mitigate GHG emissions in the transport sector have generally favoured the use of high occupancy vehicles (Finn, Abeiku-Arthur & Gyamera, 2009; Hesse, 2008; Nuworsoo, 2006; Yeboah, 2003; Akoena & Twerefou, 2002). Yet still, other studies have demonstrated that achieving improvement in vehicle technology and the phasing out of old vehicles as well as promoting travel reduction through land use densification and transport planning could hold the key to sustainable climate mitigation for the country (Abane, 2011, 1993, EPA-Ghana, 2007).

In terms of policies and strategies from the Ghanaian government to curb GHG emissions in the transport sector, three important policy statements have been mentioned in Ghana's National Transport Policy. First, the policy states that 'mass transportation will be prioritised in urban areas, aiming to move at least 80% of passengers' (GoG, 2008, p.45). Second, the policy states that 'transport planning will be fully integrated with development planning and service provision' (GoG, 2008, p.49).

Third, the policy further states that ‘fuel efficiency, conservation and pollution control measures shall be promoted for road transportation’ (GoG, 2008, p.59). It is also noteworthy that in 1992, Ghana became a signatory to the UNFCCC. Three years later, the UNFCCC was ratified by the Ghanaian government. Furthermore, in 2002, the country signed the Kyoto Protocol. Moreover, Ghana has submitted a list of what it considers as nationally appropriate mitigation actions (NAMAs) in lieu of the 18th December 2009 Copenhagen Accord. According to Cameron, van Tilburg and Wurtenberger (2011), Ghana has further outlined a policy brief that integrates Ghana’s medium-term national development policy framework (i.e. the *Ghana Shared Growth and Development Agenda 2010 – 2013*) and the list of 55 NAMAs. The government hopes that by aligning development goals, as reflected in the *Shared Growth and Development Agenda*, with climate goals, the nation would have taken its first step in prioritising the NAMAs. The mitigation actions recognise the predominant use of ‘Conventional’, ‘Euro I’ and ‘Euro II’ vehicles in Ghana. Thus, proposals have been made to promote the use of low-emission vehicles, particularly the Euro III and other vehicles which were manufactured after the Euro III models³. Measures are underway to promote and switch from the use of gasoline and diesel fuels to the use of Compressed Natural Gas (CNG), Liquefied Petroleum Gas (LPG), biofuels and electricity for public transport (GoG, 2010a). Other policy measures include the implementation of an ‘End of Life’ policy for motor vehicles and equipment with CO₂ emissions exceeding acceptable targets (GoG, 2011b).

Ghana’s climate mitigation policies and strategies for the transport sector appear to focus greater attention on mass transit, the improvement of vehicle technology as well as improvements in fuel efficiency. Unfortunately, less attention has been paid to the policy of fully integrating transport and development planning and service provision.

³ Note: Vehicles classified as ‘Conventional’ were manufactured on or before 1992; ‘Euro I’ and ‘Euro II’ vehicles were manufactured between 1993 and 2000. ‘Euro III’ vehicles were manufactured between 2001 and 2005 (Source: Environmental Protection Agency (Ghana), 2007)

To make matters worse, in Ghana, the Ministry of Local Government and Rural Development (MLG&RD) which is responsible for land use planning, appears to operate independently of the Ministry of Transport. This demonstrates the lack of emphasis on the integration of land use and transportation. Thus, Ghana may not make any realistic and significant climate mitigation gains in its transport sector. This is because, studies (see Li, 2011; Newman and Kenworthy, 2006) have found that GHG emissions are likely to be high among developing countries that have de-emphasised land use and transportation integration but have focused primarily and almost exclusively on improved vehicle technology and fuel efficiency. This is because most developing countries are beset with increased vehicle ownership, non-decommissioning of old polluting vehicles, use of substandard fuel and the lack of proper maintenance of vehicles. Inversely, among some developing countries, including Santiago, Taipei and Hong Kong, where a full integration of land use and transportation patterns have promoted dense and mixed land use as well as the location of activity points closer to residential areas, the high use of non-motorised transport modes has resulted in significant climate mitigation (Cervero, 2013; Zegras, 2012; Lin & Yang, 2009; Zhang, 2004)

Going forward and on the basis of the afore-mentioned local studies and climate mitigation policies and strategies in Ghana, this study examines how the spatial distribution of land use activity points (i.e. whether distal or proximal to residential areas of urban dwellers) influence their use of various transport modes. The study also examines the implications of the modal use on climate change mitigation, using GAMA as a case study. The study is expected to offer comprehensive and theory-driven policy guidelines to Ghanaian policy-makers and other multiple stakeholder groups tasked with climate change mitigation efforts in the country.

1.3. Research Objectives

The overall objective of this study is **to assess the land use and transportation system of GAMA and their implication for climate change mitigation in the transportation sector.**

Specifically, the study will:

1. Identify land use patterns with respect to geographical locations of residences and activity points in GAMA;
2. Identify and examine patterns of transportation behaviour in GAMA;
3. Analyse and discuss the extent to which geographical distributions of residences vis-à-vis activity point locations (for shopping, working and public service provisions) influence patterns of transportation behaviour, energy use and GHG emissions in GAMA;
4. Examine the extent to which climate mitigation could be attained through an efficient transport and land use system in GAMA.

1.4. Research Questions

1. What are the patterns and attractiveness of activity points for shopping, work and accessing public services vis-à-vis residential locations in GAMA?
2. How does the geographical distribution of residences vis-à-vis activity points for shopping, work and public services influence the use of transport modes in GAMA?
3. What are the main factors that influence modal choice by trip makers in GAMA?
4. How do observed patterns of transportation behaviour and land use patterns influence energy use and Greenhouse gas emissions in GAMA?
5. From the perspective of key stakeholders, what are the enabling and constraining factors for the adoption of a climate efficient transport system in GAMA?

1.5. Research Hypotheses

This present study is premised on the general hypothesis that GAMA's present land use system is characterised by the concentration of land use activity points for work, shopping, and accessing government services at Accra Central. Meanwhile, residential locations of trip makers are found at distant locations. This land use system has significant effects on patterns of transportation behaviour, including the type of modes used and their associated energy and emissions potentials. On the other hand, some activity points, particularly markets which generate most trips to Accra Central are also found in relative proximity to the community of residence of trip makers. Thus, trip makers living close to these community activity points are expected to make regular short-distance trips. Therefore, the first set of hypotheses in the study is stated thus:

Alternative hypothesis 1 (H_1): Long trip distance to activity points in Accra Central for working, shopping and accessing government services has a statistically significant effect on the transport modal use of GAMA trip makers;

Alternative hypothesis 2 (H_1): Short trip distance to community activity points for shopping has a statistically significant effect on the transport modal use of GAMA trip makers in their community of residence.

The second set of hypotheses underpinning this study is stated thus:

Alternative hypothesis 3 (H_1): Gender, age, education, income, household size, occupation type and car ownership status have statistically significant effects on the transport modal choice of GAMA trip makers who visit Accra Central.

1.6. Structure of Dissertation

The study has been organised into six main chapters. A general introduction is provided in the first chapter which introduces the key research problems, objectives as well as a number

of questions and hypotheses that the study seeks to find answers to. The second chapter introduces a review of previous studies. Among others, the review considers various climate mitigation theories in the transport sector, the land-use/spatial patterns and transportation nexus; as well as various spatio-socio-economic and demographic factors which influence the land-use/spatial patterns and transportation system. Also, the Systems conceptual framework that guided the conduct of this study is presented. The third chapter on methodology focuses on the complementary mixed methods research of generating quantitative and qualitative data and analysing these through statistical, geo-spatial and thematic analytical tools to serve the purpose of this study. Reflections on data quality and ethics are also dealt with under this chapter.

The fourth chapter presents the analyses of results, including the spatial distributions of trip makers' residences and activity points as well as the transportation and Greenhouse gas emission patterns that emerge in GAMA. An in-depth discussion of the implications of the research findings, against the backdrop of existing theories, constitutes the fifth chapter of this present study. Finally, the sixth chapter provides a summary of key research findings and conclusions made. Also, contributions made by the study in climate mitigation, in general, and human geography, in particular, as well as recommendations to policy actors and reflections on possible areas for further studies are presented.

CHAPTER TWO: LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK

2.1. Introduction

This chapter reviews the literature on climate mitigation strategies available for the transport sector. This is followed by a review of the literature on the general interactions between land-use/spatial structures and transportation. The chapter further reviews various spatio-socio-economic and demographic factors, as well as personal motivations, for trip makers which influence the interactions between land-use/spatial structures and transportation. The chapter concludes with a discussion of the Systems conceptual framework, which together with the reviewed literature, guide explanations in this study.

2.2. Climate Mitigation in the Transport Sector

Transportation is an indispensable component for socio-economic growth and development. An efficient transport system promotes access to health, education, markets and other centres of opportunities which ensure the overall well-being of citizens. However, as an activity that at present depends almost exclusively on the combustion of fossil-based energy, the transportation sector is one of the most significant sources of anthropogenic CO₂ emissions. Together with water vapour, methane, nitrous oxide and ozone, the high concentration of these primary GHGs in the atmosphere is now widely accepted to lead to climate change (UN-Habitat, 2011). The long-term effects on the ability of the natural and human systems to adapt to climate change have been a source of concern. These long-term effects of climate change include rising atmospheric and ocean temperatures, the melting of ice caps and glacial snow, rising sea levels, floods, droughts which could potentially cause the disappearance of a significant number of the world's plant and animal species in the not-too-distant future (Intergovernmental Panel on Climate Change (IPCC), 2007). Therefore, the global response to climate change has led to a number of international proposals, for instance, the endorsement of voluntary GHG emission reduction in Rio de Janeiro, Brazil (1992) and the

compulsory emission abatement targets set in Kyoto, Japan (1997) and Bali, Indonesia (2007).

Within the scientific community, since the 1980s, a lot of research has been conducted on how climate mitigation can be promoted in the transportation sector, particularly in the developed countries (Naess, 2012; Rowlands, 1998). The majority of the earlier studies have focused a great deal of attention on the contribution of road transportation to climate change and in terms of the appropriate and permanent mitigation strategies that could be adopted. A review of GHG mitigation strategies for on-road transportation has identified three major categories. According to Sperling, Cannon and Lutsey (2009), these categories are vehicle efficiency, low-carbon fuels and travel reduction. Earlier studies, including Stanley et al., (2011), Kromer et al., (2010) and Bristow et al., (2008), have found evidence to confirm that improvements in vehicle technological efficiency hold the key to climate mitigation. The basic argument here is that the introduction of more efficient transmissions by car manufacturers will ensure an efficient combustion of fossil fuel energy. Emphasis is placed on the use of light-weight materials in the manufacturing of cars and the aerodynamically designing of cars. Again, the adoption of electric drive propulsion technologies such as those found in hybrid cars, coupled with user education and regular car maintenance, proponents argue, will drastically mitigate emissions from transportation.

Other studies (see Schipper, 2011; Johansson, 2009; Gilbert and Perl, 2008; Lin, Chen and Niemeier, 2008; Kahn Ribeiro et al., 2007) have strongly argued in favour of a complete switch to low-carbon fuel alternatives as the best climate mitigation strategy. The main argument in the above-named studies is that the use of low-carbon fuel alternatives such as biofuels made from maize and sugar cane, the chemical conversion of plant and animal fats into bio-diesel oils, as well as the use of cellulosic materials such as grasses and trees have

major climate mitigation benefits. Also, the adoption of hydrogen fuel cells and battery electricity vehicles could have a tremendous climate mitigation impact.

In other studies (Heres-del-Valle & Niemeier, 2011; Tiwari et al., 2011; Akerman, 2011; Ewing & Cervero, 2010; Zanni & Bristow, 2010; Givoni, Brand & Watkiss, 2009; Poudenx, 2008; Roth, Rhodes & Ponoum, 2008), it has been found that the promotion of travel reduction holds the key to a more sustainable climate mitigation in the transport sector. Mechanisms for promoting travel reduction include, for instance, the densification of land use system such that activity points for shopping, working and services provision are located closer to residential locations of urban dwellers. This will minimise the dependency on the car and its associated emissions. Other mechanisms include the adoption of information and communication technologies (ICT) and multi-modalism that will promote the seamless switch between motorised and non-motorised transport modes.

According to Sperling et al., (2009, p. 4), all three major mitigation strategies – vehicle efficiency, low-carbon fuels and travel reduction – ‘provide large co-benefits, including energy cost savings, oil security, and pollution reduction’. However, the effectiveness, appropriateness and permanency of these climate mitigation theories appear to differ among geographic regions. In the developed world, particularly in Western Europe, considerable GHG mitigation gains through improvements in vehicle technology have been achieved (Dulal et al., 2011; Zamboni et al., 2009). In North America, however, the mobility culture, urban designs, free flow of capitalism, among other factors, generally favour increased car weights, size and power. Thus, improvements in vehicle technology alone have not led to any effective climate mitigation in the transport sector (UN-Habitat, 2011; Ewing et al., 2008). With respect to the adoption of low-carbon alternative fuels, the United States and many other Western European countries have made giant strides in the use of highly subsidised ethanol made from maize and sugar cane, as well as biodiesel oils, to power

transportation, resulting in large climate mitigation co-benefits (Sperling et al., 2009). With respect to reducing car travel to mitigate carbon emissions, various studies have found that most cities in the developed countries, particularly in Western Europe, have made substantial gains (Cirilli & Veneri, 2014; Naess, 2012, Van Wee, 2002; Meurs & Haijer, 2001). Notable examples of such European cities include the Dutch Randstadt area (Schwanen et al. 2001); Greater Copenhagen (Naess, 2011; Hartoft-Nielsen 2001), Aarhus (Hartoft-Nielsen, 2001), Frederikshavn (Naess & Jensen, 2002, 2004), Greater Oslo (Naess, Roe & Larsen, 1995; Roe, 2001), and Paris (Aguilera, Wenglenski & Proulhac, 2009).

The promotion of low-carbon bus rapid transit (BRT) system in cities such as Curitiba (Brazil), Bogota (Columbia), Delhi, Pune, Hyderabad (India), Lagos (Nigeria), Cape Town (South Africa) and Dar es Salaam (Tanzania) has led to major climate mitigation gains, besides co-benefits of improved service quality, reduction of traffic congestion and improved road safety. Columbia's 'TransMilenio' bus rapid transit project has been granted permission by the United Nations to trade carbon emissions under the Kyoto Protocol, perhaps an indication of endorsement of the climate mitigation being made in the transport sector of a developing country. Brazil's adoption of biofuels produced from sugar cane, in mass transit vehicles since the 1980s and more recently in its fuel-flexible vehicles, is a special case in point to support climate mitigation strides made in developing countries. The Pew Centre on Global Climate Change (2002) also found that other developing countries including China, India and South Africa have made significant GHG emission savings by as much as nearly 300 million tonnes per annum due to the fuel switch from coal to natural gas.

However, most developing countries have witnessed growing motorization due to growing affluence and high population growth rates. Developing countries generally lack proper car maintenance regimes. Again, there is a general lack of fleet renewal policies that could also ensure the decommissioning of old polluting vehicles.

These factors, according to Li (2011) as well as Newman and Kenworthy (2006) limit the overall climate mitigation gains that could be made in developing countries through an emphasis on the vehicle efficiency strategy. In terms of the low carbon fuel strategy to climate mitigation, a number of constraints may limit its adoption and implementation in developing countries. Against the backdrop of food scarcity in most developing countries, the conversion of staple foods, like maize and sugarcane into biofuels for use in vehicles, may worsen the food insecurity situation and may lead to social unrests. Following the 2008 global food crises, the use of plant-based energy for transportation activities has sparked much controversy. While the evidence is not without debate, it is reported that biofuels forced global food prices up by 75% (Chakraborty, 2008). Coupled with the above, most developing countries may find the initial capital investment involved in new transport infrastructure very prohibitive.

Owing to the constraints associated with the vehicle efficiency and low-carbon fuel strategies, various studies including Abane (2011), Zhao (2010) and Scheiner (2006) have strongly argued for the travel reduction strategy, particularly the promotion of mix land use development and the integration of land use and transport systems. Some cities in the developing world that have effectively minimised GHG emissions through the travel reduction strategy are often cited to support the need to integrate land use and transportation systems (Cervero, 2013). Unfortunately, in most cities in the developing world, including GAMA, there is a general lack of an integrated land use and transportation system, prompting calls for developing world cities to address this challenge ‘before it is too late’(Cervero, 2013, p.20). Following from this, and in consonance with the aforementioned studies (i.e. Cervero, 2013; Abane, 2011; Zhao, 2010; Scheiner, 2006), the central focus of this present study is on the land use and transportation systems nexus as a climate mitigation strategy, using GAMA as a case study.

2.3. The Land-Use and Transportation System (LUTS)

The land-use and transport system typically involves a number of sub-systems which are very much integrated. Following van Acker and Witlox (2005, p.2), these sub-systems include:

(i) the spatial distribution characteristics of land use, such as density, diversity and design; (ii) the locations of human activities; and (iii) the interaction between land uses and activities. The transportation system comprises: (i) travel demand, i.e., the volume and characteristics of travel and movement of goods, (ii) infrastructure supply, i.e., the physical characteristics of infrastructure (e.g., road capacity, speed limits), the characteristics of infrastructure use (e.g., distribution of traffic levels over time, the time table of public transportation), and the cost and price of infrastructure, vehicles and fuels; and (iii) the interaction between travel demand and infrastructure supply.

Given the interconnectedness of land use and transport system, a unit change in any one sub-system can cause a major direct change in the other sub-systems. This occurs in a series of feedback mechanisms. For instance, van Acker and Witlox (2005), as well as Wegener and Furst (1999), have shown that urban spatial patterns are exhibited in the locations of activity points for living, working, shopping etc. In order for urban dwellers to utilise these activity points, transportation systems are needed. In this sense, spatial patterns have a direct implication for travel demand. On the other hand, by opening up the urban space and promoting accessibility, transport leads to more spatial interactions. This interaction further shapes the location decisions of urban dwellers and leads to further changes to land use. In effect, land use and transport systems are inseparable. Thus, as cities continue to grow outwards, changes do occur in the spatial distributions of land use types. The phenomenon of outgrowth of cities is referred to as urban sprawl or urban decentralization.

According to the European Environment Agency (EEA) (2006, p.5), urban sprawl is generally the result of ‘unplanned incremental urban development, characterised by a low density mix of land uses on the urban fringe’. Cobbinah and Amoako (2014) and Owusu (2013) have further argued that urban sprawl is exhibited in development patterns that are patchy, dispersed and strung out, with a general tendency for discontinuity. In the United States, urban sprawl began in the early part of the 20th century due to the ‘rapid growth of private car ownership and the preference for detached houses with gardens’ (EEA, 2006, p.5). Nechyba and Walsh (2004) and Frumkin (2002) have further attributed the American urban sprawl to lower costs of commuting, growing affluence and the desire to avoid the negative externalities associated with city living, including noise, filth and other social vices. Generally, European cities have been found to have on the average spread out by 78%, whilst their population has increased by only 33% since the 1950s (Li, 2011). European countries such as Belgium, the Netherlands, southern and western Germany, northern Italy, the Paris region in France, according to an EEA (2006) report, have sprawled largely due to high population density, economic growth, regional European Union policies and the general absence of strict planning control of land use and its subdivision.

In many cities of the developing world, urban sprawl has occurred, principally due to inadequate regional planning and poor urban governance. In a study of urban sprawl in major Indian cities, for instance, Sudhira, Ramachandra and Bala (2007) argue that the paucity of effective governance has been the bane of sustainable urban growth and management. Similarly, in some major Ghanaian cities, notably GAMA and Kumasi (Ghana’s second largest and fastest growing city), earlier studies have found evidence of urban sprawl (Cobbinah & Amoako, 2014; Owusu, 2013; Doan & Oduro, 2012; Yeboah, 2003; Grant & Yankson, 2003; Grant & Nijman, 2002).

The implications of the land use and transportation system interactions, against the backdrop of urban sprawl, have been the focal point of earlier debates. Besides pollution and environmental degradation, as argued in earlier studies (Oteng-Ababio, 2013; Angel, Parent, Civco, Blei & Potere, 2011; Wasserman, 2000, 2008; Moller-Jensen et al., 2005; Frumkin, Frank & Jackson, 2004; Amuzu & Leitmann, 1994), urban sprawl promotes automobile dependency, longer commuting time and distances (Yeboah, 2003; Abane, 1993). This has negative implications for energy use and GHG emissions. Sperling et al. (2009, p. 8) argue that ‘residents in more densely populated areas and in areas with better mixes of land uses tend to emit far less GHG emissions from their travel’. Earlier, Lyons, Kenworthy, Moy & dos Santos (2003) also argued, on the basis of empirical studies conducted in 84 cities in United States, Europe, Australia and Asia, that there is a direct air pollution reduction and climate mitigation benefits from minimizing urban sprawl. This notwithstanding, Glaeser and Kahn (2003) have touted the benefits of urban sprawl by arguing that it actually promotes cleaner air, probably due to the possibility of residing in bigger houses with ample space and greenery, besides lower crime rates as well as improved public education facilities.

The land use and transportation system interactions and their implications for climate change or climate mitigation is, however, not always a straight-forward one. This is because various transport modes have different energy and emission efficiency potential. Thus, the choice of particular modes and especially the factors which influence the modal choice decisions of urban commuters are quite critical. The next section explores from the literature how spatial, socio-economic and personality differences among urban dwellers serve as useful explanatory variables on what goes into the determination of modal use by trip makers and how their decisions have implications for energy use and emissions.

2.3.1. Spatial Dimension of the LUTS Interaction

In spatially large cities of the world, earlier studies have found that there is a high use of motorised transport modes, as opposed to non-motorised transport modes such as walking and cycling. This is attributable to longer trip distances and travelling time (van Acker, Witlox & van Wee, 2007; Schwanen, 2002; Gordon, Kumar & Richardson, 1989). Inversely, when urban residents reside relatively close to activity points, studies show that there is a high use of non-motorised transport modes. In American cities, Cervero (1996) found that relative proximity to mixed-use development influenced modal use in that it facilitated non-motorised transport mode use. Badoe and Miller (2000) have criticised the methodology and the goodness-of-fit of Cervero's (1996) model. However, the conclusion that residents of dense, mixed-use residential neighbourhoods have a greater propensity to walk or bike as opposed to residents of low-density peri-urban areas is supported in other American cities, such as the Portland metro area of Oregon (Rose & Burkholder, 2009; Cervero & Kockelman, 1997). Further evidence gathered from some Western European cities (Cirilli & Veneri, 2014; Naess, 2012, Van Wee, 2002; Meurs & Haijer, 2001) all point to the fact that in densely populated areas where people live in close proximity to activity points, and where infrastructure is provided for walking and cycling, car use is less than it would otherwise have been. In cities of the developing countries where land use planning ensures relative proximity to activity points for urban residents, the evidence examined so far shows that there are less car ownership and use and there is high use of non-motorised transport modes (Cervero, 2013; Zegras 2012, 2010, 2004; Lin & Yang 2009; Zhang 2004).

The obvious climate mitigation impacts of the high use of non-motorised transport modes in dense and mixed-land use neighbourhoods is well attested to in the literature (UN-Habitat, 2011, Dulal et al., 2011; Handy, Cao & Mokhtarian, 2006; VandeWeghe & Kennedy, 2007; Van Wee, 2002; Boarnet & Crane, 2001, Newman & Kenworthy, 1999;

Gordon & Richardson, 1997; Naess, Sandberg & Roe, 1996). There are, however, some scholars who have found evidence to doubt the influence of spatial/land use factors on transport patterns (and the associated energy use and emission). Such scholars include Miller and Ibrahim (1998) and Kagermeier (1997) who argue that such mutual influence is non-existent. Crane and Crepeau (1998), as well as Kockelman (1997), also argue that the mutual influence of land use and transportation exist, albeit negligibly. Yet still, others point to the possibility of a counteracting mechanism in which savings made in money and time due to proximity to activity points could be spent on making longer leisure trips in motorised transport modes (Naess, 2012; Crane, 1996; Vilhelmson, 1990).

While the issue of long leisure trips may be valid for urban dwellers in the developed world, in the developing world context, such long leisure trips may be insignificant, due to generally high levels of poverty. Thus, savings made in money and time may be used to meet other basic needs. Therefore, the possibility of a counteracting mechanism may be negligible among urban trip makers in the developing world. Besides, in the developing world context, Abane's (2011) study supports the evidence shown in the above-mentioned international studies of a strong relationship between spatial factors and transportation patterns, particularly on modal use by urban dwellers. Earlier, following a survey of Ghanaian formal sector employees, most of whom lived at distant peri-urban localities away from their workplaces, Abane (1993) argued that the land use patterns of GAMA have promoted a high use of motorised transport modes. The study had found that much as 67% of respondents resided in the peri-urban parts of the city while commuting to and from work daily, primarily in trotros⁴ and taxis. The author concluded that 'these modes have concentrated their services between the suburbs and the city centre where demand for travel is greatest' (Abane, 1993, p.

⁴ Trotro (singular) or trotros (plural) is a local Ghanaian word, deriving its meaning from 'Three Pence', which used to be the public transport fares charged for commuting in Bedford 'mummy trucks' sometime back in the late 1950s and 1960s in GAMA (Agyemang, 2015; Abane, 2011).

223). Ten years later, Yeboah (2003) also found evidence of a mutual interaction between spatial factors and transportation systems in Ghana. Following from a review of the emergence of a new urban form in Accra, Yeboah (2003, p.109) argues that there still remains ‘a strong functional interaction between the peri-urban areas of Accra and Accra Metropolis itself. This functionality is evident in journey-to-work and shopping patterns’.

In the Ghanaian context, the above-mentioned studies have been recognised for throwing light on the urban spatial structure and transport interactions. However, there still remain important gaps to be filled. For instance, Abane (1993) found evidence of a high use of motorised transport, particularly the informal public transport. However, in view of the ever-changing consumer preferences and commuting behaviour, for instance, due to growing affluence, it is interesting to examine the mobility patterns of urban dwellers presently (i.e. 2014), in over twenty years since Abane (1993) first conducted his study. Also, Yeboah (2003) found a functional interaction between the city centre and its peri-urban areas. The functional interaction appears to exhibit a uni-directional or a one-way traffic pattern in which all traffic that originates in the peri-urban areas necessarily ends up at the city centre. However, in the light of the setting up of competing central business districts and commercial facilities in various parts of GAMA in recent years, the present direction of the functional interaction is unknown. Also, it is not clear which specific peri-urban localities most of the trips to the city centre are presently emerging from. These gaps in the existing literature have informed the first two research questions:

1. What are the patterns of residential locations vis-à-vis activity points for shopping, work and accessing public services in GAMA?
2. How does the geographical distribution of residences vis-à-vis activity points for shopping, work and public services influence the use of transport modes in GAMA?

According to van Acker et al., (2007), in order to fully understand the land use and transportation systems interactions, there is the need to include other non-spatial factors. These are socio-economic and demographic. The next section, therefore, discusses how socio-economic and demographic variables moderate the land use and transportation system interactions.

2.3.2. Socio-Economic Factors Influencing the LUTS Interaction

Socio-economic and demographic variables known to influence travel behaviour include age, gender, household size, education, occupation status, income levels and car ownership status of trip makers. In terms of age, a number of international studies (Van Acker et al., 2007; Dargay & Hanly, 2004; Schwanen et al., 2004; Rajamani, Bhat, Handy, Knaap & Song, 2003; Stead, 2001; Boarnet & Sarmiento, 1996) have found car ownership and use to be lower among young (aged below 35 years) and older people (aged above 65 years). Schwanen et al., (2004) have argued that old people in the Netherlands are generally known to walk often and use public transport quite extensively. Also, in the Portland Metro Area (USA), Rajamani et al., (2003) found that old persons often ride-share over shorter distances often for socialisation and other non-work related trips. On the contrary, a study on work-related trips in Ghana (Abane, 1993) found that older employees in Accra were less likely to use public transport (i.e. trotro) for their journeys and would rather prefer to use faster and more comfortable modes such as taxis and private cars.

With regards to gender roles, studies (van Acker et al., 2007; Schwanen et al., 2004, 2002; Simma & Axhausen, 2000) have found that men generally use cars for work-related trips more often than women. This implies that the use of cars among women may be higher with respect to their non-work related trips. The above-named studies further found that women generally walked, biked or made frequent use of the public transport more often than men.

However, while this may be true in some Western societies, such as the Netherlands and Austria where Schwanen et al., (2004) and Simma and Axhausen (2000) conducted their studies, their conclusions may not be valid for other societies. For example, in some societies, women are forbidden to drive cars, irrespective of the trip purpose. Again, given safety and cultural concerns, women are less likely to bike in certain societies where dedicated infrastructure for biking is either unavailable or is culturally unacceptable for them to do so. Changes in gender roles and the global agenda on women empowerment and gender equality issues might have changed the effects of gender on the travel behaviour of urban dwellers in recent times.

Household size has also been found to influence car ownership, and by implication, usage. Amoh-Gyimah and Aidoo (2013) have found that married formal sector employees and those with a relatively large family size in Kumasi, Ghana were significantly more likely to use cars to work than those who were unmarried or had smaller family sizes. This finding is supported by a number of international studies that conclude that the larger the household size, the greater will be the propensity to own several cars, drive for longer distances and make less use of public transport (Dargay & Hanly, 2004; Rajamani et al., 2003; Krizek, 2003; Simma & Axhausen, 2000; Cervero & Kockelman, 1997). According to Van Acker (2007), the effect of household size on modal use is also very much a function of the number of employed members and children in the household. The more people are employed in a household and the more children they have, the greater will be the level of car ownership and use.

Education, occupational status and income levels are usually related and they make major impacts on modal use decisions of commuters. Highly educated workers are more involved in jobs with a higher occupational status, which results in higher incomes, higher car ownership and use, longer travel distances and travel times (Van Acker, 2007; Dargay &

Hanly, 2004; Krizek, 2003; Schwanen et al., 2002; Stead, 2001; Kockelman, 1997; Boarnet & Sarmiento, 1996). For instance, a study of formal sector employees in Ghana showed that senior-level employees who generally have the means to afford private cars or have access to cars used them when commuting to work due to their perceived comfort and reliability (Amoh-Gyimah & Aidoo, 2013; Abane, 1993). Besides intra-city transport, Ojo, Amoako-Sakyi, Agyeman, Amenumey and Abane (2014) tested the above-mentioned socio-economic variables on users of intercity bus services on the Accra-Takoradi road in Ghana. Their conclusions on the role of socio-economic variables were very much similar to those which earlier studies had found to influence modal use for intra-city transport.

2.3.3. Trip Makers Motivations, Preferences and Perceptions of Utility

As rational beings, trip-makers select among various transport alternatives, the ones which are most likely to render them the maximum utility. The utility to be derived from different transport modes is reflected in the preferences and lifestyle options that trip makers undertake. Handy's (1996) pioneering study in Austin, Texas; Kitamura, Mokhtarian & Laidet's (1997) study in the San Francisco Bay area as well as those of van Wee (2002) in Utrecht, the Netherlands, similarly came to the conclusion that land use was rather a secondary factor when trip makers choose to walk or bike. It would appear that the utility derived from non-motorised transport modes including health benefits as well as environmental and climatic sustainability shape the decision among some trip makers to walk or bike.

In a Ghanaian study of transport modes by formal sector employees in Kumasi, Amoh-Gyimah and Aidoo (2013) found that peoples' perception of the quality of service provided by the various transport modes greatly influenced the modal use for the journey to work. Among formal sector employees, the need to get to work on time is paramount.

Hence, in this study, travel time was considered the most important in modal use decision making. Earlier on Abane (1993) found similar evidence among formal sector employees in Accra. In addition, he found that perceptions of affordability were key, as most males in junior positions and who earned low incomes used trotro which they perceived to be affordable as opposed to taxis and buses. Again, price and perceptions of comfort and reliability were key determinants in car use among respondents in senior-level positions. When in a latter study, Abane (2011) widened the scope to include all trip makers in four metropolitan Ghanaian cities, he found that in addition to affordability, the perception of commuters on the availability of various transport modes was ranked highest in the survey on travel behaviour in Ghana, while reliability and safety were ranked the least important modal use determinants. Ojo et al., (2014) also found that perceptions of quality of service measured by trip frequency, work ethics of the driving crew, availability of space for luggage, comfort, safety/security and speed were important determinants of choice of transport modes.

The literature has demonstrated that the non-spatial factors (i.e. socio-economic, demographic and service quality perceptions of urban trip makers) that moderate the land use and transportation system interactions are constantly changing. Therefore, the influencing role of these non-spatial factors on transportation patterns, particularly, modal choices of urban trip makers, can be expected to have altered significantly from what has already been found in the existing literature. In addition to the non-spatial factors, studies in GAMA (Abane, 2011, 1993; Yeboah, 2003) have stressed the role of spatial factors, particularly trip distance, in determining the modal choices of trip makers. Specifically, Abane (2011, 1993) and Yeboah (2003) have unanimously found that increasing distances between activity point locations in relation to locations of residential areas are the primary reason for the high dependence on motorised transport modes by GAMA trip. However, what is not known is the extent to which short distance trips made by GAMA dwellers to activity point locations in

their community of residence can influence their decisions to travel by motorised or non-motorised transport modes. Also, while other international studies (Cirilli & Veneri, 2014; Cervero, 2013; Zegras, 2012; UN-Habitat, 2011, Dulal et al., 2011; Lin & Yang 2009) have demonstrated the GHG emissions savings from short distance trips made with non-motorised transport modes, this has not been studied, as far as the researcher is aware, from the Ghanaian context.

Thus, going forward, the gaps in the existing literature have informed the third and fourth research questions which drive the present study:

3. What are the main factors that influence modal use by trip makers in GAMA?
4. How do observed patterns of transportation behaviour and land use patterns influence energy use and Greenhouse Gas emissions in GAMA?

The high use of low occupancy motorised transport modes for long distance trips has had adverse impacts on per capita energy use and GHG emissions in Ghana (Trans-Africa Consortium, 2010). Thus, mass transit using the bus system have been proposed in earlier studies as the way forward in achieving climate mitigation (Trans-Africa Consortium, 2010; GoG, 2008; Fouracre et al. 2003; Akoena & Twerefou, 2002). In the Ghanaian literature, the debate has been focussed on whether present users of the informal public transport and car users are more or less likely to patronise formal bus services (Amoh-Gyimah & Aidoo, 2013; Abane, 2011). Also, the challenges that beset the introduction of mass transit have received attention in the Ghanaian literature (Agyemang, 2015). Specifically, Amoh-Gyimah and Aidoo (2013) have argued that the majority of formal sector employees who presently travel to work by public transport (i.e. trotro and taxi) were willing to use bus services instead, provided the institutions they work for arranged for such services. This is in view of their perception of quality of service they could enjoy, such as reliability, ease of access, lower fares etc compared to the present informal public transport they use.

While car users, among the surveyed formal sector employees, were found to be less likely to opt for institutionally arranged buses, at least in the interim, the scholars were optimistic of a behavioural change provided the services rendered by the institutionally arranged buses offered maximum utility for the workers. Abane (2011) found evidence to the contrary when he observed that intra-urban bus services, at least the ones being run presently by the Metro Mass Transit Limited, were beset with operational challenges, notably congestion and overcrowding. Hence, commuters were less likely to patronise bus services. Agyemang (2015) also argues that the role of the incumbent informal public transport operators was critical to the success of the formal bus services in GAMA. Against this backdrop, the fifth research question which guides the present study is:

5. From the perspective of key stakeholders, what are the enabling and constraining factors for the adoption of a climate efficient transport system in GAMA?

2.4. Conceptual Framework

This sub-section discusses the theory and philosophical worldview which guided the development of a conceptual framework for the study. The interactions between land use and transportation system are characterised by causal relationships through series of forward and backward linkages as well as feedback mechanisms, as noted in the literature (van Acker & Witlox, 2005; Wegener & Furst, 1999). These linkages and feedback mechanisms represent one of the important elements of the ‘systems thinking’. The ‘systems thinking’ is originally attributed to Ludwig von Bertalanffy who has earlier integrated different systems approaches in Biology, Chemistry, Psychology, Cybernetics and Social Sciences into a General Systems Theory (GST) (Hammond, 2005; Ossimitz, 2001). Bertalanffy’s (1968) argument is that all things (as objects primarily but also as ideas) have connections with many other things and the significance of any one depends on its relationships with others.

Bertalanffy (1968), however, did not make any explicit reference to the feedback concept which is a major internal factor which characterises the dynamic behaviour patterns of systems. Thus, Jay Forrester's (1969) *Systems Dynamics*, in general and the *Urban (Systems) Dynamics*, in particular, have been credited with the introduction of new and improved tools for diagrammatising feedback structures, as well as introducing the concepts of non-linearity and time delays to solve the dynamic complexities associated with the real world. Forrester (1969) strongly argued that the real world is a multi-loop, multi-state, non-linear feedback system that reacts to the decision makers' actions in ways both anticipated and unanticipated. In other words, policies and strategies adopted today may have several unforeseen repercussions due to the interplay among multiple variables in a system. In almost half a century of its existence, the theory of urban systems dynamics has been applied in solving numerous real world urban and transportation challenges. These include America's urban crisis (Forrester, 1969), Mexico's sustainable urban management (Duran-Encalada & Paucar-Caceres, 2008); traffic congestion and informal urban transport in Accra, Ghana (Oteng-Ababio & Agyemang, 2012; Armah et al., 2010) as well as housing provision and the development of essential environmental facilities in Kumasi, Ghana (Asiedu, 2001; 1991).

Systems, whether 'closed' (i.e. have no links to or from a surrounding environment) or 'open' (i.e. have and interact with the milieu) generally, have a function, goal or purpose. Following Johnston, Gregory, Pratt and Watts (2000), systems are also characterised by 'flows', 'causal relationships', 'black-box relationships' (i.e. consequence of the link is known but the causal factors are not). Every system has a 'structure' which represents an amalgamation of interactions among various system variables, elements or sub-systems. These variables operate over time to produce complex behavioural patterns. In their operations, elements of a system may influence itself creating what is called a 'feedback loop' or a 'causal loop' which represents a closed sequence of causes and effects (Kirkwood,

1998; Richardson & Pugh 1981). However, since it is almost impossible to identify all the elements associated with the complex real world, a system's structure is usually modelled on the basis of what a researcher 'hypothesizes to be important for the problem of interest'(Armah et al, 2010, p. 257). Thus, while efficiency in vehicle and fuel technology was found in the literature (Stanley et al., 2011; Schipper, 2011; Kahn Ribeiro et al., 2007) to be important climate mitigation strategies in the transport sector, this present study on GAMA looks at travel demand reduction to climate mitigation as the key problem of interest. This is because the researcher is inspired by earlier studies (Cervero, 2013; Abane, 2011; Li, 2011; Zhao, 2010) that have found that in cities of developing countries there is a greater potential for achieving climate mitigation in transportation through an efficient and integrated land-use/transport system.

In the present study, elements of the theory of utilitarian travel demand which seek to establish the rationale for travel behaviour (as discussed in van Wee, Baker & van der Hoorn, 1997) and Owusu's (2008) analytical framework of spatial levels and factors accounting for GAMA's sprawl are adopted and adapted into a Systems conceptual framework. The Systems conceptual framework illustrates and accounts for the interactions among spatial structure, transport patterns and climate change mitigation in GAMA.

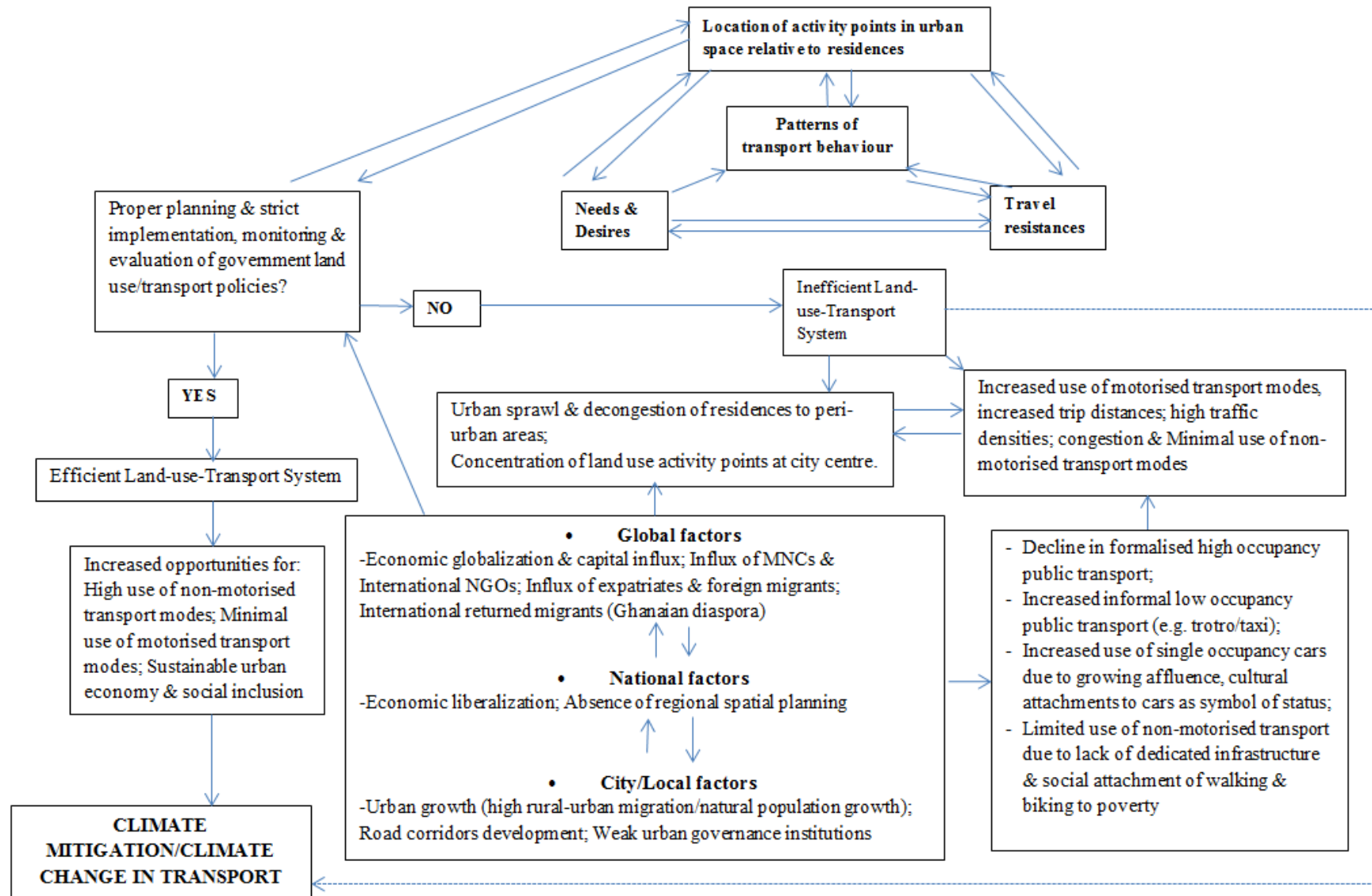


Figure 2.1: A Systems conceptual framework of land-use and transport system on climate mitigation in GAMA. Source: Adapted from Owusu, 2008; van Wee et al., 1997).

As illustrated in Figure 2.1, the location of activity points or the urban form in general, directly influences transportation behaviour by determining or constraining certain types of travel behaviour, as well as the cost and the consumption of travel (Naess, 2012; Boarnet & Crane, 2001; van Acker, Witlox & van Wee, 2007). In other words, the locations of land use activity points for work, shopping, leisure, education, cultural activities etc. across the city, usually away from the homes of urban dwellers create a travel demand. The theory of utilitarian travel demand, therefore, states that the demand for travel is based on the utility to be derived by the trip maker and not in the trip itself. As has been put forward by van Wee (2002, p. 260) ‘travel demand does not derive its utility from the trip itself, but rather from the need to reach locations where activities take place. So, from this perspective of utility, travel is seen as “derived demand”. Therefore, the pattern of transportation behaviour (including making a decision to travel to where, at what time to go, which route to travel and which particular mode to go with) is a function of the need or desire of trip makers to access activities points located elsewhere. In order to do this, trip makers must overcome travel resistances, including travel costs (in monetary and time value); quality and quality of service of competing transport modes. Oppenheim (1994, p. 31) has argued that trip makers ‘always choose the travel alternative (or the combination of alternatives when making several, joint choices) which offers them maximum utility’. Modal use, for instance, may be measured by the attributes of a particular mode, relative to competing modes. These attributes may include speed, comfort, accessibility, frequency, safety, and cost (in monetary and time value).

Besides the attributes of a mode, the measure of utility is also a function of the socio-economic and demographic attributes of the trip maker. These socio-economic and demographic attributes influence the needs and desires of individual trip makers. For instance, while low-income trip makers may be more concerned about travel costs, high-income trip makers may be more concerned about trip time.

Transportation behaviour, in turn, influences the location of activity points in the urban space in that trip patterns can also influence the spatial spread or concentration of activity points. In view of the interconnectedness, linkages and feedback mechanisms that exist between these two sub-systems (i.e. land use and transportation systems), there is the need to properly integrate land use and transport through effective policies that will enhance the efficiency in their interactions. This efficiency could be exhibited in increased use of non-motorised transport modes, particularly walking, when for instance, land use patterns make it possible for urban dwellers to reside close to their activity point locations. Already, in GAMA, as in several major cities of the developing countries, walking is a major form of low-cost mobility, especially for poor and vulnerable urban dwellers who are entangled in what has been described as a web of perpetual ‘transport poverty’ (Agyemang, 2015; UN-Habitat 2013). Again, the efficiency of land use and transportation system could also be reflected in a shift from low occupancy and energy-inefficient cars to high occupancy and an energy efficient mass transit system such as bus and light rail public transport system. This is in view of the density of human population that characterises mixed and dense land use patterns. Under the circumstances described above, the effects of an efficient land use and transportation system may be observed in terms of less use of fossil-based energy and its associated GHG emissions. This will ultimately mitigate climate change, besides other co-benefits such as the promotion of social inclusion and a sustainable urban economy through greater access to employment, education, health, services and leisure.

On the other hand, if the interactions between land use and transportation systems are not properly planned and regulated, inefficiencies could be introduced. The inefficiencies could be reflected in urban sprawl and relocation of settlements further away from the city centre which hosts the important activity points to the peri-urban areas of the city. In GAMA, a number of global, national and local driving forces operating at different spatial scales have either led to or contributed to the inefficiencies in the present urban form (Owusu, 2008).

The present urban form may promote the high use of motorised transport over longer distances, traffic congestion and less use of non-motorised transport modes for commuters. The increased use of motorised transport modes may also contribute to a further sprawl of the city. The above inefficiencies in GAMA's land use and transport system could produce a negative feedback on energy use and GHG emissions. This will contribute to climate change.

2.5. Chapter Summary

This chapter looked at the literature on climate change mitigation in the transportation sector. It has been found that while transportation has been beneficial for the progress and advancement of human societies, the almost exclusive dependence of transportation on fossil-based fuel has been detrimental for the climate. Thus, available strategies for reducing transportation's contribution to global climate change have generally focused on improving vehicle technology, fuel efficiency and reducing dependency on vehicles for human mobility. Empirical evidence backing these mitigation strategies has shown varied mitigation gains in both the developed and developing countries. For developing countries, in particular, the literature has shown that a travel demand reduction through the densification and integration of land use and transport systems is perhaps the best mitigation strategy. This is in view of the resource constraints and other local challenges in developing countries. However, in many cities of the developing countries, spatial planning and regulations on land use have not been in tandem with the transportation and mobility needs of urban residents. Urban sprawl, on one hand, and the concentration of activity points in the centre of most developing world cities, on the other hand, has promoted the high use of motorised transport modes for long distance trips. This has resulted in high energy use and GHG emissions.

The interaction between spatial factors and transportation patterns are paralleled by socio-economic and demographical factors such as gender, age, education, income, occupation type, in addition to individual perceptions of utility in various transportation

modes. The cause and effect relationships between land use and transportation system and their combined effect on climate change mitigation in GAMA have been illustrated in the Systems conceptual framework.

The next chapter –Research Methodology –discusses various data acquisition methods and techniques as well as tools for data analyses.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1. Introduction

This chapter is a discussion of the methodology that was employed to generate, analyse, interpret and present research findings. The first part of the chapter demonstrates how the methods were selected on the basis of the research questions. This is followed up with a description of the complementary mixed methods research that was adopted to generate data. Also, descriptions of how the primary data was processed and analysed, as well as a reflection of potential uncertainties identified in the data are presented. A description of the various secondary data sources that were used is also presented. The final part of this chapter deals with ethical issues and challenges encountered in the study.

3.2. Analytical Design

In this study, the nexus between land use and transportation systems is operationalised to mean the location of activity points relative to residential areas of urban dwellers; the attraction of various activity points; and the transportation patterns that are generated in response to the use of various activity points. To this end, the first research question is stated as, ‘what are the patterns and attractiveness of activity points for shopping, work and accessing public services vis-à-vis residential locations in GAMA?’ ‘Patterns’, as stated in the research question is operationalised to indicate the distances between the residential areas of selected urban dwellers and activity point locations. ‘Attractiveness’, as used in the research question, is operationalised to mean the number of trip makers who utilise various activity points and how often such activity points are utilised. ‘Residential locations in GAMA’, as seen in the research question, is operationalised to mean the localities where trips to activity points originate. In finding answers to the first research question, a two-phase questionnaire surveys were administered. In the survey on long distance trips, respondents were asked specific questions, such as the particular activity point (s) in Accra Central that

they utilised and how often they utilised these activity points. The respondents were also asked to indicate the reason(s) for the use of their activity points. The respondents were further asked about the location of their residences. In the household surveys, respondents were asked questions on activity points found in their community of residence, as well as those found in Accra Central and other parts of GAMA that they used. They were also asked to indicate the frequency of use of their activity points and the reason(s) for their use of those activity points. Distances from study sites surveyed in the household surveys were derived through a geographic information systems technique.

The second research question is: ‘how does the geographical distribution of residences vis-à-vis activity points for shopping, work and public services influence the use of transport modes in GAMA?’ The second research question is operationalised to mean the use of motorised and non-motorised transport modes by GAMA trip makers when embarking on long distance or short distance trips. ‘Long distance trips’, as used in this study, is operationalised to indicate trips made to access activity points located in Accra Central from various localities in GAMA. ‘Short distance trips’, on the other hand, are trips made to access activity points located close to the vicinity of trip makers. This research question was also investigated with the use of questionnaire surveys. Respondents were asked to indicate their main transport mode (i.e. the transport mode that covered the longest distance of their journeys) to activity point locations in Accra Central as well as those located in their community of residence. Respondents were further asked to indicate other transport modes they used, besides their main transport modes. They were also asked about how often they used their main transport modes when travelling to locations of activity points.

The third research question is stated thus: ‘what are the main factors that influence modal choice by trip makers in GAMA?’ This research question is operationalised to include all the factors which influence the decision of trip makers to choose various transport modes, as opposed to others.

The third research question is also investigated quantitatively with the use of the questionnaire survey. Respondents are asked to select from a list of mode-specific attributes which they think are their main reason(s) for using their main transport modes. They are further instructed to indicate other reason(s) not listed on the research instrument if there are any or some more. The respondents were also asked demographic and socio-economic questions, such as sex, age, educational attainment, household size, occupation type, and income.

The fourth research question is: ‘how do observed patterns of transportation behaviour and land use patterns influence energy use and Greenhouse gas emissions in GAMA?’ In this research question, ‘transportation behaviour’ and ‘land use patterns’ are operationalised to mean modal use by respondents, travel time and travel distance between homes of respondents and locations of activity points. This research question is also investigated with the questionnaire survey. Respondents were asked to indicate their total journey duration when travelling in their main transport modes from their homes to locations of activity points in minutes. Travel distances were derived through a geographic information systems technique. Observations of travel time and distance were also made by the researcher and the research assistants. Questions on energy use and GHG emissions were posed to respondents who travel to activity point locations in their personal transport means. Car users in the sample were asked to indicate some details about the cars they normally use for their trips to activity points, including fuel type, manufacturing date, total kilometres travelled, engine capacity and average monthly fuel purchased or consumed. Car users were also asked to indicate how often they serviced their cars. To investigate the energy use and emissions from respondents who are public transport users, a multi-participant interview involving six trotro drivers was conducted.

The fifth research question is stated as: ‘from the perspective of key stakeholders, what are the enabling and constraining factors for the adoption of a climate efficient transport

system in GAMA?’ The phrase ‘climate efficient transport system’ is operationalised in this study to indicate mass transit or a bus rapid transit system. In order to investigate this research question, a questionnaire survey was used to ask respondents on their willingness to use a proposed bus rapid transit system for GAMA and their willingness to use non-motorised transport modes to activity point locations. A multi-participant interview involving six trotro drivers and an interview with an official of a public transport operator union were conducted to ask for the perspective of incumbent transport operators on the proposed mass transit for GAMA. Informant interviews with two government officials and two social scientists were further conducted to provide a stakeholder’s perspectives to supplement the other data generated for the study.

At the initial stages of the study, the researcher decided to use different quantitative and qualitative techniques to collect and analyse data, in what is simply referred to as the ‘mixed methods design’. In theory, equal weights were supposed to have been applied to both quantitative and qualitative components in this study. In practise, however, the former dominated the latter. This is a challenge that has been pointed out in some earlier studies (Teye, 2012; Morse, Wolfe & Niehaus, 2006; Johnson & Onwuegbuzie, 2004). Under such circumstances, Teye (2012) and Sale, Lohfeld and Brazil (2002) have proposed the term ‘complementary mixed methods design’. Following these authors, the complementary mixed methods design has been adopted for use in this present study. This is because, as argued above, results from the qualitative method are used to supplement the results derived from the quantitative method.

3.3. Research Methodology

The complementary mixed methods design adopted in this study is based on the philosophical world view of pragmatism. The pragmatism philosophical worldview derives from the works of Charles Sander Peirce, William James, George Herbert Mead, John

Dewey, W. V. O. Quine, Richard Rorty, just to name a few. Pragmatists argue that researchers must emphasise the research problem and use ‘pluralistic approaches to derive knowledge about the problem’ (Creswell, 2014, p.11). In the light of this, the pragmatic philosophical worldview provided the researcher with the liberty to freely select from both quantitative and qualitative approaches (Creswell, 2014). The use of complementary mixed methods approach in research has not been without controversies (Teye, 2012; Bazeley, 2004; Sale et al., 2002). Opponents of complementary mixed methods argue that both quantitative and qualitative research approaches are radically opposed to each other by reason of their different ontological and epistemological orientations (Clarke, 2009; Meeto & Temple, 2003). Quantitative research was earlier mainly identified with the positivist paradigm which assumes that human behaviour can be explained or even predicted in terms of cause and effect by ‘carefully and objectively collecting data regarding social phenomena’ (Kitchin & Tate, 2000, p. 8). Qualitative research, on the other hand, is inspired by the interpretive philosophical paradigm. This paradigm recognises the complexity of social reality and therefore is one argument that social research must simply explain people’s behaviours and subjective positions (Bryman, 2001).

On the other hand, proponents of the complementary mixed methods argue that both quantitative and qualitative approaches have their inherent strengths and weaknesses (Kumar, 1996). Quantitative research is based on numeric or statistical techniques and has a major advantage of being able to produce ‘objective’ generalisations and predictions (Mikkelsen, 2005; Neuman, 2003). Quantitative research further enables the possibilities for modelling and establishing correlations between different variables in a survey (Castro, Kellison, Boyd & Kopak, 2010). The strengths notwithstanding, quantitative research cannot answer all questions relating to the complex social world (Moghaddam, Walker & Harre, 2003; Johnston et al, 2000; Brannen, 1992; Pratt, 1989).

Qualitative research methods, including interviews and the multi-participant interview discussion, as have been used in this study, make it possible to generate thorough information on the ‘experiences, perceptions, emotions, beliefs and behaviours of respondents’ (Teye, 2012, p. 380). Qualitative methods have the added advantage of being comparatively more flexible and reflective than quantitative research (Minichiello, Aroni, Timewell & Alexander, 1995). However, limitations of the researcher’s bias and inability to produce universally consistent conclusions are often associated with doing unqualified qualitative research (Plano Clark, Huddleston, Churchill, Green & Garrett, 2008; Rudestam & Newton, 1992).

In the light of this, this study draws inspiration from the Kitchin and Tate’s (2000, p. 40) argument that the two research approaches must be seen ‘as a *continuum* rather than polar opposites’. Therefore, the adoption of the mixed methods research in this study is justified in the sense that it makes it possible to tap into the strengths of both research approaches. In addition to these various primary data sources, the study benefits from several secondary data sources as well. Therefore, not only has the scope of the study broadened but in addition, its validity has been strengthened. In terms of explanation, the quantitative research component provides descriptive and inferential statistics to describe general trends and behavioural patterns. The qualitative research component, on the other hand, complements the quality of the explanation by providing some of the reasons behind observed patterns. It cannot be overemphasised that the collection of quality and trustworthy data on passenger travel behaviour is a daunting task, particularly in developing countries (Stopher & Jones, 2003; Richardson, Ampt & Meyburg, 1995). This provides further justification for the use of the complementary mixed method design so as to address the research questions from different perspectives. In the next section, a detailed description of how the quantitative component of the complementary mixed methods research was used in this study is presented.

3.4. Quantitative Research Component of the Study

Quantitative data involving 800 trip makers who are non-residents of Accra Central but who make regular trips to the area to access its high-value activity points were collected with the use of interview-based questionnaires (see Appendix 12 and 13). The questionnaire administration was done as cross-sectional surveys. The use of interview-based questionnaires in this study facilitated inter-personal contact between the researcher and the researched. This resulted in higher response rates, as has been articulated in earlier studies (Behrens, Diaz-Olvera, Plat & Pochet, 2006; Yansaneh, 2005; Kitchin & Tate, 2000). The draft questionnaires were piloted prior to the actual fieldwork. The pilot surveys helped to clarify and re-word portions of the research instrument, thereby minimising potential non-response errors in the actual field data. Besides socio-economic and demographics items, the questionnaires measured the travel behaviour patterns of respondents, including mode of travel, trip frequency and trip purpose (i.e. whether work or non-work related). These transport-related items are known to generally influence emission levels in urban areas.

Before the commencement of the surveys, a two-day reconnaissance survey was conducted at sampled traffic lights which mark the entry points for vehicular traffic into Accra Central and at various entry points to Tema Station in Accra Central (see Appendix 14). This was done to identify two of the most important activity points which generate the most traffic to Accra Central so as to use their locations as the study sites. The use of the reconnaissance survey was necessary because the researcher was unable to identify, from the reviewed literature, the nature of traffic volumes to various activity point locations in Accra Central. Also, the selection of only two of the most important activity points is justified by time and resource constraints which made it impossible to consider all activity points. A systematic sampling and an interview guide were used for this exercise (see Appendix 15). Counting from the selected traffic light, every third vehicle in the queue is accosted and the driver interviewed.

This was repeated for every other third vehicle from a previously surveyed vehicle until all stationary vehicles at a particular time have been surveyed or until the traffic lights turned green for them to continue their journey into Accra Central. Trip makers who had arrived in trotros were interviewed after they had alighted at various entrances to the Tema station [Lorry Park] through a non-probabilistic convenience sampling technique. The surveys involved only respondents who were not residents of Accra Central and who were willing to participate in the survey. The reconnaissance survey revealed that commercial (40.2%) and governance (26.6%) land use activity points were the major destinations of trip makers. Specifically, most respondents indicated that their main trip purpose was to work and/or shop at the Makola Market as well as in the Ministries Area. These two locations were then chosen as the study sites for the first stage of quantitative data generation on long distance trips. As illustrated in Table 3.1, during the data generation on long distance trips, 400 respondents were surveyed at various locations at the Makola Market and in some selected ministries at the Ministries Area. Appendix 16 shows various study sites for the long distance trip surveys.

In the second stage of quantitative data generation on short distance trips, three localities were selected for the conduct of household surveys. The selection of these three localities was considered by the researcher as practicable in view of time and resource constraints. In choosing the three localities, the researcher set up three criteria that must be met in order to be included in the selection: first, the selected locality must be among the top three localities in GAMA with respect to frequency of visits to Accra Central by its residents (i.e. as found in the data on long distance trips). Second, the selected locality must not be located within the Accra Metropolis where Accra Central is found. Third, a selected locality must show evidence of significant demographic and housing growth for the periods 1970, 1984 and 2000 when various studies (Owusu, 2013; Grant & Yankson, 2003; Yeboah, 2003) have confirmed

that were the periods when GAMA sprawled significantly⁵. Based on pre-analyses of the data on long distance trips, Kasoa, Teshie and Madina emerged as the three localities that satisfied the above criteria. The three localities differ in terms of their respective distances to Accra Central; road network capacity; population sizes as well as access to various activity points in GAMA. Thus, the differences provide a useful basis for their comparisons for analytical purposes. Appendix 17 shows various study sites in the selected localities.

The quantitative data generated on long distance trips and short distance trips respectively was done so as to answer a number of important sub-research questions with the aim of finding answers to the overall research questions and objectives guiding the study. For instance, the data on long distance trips was meant to answer questions like where do trip makers travel from to Accra Central?; what is the attractiveness of various activity points in Accra Central?; are these activity points specialised and peculiar to Accra Central or not?; what are the transport modes used by long distance trip makers (who access activity points in Accra Central)?; and how much energy and GHG emissions is associated with long distance trips? The data on short distance trips was also meant to answer questions like do trip makers in the three selected localities have other opportunities to access activity points which are located outside of Accra Central?; If so, why do they still find it relevant to access Accra Central activity points?; what are the transport modes used by short distance trip makers (who access nearby activity points)?; and how much energy and GHG emissions is associated with short distance trips?

3.4.1 Sampling Methods and Data Sources

Earlier studies (Behrens et al., 2006; van der Reis & Lombard, 2003; Godard, 2000; van der Reis, 1997) have found that the determination of an appropriate and adequately representative sample size for surveys conducted in developing countries where resources are relatively

⁵ Appendix 29 provides census data to illustrate the growth trends of these three localities

scarce is a huge challenge. Very often, the use of large sample sizes in surveys connotes the idea that ‘more is better’ and that the larger the sample size, the closer to reality the outcome will be (Twumasi, 2001; Kitchin & Tate, 2000). Yansaneh (2005) has however strongly disagreed with this generally held notion. The argument is that large sample sizes do not necessarily reflect the true characteristics of the general population as there may be a correspondingly large number of non-sampling errors. In the light of the above and on the basis of Yamane’s (1967) simplified statistical table, a total sample size of 400 respondents was considered appropriate for the data on long distance trips. Yamane’s (1967) simplified statistical table states thus:

$$n = \frac{N}{1+N(e)^2}$$

where n is the sample size, N is the population size and e is the level of precision. The sample size assumes a sampling error of $\pm 5\%$, a confidence level of 95 % and a 0.5 maximum variability.

In the adoption of this sample size, the main considerations were the research objectives and the population size of GAMA. The use of Yamane’s (1967) simplified statistical table as the statistical basis for sample size selection in this study is justified in the sense that it assumes a normal distribution of salient characteristics among the sample population being measured (Appeaning-Addo, 2012; Israel, 1992).

At Makola Market, two main groups of trip makers were identified. These are traders and shoppers. In earlier discussions with an administrator and the Queen of the Makola Market, it was revealed that in most cases, sellers do not necessarily trade in specific products over longer periods; they regularly change their products to reflect demands from shoppers. Armed with this information, the market was clustered, not in terms of products on sale, but on the scale of trading activities. Thus, wholesalers, retailers and hawkers (i.e. itinerant traders) of cosmetic products, textiles and foodstuffs were identified.

Each category of traders was assigned a predetermined sample size of 40. The wholesalers and retailers were selected through a systematic sampling technique. The researcher chose a random start on the lists of registered stalls and sheds as was provided by the market administrator. Beginning from the first number obtained through a lottery system, every other 3rd numbered stall or shed was selected until the total sub-sample was obtained for that group. This was to ensure that each individual in the population has an equal chance of being selected. The selection of the hawkers (i.e. itinerant traders) was based on accidental sampling. The nature of their trading activities is such that they are not stationary at a particular place for a longer time. However, depending on their availability and willingness to participate in the survey, they were invited over to the administrator's office where the interviews are carried out.

In view of the specialised services Makola Market offers, the study assumed that there will be more shoppers than sellers at the times the surveys were conducted. Accordingly, the sub-sample of shoppers was predetermined at 200. The first category of shoppers were primarily retailers (N=90) who come very early in the morning at about 5:30 a.m. and 6:30 a.m. to buy cosmetics, textiles and foodstuffs in relatively larger quantities for subsequent selling in smaller quantities in other local markets found in GAMA and beyond. The second category of shoppers (N=110) were the regular daytime shoppers who usually visit the market to buy in various quantities, basically for their own consumption. Two specific time windows, between 7:00 a.m. and 9:00 a.m. and also, 9:30 a.m. and 11:30 a.m. were chosen within which the second category of shoppers was selected through an accidental sampling technique. In conducting surveys in a large open space such as a market, there is always the tendency for some respondents to appear multiple times in the sample. However, this sampling error is discounted in that shoppers and sellers have travelled to the market principally for trading activities and not to be 'bothered' with a long set of questions.

Also, prior to the questionnaire administration, selected respondents were asked whether they had already participated in the survey at an earlier period or with any of the assistants spread across the market.

In the selection of respondents from the Ministries Area, a total of 24 ministries of the state (as published on the Ghana government's official website [www.ghana.gov.gh] accessed on May 12, 2014] were identified. Through a simple random technique (i.e. lottery system), five ministries of the state were selected from this list. On the basis of prior discussions with the human resource directors at the selected ministries, potential respondents were stratified into senior and junior staff groups respectively. Respondents were then selected based on a lottery system. In all, 50 formal sector employees made up of senior staff (N=25); junior staff (N= 25) were surveyed through a simple random sampling. Also, visitors who came to transact various businesses within the selected ministries were captured (N=30). This was done through an accidental sampling technique until the required sub-sample had been obtained per ministry. In all, 400 respondents were interviewed in the long distance trips sample. Appendix 18 provides a summary of the attribute information on the data on long distance trip makers. It was found that in terms of their geographical distribution, the majority of long distance trip makers –approximately 85% (N=338)–reside in GAMA compared with 15% (N=68) who are non-GAMA residents but regularly visit the central business district. Since the focus of the study is actually on GAMA, the greater part of the analysis in this study is based on only the 338 respondents.

During household surveys, a total sample size of 400 was predetermined, based on the above-mentioned assumptions of Yamane's (1967) statistical formula. The unit of analysis in the surveys is the 'household'. The 'household' is an important sampling unit in most African cities. However, the concept lacks a universal definition (Behrens et al., 2006; van der Reis & Lombard, 2003; Gil & Omaboe, 1993). For the purpose of this study, a 'household' is defined as per the Ghana Statistical Service official definition which includes a 'person or a group of

persons, who live together in the same house or compound, share the same house-keeping arrangements and recognize one person as the head of household' (Ghana Statistical Service, 2012, p. x). A household, therefore, may consist of the nuclear and extended family members as well as house helps co-habiting in a house. Head of households in the sampled houses constitutes potential respondents, based on their availability and willingness to participate. The term 'heads of households', as used in this study, are individuals 'who wield economic and social responsibility for the entire household' (Ghana Statistical Service, 2012). In their absence, all available and willing adults are considered potential respondents in this study. At the time of conducting the household surveys, the latest (2012) national population and housing census on GAMA was not readily available in a format that could be considered useful for the purpose of this study. As a way out, the researcher adopted a proportionate stratification sampling technique. In this sampling technique, each stratum was assumed to be proportionate to its size relative to the entire population under study. In other words, the sample size of each of the three localities, hereafter referred to as Phase 2, was determined by its proportion of the aggregate frequencies of the three top-most peri-urban localities found in the data on long distance trips, hereafter referred to as Phase 1. The estimation equation is given as:

$$\frac{n}{\Sigma N}(400)$$

Where 'n' = Fraction of Phase 1 top three locality frequencies

'N' = Summed frequencies of Phase 1 top three localities

The outcome of the application of the above formula on the three selected localities is illustrated in Table 3.1. For example, among the respondents who resided in the three top-most peri-urban localities in the Phase 1 data, 28 were from Kasoa. This figure represented 0.38 of the proportion of all trip makers who lived in the three top-most peri-urban localities (N=74).

When 0.38 was multiplied by the predetermined Phase 2 sample size of 400, a total sub-sample size of 151 was obtained for the conduct of household surveys in Kasoa.

Table 3.1: Sample size determination for household surveys

Localities	Phase 1 Total	Proportion of Phase 1 Total	Phase 2 sample size
Kasoa	28	0.38	151
Teshie	26	0.35	141
Madina	20	0.27	108
Total	74	1	400

Source: Author's own derivations, 2014

Following the selection of sample sizes for these communities, a stratified multistage cluster random sampling design was employed to select respondents for the household surveys. The application of the multi-stage sampling technique is justified due to the virtual non-existence of a proper residential address system and/or fixed telephones in some parts of Accra (Yansaneh, 2005). Low levels of education, especially in the high-density low-income areas have also necessitated the adoption of this sampling technique (Behrens et al., 2006). The multistage sampling design was implemented in two stages. In stage 1, a stratified sampling of residential units into clusters was performed following a reconnaissance survey of the three localities. Stratification assumes that the population within a particular class will exhibit similar socio-economic characteristics. However, the challenge with this logic is that the correlations among units in the same cluster could inflate the variance, in other words, the precision of survey estimates could be lowered significantly, compared with a design in which households are not clustered (Yansaneh, 2005).

Previous studies (Appeaning-Addo, 2012; Songsore et al., 2009; Agyei-Mensah & Owusu, 2009; Benneh et al., 1993) have stratified GAMA based on housing density and demographic characteristics into low income, middle income and high-income sectors respectively. The stratification of households into any of the three income clusters can be problematic, particularly against the backdrop of an earlier study (Asiama, 1985) that found

some extremely wealthy people in Accra lived in areas that are generally classified as low-income sectors. In view of this, the stratification of households into income sectors, in this study, is based on the dominant housing characteristics and housing types. These are used as proxies for the socio-economic and environmental conditions in each cluster.

The first cluster –high-density low-income housing types –is generally composed of single housing units which serve as the habitation for individual households. In many instances, there are several of such individual households living in different units of the same compound, a phenomenon referred to as ‘multi-habitation’ or the compound housing system (Apeaning-Addo, 2012). Thus, a key defining characteristic of low-income houses is that of high density. Finally, low-income houses are generally characterised by the lack of high walls or barbed-wire fences to separate one housing unit from the other and also to provide security for the occupants (see Appendix 19). In sharp contrast, the second cluster –low-density high-income housing types –are generally made up of large housing units with bigger compounds and which are designed to reflect modern architecture and aesthetics. These houses are generally inhabited by single households, thus, density is comparatively low. Finally, high-income houses are generally characterised by high walls mounted with barbed-wire and other electronic devices to ward off intruders and to keep the occupants safe (see Appendix 20). The third cluster is called medium density middle-income housing types. Compared to low-income houses, middle-income housing types are fairly large and densities are relatively low. While some middle-income houses may have walls to separate one household from the other (see Appendix 21), such walls are usually not mounted with the high-tech barbed wires and electronic devices which are key defining characteristic of the high-income housing types. In stage 2 of the multistage sampling design, each cluster in the study area is assigned a pre-determined cluster size or the total number of households to be interviewed, as illustrated in Table 3.2.

Table 3.2: Clusters employed in the household surveys

Cluster	Teshie		Kasoa		Madina	
	Suburbs	Size	Suburbs	Size	Suburbs	Size
1	Maami	47	Zongo Adakope	25 25	Zongo	36
2	Tsui-Bleoo	47	CP	50	Libya Quarters/UN	36
3	GREDA Estates	47	Iron City Blue Gate Blue Top	20 15 16	Madina Estates	36
Total (N)		141		151		108

Source: Author's own derivations, 2014

The classification of the study sites into clusters is meant to examine the influencing roles of spatial and socio-economic variables which are hypothesized in this study to greatly influence patterns of transportation behaviour among GAMA residents. In other words, the choice of transport modes, trip purposes, vehicle ownership and usage, as well as frequency of trips which are known to directly impact GHG emissions in the city, are a function of the geographical and socio-economic status of the individual. In stage 2 of the multistage sampling design, systematic sampling technique was employed in the selection of every 5th house beginning from a starting point. In situations where a selected house did not have a household head to answer the questions or the potential household heads declined to participate in the survey, any other available and willing adults were considered, else the next house immediately after it was considered. The process was repeated until the desired cluster size for a locality has been obtained. Appendix 22 illustrates the salient characteristics of the household survey data. The qualitative part of the complementary mixed methods research adopted in this study is presented in the next section.

3.5. The Qualitative Research Component of the Study

Interviews were conducted with 6 key informants who were carefully selected from the perspective of transport policy makers and managers; transport industry players; as well as social scientists who are experts in the fields of urban transport and spatial planning.

Appendix 23 provides an overview of the key informants. Each of the conversations with the key informants lasted an average of 60 minutes. The interviews were held in the offices of the informants. Where consent was given by the informants, the interviews were recorded with a tape recorder. Interview guides were used to guide the flow of the conversation. The informants provided factual knowledge that was otherwise hard to obtain. For instance, government officials were interviewed to find out what policy makers were doing with respect to public transportation in GAMA. Specifically, the study sought to find out what the present status of public transport supply in GAMA. Also, government policies to improve transport delivery, particularly with the implementation of the policy on mass transit were discussed. Finally, the officials were interviewed on what measures were put in place to address concerns of existing public transport operators.

Based on the responses provided by some trotro drivers which contradicted what the government officials have said concerning their involvement in the proposed mass transit policy, the researcher interviewed a top official of the trotro drivers' union for clarity. Also, the interview focussed on some aspects of the quantitative survey that delved into the perception of commuters on the quality of paratransit services being provided by trotro drivers. Furthermore, efforts being made by the leadership to address concerns of commuters were discussed. Similar questions were also posed to a senior official of the Metro Mass Transit bus company. The two social scientists were interviewed on regional and land use planning as well as transportation issues in Ghana, and specifically on GAMA. Also discussed were the main challenges confronting land use and transportation system in GAMA and what can be done to address the challenges. The researcher accepted the information presented by these informants as valid. Upon reflection, however, key informants can sometimes be biased in the information they provide, as has been cautioned in an earlier study (Mikkelsen, 2005).

Observations in the form of travel surveys were conducted over a 5-day period on-board selected trotros that ply the main corridors linking Accra Central to the three selected localities.

The participant observations took place within the morning peak periods (i.e. between 6 a.m. to 9 a.m.). The researcher was assisted by two research assistants in doing these travel surveys. On each day, the researcher and the research assistants started their journeys at different times within the 6a.m. to 9 a.m. time window. This was done to ensure variance in the travel time survey. This was also meant to capture the nature of road conditions, particularly, traffic congestion. Again, this approach was intended to introduce randomness in the selection of the probe vehicles. Drivers were not informed about the objective of our travel prior to the starting of the journey. This was to avoid any unintended influence our presence may have on the driver's behaviour. At the end of each day's journey at Accra Central, the research team introduced themselves and the objective of their trips to the drivers. The drivers were then interviewed on their fuel use and vehicle maintenance. An interview guide was used to direct the conversations (see Appendix 24). The purpose of the observation was two-fold. First, it was to afford the researcher the opportunity to cross-check the factual responses in the survey, particularly on the perception of travel time by respondents, as has been provided in the data on long and short distance trips by the respondents. Second, it was to afford the researcher the opportunity to study the operational characteristics of drivers which influence their energy use and its associated GHG emissions.

One multi-participant discussion, involving a group of six drivers who normally transport trip makers in the three selected localities to Accra Central was organised. This was to probe further some of the views already obtained from the interviews. The discussion delved deeper into the vehicular activity and fuel consumption patterns of trotro drivers. Also, as major industry players, their views on the mass transit policy that the government of Ghana intends to implement were also discussed. The main benefit of the group discussion was that the researcher was afforded the opportunity to observe the discussants debate, agree or disagree with comments expressed by other discussants until a position generally held by the group was found.

In a way, this approach was a practical way of ensuring that the findings contained in this study corresponds to some of the trotro drivers' experiences. The down side is that the members could have acted in a way that could have prevented a discussant from freely expressing an opinion which may be true, but which the group collectively did not want to share with outsiders. Appendix 25 and 26 illustrate the interview guide used for the focus group discussion as well as an overview of trotro drivers from whom the qualitative data were generated.

3.6. Data Processing and Analyses

Data processing commenced during the data collection on long distance trips to ensure that all questionnaires were completely and accurately filled out. The questionnaires were coded with the assignment of unique numbers to each answer which falls in a predetermined class and with common characteristics. This was followed by the tabulation of quantitative data in the Statistics Package for Social Sciences (SPSS). A number of statistical tests were performed. These include the descriptive statistics and cross tabulations performed on the quantitative data to measure the association of a trip maker's socio-economic and demographic status with modal use. Descriptive statistics performed on the attractiveness of various activity points are presented as column charts for comparative analysis. The Pearson chi-square was performed simultaneously to test whether any observed differences in the data were indeed statistically significant. Following after Kitchin and Tate (2000), the chi-square test was done by calculating the observed frequency minus the expected frequency and dividing by the expected frequency in each cell. The output was then summed to obtain the chi-square value. This is illustrated by the formula:

$$X^2 = \sum_{i=1}^n \frac{(O_i - E_i)^2}{E_i}$$

where 'O' is the observed frequency; 'E' is the expected frequency

The chi-square value obtained at 0.05 significance level as well as the degrees of freedom provided inputs for calculating the p-value. The p-value provided the basis for the acceptance of the alternative hypotheses underpinning the study. In addition, Cross Tabulations were performed on all long distance trip makers in GAMA (in the data on both long and short distance trips) to measure the association of trip makers' perceptions on climate variability and climate mitigation strategies, particularly on mass transit and their present modal use.

A Multinomial Logit (MNL) analysis was performed in order to test the main effects of selected predictor variables (socio-economic, demographic, spatial and mode attributes) on the dependent variable (modal use). The MNL has been used extensively in modelling urban travel demand in earlier studies (Abane, 2011, 1993; Dong, Ben-Akiva, Bowman & Walker, 2006; Ben-Akiva & Bowman, 2000; Swait & Ben-Akiva, 1987; Ben-Akiva & Lerman, 1974). This is because, the MNL as a generalised binary logit model is very efficient in modelling transportation data that are primarily categorical. The MNL is based on the Random Utility Theory which postulates that when provided with alternatives, an individual is most likely to select an alternative that is most likely to yield the highest utility (Dong et al., 2006). Utility, in this context is a function of how trip makers perceive a particular mode's level or quality of service, measured among other things, by how comfortable, available, safe, convenient, fast and affordable the mode is. This utility measure is modelled against the backdrop of socio-economic and spatial factors which are also hypothesized to influence modal use by trip makers. Following after Abane (2011), the utility measure, including the co-efficient and odd ratios, as well as the statistical significance or otherwise of the variables is illustrated in the formula:

$$P_{jq} = 1/M \sum f_i(X_q)q,$$

where P_{jq} represent the probability of q selecting mode j ; X_q is a set of variables influencing mode choice; M represents the sample population of the individuals; and f_1 the choice function.

The MNL model parameters were estimated through an iterative maximum-likelihood algorithm. This first stage of the analysis was to identify statistically significant variables with which to carry out the next stage of analysis. Socio-economic and spatial factors including gender, age, education status, occupation type, car ownership status and trip distances which were found to influence modal use were included in the model. Also, mode-specific attributes such as comfort, availability, convenience and affordability which are known to influence individual trip maker's perception of service quality were included in the model. Appendix 27 summarises all the variables that were included in the MNL model as well their descriptions.

Proximity analysis was performed with the Multiple Ring Buffering tool in the ArcGIS software. This geo-processing exercise was necessary to map and classify all three selected households into 'near', 'moderate' and 'long' distance classes at specified distances away from the main community markets. The community markets were Old Market (Kasoa); Madina Market (Madina) and Lascala Market (Teshie). These community markets represent major activity points which greatly influence patterns of transportation behaviour at the community level. The geographic coordinates of all households, as well as those of the main community markets were simultaneously picked up during the survey period with hand-held Global Positioning System (GPS) units. The proximity analysis, therefore, was based on the GPS-generated coordinates in the household surveys.

A Binary Logistic Regression of various socio-economic, demographic and spatial factors to predict the use of motorised or non-motorised transport modes was conducted on the household survey data. This was to examine the patterns of transportation behaviour in the three selected communities in view of the relatively shorter commuting distances between residences and the main community markets, against the backdrop of socio-economic and demographic variations among trip makers. Distance as a spatial factor was recoded as a dummy.

Households classified as ‘near’ in the Proximity Analysis were used as the reference category in the regression model and coded as zero (0). Thus, the reference category for the various communities were Zongo and Adakope (Kasoa); Zongo (Madina) and Maami (Teshie). Other households classified under ‘moderate’ and ‘long’ distances in the Proximity Analysis were reclassified as ‘far’ and coded as one (1) for the regression analysis.

Interviews which were conducted in the local Ghanaian language (i.e. the multi-participant interview with trotro drivers; interviews with a trotro drivers’ union official and a representative of Metro Mass Transit Limited) were translated into English while being transcribed. The remaining interviews were held in English and were simply transcribed. Following the transcription of qualitative data, the results were analysed for patterns or themes which were then presented as direct quotes.

3.7. Data Limitations

The primary data on which this study is based is beset with some limitations. First, similar to Abane (1993, 1990), some respondents shied away from sharing their specific personal details, especially on income and age. There were some formal sector employees who stated their incomes as a range, and averages were calculated based on their responses. Additional earnings such as per diems, bonuses and allowances were not included in the survey. This can further have introduced uncertainties in the income data since respondents may be earning more than they actually reported. Some informal sector employees could not readily indicate their incomes. Therefore, for this group of respondents, their specified daily savings was treated as their incomes. In spite of the explanation that this study was simply for academic purposes, most respondents took the opportunity afforded them to express their frustration over the poor economic performance of the ruling government before going ahead to state their incomes to the researcher. Under such circumstances, it is impossible to determine whether respondents purposefully understate or exaggerate their real incomes depending on

their political sentiments. This could also serve as a source of uncertainty in the personal data generated from the respondents.

Second, translating survey questions from English language into the Ghanaian languages –Twi, Ga and Hausa –for a majority of respondents could have introduced some distortions. For instance, mode-specific attributes which are known to influence modal choice, such as ‘comfort’ and ‘safety’ were particularly difficult to translate. ‘Comfort’, in Twi, might literally translate as ‘ahodwo’ or ‘ahotor’. Depending on the context, this term might also mean ‘peace of mind’. ‘Safety’, in Ga, might literally translate as ‘nije oshina’ which means ‘avoid accident’. However, ‘safety’, in English, might mean more than the mere avoidance of accidents to include dependability and trustworthiness. To overcome this challenge, an in-house demonstration using English and these three major local languages was organised prior to the data collection. Also, daily meetings were held to discuss new challenges with the translation and other practical matters related to the conduct of the survey.

Third, the use of research assistants in the field survey could have introduced some uncertainties in the data. This is because while only university graduates were hired, trained and paid to gather the data, most of them had no basic training in transportation research. Again, the pressure on them to meet daily targets could have made some of them less critical and thorough with responses being collected from the respondents. Perhaps, the in-house demonstration prior to the actual field survey and the regular meetings while the surveys were on-going could have discounted some of these concerns.

Fourth, information on energy use obtained from the selected trotro drivers was found to contain some errors. It was challenging for the drivers to isolate and indicate their specific fuel use for trips made to the study area from trips made to other areas that were not considered relevant for the study.

A discussion of various secondary sources of data adopted in the study ensues in the next section.

3.8. Secondary Sources of Information and Data

Secondary sources of information that have been used in this study include previous scientific research on climate change mitigation in transport, specifically on the influence of land use and travel behaviour that are published in academic journals; printed books and national policy documents. Doctoral theses and previous publications on GAMA are also heavily relied on. In light of the errors identified in the primary data on energy use by trotto drivers, the study used secondary data published in the Ghana's Vehicular Emissions Inventory (EPA-Ghana, 2007) to supplement other findings made in the study. Official population and housing census reports and Landsat Satellite images of the study area are other secondary data that were used in the study.

3.9. Ethical Considerations and Challenges Encountered in the Study

The importance of ethics in research cannot be over-emphasised (Shamoo & Resnik, 2009; Malhotra & Birks 2007). To this end, the objectives of the research were thoroughly explained to respondents for their consent before all interviews were conducted. Respondents were assured utmost confidentiality. Data and findings arrived at in this study are honestly and objectively presented to the best of the researcher's ability. Care has been taken to ensure that proper acknowledgement is given to all materials used in the study which are not the original thoughts of the researcher. In the generation of data, however, some challenges to the study might have resulted in unintended ethical concerns.

First, the use of contacts, such as the Makola Market administrator and the leader of the traders, the human resource directors in the selected ministries and the local opinion leaders for the household surveys, paved the way for a smooth entry into the various study sites.

It further helped to gain the cooperation of respondents. However, there was the tendency for some of the contacts to influence the researcher in the choice of respondents for the survey. The researcher carefully ensured that the contacts only provided the overall access to all potential respondents, and on the basis of sampling procedures, the researcher and his team led the survey.

Second, at the time of conducting the surveys, housing units in some of the low-income neighbourhoods were not properly demarcated from others. The general lack of a functioning address system (for houses and also for streets) in some GAMA communities, during the survey period, made it difficult to fully implement the systematic sampling procedures as was originally intended. Also, there were instances where selected housing units had more than one household being resident there. As a way out, the researcher chose to interview only one household per residential unit.

Third, household heads in most of the high-income suburbs surveyed were not available during the day time. Interviews for this category of respondents were held mostly in the evening, between 17:00 and 18:00 during weekdays, and on Sunday afternoons.

For obvious security reasons, some selected interviewees insisted that the interviewers stood in front of their gates and engaged them in the conversation while they themselves stood inside the gates. There was the tendency for the interviewer to speed up the interviews and finish within the limited time and space provided. This could have had the undesired consequence of compromising the quality of responses obtained. However, this is compensated for by the reason that following several periods of asking the same questions over and over again to a different group of respondents, under a more relaxed atmosphere, the interviewer is conversant with the survey instrument, thus ensuring that the interviews are fairly conversational.

Fourth, accessing official data and technical reports from public institutions was sometimes difficult as some officials were hesitant to release these materials. In situations where public officials have been generous to release such information, the researcher later

found them to be fairly old and not updated. For instance, the Environmental Protection Agency's national vehicular emission inventory was published in 2007. In the absence of fairly recent data on energy use and emissions, the researcher was compelled to use them as they were.

Fifth, research fatigue and apathy among some interviewees were major setbacks in this study. In order for them to participate in the study, the selected trotto drivers in the multi-participant interview insisted on being motivated financially, for what they argued was a waste of their productive time when they should be driving to earn their daily sales. The researcher, therefore, had to pay for their services, after the interview had concluded. On the one hand, this might be seen as unethical and that their responses were probably influenced by the anticipated financial gains. On the other hand, but for the decision to agree to their terms of engagement, the part of the study that involved these drivers could never have materialised.

3.10. Chapter Summary

In this chapter, a discussion of data used and the methods employed in obtaining the data has been presented. Using an analytical design, the research questions underpinning the study were operationalised and properly defined. Inspired by the pragmatic philosophical worldview, the study adopted the complementary mixed methods research approach. Quantitative primary data was obtained principally through questionnaire surveys. Qualitative primary data was derived from the key informant and multi-participant interviews as well as direct observations. Various statistical and geo-spatial analyses were performed on the quantitative data. The qualitative data was subjected to thematic analyses. Secondary sources of information, particularly Ghana's Vehicular Emissions Inventory (EPA-Ghana, 2007), were also relied on in the study. Some data limitations, as well as ethical issues and field challenges, were all addressed in the chapter.

**CHAPTER FOUR:
BACKGROUND TO THE STUDY**

4.1. Introduction

This chapter provides contextual information of the study area. The first part of this chapter discusses the reasons for the choice of GAMA as the study area. This is followed up with a discussion of some key characteristics of the study area, including its administrative and functional compositions, as well as its geography and population. The second section of the chapter discusses GAMA's growth, the factors that have contributed to its growth and how the present land use patterns have evolved. The third part of the chapter provides a discussion on the general characteristics of transportation in GAMA.

4.2. The Characteristics of GAMA

The Greater Accra Metropolitan Area (GAMA) was selected as the main study area. The choice of GAMA as the study area, first of all, is due primarily to information gathered from earlier studies reviewed, which have examined the drivers of Accra's contributions to climate change particularly the inefficiencies in its present spatial structure and transportation system (Abane, 2011,1993; Trans-Africa Consortium, 2010; Yeboah, 2003). This is because, according to Yankson (2012, p.7), 'planners in the past were not conscious of the GHG implications of urban form so they can make a sound, locally relevant land use decisions'. Thus, official policy reports of the government of Ghana have identified urban sprawl as a major challenge for high fossil fuel use and GHG emissions in GAMA and have recommended a proper streamlining of land use and transport systems for the city (GoG, 2011b; GoG, 1991).

Second, the city is located along the coast and very severe erosion is a common feature. Owusu (2012) has found that coastal communities such as Glefe, La and Nungua have been worst hit by erosion. Also, perennial flooding has occurred in generally low-lying areas such as Odawna, Osu Kinkawe, Ablekuma North and South and Okaikoi North and

South. Windstorms have been occurring rapidly in GAMA. Against the backdrop of the high concentration of human activities, any additional impact from climate change on the city will be calamitous. Therefore, a thorough understanding of the dynamic forces and systems that drive GAMA's generation of GHGs 'is fundamental in helping urban policymakers, enterprises and consumers target the readily available options to reduce those emissions' (UN-Habitat, 2011, p.3).

Some earlier studies (Oteng-Ababio, Melara Arguello & Gabbay, 2013; Yankson, Kofie & Moller-Jensen, 2005) have conceptualised GAMA as the much wider area of the Greater Accra region that was originally composed of the Accra Metropolitan Assembly (AMA), the Tema Municipal Assembly (TMA) and the Ga District Assembly (GDA). By 2012, however, GAMA had metamorphosed into twelve autonomous but physically and functionally integrated administrative divisions, as illustrated in Appendix 11. These subdivisions have been occasioned by rapid population growth and Ghana's decentralisation policy that aims to devolve and de-concentrate governance from the central government to local metropolitan, municipal and district assemblies. Each administrative division has a Chief Executive Officer who is appointed by the President and endorsed by the members of the local assembly.

The Accra Metropolitan Assembly (AMA) administers what the World Bank (2015) refers to as 'Accra city proper'. This is a 200 km² stretch of land which hosts Ghana's most diversified economy in terms of the concentration of several industries, administration, marketing, finance, insurance, transportation and tourism firms. Much of the city's important activity point locations are found in the area called Accra Central⁶. Beyond Accra Central, a number of competing satellite business districts has emerged in recent decades. They include, for instance, the mixed commercial development at the Accra Airport City, the Accra Mall,

⁶ Accra Central is delineated by the Ring Road corridor which runs all the way from the Korle Lagoon in the west, through Kwame Nkrumah Circle and the Independence Avenue to Osu in the east.

the A & C Mall, and also the Kaneshie and Dansoman commercial hubs. However, Accra Central has maintained its enviable status as the most important commercial, administrative and cultural nerve centre of GAMA. The concentration of these high-value land use activity points continues to make Accra Central the single most important centre of attraction for both human and vehicular traffic. An earlier study by the Department of Urban Roads (2001)⁷ has confirmed Accra Central as the most congested part of the city with an estimated 80% of vehicular traffic emanating from it.

As an integral part of GAMA, the Tema Metropolitan Assembly (TMA) hosts Ghana's major sea port and industrial hub at Tema. Facilities here equally attract human and vehicular traffic, particularly from the working class. However, the high concentration of centres of opportunities at Accra Central and the availability of a fast connection between these two parts of Metropolitan Accra via the Accra-Tema Motorway promote regular traffic flows into Accra Central. Urban sprawl and an unsupervised physical expansion from the metropolitan boundaries of Accra during the 1960s have led to the emergence of the peri-urban and physically undeveloped Ga District. The Ga district witnessed massive population growth resulting in the carving of several districts out of it (see Appendix 11). The Ga districts are linked to Accra Central by a number of important highways (Owusu, 2013). These highways foster regular commuting by residents in the Ga districts to Accra Central in order to access the high-value land use functions concentrated there.

In terms of size, GAMA covers 1,079 km² (33%) of the Greater Accra region's total land surface of 3,245 km² (Ghana Statistical Service, 2005a). Against this backdrop, it is interesting to note that GAMA is home to about 3.7 million inhabitants, that is close to about 96 % of the Greater Accra region's total population of around 4 million (Ghana Statistical

⁷ http://www.ama.ghanadistricts.gov.gh/?arrow=atd&_3&sa=1158 Date accessed 15/05/2015

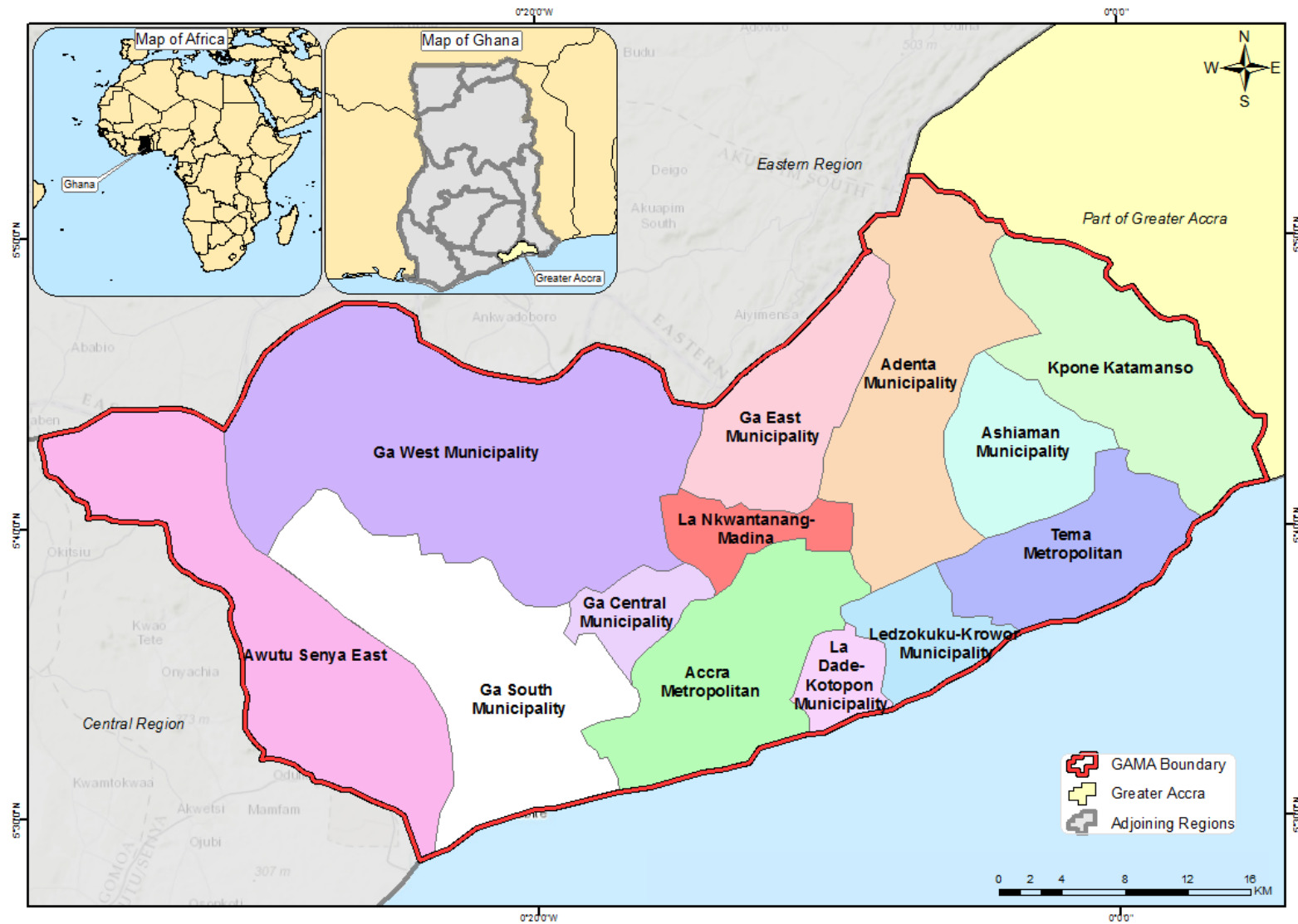
Service, 2012). This makes GAMA the most densely populated and the single largest urban conurbation in all of Ghana.

In this study, the Awutu Senya East Municipality is also included in the operational definition of GAMA. Administratively, this municipality is part of the Central Region of Ghana. However, its administrative capital –Kasoa –has been found in an earlier study to be functionally linked to the Greater Accra region, and in particular, Accra Central in terms of the high number of trips made by residents to work and shop (Yeboah, 2003). Also, a personal conversation by the researcher with a leading social scientist supports the inclusion of the Kasoa town as part of the contiguously developed area, as seen in the comments below:

Due to the presence of a physical barrier (i.e. the Weija dam), the inclusion of Kasoa into the GAMA definition may be difficult. However, one cannot entirely dismiss it as being too far from being part of the contiguously developed area. This is because, in terms of commuting, the linkage between Accra Central and Kasoa is even much stronger than with the northern parts of GAMA (Yankson, P.W.K, personal communication, September 10, 2014).

Therefore, the operational definition of GAMA in this study includes all localities in the administrative areas illustrated in Figure 4.1.

Figure 4.1: A Map of Greater Accra Metropolitan Area (GAMA) showing its constituent political administrative areas



4.3. Evolution of GAMA's Present Land Use System

In order to fully appreciate the present spatial structure, it is in order to recapture how GAMA, or also referred to as Accra in the ensuing paragraphs, has emerged from what used to be a small 'fish village' located to the east of the *Korle* lagoon at the end of the sixteenth century into the most urbanised centre in Ghana (Stanley, 1874; cited in Acquah, 1972). This hitherto insignificant 'fish village' grew exponentially due to the town's advantageous geographical location which permitted trade with nearby European forts; the relative security from attacks by the *Akwamu* tribe and most importantly, the transfer of the British colonial administration from Cape Coast to Christiansborg, Accra on 19th March 1877 (Benneh, Nabila, Songsore, Yankson & Teklu, 1990; Dickson, 1969; Boateng, 1960). Other factors include the construction of the Accra-Kumasi railway between 1905 and 1923 and the general economic prosperity brought about by the cocoa industry.

Dickson (1971) argues that the layout of Accra, like all other towns in the southern parts of Ghana, needed to be re-designed and rebuilt to address the challenges posed by centuries of haphazard development by the natives. Unfortunately, this was not done. Accra in 1877 was composed of the ill-planned Ussher Town and James Town which were primarily inhabited by the indigenes. In the words of Stanley, (1874; cited in Acquah, 1972, p. 27) the native towns had been constructed 'without regards to order or to any symmetrical arrangement' and was characterised by 'thatched buildings arranged in a haphazard manner and separated by narrow, crooked streets'. The only exceptions were a few well-kept houses that belonged to rich African merchants. In contrast, European merchants, missionaries, and administrators resided in or had their headquarters in the well-planned Victoriaborg (site of modern-day Bank of Ghana, Ministries and the Independence Square) and Christiansborg (modern day Osu).

Stanley, (1874; cited in Acquah, 1972, p. 27) further notes, that the European and native residential areas were physically separated by ‘a vast stretch of plain country, and a winding lagoon of green water’. In light of Accra’s new status as the administrative capital of the Gold Coast, the colonial government provided other amenities such as a Cable Office, the Supreme Court, the Telegraph Office and the European Club (Acquah, 1972). These factors started the process that has led to the concentration of high-value activity points in the Victoriaborg, Christiansborg, Ussher Town and James Town complexes, which are now known as Accra Central (see Appendix 1, 2 and 3). Strict land use planning regulations were enforced only in the European quarters to the neglect of the largely unplanned African quarters (Songsore, 2003; Odame, 1996; Drakakis-Smith 1987). This, in the view of Odame (1996), could be due to the indirect rule system of the British administration that barred them from interfering with ‘customary lands’, which are owned by local chiefs, families, or clans. Customary lands are usually sold freehold to private individuals for development (Odame, 1996; Larbi, 1994; Brobby, 1991).

In 1892, however, the colonial government introduced the Towns Ordinance that legally allowed her to compulsorily acquire ‘state lands’ and exercise management functions over ‘vested lands’. Strict enforcement of land-use planning was concentrated only in the European residential areas and on lands that were owned or managed by the state to the neglect of the vast customary lands. This colonial policy, in the view of Odame (1996), marked the genesis of Accra’s planning and development challenges to date. He further notes that in 1956, a year prior to Ghana becoming independent, less than 40% of Accra’s municipal boundary had been fully developed. Thus, the colonial administration could have done more to re-plan, direct and control the development of the city. However, it is important to note that under the governorship of Sir Gordon Guggisberg in the Gold Coast (1919-1927), Accra had a major infrastructural facelift.

In particular, the 10-year development plan (1920-1930) which has been touted by Adarkwa (2012, p.3) as the ‘first of its kind in the world’ led to the construction of the Achimota School, the Korle Bu hospital, the Korle Lagoon bridge and several roads radiating out of Accra Central. According to Fuseini and Kemp (2015), these colonial investments are still relevant in the contemporary Ghanaian economy as they were back then in the 1920s and 1930s. However, the construction of these funnel-like road networks, in particular, could have initiated the mechanisms that promoted the sprawl in the city. This is because it made it possible to build more commercial and residential settlements further away, but still linked up to the old built-up and congested city centre that hosted the city’s high-value activity points (Acquah, 1972). Some of the new commercial and residential settlements included Tudu, Adabraka, Korle Gonno, Korle Bu, Mamprobi and Sabon Zongo. Again, the aftermath of the 1939 major earthquake in Accra saw the construction of new housing estates by the colonial government –an intervention that has been described by critics as a hasty housing policy meant for the colonial bureaucracy but which did not sufficiently address the housing needs of residents and the spatial planning that Accra needed (Appeaning-Addo, 2012; Acquaaah-Harrison, 2004, Hornsby-Odoi & Glover-Akpey, 1988). The new housing estates were built at Christiansborg, South La, Kaneshie and Abossey Okai (Acquah, 1972). Later on in 1943, La was incorporated into the Accra Municipality. The municipality boundary was allowed to sprawl further as ‘an almost unbroken chain of buildings’ (Acquah, 1972, p. 28) was allowed to be built along the coastal road. Thus, by 1943 Accra had grown exponentially and its total built-up area was around 104 kms² (Addae-Bosompra, 2009).

In 1944, the city of Accra had its first town plan. Then, in 1945, the Town and Country Planning Ordinance (CAP 84) was passed which among other things has led to the setting up of Development Control Units within the Town and Country Planning Department to plan, coordinate and ‘control’ spatial development nationwide.

In terms of population growth, Dickson (1971) found, that largely due to increase in commercial activities and the establishment of Government offices in Accra, coupled with opportunities for better education and health services, Accra witnessed a rapid population growth from a mere 19,582 in 1911 to 41,124 and 60,726 in 1921 and 1931 respectively. When Ghana attained political independence from British colonial rule in 1957, not much was done by the new administration to restructure the fundamental spatial laws, planning procedures and indeed the overall organizational and spatial structures the country had inherited from her colonial past (Songore, 2003; Odame, 1993). It needs to be mentioned that Accra's old 1944 Town Plan was replaced by a more comprehensive plan in 1958. Later on, the 1961 Master Plan for the Accra-Tema metropolitan area was prepared by Doxiadis Associates to formally integrate Accra, Tema, Nungua and an Industrial Belt along the motorway. The spatial planning law CAP 84 was replaced in 1993 by the Local Government Act (Act 462). Other laws regulating land use planning in Ghana include the National Development Planning Systems Act (Act 479 of 1994) and the National Development Planning Commission Act (Act 480 of 1994).

While the plans and laws were designed for the purpose of guiding the overall development of the city, they remain generally unimplemented (GoG, 1991). While spatial planning and control have largely been ineffective, the post-independence policy of accelerated industrialization and expansion in the commercial sectors between 1960 and 1970 led to massive rural-urban migration into Accra. Most scholars (Owusu, 2013; Doan & Oduro, 2012; Yeboah, 2003, Grant & Nijman, 2002; Grant & Yankson, 2003), however, agree that the real impetus to Accra's present sprawl-like development patterns started in the early 1980s when macroeconomic reforms were adopted. Thus, the way was paved for a number of local and global forces to modify the spatial configuration of Accra. For example, the boom in the service sector in Accra following the adjustment programmes led to massive

capital and human resource inflows. Available population figures indicate that while Accra's population was a mere 450,000 in 1960, the population has soared to 1.3 million and 2.7 million for the 1984 and 2000 census years (Ghana Statistical Service, 2005b). The pressure on land resources, particularly for housing for this teeming population is high. Thus, private estate developers have stepped in to address the mismatch between demand and supply of the housing market, leading to the development of gated communities, usually for the middle and high-income urban residents (Asiedu & Arku, 2009). For the Greater Accra Metropolitan Area (GAMA), Wellington (2009) argues that it is the uncontrolled private land use development that has caused the city to sprawl, as developers prefer to develop at the outskirts of the city where the cost of land is relatively low. GAMA's built-up area is also estimated to have soared from around 133 km² in the mid-1980s to above 344 km² in 2000 (Owusu, 2013).

On the demand side, the car-owning middle and high-income residents usually find this peri-urban development very attractive due to improved road networks in the past decades (Doan & Oduro, 2012). For the majority of the urban poor, the above-mentioned challenges in the Ghanaian housing sector have forced them to live in slums and informal squatter settlements dotted in and around the city. A significant proportion of this group, however, are known to live in the peripherals of the city where rent values are usually lower and there is the possibility of 'multi-habitation' (Apeaning-Addo, 2012; Yankson et al., 2005). Owusu (2013) therefore has found evidence to conclude that due to the breach of greenbelts and natural boundaries that were meant to serve as barriers to Accra's out-growth, leapfrog sprawl are a common feature in the city as a whole.

4.4. Evolution of GAMA's present Transportation System

Public transportation in GAMA is dominated by the informal paratransit services, popularly known as trotro. Trotros come in various car makes and models but the most common ones include the Mercedes-Benz 207, the Mercedes-Benz Sprinter, the Nissan Urvan, the Toyota Hiace, and the Ford Transit. Generally, the types of vehicles include micro (10-15 passengers), mini (16-25 passengers) and midi (26-44 passengers) buses. Mini-buses, however, appear to be more dominant on GAMA roads. See appendix 4, 5 and 6 on the make and models of vehicles normally used for trotro paratransit services in GAMA. According to Fouracre et al., (1994), the high growth in commercial vehicle numbers between 1984 and 1991 appears to coincide with the Economic Recovery Programme adopted by the country. The driving profession offered job opportunities for some retrenched public service employees as well as for the many unemployed and mostly semi-literate youth most of whom had migrated to Accra in search of non-existent jobs. Ofoosu-Dorte (1992) also contends that a 1989 ban on the use of all less than 23-seater minibuses from operating beyond 50 kilometres away from the city centre gave an impetus to the trotro system with the conversion of an estimated 10,800 mini-buses to intra-urban and urban-peri-urban paratransit service.

Coupled with the above, the gap in public transport supply following the divestiture of the formal state-owned Omnibus Services Authority (OSA) and City Express Service (CES) bus companies, in line with structural adjustment policies in the 1980s, was quickly filled by the informal sector transport operators in GAMA. The OSA was established in 1969 to superintend all Local Council bus operations in Ghana. Then in 1972, the Omnibus Services Decree was promulgated to formally separate the regulatory functions of the Authority (establishing a Licensing Authority) from its bus service delivery activities. The bus service was then incorporated into a limited liability company known as OSA Limited. The OSA Limited was provided an enabling environment, including tax and duty reliefs on the

importation of vehicles and spare parts. As a completely state-owned enterprise, the bus company was run down due to growing managerial inefficiency and corrupt acts. The words of Agyeman-Duah (1987) best encapsulate the overall attitude which might have led to the poor performance of the bus company. He argues that government property (or *abandea* in the local parlance) ‘can be stolen, abused or destroyed with no direct consequences. The government is still considered to be a foreign entity, and too many people feel no compunction or obligation to protect its property or services’ (Agyeman-Duah, 1987, pp. 614–615). Meanwhile, the CES) another state-owned transit company, was formed in 1981, as a special Department within the then Ministry of Transport and Communications, following the delivery of 600 new Tata buses. The CES suffered a fate similar to that of the OSA bus company. According to Fouracre et al., (1994), the contribution of CES to urban transport was so negligible that by January 1992, its overall mileage was less than 10 percent. The collapse of these two state-owned bus companies therefore paved the way for the private sector to completely take over public transport in GAMA.

After decades of operation, trotro drivers and owners have unionised with the help of the past governments who have provided credit facilities in a quid pro quo manner whereby the unions use their large membership base to politically support such governments (Abane, 2011). Earlier studies have identified the Ghana Private Road Transport Union (GPRTU) as the largest trotro operator union in Ghana (Addo, 2005, 2002; Fouracre, Kwakye, Okyere & Silcock, 1994). However, it is important to note that given the free entry and exit character of paratransit operations, new members can join while old members may exit the driving profession at any point in time. Thus, it is nearly impossible to know exactly how many drivers and seats there are for GAMA trip makers. However, an earlier study (GoG, 2004) conservatively put the membership of the GPRTU at around 17,000 members strong and which controls an estimated 80% to 90% of the public transport market.

Seven years on, Abane (2011) also found that the GPRTU alone had an estimated 400, 000 vehicles of all makes and models being operated by some 40, 000 professional and temporary drivers with the help of 15,000 porters, drivers' mates (aides) and support staff. Other major public transport operator unions include the Progressive Transport Owners Association (PROTOA) and the Co-operative Transport Union, though the latter is focussed more on shared taxis. It must be pointed out here that the use of mini-buses for paratransit services is not particularly unique to GAMA. It has major footprints in most parts of the developing world. On the African continent, they are called by several local names including Matatus (Kenya), Combis (South Africa), Cars Rapides and Ndiaga Ndiaye (Senegal), Molues and Danfo (Nigeria), just to name a few.

In recent times, motor-taxis services, known as Okada have become the preferred public transport mode for many transportation-disadvantaged residents in GAMA (Oteng-Ababio & Agyemang, 2012). The popularity of the informal paratransit services is fuelled by their ability to offer on-demand mobility over a wider service coverage area for transit-dependent urban dwellers, but more importantly, they are relatively cheaper. However, according to Cervero and Golub (2007), the informal mini-bus services may contribute to traffic congestion, air and noise pollution, and traffic accidents. Thus, in an attempt to address some of the challenges confronting GAMA's public transport system, a quasi-private bus company known as the Metro Mass Transit (MMT)⁸ limited has been incorporated since 2003 to serve residents in GAMA and beyond. The MMT limited is 45% owned by the Ghanaian government (through the Ministries of Transport and Local Government and Rural Development) and 55% by private entities. The MMT appears to struggle with some operational and technical challenges which have limited its capacity to serve commuters. For instance, as of 2007, the MMT only had 400 buses (51%) countrywide in good working

⁸ See appendix 7 on a high occupancy VDL bus used by the MMT in GAMA.

condition, out of a total of 779 buses (World Bank, 2015). Charter bus services are also being provided albeit on a limited scale by private companies, notably, Kingdom Transport Services and Agate Transport Services, to GAMA trip makers. Thus, it is not surprising that only 0.3% of commuters in Accra use formal public buses (World Bank, 2015).

Rail services are also limited in GAMA, with the exception of the Nsawam-Accra-Tema rail line. Besides public transport services described above, a growing number of private cars are observed on the roads of GAMA with its attendant high demands on fossil energy use and subsequent emissions. See appendix 8 and 9 on single occupancy cars locked up in traffic congestion during morning and evening rush hour periods in GAMA. According to a Government of Ghana (2013; cited in World Bank, 2015) report, between 2000 and 2010, Ghana registered 24, 000 private cars annually and the number is likely to increase. Walking is also an important means of transport for some urban dwellers, particularly the poor and vulnerable members of society (Agyemang, 2015; UN-Habitat 2013). In GAMA, 11% of commuters have been found to walk (World Bank, 2015). Ghana's national transport policy wants to introduce formal mass transit services for GAMA, and other major Ghanaian cities. In GAMA, pilot schemes are planned on the Accra Central (Tema Station) to Pokuase, Accra Central (Tema Station) to Adenta and the Accra Central (Tema Station) to the Beach Road corridors respectively (see Appendix 10).

4.5. Chapter Summary

In this chapter, the selection and justification of GAMA as the study area has been presented. Also, the evolution of GAMA's spatial structure and transport systems is discussed. In sum, it has been shown in this chapter that from its initial status as a small fishing village, a number of important historical and political factors have contributed significantly to make GAMA the most urbanised area in Ghana.

GAMA's spatial structure which appears to favour the city core with respect to the concentration of important activity point locations has been traced to deliberate colonial policies. Macroeconomic reforms undertaken in the post-colonial era have further strengthened the importance of the city core even as the city continues to sprawl. Residential areas have increasingly been sited further away from the city core. The spatial structure has resulted in regular interactions between the city core and GAMA's residential areas. The chapter also showed that public transport is characterised generally by the informal paratransit services. This is in response to the gap left behind following the collapse of formal public transport. Private cars and formal bus services, albeit limited in coverage, are other transport means available in the city. The regular use of these motorised transport modes between the city core and the residential areas affect energy use and GHG emissions in GAMA.

CHAPTER FIVE: ANALYSES OF RESULTS

5.1. Introduction

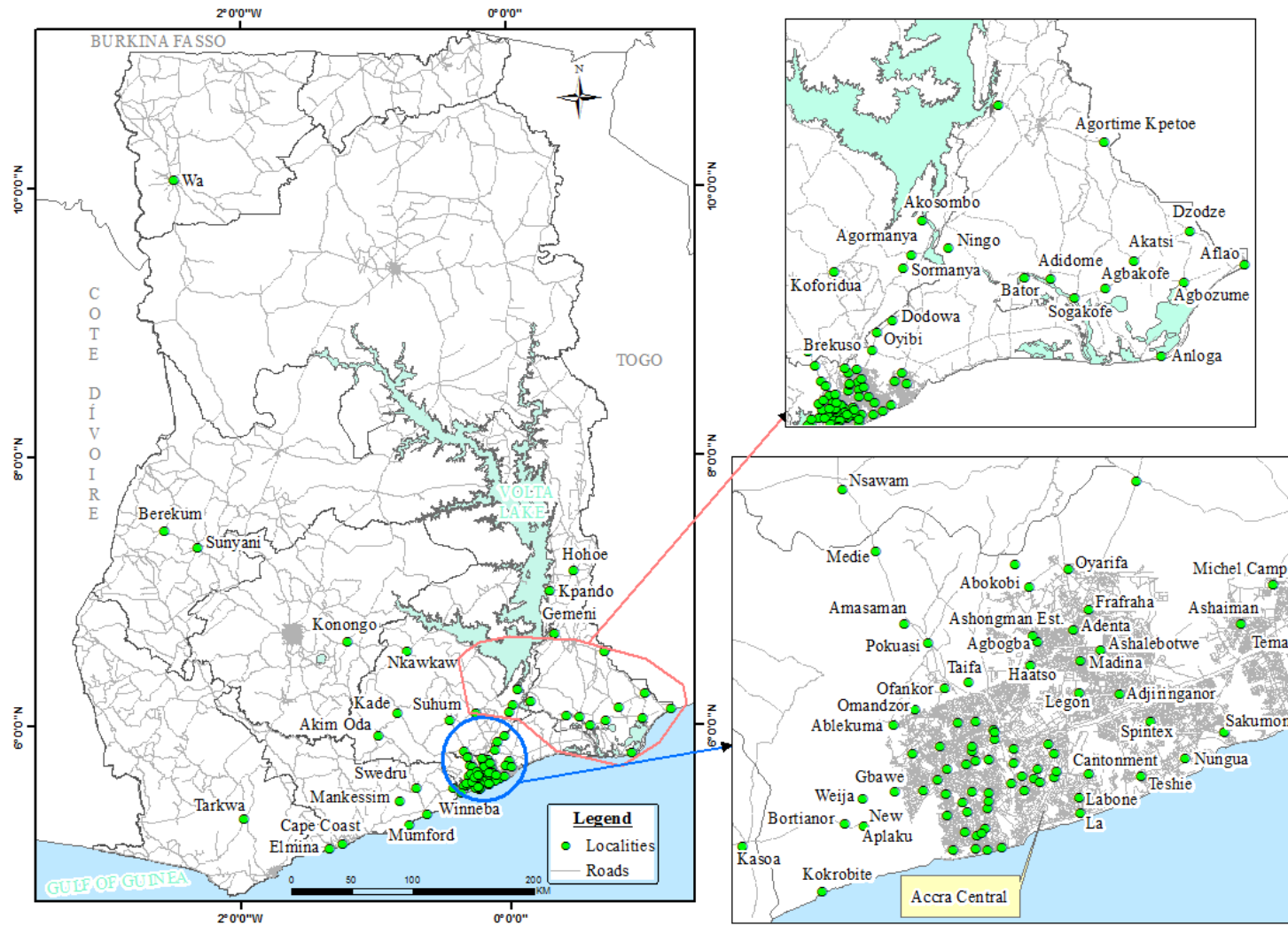
This chapter, first of all, introduces the findings made with respect to spatial patterns of residential locations vis-à-vis activity points in GAMA. The concentration and attractiveness of specific land use activity points particularly in Accra Central, and also in other areas of GAMA are considered as well. Second, findings made on patterns of transportation behaviour are presented. Specifically, the chapter describes the modal use of GAMA trip makers, the factors which influence modal choice, the energy and Greenhouse gas implication of existing modal use and perceptions of key stakeholders on climate mitigation in GAMA's transportation system.

5.2. Patterns of Trip Makers' Residential and Activity Point Locations

5.2.1. Patterns of Residential Locations of Trip Makers in GAMA

As already mentioned in the methods section, during the data collection on long distance trip makers, 400 respondents were surveyed at various locations at the Makola Market and selected ministries in Accra Central. Respondents were asked to indicate where their trips to Accra Central originated from. Figure 5.1 demonstrates the various trip originating points of surveyed respondents. What this figure illustrates is that trip makers commute from various localities in Ghana in order to access activity points found in Accra Central.

Figure 5.1: A regional map of Ghana indicating residential localities of Accra Central trip makers



Source: Field data, 2014

The majority of long distance trip makers (i.e. 338 respondents) were found to be residents of GAMA. Thus, the following analyses of the data on long distance trips are based on the 338 trip makers only. Again, it should be noted that for analytical purposes, the GAMA residential locations where long distance trip makers commute from have been grouped under ‘urban’ and ‘peri-urban’. The primary criterion for the classification is the relative distances of these GAMA residential locations to the city centre. In doing this classification, the study adopted Cobbinah and Amoako’s (2014) classification scheme whereby all residential areas found within 10 kilometres from the city centre were classified as ‘urban’. Localities found beyond the 10-kilometre radius, on the other hand, are generally classified as ‘peri-urban’. On the basis of this classification, the data showed that the majority of trip makers in GAMA reside in the peri-urban areas of the city, particularly in Kasoa, Teshie and Madina. Table 5.1 summarises the major localities in GAMA where trip makers who visit Accra Central reside.

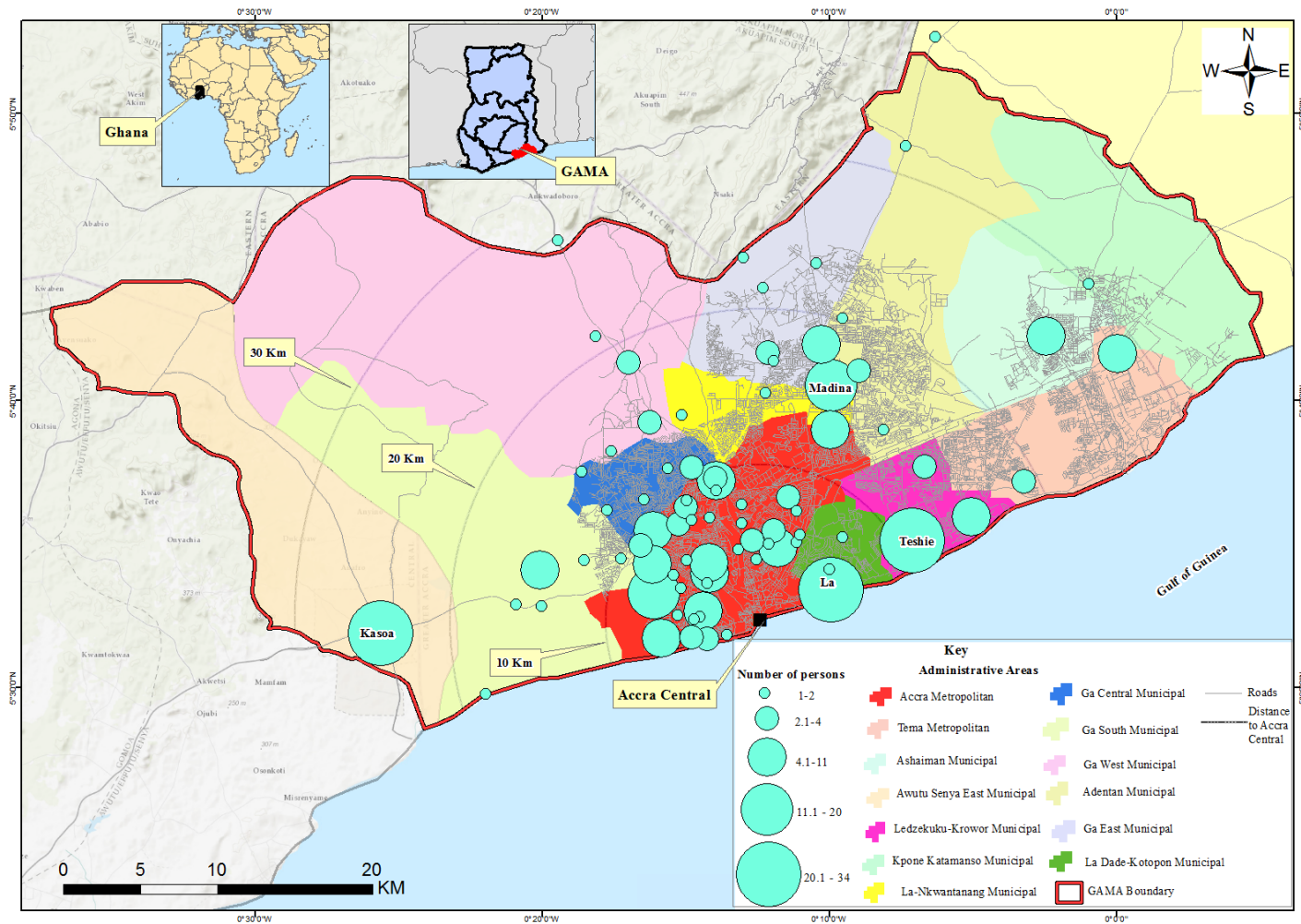
Available Landsat images covering GAMA for the periods 1986, 2000 and 2014 (see Appendix 28) provide clear indications that the city’s built up area has dramatically expanded with time. Thus, it is not surprising that trip makers who visit Accra Central are found to be living at distant locations, averaging 6.7 and 19.5 kilometres for urban and peri-urban trip makers respectively to the city centre. Figure 5.2 shows all localities in GAMA where long distance trip makers commute to Accra Central.

Table 5.1: Origin-destination characteristics of trip makers to Accra Central

Locality	Frequency (N)	Percentages (%)	Distance from Accra Central (km)	Status
La	34	20.6	5.7	Urban
Dansoman	27	16.4	7.8	Urban
Kaneshie	7	4.2	4.7	Urban
Nima	7	4.2	5.2	Urban
Odorkor	6	3.6	8.7	Urban
Achimota	6	3.6	9.2	Urban
Kwashieman	6	3.6	9.3	Urban
Laterbiokorshie	6	3.6	4.9	Urban
Bubuashie	6	3.6	5.5	Urban
Chorkor	5	3.0	5.2	Urban
Others	55	33.6	-	Urban
Total	165	100		
Kasoa	28	16.2	27.5	Peri-urban
Teshie	26	15	13	Peri-urban
Madina	20	11.6	16.8	Peri-urban
Nungua	11	6.4	16.9	Peri-urban
Adenta	9	5.2	18.8	Peri-urban
Tema	9	5.2	31.6	Peri-urban
Ashaiman	7	4	30.2	Peri-urban
Legon	8	4.6	13.7	Peri-urban
Weija	6	3.5	17	Peri-urban
Others	49	28.3	-	Peri-urban
Total	173	100		

Source: Field data, 2014

Figure 5.2: Relative commuting distances between activity point locations (in Accra Central) and residential localities of trip makers.



Source: Field data, 2014

In a nutshell, this section of the analysis attempted to answer the second part of the first research question by identifying the spatial distribution of residential locations of trip makers who visit Accra Central. A major pattern observed in this section is that while trip makers to Accra Central were found to reside at various locations throughout Ghana, the majority are known to reside in the peri-urban areas that are located about 10 kilometres away from the city centre. This indicates urban sprawl and the growing distance at which trip makers find themselves, relative to activity points in GAMA. This is the focus of the next section.

5.2.2. Spatial Distribution of Land Use Activity Points in GAMA

Long distance trip makers were presented with a list of activity points in Accra Central for them to indicate which ones they have accessed and how regularly they do so. They were also asked to indicate other activity points not mentioned on the questionnaire but which they use when they visit Accra Central. Their responses were subjected to statistical analyses to determine the attractiveness and the intensity of use of various land use activity points found in Accra Central. The respondents who embarked on long-distance trips were grouped under ‘work-related’ and ‘non-work related’ trip makers. The classification is based on the primary motivation for visiting Accra Central. Therefore, the first category of respondents is trip makers who indicated that they visit Accra Central primarily to work in the Ministries Area or at the Makola Market. The second category, on the other hand, primarily visited Accra Central to shop or to access public services at the Makola Market and the Ministries Area respectively. This classification is deemed necessary given that the various trip makers may gauge the attractiveness of activity points differently based on how beneficial or otherwise those activity points are to them as individuals. Table 5.2 highlights the key characteristics of these two groups of trip makers. A noteworthy finding in Table 5.2 is the high representation of trip makers who visit Accra Central for non-work purposes.

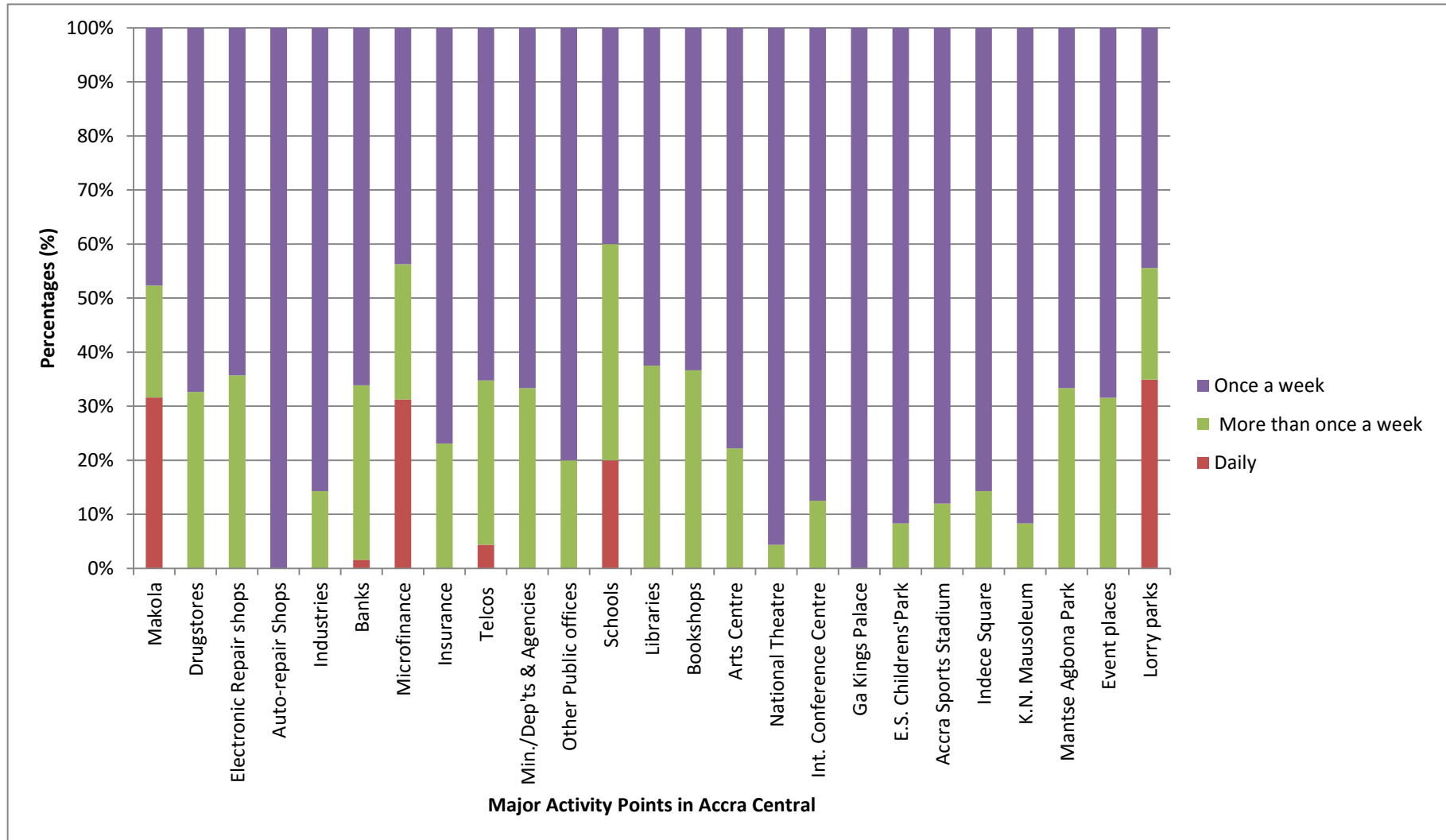
Table 5.2: Types of GAMA trip makers who visit Accra Central

Location	Category		Frequency	Percent
	Work-related trip makers (N=156)			
Makola Market	Early Daytime Traders (Wholesalers)		39	11.5
	Daytime Traders (Retailers)		32	9.5
	Hawkers		38	11.2
Ministries Area	Senior Staff		24	7.1
	Junior Staff		23	6.8
Location			Frequency	Percent
Makola Market	Early Daytime Shoppers (Retailers)		64	18.9
	Daytime Shoppers		95	28.1
Ministries Area	Users of public services		23	6.8
TOTAL			338	100.0

Source: Field data, 2014

Figure 5.3 illustrates the intensity of use or attractiveness of various activity points in Accra Central for non-work related trip makers. Based on the percentages obtained from respondents who indicated their use of various activity points in Accra Central, the most intensively used ones are the Makola Market, microfinance agencies, various schools and the lorry parks. These activity points were utilised on a daily basis or at least more than once in a week by the respondents.

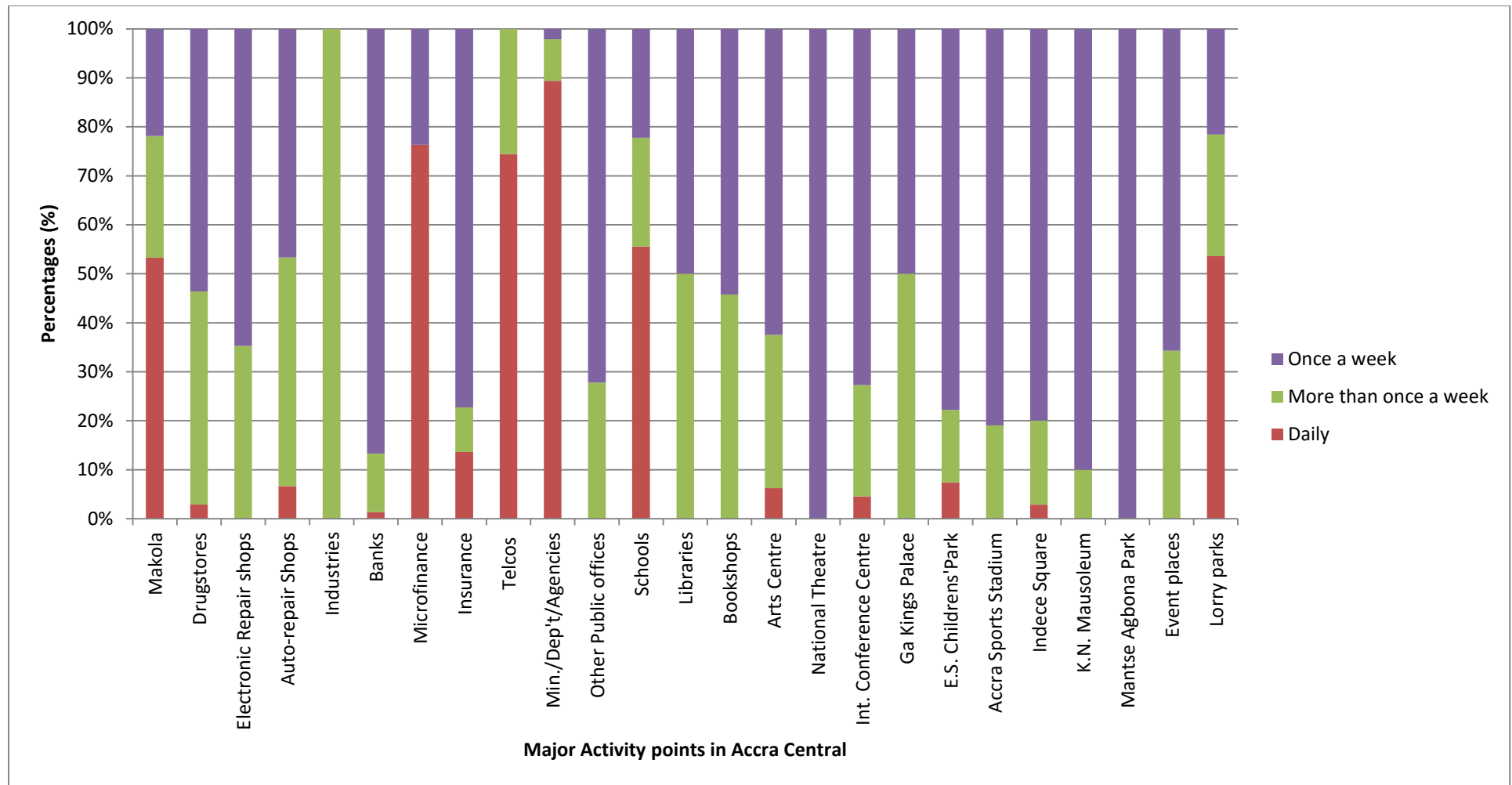
Figure 5.3: Frequency of use of activity points in Accra Central by non-work related trip makers (N=182)



Source: Field data, 2014

In Figure 5.4, the intensity of use or attractiveness of various activity points in Accra Central for trip makers who primarily visit for work-related purposes is illustrated. On the basis of percentages calculated on only respondents who mentioned their use of various activity points, the most highly used activity points are the Makola Market, microfinance agencies and the head offices of various telecommunication companies. The rest are the ministries, departments and agencies of the state, as well as, schools and the lorry parks. The respondents indicated that they used these activity points daily or at least more than once in a week. An interesting finding in Figure 5.4 is the evidence of multiple activity point utilisation among Accra Central work-related trip makers. In other words, while trip makers primarily visit their offices and shops in Accra Central to work, they take the opportunity to access other activity points which are located in the immediate vicinity.

Figure 5.4: Frequency of use of activity points in Accra Central by work-related trip makers (N=156)



Source: Field data, 2014

The data was further analysed to determine the type of goods and services with respect to how specialised or otherwise they were to Accra Central. In other words, which Accra Central goods and services were particularly unique to the area, therefore making it attractive to trip makers? Also, which goods and services were not so specialised in that they could also be obtained elsewhere besides Accra Central? As illustrated in Table 5.3, the study found that the majority of long distance trip makers are drawn to Accra Central by reason of the concentration of specialized activities including opportunities to purchase commercial products at wholesale prices as well as government services rendered to the public which apart from the Ministries Area cannot be found in any other place in GAMA. Wholesale trading and public services were also found to be important specialised activity points which attracted work-related trip makers (i.e. government employees and Makola women) to Accra Central. As seen in Plates 1 and 2, specialised commercial activities such as bulk trading in food and textiles make the Makola Market an important trip destination point in Accra Central.

Table 5.3: Activity types attracting long distance trip makers to Accra Central

Category	Description	Frequency (N)	Percentages (%)
Specialised	Early morning wholesale & retail of cosmetics, textiles & food products at Makola Market; Public services performed only at the Ministries Area	173	51.2
Non-Specialised	Daytime selling & buying of general products at Makola Market which are also found elsewhere in GAMA	165	48.8
Total		338	100

Source: Field data, 2014

Plate 1: Wholesale of food products at the Makola Market



Source: Field data, 2014

Plate 2: Wholesale of textiles at the Makola Market



Source: Field data, 2014

Table 5.4 summarises the reasons for the high use of commercial and governance activity points in Accra Central, according to trip makers in the non-work category. A key observation is the high representation of trip makers who explained that the convenience associated with having a one-stop-shopping experience as well as the concentration of specialised goods and services were the key determinants for their decision to visit Accra Central.

Table 5.4: Non-work long distance trip makers' reasons for visiting Accra Central (N=182)

Concentration of retail & commercial goods together at Accra Central			
Item 1	Response	Frequency (N)	Percentages (%)
	Yes	146	80.2
Concentration of highly specialised services (e.g. government businesses at the Ministries Area & wholesale of certain goods & services at Makola)			
Item 2	Response	Frequency (N)	Percentages (%)
	Yes	62	34.1
Concentration of several service centres, (e.g. banks, telecom companies & major bookshops)			
Item 3	Response	Frequency (N)	Percentages (%)
	Yes	20	11
Other reasons			
Item 4		Frequency (N)	Percentages (%)
	Competitive pricing of goods	6	3.3
	Business Purpose	5	2.7
	School	1	0.5

Source: Field data, 2014

In view of the high utilisation of commercial and governance activity points found in Accra Central, the analysis delved into the use of similar activity points in other parts of GAMA. In the data on long distance trip makers, trip makers primarily from Kasoa, Teshie and Madina were found to make regular visits to Accra Central. It was necessary therefore to find out where, in addition to Accra Central, do trip makers in these three localities travel to in order to access other commercial and governance activity points. During the household surveys, a list of some major commercial and governance activity points found in various parts of GAMA was presented to the respondents to indicate which ones they use, including those found in the local community of residence of trip makers. Respondents were also provided with the opportunity to state other activity points in GAMA they use, but which have not been included in the questionnaire.

Plate 3: Small scale retailing of textiles at the Madina Market



Source: Field data, 2014

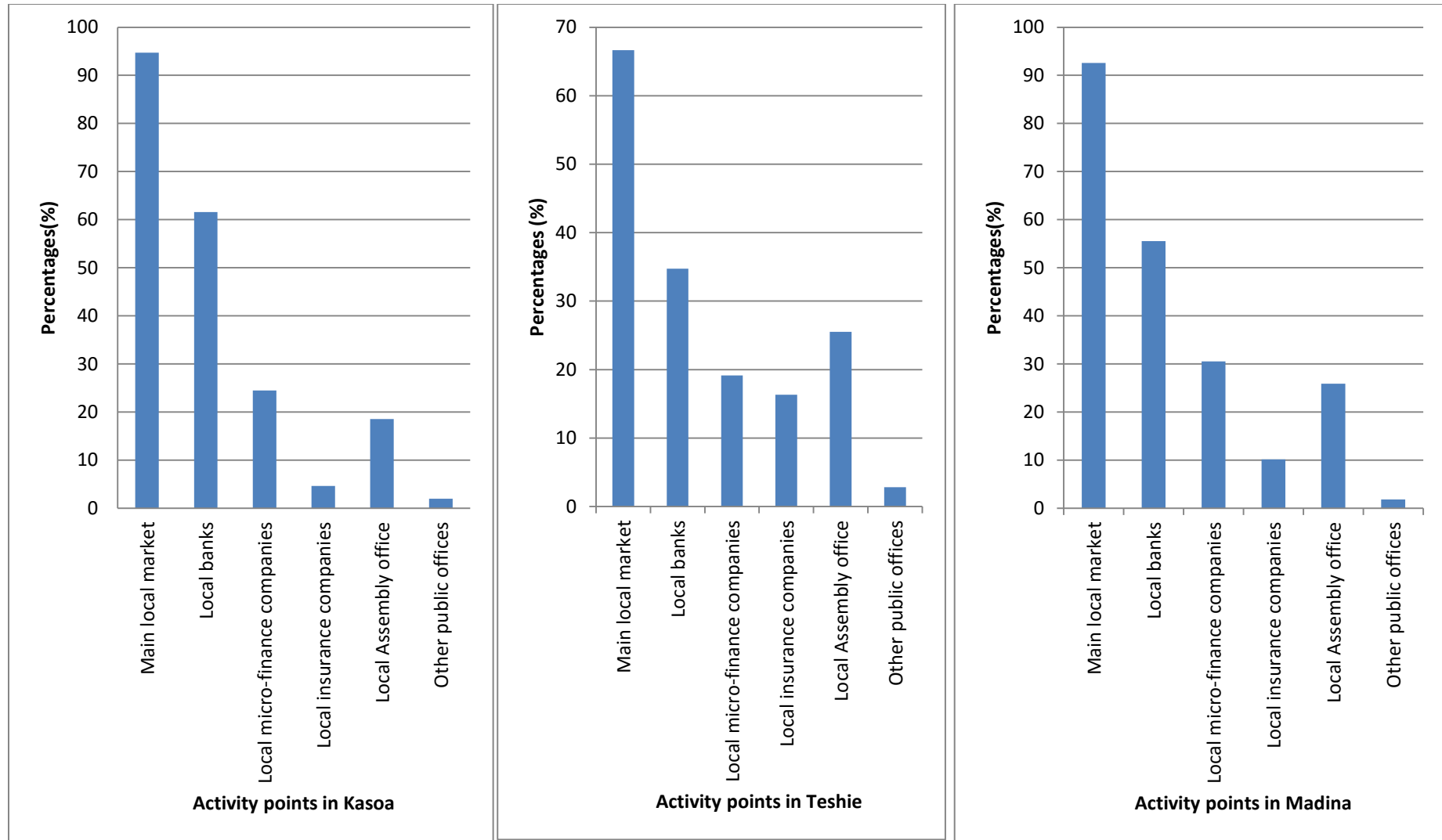
Plate 4: Front view of the Madina Market; a major destination for human and vehicular traffic in GAMA



Source: Field data, 2014

Figure 5.5 provides the evidence to show that in all three localities, there is a relatively high use of commercial activity points, particularly local community markets. Comparatively, the percentage use of local community markets appears to be much higher (over 90%) in both Kasoa and Madina compared to Teshie where less than 70% of the sampled population indicated their use of this activity point. Observations made by the researcher revealed that local markets in Madina and Kasoa were relatively larger, performed a variety of commercial functions and had regular periodic market days compared to Teshie. This may partly account for the observed variations in the utilisation of local community markets in these three localities. Banking facilities tend to be sited close to areas where business activities are brisk. This may also explain the relatively high use of banking services by respondents in both Kasoa and Madina, compared to Teshie. At the Madina market, for instance, the retailing of textile products (see Plate 3), among other commercial activities, serve as important sources of attraction for human and vehicular traffic, as illustrated in Plate 4.

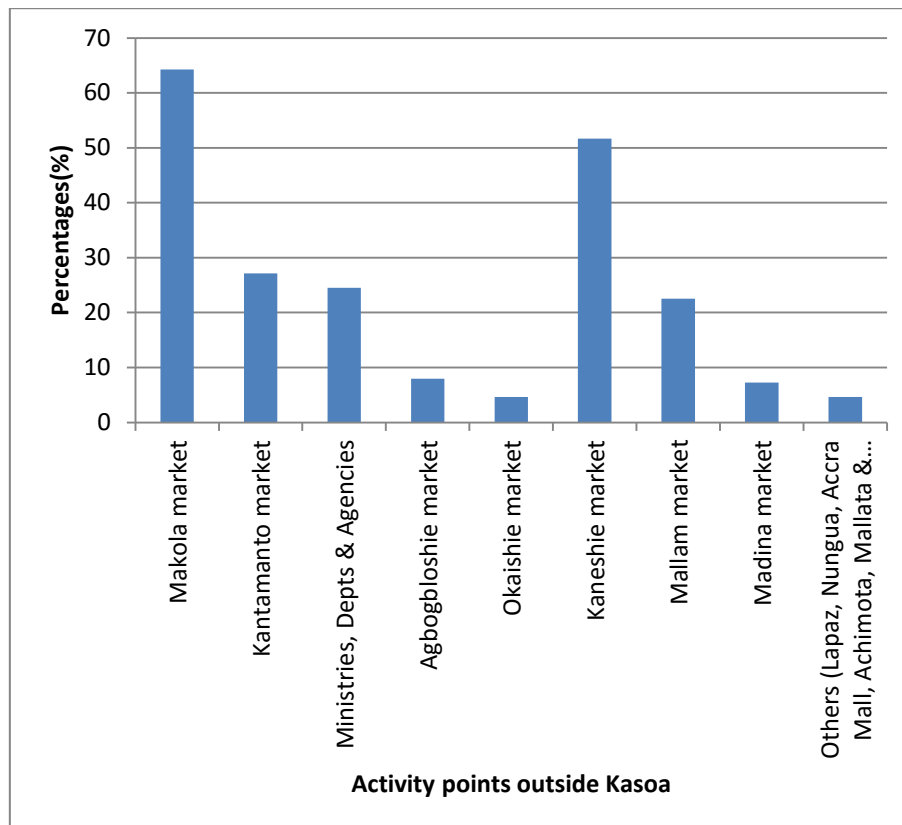
Figure 5.5: Short distance respondents and their use of commercial and governance activity points in their local community

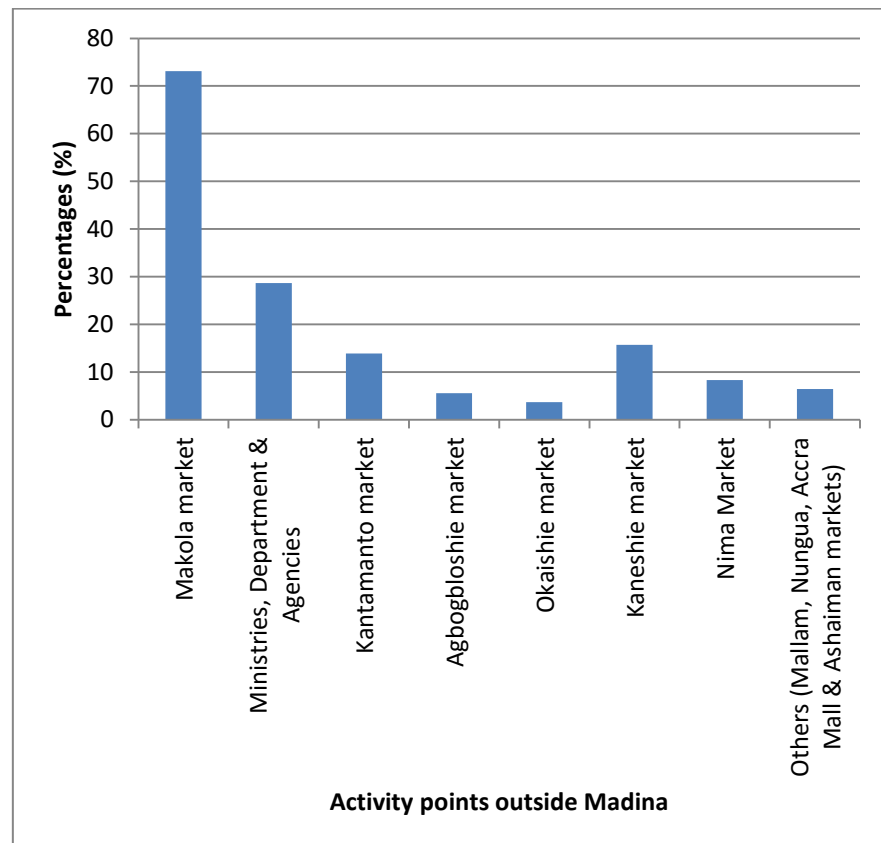
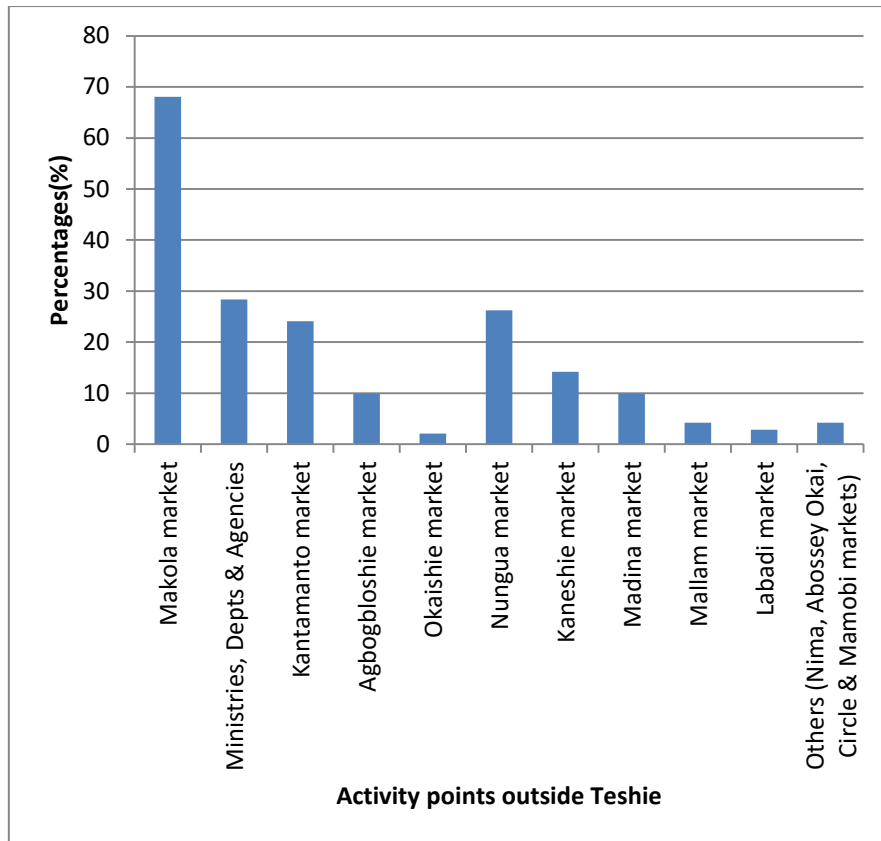


Source: Field data, 2014

However, the use of the local districts assemblies which represent activity points where government services could be accessed was relatively low in comparison with the relatively high percentage of trip makers in these localities who indicated their visit to the Ministries Area to access government services. As illustrated in Figure 5.6, besides the Ministries Area, the Makola Market featured prominently as a major commercial activity point found within Accra Central used by the majority of trip makers who were involved in the household surveys. Outside of Accra Central, the Kaneshie Market was identified across all three localities as an important activity point that trip makers use. Another observation in Figure 5.6 is that the Madina market was found to be used by trip makers in Kasoa and Teshie. In contrast, none of the respondents in Madina indicated their use of local markets found in Kasoa and Teshie. This finding is a bit surprising given that the Kasoa market, for instance, is an important regional market in GAMA.

Figure 5.6: Use of commercial and governance activity points in other parts of GAMA





Source: Field data, 2014

The reasons provided by the trip makers in the selected localities for accessing commercial and governance activity points in Accra Central, as illustrated in Table 5.5, are almost similar, particularly with reference to variety and shopping convenience that is found in Accra Central. In addition, the respondents visited Accra Central because they could not obtain specialised services in their community of residence unless they travelled to Accra Central.

Table 5.5: Trip makers' reasons for visiting Accra Central

		Frequency (N)	Percentages (%)
Concentration of retail & commercial goods together at Accra Central			
Item 1	Yes	246	61.5
	No	151	37.8
	Non-response	3	0.7
	Total	400	100
Concentration of highly specialised services (e.g. government businesses at the Ministries Area & wholesale of certain goods & services at Makola)			
Item 2	Yes	231	57.8
	No	165	41.2
	Non-response	4	1
	Total	400	100
Concentration of several service centres, (e.g. banks, telecom companies & major bookshops).			
Item 3	Yes	59	14.8
	No	333	83.2
	Non-response	8	2
	Total	400	100

	Work place located at Accra Central		
	Yes	15.3	61
Item 4	No	82.7	331
	Non-response	2	8
	Total	100	400

	Frequency	Percentages
	(N)	(%)
Competitive prices of goods	13	3.3
Proximity to customers	5	1.3
Study market prices to sell my own goods	1	0.3
Transit to my hometown	1	0.3
Visit family	1	0.3
NO other reasons	1	0.3
Total	379	94.8
	400	100

Source: Field data, 2014

In summary, this section of the analysis sought to answer the first part of the first research question by mapping out locations of activity points which attracted trip makers from various GAMA localities. In terms of the patterns and attractiveness of various activity points in GAMA, this section has demonstrated that a majority of trip makers are attracted to Accra Central to shop, work or access government services. This is in view of the concentration of both specialised and non-specialised commercial and governance activity points. These include the wholesale and retail of some goods at the Makola Market, as well as public services performed only at the Ministries Area. The section has also shown that trip makers accessed other commercial and governance activity points located nearby and at various locations in GAMA.

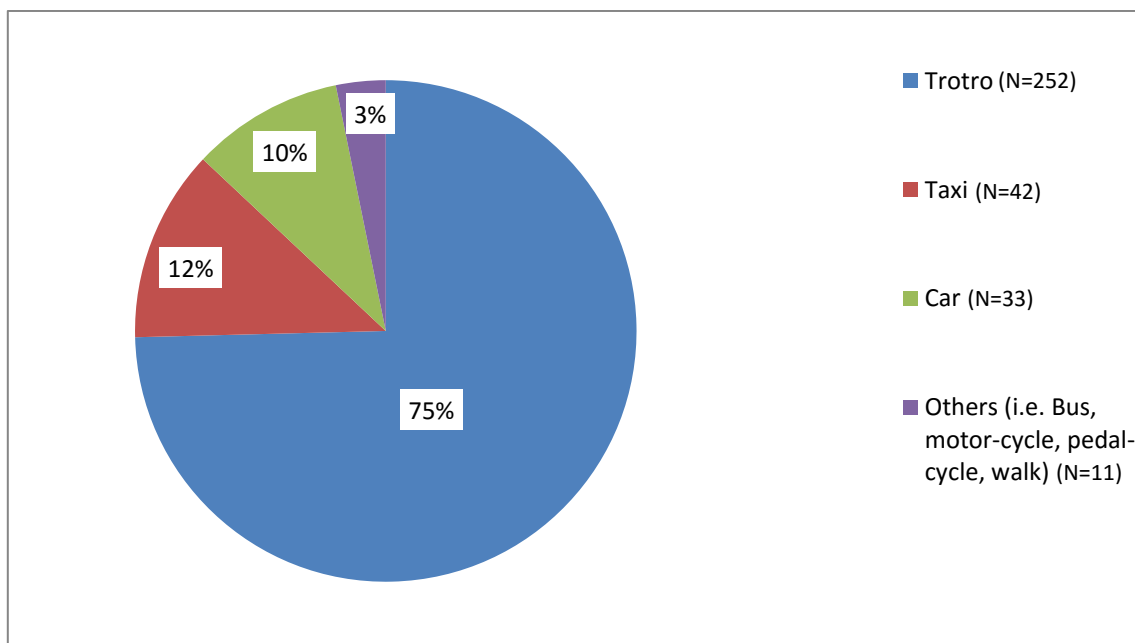
The next section presents findings made with respect to transportation patterns, particularly modal use among GAMA's long distance trip makers (who visit Accra Central) as well as short distance trip makers (who access nearby activity points).

5.3. Patterns of Transportation Behaviour in GAMA

5.3.1. Transport Modal Use to Activity Points in GAMA

The study found a high use of motorised transport modes for all long distance trips made to Accra Central by GAMA trip makers. As illustrated in Figure 5.7, these motorised transport modes are trotro, taxi and car. Compared to the taxi and car, the trotro is, by far, the most utilised motorised transport mode for trips to Accra Central. The use of other forms of transport, including formal bus/transit services and motorbikes as well as non-motorised transport modes such as bicycles and walking were quite insignificant among trip makers. It is also significant to note that while rail services have a modest presence in GAMA, none of the surveyed trip makers indicated their use of this motorised transport mode.

Figure 5.7: Transport modes used by long distance trip makers (N=338) to Accra Central



Source: Field data, 2014

In light of the above observations, subsequent analyses of the modal use of trip makers resident in GAMA are based exclusively on the three most frequently used motorised transport modes, i.e. trotro, taxi and car. In the ensuing paragraphs, the analyses take a deeper look at the use of these three popular transport modes by various categories of trip makers. This was to observe whether specific groups of long distance trip makers who are exclusively GAMA residents are more predisposed to use one form of motorised transport mode as opposed to the other. Table 5.6 indicates that gender has a statistically significant effect on modal use among long distance trip makers. Compared to male trip makers, females were by far the largest group of trip makers who visit Accra Central by public transport, i.e. trotro and taxis. Male trip makers, on the other hand, made significant use of cars when visiting activity points in Accra Central.

Table 5.6: Most frequently used modes of long distance trip makers by gender

Mode	Male		Female		Total
	No.	%	No.	%	
Trotro	47	69.1	205	79.2	252
Taxi	1	1.5	41	15.8	42
Car	20	29.4	13	5	33
Total	68	100	259	100	327

Note: $\chi^2 = 41.105^{***}$; DF=2; $p^{***} < .001$; 11 cases which did not use Trotro/Taxi/Car are excluded. Source: Field data, 2014

As illustrated in Table 5.7, age was found to have a strong statistical effect on modal use of long distance trip makers. The majority of trotro users are between the ages of 20 and 29 years. Beyond this age group, trotro use decreases with increasing age of trip makers. Among taxi users, a majority are found within the 40-49 year group. Among trip makers who indicated that they travelled by car to Accra Central, those in the 50-59 year cohort were the highest. A revealing observation in Table 5.7 is that car use was not popular among trip makers who are less than 20 years as well as those who are 60 years and above.

Table 5.7: Most frequently used modes of long distance trip makers by age

Age	<20	20-29	30-39	40-49	50-59	60+	
Mode	Percentages						Total
Trotro	2.4	35.3	25.4	20.6	12.3	4	252
Taxi	2.4	9.5	21.4	38.2	9.5	19	42
Car	0	12.1	27.3	21.2	39.4	0	33
Total	2.1	29.7	25.1	22.9	14.7	5.5	327

Note: $\chi^2= 50.152^{***}$; DF=10; $p^{***}<.001$; 11 cases which did not use Trotro/Taxi/Car are excluded. Source: Field data, 2014

When the data is further analysed to account for the differences among trip makers with respect to their level of educational attainment, trotro use was observed among trip makers whose highest educational attainment was at the basic level and also for those who had had no formal educational at all. Taxi use was very common, particularly, among trip makers who had attained second cycle education. Car use was very high among trip makers with a high level of formal education. Trip makers who said they had obtained tertiary level education were over two times more predisposed to using cars compared to car users whose highest education was at the second cycle level. Also, trip makers who had only basic or no formal education at all never travelled in cars when visiting Accra Central. A summary statistics of the above findings, as well as a demonstration of a strong statistical relationship between the predictor and dependent variables, are illustrated in Table 5.8.

Table 5.8: Most frequently used modes of long distance trip makers by education

Education	No formal education	Basic	Second cycle	Tertiary	
Mode	Percentages (%)				Total
Trotro	13.9	23.4	41.3	21.4	252
Taxi	16.7	23.8	54.8	4.7	42
Car	0	0	27.3	72.7	33
Total	12.8	21.1	41.6	24.5	327

Note: $\chi^2= 55.096^{***}$; DF=6; $p^{***}<.001$; 11 cases which did not use Trotro/Taxi/Car are excluded. Source: Field data, 2014

Table 5.9 shows that there is no statistical relationship between household size and modal use among the sampled GAMA trip makers. A closer look at the table reveals that there is a higher representation of car users among trip makers with larger household size (11 and above persons). Comparatively, trip makers with smaller household sizes (i.e. 1-5 and 6-10 persons) were found to travel more in taxis and trotros respectively.

Table 5.9: Most frequently used modes of long distance trip makers by household size

	1-5	6-10	11-15	Above15	
Mode	Percentages (%)				Total
Trotro	78.6	19.0	1.6	0.8	252
Taxi	83.3	14.3	2.4	0	42
Car	75.8	18.2	3.0	3.0	33
Total	78.9	18.4	1.8	0.9	327

Note: $\chi^2= 3.037$; DF=6; 11 cases which did not use Trotro/Taxi/Car are excluded.

Source: Field data, 2014

Table 5.10 indicates a strong statistically effect of occupation type on modal use among the surveyed trip makers. In terms of the occupation type of trip makers, the study found that trip makers who identified themselves as self-employed, basically in the commercial sector, travelled more by taxis and relatively less with trotros. Those who said they were either unemployed or had no regular incomes (classified as 'others' in Table 5.10) such as

apprentices, shop attendants and students were found to rely on trotro for their journeys to Accra Central. Car use was relatively high among the salaried and formal sector employees.

Table 5.10: Most frequently used modes of long distance trip makers by occupation

	Unemployed	Self-employed	Salaried/Gov't employee	Others	
Mode	Percentages (%)				Total
Trotro	5.6	74.2	13.9	6.3	252
Taxi	0	88.1	7.1	4.8	42
Car	0	33.3	66.7	0	33
Total	4.3	71.9	18.3	5.5	327

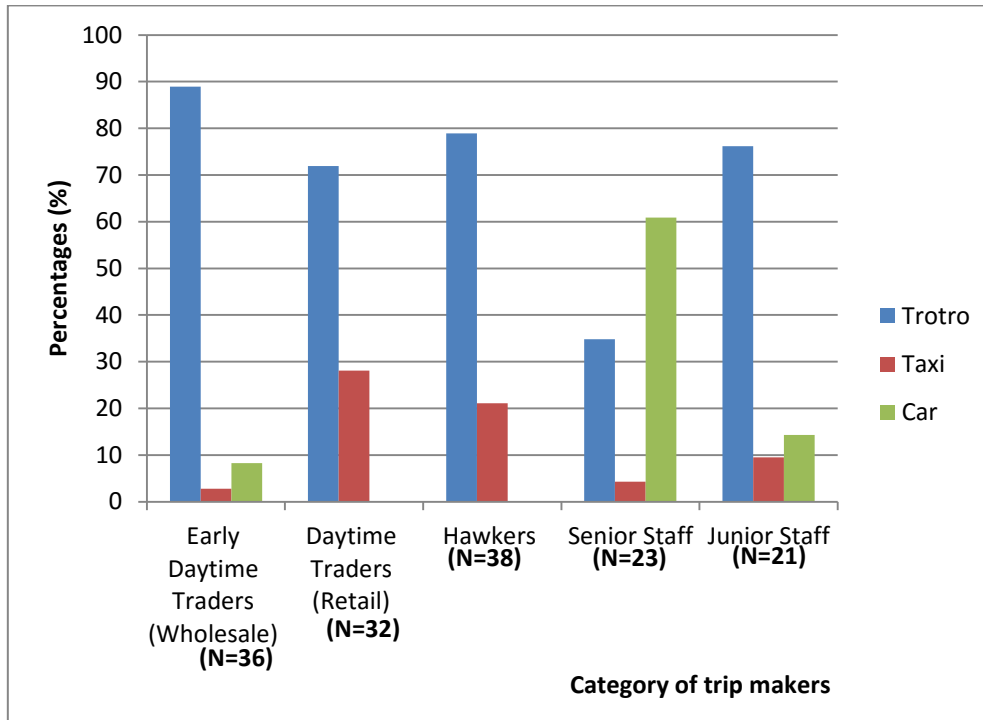
Note: $\chi^2=62.495^{***}$; DF=6; $p^{***}<.001$; 11 cases which did not use Trotro/Taxi/Car are excluded. Source: Field data, 2014

When the 'self-employed' and 'salaried/government employee' categories of trip makers are further divided to reflect either the scale of activity (i.e. wholesaler/retailer) or rank (i.e. senior/junior staff), a different pattern of transportation behaviour emerges. For instance, while salaried and government workers are generally identified with high car use, Figure 5.8 demonstrates that top officials classified as senior staff, including directors, deputy directors and secretaries/stenographers were the ones who to a large extent depended on cars to make their trips. Professional drivers employed in the formal sector are technically classified as junior staff. However, by virtue of some of them keeping the official vehicles at their residences after work, Figure 5.8 indicates that some junior staffs also used cars for their trips into Accra Central. Apart from this group, other junior staff employees in the formal sector, including security men, cleaners, messengers and national service personnel (who are young graduates attached to the various ministries but technically not classified as employees) greatly rely on trotro for their trips to Accra Central.

In the informal sector, market women who engaged in wholesaling activities were more likely to use cars compared with those who engage in retailing activities at the Makola

Market during the daytime. The second category of traders was found to highly use taxis relative to the first category.

Figure 5.8: Most frequently patronised modes used by work-related long distance trip makers (N=156)

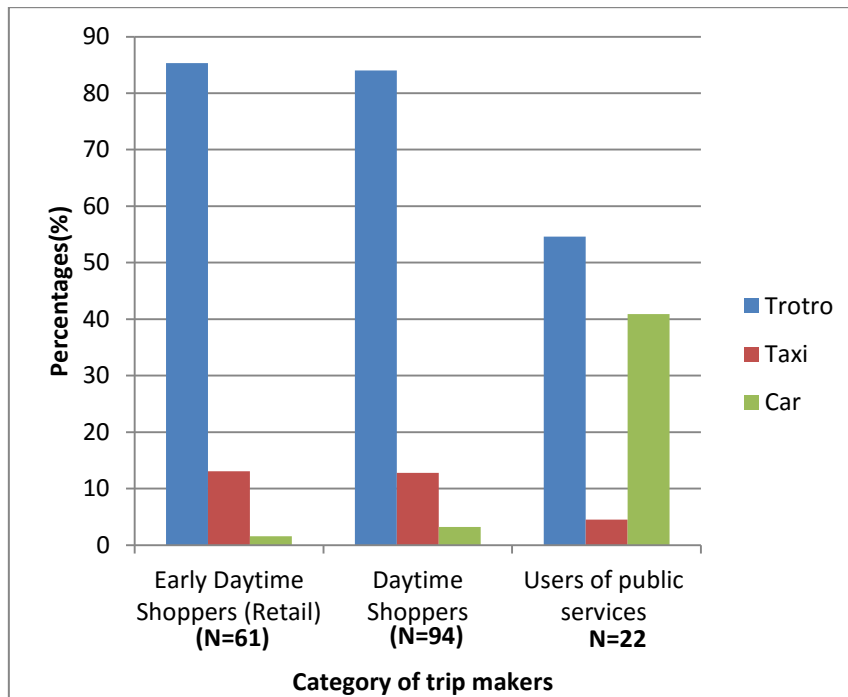


Note: 6 cases which did not use Trotro/Taxi/Car are excluded.

Source: Field data, 2014

Similarly, trip makers who visited Accra Central primarily to shop at the Makola Market or access public services at the Ministries were analysed to observe their modal use. Figure 5.9 illustrates the various sub-groups and the percent use of the three popular transport modes. What stands out in Figure 5.9 is the high use of cars among trip makers who indicated that they had come to Accra Central primarily to access government services. Among shoppers, irrespective of type, trotros were extensively used compared to taxi services.

Figure 5.9: Most frequently patronised modes used by non-work long distance trip makers (N=182)



Note: 5 cases which did not use Trotro/Taxi/Car are excluded. Source: Field data, 2014

Table 5.11 indicates a statistically significant effect of trip distance on modal use. A closer scrutiny of the table indicates that as the trip distance increases beyond 11 kilometres from the residential locations of trip makers to activity points in Accra Central, most trip makers make use of trotros and cars respectively. On the other hand, taxi use is substantially high for trips made within a 10-kilometre radius from Accra Central to the homes of trip makers.

Table 5.11: Most frequently patronised modes by trip distance

	less than 5Km	5-10km	11-15km	Above 15km	
Mode	Percentages (%)				Total
Trotro	6.0	38.1	16.7	39.3	252
Taxi	9.5	71.4	9.5	9.5	42
Car	12.1	24.2	15.2	48.5	33
Total	7.0	41.0	15.6	36.4	327

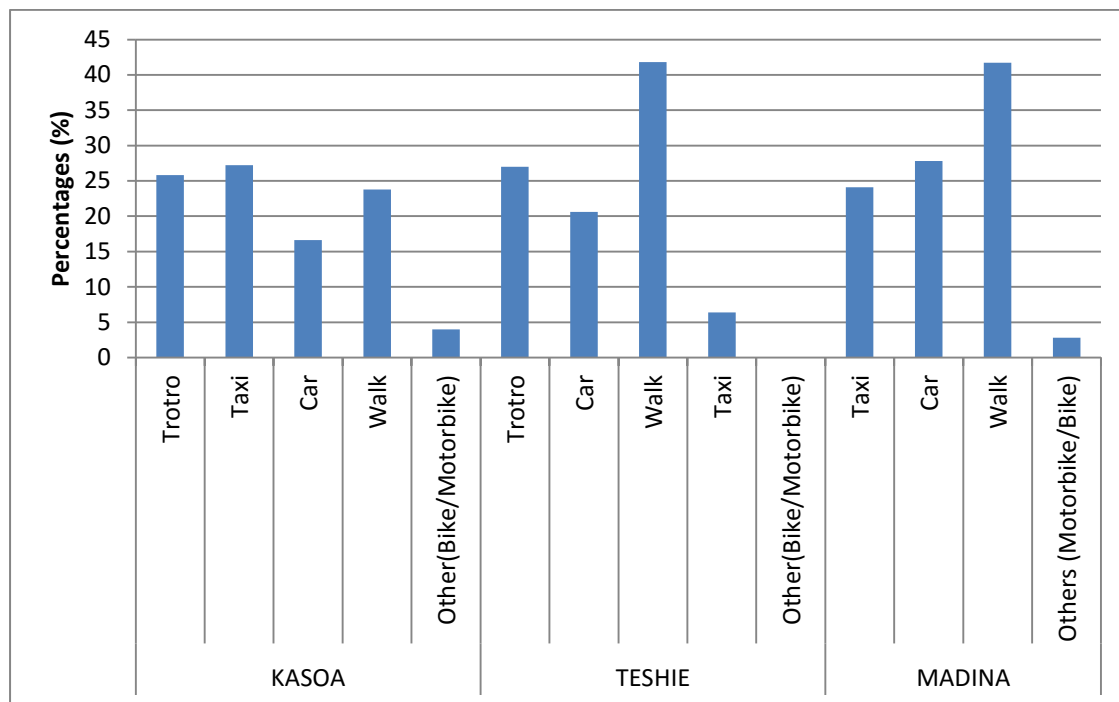
Note: $\chi^2 = 25.693^{***}$; DF=6; $p^{***} < .001$; 11 cases which did not use Trotro/Taxi/Car are excluded. Source: Field data, 2014

From the above description of long distance trips that are made to Accra Central, the following key patterns are highlighted. There is a high use of motorised transport modes, particularly trotro. Trotros are generally used by females, the youth, the less educated and the unemployed/ no regular income earners. The rest are shoppers and long distance trip makers. Taxis are generally used by older females, the highly educated and the self-employed (i.e. retailers). Also, trip makers who make short trips (within 10-kilometre radius) usually do so in a taxi. Cars are generally used by older males, the most highly educated, salaried and top officials in the formal sector. Car users also include the self-employed (i.e. wholesalers) in the informal sector, users of public services as well as long distance trip makers. While the income variable was not empirically tested in this study, the findings from the other socio-economic and demographic variables confirm what could be anticipated. For instance, as the education (and with it, income) of trip makers increase, there is the tendency for them to use personal means of transport, as opposed to public transport (i.e. trotro and taxi). The above patterns provide answers to answering part of the second research question in the study.

Modal use for short distance trips is illustrated in Figure 5.10. The study found that walking was very popular among surveyed trip makers in the Madina and Teshie communities, compared with their counterparts in Kasoa.

The use of taxis was relatively common among surveyed trip makers in both Kasoa and Madina. Trotro was also patronised, particularly in Kasoa and Teshie. However, in contrast to these two communities, none of the surveyed trip makers in the Madina sample indicated their use of trotros, notwithstanding the high number of trotros generally found all over GAMA. The use of motor and pedal cycles was comparatively low both in Kasoa and Madina. In the Teshie sample, none of the surveyed trip makers indicated their use of motor and pedal cycles.

Figure 5.10: Transport modes used by short distance trip makers to community activity points



Note: Kasoa (N=151; Missing value: 2.6%); Teshie (N=141; Missing value: 4.3%); Madina (N=108; Missing value: 3.7%) Source: Field data, 2014

Similar to the data on long distance trip makers, further statistical analyses were performed on the data on short distance trips to see whether the use of transport modes varied among different sets of trip makers. Female trip makers in all three surveyed communities were found to rely more on public transport modes (i.e. trotro paratransit services both in Kasoa and Teshie as well as taxis in Madina).

Walking was also very common among female trip makers in the three communities. The use of cars was very high among male trip makers in the three selected localities. In the two communities where motor and pedal cycles were used among trip makers, a total male dominance was observed. Table 5.12 encapsulates a summary statistics of modal use by gender categories in the three localities. The table further demonstrates a strong statistical effect of gender on modal use.

Table 5.12: Modal use of short distance trip makers by gender

Locality	Mode	Male		Female		Total	
		No.	%	No.	%	No.	%
KASOA	Trotro	17	21.5	22	32.4	39	26.5
	Taxi	22	27.8	19	27.9	41	27.9
	Car	20	25.4	5	7.3	25	17
	Walk	14	17.7	22	32.4	36	24.5
	Others (Motorbike/Bike)	6	7.6	0	0	6	4.1
	Total	79	100	68	100	147	100
Note: $\chi^2= 16.910^{***}$; DF=4; $p^{***}<.001$; 4 missing cases							
TESHIE	Trotro	13	20.3	25	35.2	38	28.1
	Taxi	5	7.8	4	5.6	9	6.7
	Car	20	31.3	9	12.7	29	21.5
	Walk	26	40.6	33	46.5	59	43.7
	Total	64	100	71	100	135	100
Note: $\chi^2= 8.564^{***}$; DF=3; $p^{***}<.001$; 6 missing cases							
MADINA	Taxi	9	18.4	17	30.9	26	25
	Car	26	53.1	4	7.3	30	28.8
	Walk	11	22.4	34	61.8	45	43.3
	Others (Motorbike/Bike)	3	6.1	0	0	3	2.9
	Total	49	100	55	100	104	100
Note: $\chi^2= 33.114^{***}$; DF=3; $p^{***}<.001$; 4 missing cases							

Source: Field data, 2014

Table 5.13 indicates that age statistically affects modal use in all three localities. A closer look at the table shows that among public transport users, trotros and taxis were generally popular across all age groups. Public transport was used by older and younger trip makers alike. Car use was comparatively higher among older trip makers, especially persons aged between 40 and 49 years. Walking to community activity points was found to be high for trip makers aged between 20 and 39 years in all three localities. Notable variations with respect to the use of motor and pedal cycles were observed in both Kasoa and Madina. Trip makers aged between 20 and 49 years were found in the Kasoa sample to use motor and pedal cycles. In the Madina sample, respondents who use these two modes were all found in the 30-39 year group.

Table 5.14 illustrates that education does significantly influence modal use among trip makers. In all three localities, there was high use of cars and less use of walking among the highly educated class. On the contrary, car use was nil among people of no formal education or those with only basic education. This category of trip makers walked extensively and also used motor and pedal cycles. Trip makers who had attained second cycle education were generally associated with high use of public transport, notably trotro and taxi.

Table 5.13: Modal use of short distance trip makers by age

		<20	20-29	30-39	40-49	50-59	60+	Total
Mode		Percentages (%)						
KASOA	Trotro	2.6	33.3	33.3	17.9	5.1	7.7	39
	Taxi	4.9	12.2	24.4	39.0	9.8	9.8	41
	Car	0.0	4.0	28.0	60.0	4.0	4.0	25
	Walk	5.6	38.9	33.3	11.1	8.3	2.8	36
	Others (Motorbike/Bike)	0.0	33.3	33.3	33.3	0.0	0.0	6
	Total	3.4	23.8	29.9	29.9	6.8	6.1	147
Note: $\chi^2= 32.845^{***}$; DF=20; $p^{***}<.001$; 4 missing cases								
TESHIE	Trotro	0.0	15.8	36.8	23.7	10.5	13.2	38
	Taxi	0.0	0	44.4	44.4	0.0	11.1	9
	Car	0.0	0	31.0	51.7	17.2	0.0	29
	Walk	1.7	23.7	25.4	16.9	18.6	13.6	59
	Total	0.7	14.8	31.1	28.1	14.8	10.4	135
Note: $\chi^2= 27.489^{***}$; DF=15; 6 missing cases								
MADINA	Taxi	3.8	11.5	46.2	19.2	15.4	3.8	26
	Car	0.0	6.7	36.7	36.7	10.0	10.0	30
	Walk	0.0	13.3	51.1	20.0	11.1	4.4	45
	Others (Motorbike/Bike)	0.0	0.0	100	0.0	0.0	0.0	3
	Total	1.0	10.6	47.1	24.0	11.5	5.8	104
Note: $\chi^2= 12.153^{***}$; DF=15; 4 missing cases								

Source: Field data, 2014

Table 5.14: Modal use of short distance trip makers by education

		No formal education	Basic	Second cycle	Tertiary	Total
Mode		Percentages (%)				Total
KASOA	Trotro	2.6	38.5	41	17.9	39
	Taxi	4.9	24.3	29.3	41.5	41
	Car	0	16	16	68	25
	Walk	13.9	41.6	30.6	13.9	36
	Others (Motorbike/Bike)	16.7	49.9	16.7	16.7	6
	Total	6.1	32	29.9	32	147
Note: $\chi^2=33.404^{***}$; DF=12; $p^{***}<.001$; 4 missing cases						
TESHIE	Trotro	5.3	57.9	26.3	10.5	38
	Car	0	10.3	24.1	65.6	29
	Walk	13.5	37.3	33.9	15.3	59
	Taxi	0	22.2	55.6	22.2	9
	Total	7.4	36.3	31.1	25.2	135
Note: $\chi^2=43.762^{***}$; DF=9; $p^{***}<.001$; 6 missing cases						
MADINA	Taxi	3.8	26.9	42.4	26.9	26
	Car	0	3.3	0	96.7	30
	Walk	28.9	48.9	8.9	13.3	45
	Others (Motorbike/Bike)	0	66.7	33.3	0	3
	Total	13.4	30.8	15.4	40.4	104
Note: $\chi^2=80.498.762^{***}$; DF=9; $p^{***}<.001$; 4 missing cases						

Source: Field data, 2014

The study found that among Kasoa trip makers with larger household sizes, in the range of 11 persons and above, there was high use of public transport (i.e. trotro and taxi). Comparatively, the majority of trip makers who walked to commercial activity points had smaller household sizes, ranging from 1 to 5 persons on the average. At Madina, however, the study found that the majority of public transport users (i.e. taxi) had a relatively smaller household size in the range of 1 to 5 persons. Car use and walking was common among trip makers with larger household sizes, of six persons and above. In the Teshie sample, cars were used mostly by trip makers with larger families, similar to the other two communities.

Similar to the Madina sample, Teshie trip makers with relatively smaller family sizes are to a large extent associated with taxi use. Table 5.15 highlights the key findings. As seen in the table, no statistically significant relationship was found between the independent and the dependent variables.

Table 5.15: Modal use of short distance trip makers by household size

Mode	1-5	6-10	11-15	Above 15	Total	
	Percentages (%)					
KASOA	Trotro	61.6	33.3	0	5.1	39
	Taxi	63.4	31.7	4.9	0	41
	Car	60	40	0	0	25
	Walk	75	25	0	0	36
	Others (Motorbike/Bike)	83.3	16.7	0	0	6
	Total	66	31.2	1.4	1.4	147
Note: $\chi^2=13.245$; DF=12; 4 missing cases						
TESHIE	Trotro	68.5	28.9	2.6	0	38
	Car	62.1	34.5	0	3.4	29
	Walk	69.5	27.1	1.7	1.7	59
	Taxi	77.8	11.1	11.1	0	9
	Total	68.2	28.1	2.2	1.5	135
Note: $\chi^2=7.087$; DF=9; 6 missing cases						
MADINA	Taxi	76.9	23.1	0	0	26
	Car	63.3	36.7	0	0	30
	Walk	60.1	33.3	4.4	2.2	45
	Others (Motorbike/Bike)	66.7	33.3	0	0	3
	Total	65.4	31.7	1.9	1	104
Note: $\chi^2=5.565$; DF=9; 4 missing cases						

Source: Field data, 2014

When the data was disaggregated by the occupational status of trip makers, the study revealed that across the three communities, car use was high among salaried and government employees. On the other hand, the majority of people who are unemployed or those under apprenticeship, national service personnel and those not on regular incomes made massive

use of public transport, notably trotro and taxi. Again, walking was found to be high among the unemployed, self-employed and others not on regular incomes, but not among salaried or government employees, as has been illustrated in Table 5.16.

Table 5.16: Modal use of short distance trip makers by occupation

Mode	Unemployed	Self-employed	Salaried/Gov't employee	Others	Total
	Percentages (%)				
Trotro	0	76.9	20.5	2.6	39
Taxi	4.9	53.7	34.1	7.3	41
Car	0	52	48	0	25
Walk	5.6	75	16.6	2.8	36
Others (Motorbike/Bike)	0	66.7	33.3	0	6
Total	2.7	65.3	28.6	3.4	147

Note: $\chi^2= 16.017$; DF=12; 4 missing cases

Trotro	10.5	68.5	18.4	2.6	38
Car	3.4	55.2	41.4	0	29
Walk	8.5	69.5	16.9	5.1	59
Taxi	11.1	88.9	0	0	9
Total	8.1	67.4	21.5	3	135

Note: $\chi^2= 12.503$; DF=9; 6 missing cases

Taxi	11.5	69.3	19.2	0	26
Car	0	50	50	0	30
Walk	4.4	82.2	13.3	0	45
Others (Motorbike/Bike)	0	100	0	0	3
Total	4.8	70.2	25	0	104

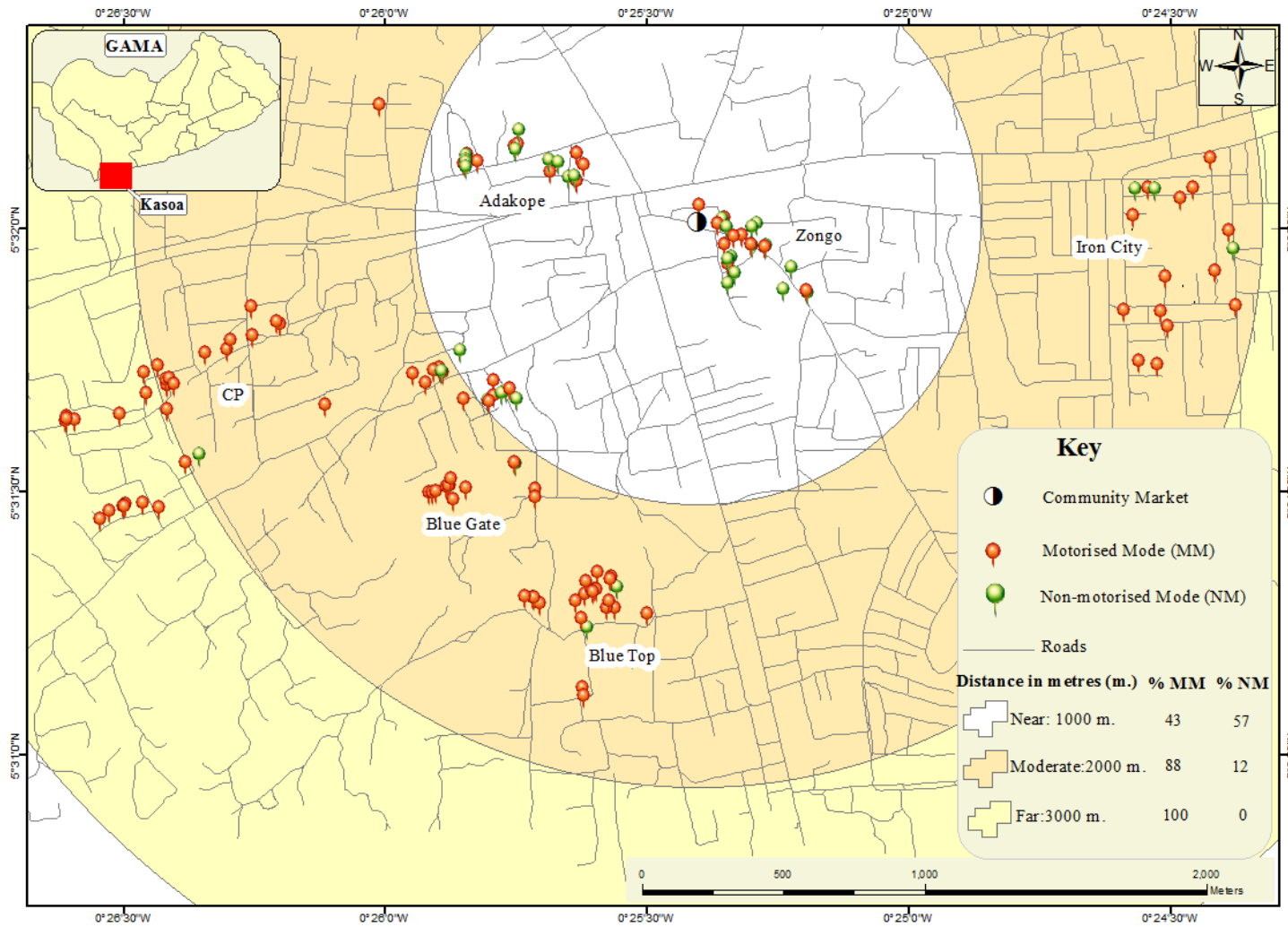
Note: $\chi^2= 18.149^{***}$; DF=6; $p^{***}<.001$; 4 missing cases

Source: Field data, 2014

Geospatial analyses were performed on the data on short distance trips to determine the role of distance on modal use among trip makers. Respondents were grouped according to the relative locations of their residences to the main community markets which they regularly commute to. The results are illustrated in Figures 5.11, 5.12 and 5.13 respectively.

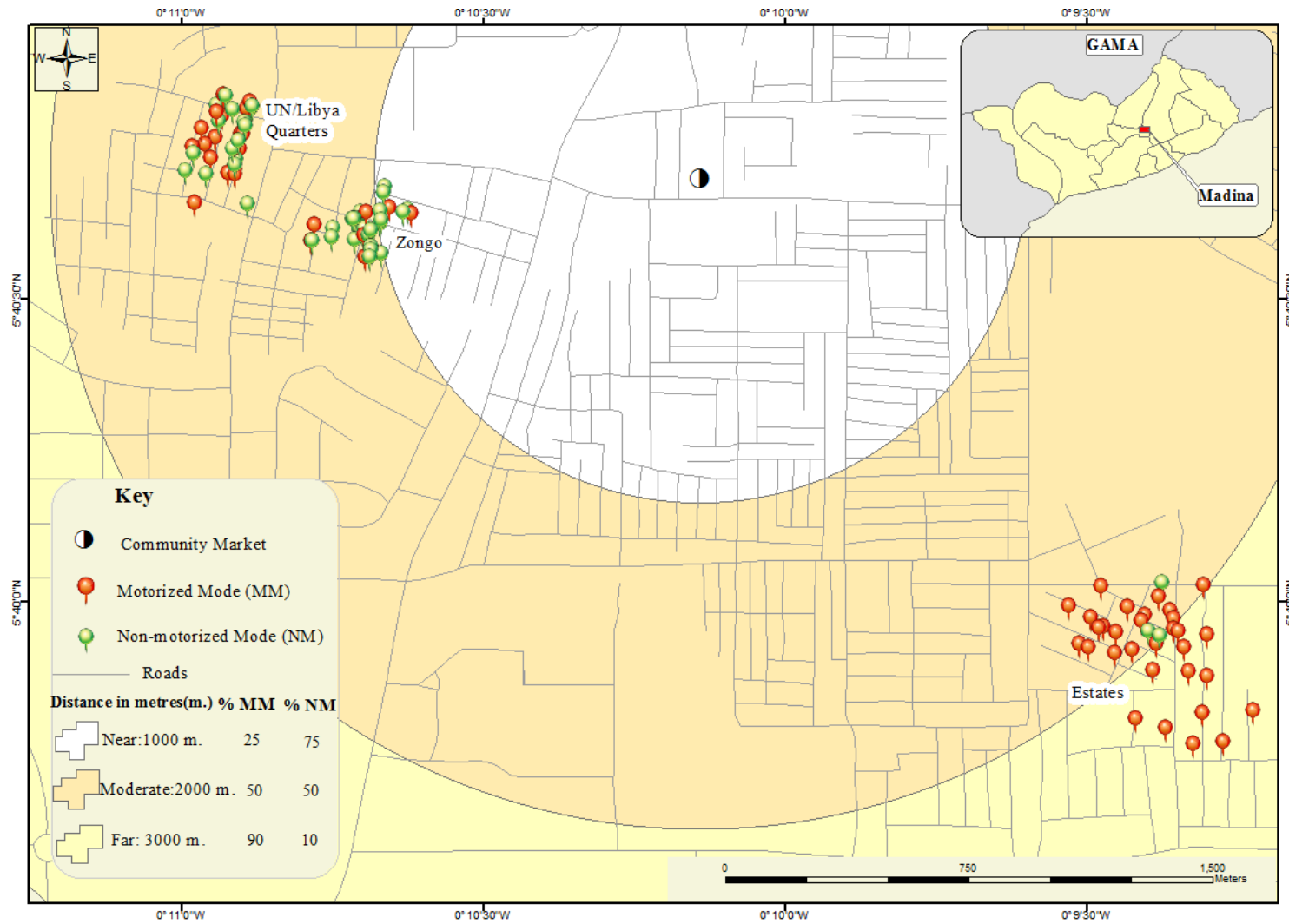
In all three sampled communities, non-motorised transport modes, notably walking, was found to be high among trip makers whose houses were located relatively close to the major community markets where commercial activity points are accessed. However, as trip distances increase, non-motorised transport mode use was found to decline. For instance, among Kasoa trip makers, the use of non-motorised transport modes reduced drastically by 45% when trip distance increased from 1000 metres to 2000 metres away from the Old Market. An increase in trip distance by an extra 1000 metres resulted in zero use of non-motorised transport modes. Similar patterns are observed among trip makers in the two remaining communities. What the diagrams further demonstrate is that in all three communities, an increase in trip distances from the homes of trip makers to the local activity points resulted in increased use of motorised transport modes.

Figure 5.11: Modal use by distance between homes of trip makers and community market (Kasoa)



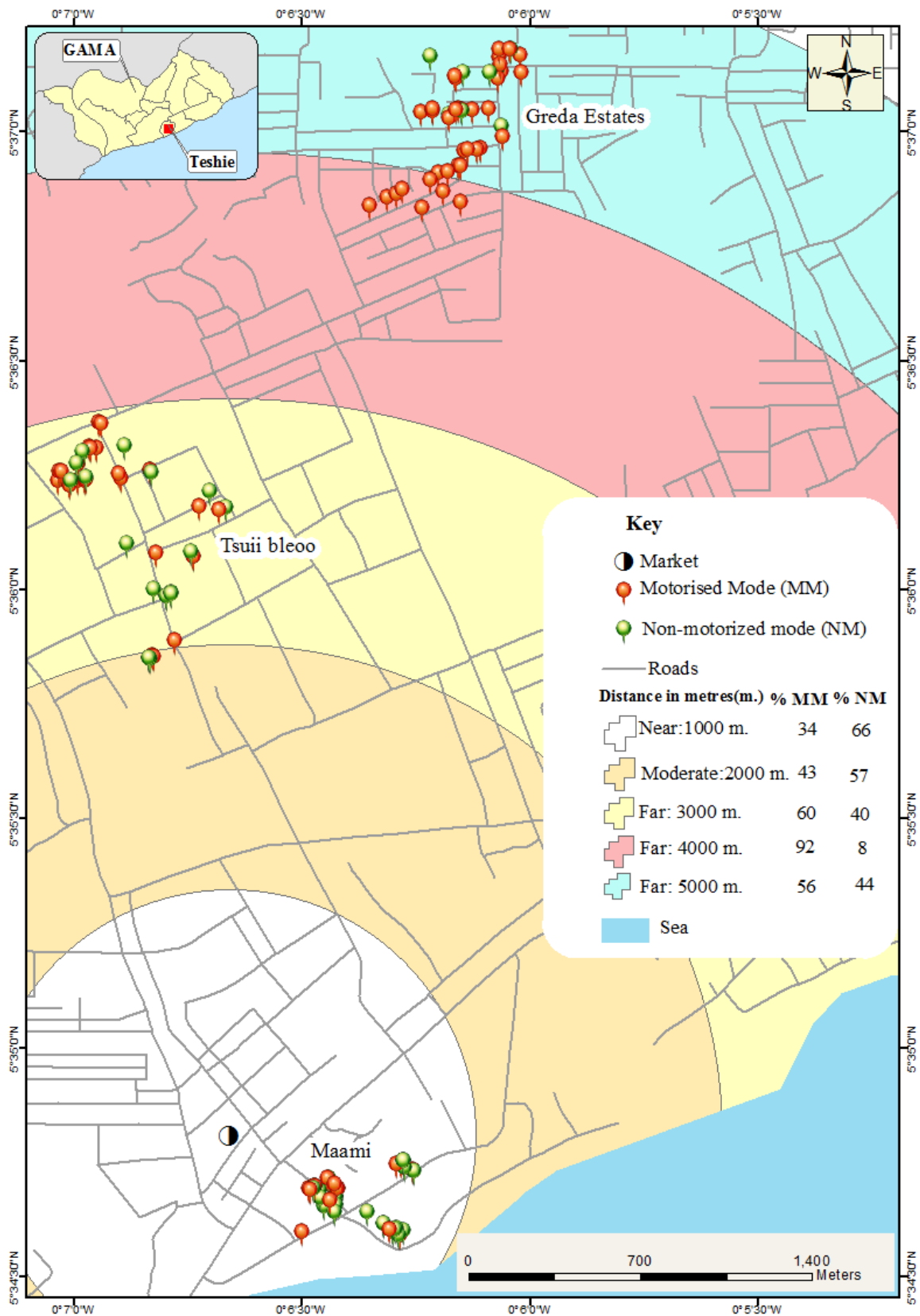
Source: Field data, 2014

Figure 5.12: Modal use by distance between homes of trip makers and community market (Madina)



Source: Field data, 2014

Figure 5.13: Modal use by distance between homes of trip makers and community market (Teshie)



Source: Field data, 2014

The foregoing description of modal use for short distance trips has identified the following key patterns. Non-motorised transport modes, especially walking is high in all three localities. However, as trip distances increase, non-motorised transport mode use was found to decline. Walking is usually done by females, the youth (in Kasoa), the aged (in Madina) and the less educated. Also, the unemployed/ no regular income earners, the self-employed and trip makers whose houses were located relatively close to activity points walked. The use of both pedal and motorcycles to community activity points was usually done by males, the youth and the less educated. Pedal and motorcycles were used in Kasoa and Madina but not in Teshie. Trip makers who visit community activity points in Kasoa and Madina in taxis were generally females and the highly educated class. Also, the unemployed/ no regular income earners were found to use taxis. Teshie trip makers did not use taxis for short distance trips. Users of trotro for short distance trips in Kasoa and Teshie were mostly females and the unemployed/ no regular income earners. Trip makers in Madina did not use trotro for short distance trips. Trip makers who make short distance trips in cars are usually older males, the most highly educated as well as salaried and government employees. The above patterns are expected, with the exception of the non-use of trotro (in Madina) and taxis (in Teshie) for short distance trips. This is because these public transport modes are found in almost every part of GAMA. The description above of modal use for short distance trips contributes to providing answers to the second research question.

The next section takes a look at the factors which determine the choice of transport modes among trip makers.

5.3.2. Factors Influencing Modal Choice among GAMA Trip Makers

Long distance trip makers were asked to indicate their agreement or disagreement with a set of questions on factors which they consider to be important when selecting particular modes of transport over others. Respondents were further asked to indicate if there were other reasons not captured on the questionnaire that also informed their modal choice decisions. The responses were categorised according to various user groups (i.e. trotro, taxi and car users respectively) to observe differences and commonalities in modal choice decision-making by trip makers in the various groups.

The data showed that, in order of importance, trip makers who chose trotro did so primarily because they perceived the paratransit services to be readily available, affordable, and also offered the possibility of door-to-door services. In other words, the practice whereby trotro operators allow passengers to alight at any location of their choice other than the specifically earmarked bus stops made trotro use very convenient for trip makers. Other trotro users were also motivated to board trotros due to its high departure frequencies. In order of importance, the majority of taxi users consider comfort, the flexibility of alighting at the commuter's desired location (just as trotro users), speed and timeliness as well as safety in this order of importance when deciding to board a taxi. The majority of car users, on the other hand, considered the freedom and ease of mobility foremost in the sense that by virtue of the car being at their disposal, they can travel as and when they desire, in contrast to the two public transport modes. Again, compared to other modes, most car users perceived cars to be the most available, safe, fast and offered them the best chance to evade traffic congestion. Tables 5.17, 5.18 and 5.19 present the various mode specific attributes which were considered as important or less important among various groups of motorised transport modes users.

Table 5.17: Mode-specific attributes which influence the choice of trotro by trip makers

Total (N=252)	Agree	Disagree
Availability	89.3	10.7
Affordability	82.1	17.9
Convenience (i.e. alighting at place of choice)	79.4	20.6
Frequent departure	78.2	21.8
Safety	65.9	34.1
Long distance	62.7	37.3
Comfort	62.3	37.7
Speed	62.3	37.7
Evading traffic congestion	56.0	44.0
Least polluting	31.7	68.3
Lack of transport options	20.2	79.8
Short distance	18.3	81.7

Source: Field data, 2014

Table 5.18: Mode-specific attributes which influence the choice of taxi by trip makers

Total (N=42)	Agree	Disagree
Comfort	100	-
Convenience (i.e. alighting at place of choice)	95.2	4.8
Speed	95.2	4.8
Safety	90.5	9.5
Frequent departure	85.7	14.3
Availability	85.7	14.3
Long distance	69.0	31.0
Affordability	50.0	50.0
Least polluting	45.2	54.8
Evading traffic congestion	38.1	61.9
Short distance	14.3	85.7
Lack of transport options	11.9	88.1

Source: Field data, 2014

Table 5.19: Mode-specific attributes which influence the choice of car by trip makers

Total (N=33)	Agree	Disagree
Convenience (i.e. alighting at place of choice)	100	-
Frequent departure	100	-
Availability	97.0	3.0
Safety	90.9	9.1
Speed	87.9	12.1
Evading traffic congestion	81.8	18.2
Affordability	75.0	25.0
Least polluting	72.7	27.3
Long distance	30.3	69.7
Comfort	21.2	78.8
Lack of transport options	15.2	84.8
Short distance	9.1	90.9

Source: Field data, 2014

Aside the above-mentioned mode specific attributes, the results as already shown in Tables 5.6 through to 5.11 demonstrate that when treated in isolation, there is a statistically significant relationship between a trip maker's gender, age, educational status, occupation type, travel distance and modal choice in GAMA at a 99% confidence interval. In other words, with the exception of household size which was found not to be statistically significant, these socio-economic and spatial variables influenced modal choice among trip makers in GAMA. However, a model of the data on long distance trip makers through the Multinomial Logit (MNL) analysis produced results which generally do not support the strong statistical significance obtained for some of the predictor variables presented in Tables 5.6 through to 5.11 which were obtained through the Chi-Square test of statistical significance. Illustrated in Table 5.20, the MNL model is statistically robust and shows a good fit with a Pearson chi-square value of 240.202 which was significant at 99% confidence level.

A Nagelkerke R^2 of 0.76 shows that the model correctly predicts 76% of the variance in modal choice among long distance trip makers. In addition, the dataset used for the model did not over-disperse as seen in the deviance chi-square value which was not significant.

Table 5.20: Multinomial Logit analysis estimating the effects of the predictors on modal choice among trip makers

	B (SE)	Wald	Odds Ratio	95% CI for Odds Ratio	
				Lower	Upper
TROTRO					
Intercept	59.058 (6.972)***	71.759			
<i>Socio-spatial</i>					
Gender	-1.593 (1.086)	2.153	0.203	0.024	1.707
Age	-0.104(0.051)*	4.131	0.901	0.815	0.996
Education	-0.72 (0.229)**	9.897	0.487	0.311	0.762
Car Ownership	-4.471 (1.354)**	10.903	0.011	0.001	0.163
Household size	-.564 (.806)	0.491	0.569	0.117	2.758
Trip duration	-0.012 (.017)	0.524	0.988	0.956	1.021
Distance	0.065 (0.067)	0.949	1.067	0.936	1.217
<i>Service Quality</i>					
Availability	-2.318 (2.828)	0.672	0.098	0.000	25.136
Comfort	-.792 (1.513)	0.274	0.453	0.023	8.786
Convenience	-15.231 (1.023)***	221.751	2.43E-07	3.27E-08	1.80E-06
Affordability	-0.32 (1.459)	0.048	0.726	0.042	12.674
Speed	0.203 (1.564)	0.017	1.225	0.057	26.25
Departure Frequency	-18.647 (.844)***	488.49	7.98E-09	1.53E-09	.4.169E-008
Traffic avoidance	-1.487 (1.213)	1.503	0.226	0.021	2.436
Safety	-1.696 (1.512)	1.258	0.183	0.009	3.553
Least Smoking	-2.673 (1.24)*	4.649	0.069	0.006	0.784
Distance_Far	-0.22 (1.002)	0.048	0.803	0.113	5.727
Distance_Near	-1.157 (1.443)	0.644	0.314	0.019	5.313
No options	.034 (1.323)	0.001	1.035	0.077	13.832

TAXI					
Intercept	40.176 (2222.562)	0.000			
<i>Socio-spatial</i>					
Gender	-2.199 (1.564)	1.977	0.111	0.005	2.378
Age	-.062 (.055)	1.306	0.94	0.844	1.046
Education	-.633 (.237)**	7.16	0.531	0.334	0.844
Car Ownership	-6.262 (3.259)*	3.693	0.002	3.21E-06	1.132
Household size	.348 (0.835)	0.174	1.416	0.276	7.282
Trip duration	-0.023 (0.022)	1.066	0.977	0.936	1.021
Distance	-.095 (0.088)	1.162	0.91	0.765	1.081
<i>Service Quality</i>					
Availability	-4.16 (2.916)	2.035	0.016	5.15E-05	4.734
Comfort	17.173 (2222.552)	0.000	28720295.1	0.000	.b
Convenience	-14.694 (.000)	.	4.16E-07	4.16E-07	4.16E-07
Affordability	-2.137 (1.507)	2.01	0.118	0.006	2.263
Speed	2.157 (1.884)	1.311	8.643	0.215	346.691
Departure Frequency	-19.425 (.000)	.	3.66E-09	3.66E-09	3.66E-09
Traffic avoidance	-2.863 (1.348)*	4.509	0.057	0.004	0.802
Safety	-1.848 (1.737)	1.132	0.158	0.005	4.741
Smoking	-1.365 (1.353)	1.017	0.255	0.018	3.623
Distance_Far	-.276 (1.156)	0.057	0.759	0.079	7.317
Distance_Near	-2.732 (1.577)	3.001	0.065	0.003	1.432
No options	0.115 (1.537)	0.006	1.122	0.055	22.805

Note: $R^2 = 0.76$ (Nagelkerke); Model Fit $\chi^2 = 240.202$ ***; Goodness-of-Fit $\chi^2 = 253.612$ (df=540), Deviance = 157.158 (df=540); -2 Log Likelihood = 397.361; *p<.05, **p<.01, ***p<.001; *Car is used as reference category.*

Source: Field data, 2014

As illustrated in Table 5.20, age, education and ownership of personal car were the main socio-economic variables that were found to be significant predictors of choosing trotro among long distance trip makers.

Similarly, perceptions of convenience, frequency of trip departures and less emission of smoke were found to be significant predictors of the choice of trotro among survey respondents. Compared to car use, Table 5.20 indicates that a unit increase in a person's age and years of formal education result in a decreased odds for commuting to activity points in Accra Central in a trotro by 10% and 51% respectively. Table 5.20 further shows that the odds of choosing trotro among commuters who either personally own cars or have the possibility to rideshare in someone else's car when travelling to Accra Central decrease by as much as 99%. Beyond the personal attributes of the individual commuter, the perceived quality of service offered by a particular transport mode also predicts their modal choice decisions. The study found that among trip makers who perceive trotro to be more convenient in terms of allowing them to alight at any place of their choosing have 2.43 times the odds for travelling by trotro than by car. It means they have an increased odd for choosing trotro because of the perceived convenience. People who perceive the high departure frequencies of trotro have 7.98 times the odds for travelling by trotro than by car. It means these trip makers are about 8 times more likely to travel by trotro because of the perceived high frequencies. The data further reveals that the odds of choosing trotro among individuals who perceive cars to emit the least smoke decreases by 93%. In other words, it is less likely that a person owning a personal means of transport will choose trotro due to the perceived high emission of smoke that accompanies trotros.

As illustrated in Table 5.20, education and ownership of personal car were the two main socio-economic variables that were found to be significant predictors of the choice of taxi among long distance trip makers. Similarly, the perception that taxi drivers can re-route through secondary road networks that are less congested was the only mode-specific attribute that was found to be a significant predictor of choosing a taxi among survey respondents.

The study further found that a unit increase in the years of formal education of a trip maker decreases his/her odds for travelling by taxi by 47%. This means that compared to the choice of a car, a trip maker of higher educational status was 47% less likely to choose a taxi. As has been found in Table 5.20, trip makers who have their personal cars or have the possibility of ridesharing with other car owners have a 98% decreased odds for commuting by taxis. Table 4.20 further shows that trip makers who perceive the use of cars to be more flexible in terms of the possibility of dodging congested road corridors were less likely to travel by taxis by as much as 94%. Finally, the table further demonstrates that the car ownership status of GAMA trip makers has a statistically significant effect on modal use.

A Binary Logistic Regression was performed on the data on short distance trip makers to examine the effect of distance on modal choice. This was necessary to test the second alternative hypothesis in this study that says that trip distance to community activity points for shopping has a statistically significant effect on the transport modal choice of GAMA trip makers. Confirming the stated alternative hypothesis, Table 5.21 indicates that when distance is isolated from other possible interacting factors and regressed as a stand-alone variable, a statistically significant relationship between distance and modal choice in Madina; Kasoa and Teshie were found in the data. When the data on short distance trip makers was subjected to a second Binary Logistic Regression, this time including socio-economic and demographic factors such as age, education, household size, occupation type, car ownership status of trip makers, together with distance, the results were slightly different, particularly regarding statistical significance, from the ones illustrated in Table 5.21. The results obtained in the second Binary Logistic Regression are shown in Table 5.22.

Table 5.21: Distance and modal choice among short distance trip makers when accessing community markets

	Variable Name	B (SE)	Wald	Odds Ratio	95% CI for Odds Ratio		% Correctly Classified
					Lower	Upper	
KASOA	Constant	-0.205 (0.287)	0.508	0.815			77.6
	Distance	2.273 (0.430)***	27.938	9.707	4.179	22.547	
<i>Note: R2 = .285 (Nagelkerke); -2 Log Likelihood = 136.249; ***p<.001</i>							
MADINA	Constant	-1.179(0.404)***	8.499	0.308			73.1
	Distance	2.095 (0.483)***	18.799	8.125	3.152	20.946	
<i>Note: R2 = .255 (Nagelkerke); -2 Log Likelihood = 120.858; ***p<.001</i>							
TESHIE	Constant	-0.661 (0.308)	4.616	0.516			67.4
	Distance	1.424(0.384)***	13.772	4.152	1.958	8.805	
<i>Note: R2 = .138 (Nagelkerke); -2 Log Likelihood =170.370; ***p<.001</i>							

Source: Field data, 2014

Table 5.22 shows that modal choice in Kasoa was influenced by distance; age, education, household size and ownership of a personal car. At Kasoa, trip makers who commute to the Kasoa Old Market from distant suburbs such as Iron City, CP, Blue Gate and Blue Top had seven times increased odds for choosing motorised transport modes, perhaps due to increasing distance away from the activity point in question. Also, trip makers who owned and had access to cars were four times more likely to choose this motorised transport mode whenever they visit the community market. Furthermore, a unit increase in a person's age, years of formal education, and household size increased the likelihood of choosing motorised transport modes at Kasoa.

In the Madina sample, it was found that while the first model indicated a statistically significant relationship between distance and modal choice, the second model could not identify any statistically significant relationship at all between distance and modal choice.

This indicates a possible correction for multicollinearity in that distance could have been related to other socio-economic and demographic variables in influencing modal choice. In other words, distance on its own was not found to influence modal use among trip makers in Madina. However, age and education were found to be statistically significant to modal choice in Madina. Also, occupation and ownership of car were important factors for modal choice in Madina. The study found that trip makers who owned or had access to personal cars had five times increased odds for choosing them to the community commercial activity points. As was found in the Kasoa sample, a unit increase in a person's age, education and occupational status led to an increased likelihood of choosing motorised transport modes to commercial activity points located in the community.

In the Teshie sample, the second model confirmed the first model that distance greatly influenced modal choice. It was found that trip makers who are located further away from the Lascala Market in places like Tsui Bleoo and GREDA Estates had three times increased odds of choosing motorised transport modes. The study also found a statistically significant relationship between ownership of car and modal choice among trip makers in Teshie. Trip makers who owned or had access to cars were four times more likely to go with them whenever they visited the community market.

Table 5.22: Modal choice influencing factors of short distance trip makers when accessing community markets

	Variable Name	B (SE)	Wald	Odds Ratio	95% CI for Odds Ratio		% Correctly Classified
					Lower	Upper	
KASOA	Constant	-3.297 (1.368)**	5.809	0.037			82.3
	Distance	1.874(0.493)***	14.47	6.515			
	Age	0.047(0.020)**	5.608	1.049	1.008	1.091	
	Education	0.120 (0.072)*	2.764	1.127	0.979	1.298	
	Household size	0.199(0.112)*	3.17	1.22	0.98	1.519	
	Own Car	1.360(0.814)*	2.793	3.898	0.791	19.219	
Note: R2 =.442 (Nagelkerke) ; -2 Log Likelihood = 115.298; *p<.05, **p<.01, ***p<.001							
MADINA	Constant	-3.483(1.990)*	3.062	0.031			83.7
	Age	0.069(0.034)**	4.171	1.072	1.003	1.145	
	Education	0.371 (0.116)***	10.253	1.449	1.155	1.818	
	Occupation	-1.553(0.805)*	3.723	0.212	0.044	1.025	
	Own Car	1.549(0.667)**	5.388	4.708	1.273	17.418	
Note: R2 =.599 (Nagelkerke) ; -2 Log Likelihood = 81.122; *p<.05, **p<.01, ***p<.001							
TESHIE	Constant	-0.681(1.099)	0.384	0.506			74.8
	Distance	0.931(0.446)**	4.352	2.537	1.058	6.085	
	Own Car	1.398(0.490)***	8.12	4.046	1.547	10.58	
Note: R2 =.262 (Nagelkerke); -2 Log Likelihood =155.633; **p<.01, ***p<.001							

Source: Field data, 2014

The description of modal choice determinants by GAMA trip makers answers the third research question. The following patterns are highlighted: A major pattern that was observed in the data (i.e. both long and short distance trips) is that the decision to use various transport modes is influenced by the personal circumstances of trip makers, such as their demographic and socio-economic statuses, together with the distances they have to commute from their homes to activity point locations. Also, the mode-specific attributes of the three major motorised transport modes, which trip makers used in determining their level of service quality, were key determinants of modal choice by trip makers in GAMA. These attributes include availability, affordability, comfort, convenience, high rate of departure, among others.

Among short distance trip makers, the key modal choice factors varied across the three selected localities. For instance, distance was generally found to influence the modal choice for trips in Kasoa and Teshie, but not in Madina. In Kasoa, socio-economic factors such as age, education, household size and car ownership status of trip makers positively influenced their modal choices. In Madina, these socio-economic factors were age, education, occupation type and car ownership status. In Teshie, the car ownership status of trip makers was the major socio-economic variable that influenced their modal choices.

The next section takes a look at the ramifications of GAMA's observed modal use on energy and Greenhouse gas emissions.

5.3.3. Modal Use Implications on Energy Use and Greenhouse Gas Emissions in GAMA

The relative high use of motorised transport modes, particularly trotros and also taxis and cars for long distance trips can have major negative implications for energy use and GHG emissions. This is because, as illustrated in Table 5.23, average travel times, as reported by trip makers, are usually long considering the commuting distances involved.

Table 5.23: Reported trip duration per transport mode from selected localities to Accra

Central				
	Distance (in kilometres)	Mode	Average Travel Time (minutes)	Standard deviation
Kasoa (N=148)	28	Trotro	70	36.3167
		Taxi	81	61.5359
		Car	71	31.8259
Teshie (N=135)	17	Trotro	50	39.2653
		Taxi	81	41.5546
		Car	46	16.1218
Madina(N=102)	13	Trotro	61	22.662
		Taxi	68	31.8198
		Car	55	20.16

Source: Field data, 2014

Table 5.24 demonstrates results obtained in the observations of travel time in some sampled trotros from the three localities to Accra Central. Comparatively, average travel times were much higher in the case of trips originating from Kasoa to Accra Central and from Madina to Accra Central. While trip makers reported an average travel times of 70 and 61 minutes respectively for the Kasoa to Accra Central and Madina to Accra Central trips (in Table 5.23), the average travel times were observed to be 144 and approximately 71 minutes (in Table 5.24). In the case of the Teshie to Accra Central trips, the observations found an average travel time that was lower (in Table 5.24) than what was reported by the trip makers (in Table 5.23).

Table 5.24: Observed trip duration using trotro from selected localities to Accra**Central**

	Distance (in kilometres)	Av. Travel time (in minutes)	Av. Travel delay (in minutes)	Total
Kasoa	28	101.4	42.6	144
Teshie	17	35.2	5.4	40.6
Madina	13	58.6	12.2	70.8

Source: Field data, 2014

The relatively high use of the trotro, in particular, over such long journey duration, has negative implications for energy use and GHG emissions. This is because an earlier data (EPA-Ghana, 2007) have demonstrated that a majority of the trotro in GAMA are based on the use of Conventional and Euro I type cars (i.e. manufactured before 1992 and 1994). These Conventional and Euro I type vehicles are imported from the developed world generally as second-hand or fairly used vehicles. Thus, they may not have well-functioning fuel combustion and GHG emission control systems such as catalytic converters. This can result in an inefficient combustion process and the emissions of GHGs and other air pollutants as illustrated in Plate 5. The EPA-Ghana (2007) data reveals that fuel consumption and its associated GHG emissions from public transport in Accra was around 1914.77 Gigagrammes (Gg) and 6072.27 tonnes of carbon dioxide equivalent (tCO₂e) respectively. As illustrated in Table 5.25, the data further goes on to show that Carbon dioxide (CO₂) is the largest GHG, accounting for about 96% of all emissions during the five-year survey.

Table 5.25: Aggregate energy use and emissions in Accra

Year	Population	FC(Gg)*	CO ₂ Equivalent Emission			
			CO ₂	N ₂ O	CH ₄	Total GHGs
2000	170884	247.23	758.73	26.65	2.42	787.8
2001	185107	269.14	808.86	28.65	2.69	840.2
2002	211074	308.22	928.19	33.05	2.99	964.23
2003	222065	323.52	994.55	34.57	3.2	1032.32
2004	250784	364.76	1119.4	39.06	3.59	1162.07
2005	280711	401.9	1237.9	43.8	3.98	1285.65
Total	1320625	1914.77	5847.6	205.78	18.87	6072.27

*Note: Fuel consumption (Gg)/annual km travelled

Source: The Environmental Protection Agency, Ghana (EPA-Ghana, 2007)

Plate 5: Inefficient combustion of fossil fuel by a Teshie-Accra Central bound trotro

Source: Field data, 2014

On the other hand, as already illustrated in Figures 5.11 through to 5.13, short distance trips made to community activity points (as opposed to long distance trips made to Accra Central) resulted in a relative high use of non-motorised transport. Thus, even though cumulatively, motorised transport modes were still high (N=257) compared to non-motorised modes (N=143) for short distance trips in all three localities, short distance trips could result in some

substantial energy and GHG emission savings. The study found variations in the three selected localities with respect to how far trip makers were likely to use non-motorised transport modes, particularly walking to nearby activity point locations. However, a common pattern that was found in all three localities is the high likelihood of walking (57% in Kasoa; 75% in Madina and 66% in Teshie) for trips made within a 1000 metre radius. The implication of this finding is that it is reasonable to expect more people to walk to activity points found within a 1000 metre radius. Beyond this distance, walking generally becomes minimal and is, in turn, replaced with commuting by motorised transport modes. This also implies that energy and GHG emission savings are higher for trips made within a walkable distance of 1000 metres in the three surveyed localities. Given the fact that non-motorised transport is associated with zero CO₂ emissions, this could imply that short distance trips made within a 1000 metre radius by trip makers were found to have saved about 57%, 75% and 66% respectively of fuel use and GHG emission in Kasoa, Madina and Teshie.

Beyond this threshold, however, the relationship between distance and walking appears to be context-specific. For example, walking was still high for some residents living about 2000 metres away from community markets in both Teshie (57%) and Madina (50%). For Kasoa, this was remarkably low (12%). Apart from Teshie where about 40% of trip makers were found to walk to activity point locations found within a 3000-metre radius, the two remaining localities showed a sharp drop in the likelihood of walking among trip makers. A surprising finding in the Teshie sample is that about 44% of trip makers indicated they walked for about 5000 metres to the community market. This is surprising given that the majority of this percentage includes males, the well-educated and trip makers who had indicated that they owned or had access to a personal car. This finding can imply that distance alone may not be the only reason why trip makers choose to walk. There could be other reasons which this present study could not find answers to.

In view of the per capita energy use and GHG savings that are associated with the use of buses, particularly the fairly new and fuel-efficient ones, the study sought to investigate the perception of trip makers on a proposed bus rapid transit system in GAMA. On a five-point Likert scale where 1 = Strongly disagree and 5 = Strongly agree, trip makers were asked to rate their responses to the question ‘If new, fuel-efficient and comfortable express buses or train services are introduced in Accra for commuting between home and Accra Central, I prefer to use them even if I have my own car’. The responses were recoded into ‘No’ for trip makers who selected the options ‘Strongly disagree’ and ‘Disagree’ while the responses of those who indicated ‘Strongly agree’ and ‘Agree’ were recoded as ‘Yes’. However, trip makers who selected the option ‘No idea’ were recoded as ‘Indifferent’. The responses are cross-tabulated with the present means of transport used by trip makers to Accra Central and illustrated in Table 5.26. The study found that the majority of trip makers who rely on their own personal means of travel, whether as drivers or passengers of private cars, as well as those who presently commute by public transport, indicated their willingness to switch to mass transit under conditions of comfort, fuel efficiency and timeliness. It should be emphasised here this finding is only indicative of the probability of opting for an alternative means of transport that trip makers are yet to experience. Their perception of maximum utility in a futuristic transport mode is subject to change.

Table 5.26: Average perception of surveyed trip makers on their willingness to switch to mass transit

Response	Transport Modes		
	Non-Motorised (N=6)	Personal Means (N=136)	Public Transport (N=569)
No	33.4	18.3	20.3
Indifferent	33.3	-	10.2
Yes	33.3	81.7	69.5

Source: Field data, 2014

The study found that stakeholders, including government officials responsible for urban transport, social scientists and paratransit operators alike were in favour of the need to improve GAMA's public transport system through a mass transit system, as seen in the two comments below:

Accra has reached a stage where we need a light rail or tram system. But the energy situation is what probably may not at this stage permit us to do it. Perhaps, the introduction of the bus rapid transit system will go a long way to assist in this regard (Social Scientist 1).

They [trotro drivers] have been fulfilling the mobility needs of the people. However, [in view of a number of challenges associated with their operations], government's intention is that 80% of travel in Accra should be done by one means of mass transit or the other (Government Official 1).

However, these stakeholders, particularly the government officials and the current paratransit operators appear to have totally different and somewhat opposing perspectives on how to revamp GAMA's public transport system through the adoption of a bus rapid transit system for the city. While government officials expressed optimism about the success of the proposed mass transit, the existing trotro operators appear to be confused and sceptical of the main focus and intentions of the proposed mass transit system. This is reflected in the comments below:

With respect to addressing possible agitations from the current public transport operators, we have involved them at every stage of the project. Initially, they objected to the project. We encouraged operator unions plying the affected routes to form limited liability bus companies to run the day-to-day supply of bus services. This proposal eventually won their approval and removed all the opposition to the project (Government Official 1).

Somebody wants to make an undue profit out of our sweat. Let me state the truth.

There is somebody behind this plot to kick us out of business and it will never happen! I was privy to this information a long time ago due to the regular meetings we have with our leadership. If they dare implement this policy, you will see what will happen in this country (Member 3, GPRTU).

If a driver of a big bus can simultaneously take passengers who ordinarily should have been shared among three drivers, how will the remaining two drivers feed themselves and their families? They will be kicked out of their jobs (Member 4, GPRTU).

The first part of the description above helps answer the fourth research question on the modal use implications for energy use and GHG emissions in GAMA. Notable patterns that emerged were that long distance trips made entirely with motorised transport modes over longer time periods may negatively impact on high energy use and GHG emissions. It was revealed that short distance trips made to nearby locations of activity points were associated with a relatively high use of non-motorised transport, especially walking which translated into less energy use and GHG emissions. The second part of the description above helps answer the fifth research question concerning the perspective of key stakeholders on the adoption of a climate efficient transport system. The analysis showed that stakeholders, including government officials, the current public transport operators, social scientists as well as the travelling public surveyed, were found to have divergent views on a proposed mass transit for GAMA. The next section presents a general summary of key findings in the analysis chapter that will be the focus of the discussion chapter.

5.6. Chapter Summary

In a nutshell, this chapter presented findings made largely from empirical data and to a lesser extent from secondary data sources. The analysis was focused on key thematic sections, including the patterns of residential locations relative to locations of activity points in GAMA, in addition to transport patterns that emerge from the above. The nexus between spatial and transportation patterns on energy use and Greenhouse gas emissions was also touched on.

With regards to patterns of residential locations relative to locations of activity points in GAMA, it was revealed that residences of trip makers were widely spread and at distant locations to activity point locations in GAMA. A strong functional interaction was established between Accra Central, which hosts several attractive specialised and non-specialised activity points, and GAMA's peri-urban areas where most trips originate from. Commercial, governance and transportation/circulation land use types were found to be the most important activity points for long distance trip makers. The functional interaction between Accra Central and GAMA's peri-urban areas was thus exhibited in journeys made to work and shop as well as to access public services. The study further found that there were a number of important activity points, besides those found in Accra Central, which were regularly used by trip makers in the peri-urban areas of GAMA, together with those found in the immediate residence of trip makers.

The locations of residences vis-à-vis activity points for shopping, work and public services influence the use of transport modes in GAMA. While both long and short distance trips are largely characterised by a high use of motorised transport modes, in the case of the latter, a substantial use of non-motorised transport modes, particularly walking was found. Commuting distance between activity point locations and the homes of trip makers was a key determinant in the use of different types of transport modes.

As the commuting distances increase, there is a high tendency for trip makers to use motorised transport modes, as opposed to non-motorised transport modes, even for short distance trips. Besides commuting distance, the use of transport modes for both long and short distance trips was found to vary based on the demographic and socio-economic status of trip makers. Modal choice decision making was also found to be related to a number of spatio-socio-economic and demographic factors, together with perceptions of trip makers on the service quality provided by various transport modes. Long distance trips were generally associated with long travel time, high energy use and GHG emissions. By siting activity points in relative proximity to trip makers, short distance trips were generally characterised by walking, which may contribute to energy and GHG emission savings. Indications were generally found with respect to a high preference for mass transit in GAMA, despite some challenges.

The next chapter thoroughly discusses the implications of the above findings on climate mitigation for the Greater Accra Metropolitan Area.

CHAPTER SIX: DISCUSSION OF RESULTS

6.1. Introduction

In this chapter, the implications of the various research findings are discussed. The chapter delves into issues such as the geographical patterns of residences and activity point locations; the ramifications of GAMA's present spatial patterns of physical mobility of urban dwellers and the key determinants of modal use by trip makers. Also, the energy use and GHG emission implications of the present spatial and transportation patterns are explored. Finally, the discussion wraps up with a look at factors for the promotion of mass transit in GAMA.

6.2. Patterns of Residential Locations vis-à-vis Activity Points in GAMA

A lot of attention has been focused on the land use patterns in GAMA in earlier studies (Owusu, 2013, 2008; Grant & Yankson, 2003; Songsore, 2003; Grant & Nijman, 2002; Odame, 1996; Drakakis-Smith 1987). It has already been established that GAMA's land use pattern has been characterised, on the one hand, by the concentration of activity points at the city centre and on the other hand, by high population growth and a sprawl-like development. The functional linkages between the city centre and its sprawling peri-urban areas are also well attested to in the literature. Finally, GAMA's colonial experience and the interplay of several local, regional and international forces have been held largely accountable for its present land use patterns. The present study found it necessary to re-examine the current urban form as well as identifying the present status of functional interlinkages in GAMA. This is justified in the sense that the processes of urban growth are dynamic and consistently produce new urban forms and thus enable some functional interlinkages while constraining others. Hence, the relevance of the first research question driving this study. In finding answers to the first research question, empirical data obtained through questionnaire surveys and interviews were analysed through statistical, geo-spatial and thematic analytical tools to demonstrate GAMA's present locations of residences vis-à-vis activity point locations.

The ensuing discussions of empirical findings on GAMA's present spatial patterns are carried out against the backdrop of existing literature as well as the Systems conceptual framework.

A major finding made in the study is that trip makers travel from all over Ghana in order to access activity points found in Accra Central. The concentration of major activity points, including government administrative functions, commercial and service centres in the southern parts of Ghana, generally, and specifically in the Accra Central area, has served to make Accra an important destination for trip makers from all over the country. This finding confirms earlier studies (Fuseini & Kemp, 2015; Adarkwa, 2012; Songsore, 2003; Dickson, 1968) that have found an uneven distribution of development activities in Ghana that has favoured the southern parts of the country, notably Accra.

The study further found that a large number of trip makers who access activity points in Accra Central resided in the peri-urban GAMA localities, notably Kasoa, Teshie and Madina. This finding is consistent with existing literature (Owusu, 2013; GoG, 2010b; Yeboah, 2009), that has identified these three peri-urban localities as the hotbed for much of GAMA's rapid population growth and uncontrolled sprawl-like development in recent decades. Specifically, Yeboah (2003) has found that the growth of GAMA has occurred principally in the peri-urban areas, notably Tema to the east, Ga Rural to the north and west (where Madina is located), and Awutu-Effutu-Senya (where Kasoa is found) to the east of Accra Metropolis.

The Systems conceptual framework and existing literature on GAMA's growth and expansion may offer a useful explanation on the empirical findings made with respect to why the majority of trip makers are found to reside in Kasoa, Teshie and Madina. As illustrated in the Systems conceptual framework, the adoption of new macroeconomic reforms which liberalised the Ghanaian economy through trade, globalization, removal of foreign exchange restrictions and the ease with which building materials and foreign remittances could be transferred resulted, among other things, in investments in housing estates, such as the

GREDA Estates in Teshie. This is seen in the comments below of a social scientist on the effects of macroeconomic reforms on GAMA's growth:

The building industry boomed due to investments made by Ghanaians living abroad as well as by resident Ghanaians who found investments in fixed assets a more secure form of investment against inflationary tendencies. In addition, real estate companies such as GREDA emerged due to the encouragement offered by the prevailing housing policy. Thus, in addition to the few government-controlled residential development agencies, private enterprises also entered the building market to build for the middle class and expatriates who could afford (Social Scientist 2).

This is consistent with earlier studies (Doan & Oduro, 2012; Yankson et al., 2005; Asiedu & Arku, 2009) which found evidence of a rise in the construction of gated housing estates all over GAMA during the adjustment periods. Also, the encouragement given to Ghanaians in the diaspora to invest in their country and their desire to be unique may account for the naming of suburbs of newly developing towns after places that the original developers might have lived in prior to their relocation to Ghana. In Madina, for instance, local names of some parts of the town including 'UN', 'Libya Quarters' and 'Washington' may be an indication of the effects of globalisation and international migration on GAMA's growth as has been found in earlier studies (Yeboah, 2003, 2000). Also, Kasoa, for instance, in 1970 had only 863 inhabitants. A year after the implementation of the structural adjustment policies, the number of people living in the village had increased to 2,597, representing a 33% increase. In 2000, the settlement had a total population of 34,719 inhabitants, representing an increase of about 7.5% (Ghana Statistical Service, 2005b).

Appendix 29 provides a further illustration of key population and housing statistics to demonstrate rapid population growth and expansion of the built-up areas of Kasoa, Teshie and Madina through the 1970, 1984 and 2000 censal years.

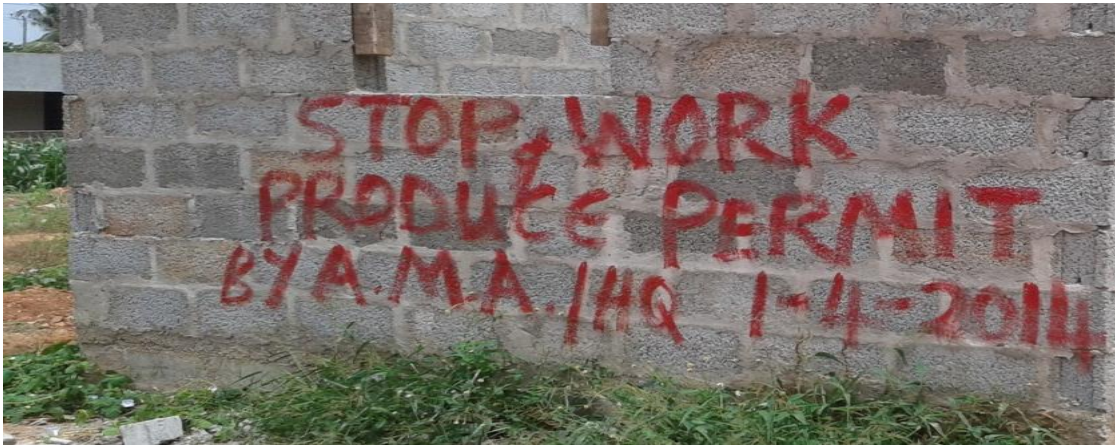
A further explanation for the peri-urban development is found in the population increase and its accompanying pressure on land resources in the Accra Metropolis. Macroeconomic reforms led to high international and foreign-based Ghanaian capital and human inflows, rural-urban migration (due to a boom in the service sector and informal trading activities). Together with natural increase, the teeming population found housing in Accra Metropolis increasingly difficult, thus forcing most of them to seek residence in the peri-urban 'dormitory towns' such as Kasoa, Teshie and Madina from where they could commute to the Metropolis.

Another factor that might explain the continual population increase in GAMA's peri-urban areas is the construction and rehabilitation of major road corridors that link the Accra Metropolis to the peri-urban areas. Specifically, Kasoa and Madina are linked to Accra Central through the CBD-Mallam-Kasoa and the CBD-Madina-Aburi dual carriageways. As noted in the Systems conceptual framework and confirmed in earlier studies (Owusu, 2013; Doan & Oduro, 2012), these fast-connecting road corridors encourage city outgrowth, particularly for car-owning residents as well as for those in need of cheap rented accommodation in the peri-urban areas.

Finally, the lack of proper planning and strict implementation, monitoring and evaluation of land use regulations continue to drive population growth and urban sprawl in GAMA's peri-urban localities. Very often, the government working through the Town and Country Planning Department prepare land use schemes which are supposed to be enforced by the building inspection divisions in the various local assemblies. Meanwhile, a greater part of the lands in GAMA do not belong to the government but to chiefs and local clan heads who release the lands to private estate developers. The government again misses the opportunity to control the development of land through a land title registration process which is frustratingly cumbersome leading many developers to quickly build without recourse to laid-down regulations.

City authorities fail to respond in time and in most instances act to stop such development when they are almost at the completion stages (see Plate 6). Hence, GAMA's peri-urban localities are generally characterised by spontaneous and unplanned development, which are some of the major descriptions of urban sprawl.

Plate 6: A typical case of development preceding spatial planning in GAMA



Source: Field data, 2014

This present study found evidence of strong functional linkages in GAMA's urban space. Earlier studies, including Yeboah (2003) and Abane (1993) have argued that the functional linkage between the city core and its peri-urban localities was exhibited in journey to work and shop patterns. Expanding on the earlier studies, this present study found that the functional interaction between the city core and GAMA's peri-urban areas is not limited to work and shopping patterns alone, but it also includes journeys made to access public services performed by the government through its ministries, agencies and departments. The functional linkages between the city centre and its peri-urban localities, particularly with respect to accessing government services in the Ministries Area, may be explained by two possible reasons.

First, government services rendered to the public through the ministries, agencies and departments of state are generally specialised, high-order services which are only accessible at the Ministries Area of Accra Central. Second, the local governance system in Ghana has not been empowered enough to perform their core mandate of bringing government services

closer to the citizenry as enshrined in the Local Government Law of 1988. The law allows for the establishment of several directorates including physical planning, health, transport, agriculture, works, waste management, trade, industry and tourism, just to name a few at the local metropolitan, municipal and district assemblies to provide similar services performed by the central government through the ministries, agencies and departments. However, the local assemblies are generally under-resourced and still rely on the central government for financial and logistical support. In view of occasional delays by the central government in releasing resources under the District Assemblies Common Fund to these local district assemblies, the latter are generally unable to render quality services to the citizenry in their jurisdiction. The implication is that except perhaps when there is the need to pay one's property and income tax rates at the local offices of the assemblies, one may still find it imperative to access government services at the Ministries Area of Accra Central. This point is also valid for some specialised, high-order commercial products found in the major commercial activity points, notably the Makola Market. It is reasonable to expect that the possibility of obtaining specialised high-order goods in bulk and at relatively cheaper wholesale price for such commodities as textiles, which are generally imported from outside of Ghana, as well as for some food produce which are later sold in smaller quantities at local markets for profit was a major incentive for visiting Accra Central among surveyed respondents.

While in Accra Central, trip makers, whether primarily visiting to work or to perform non-work activities have the possibility of accessing other important activity points which are found in relative proximity. The notable ones, as was found in the study, were pharmaceutical outlets, microfinance agencies, banks and banking facilities such as automatic teller machines as well as bookshops and head offices of major telecommunications companies. But for the head offices of the telecommunications companies, one may consider all the other major activity points which are equally attractive to trip makers as not being so specialised and

uniquely located in Accra Central. It was, therefore, surprising that trip makers still chose to visit these activity points from various GAMA locations. It is even intriguing to note that the main reasons provided by the group of trip makers who regularly use the above important activity points were no different from reasons provided by their colleague trip makers who found other activity points rather more important than the ones mentioned above. The possible explanation one can offer is that the pharmaceutical outlets, the banks and automatic teller machines, the microfinance agencies, the bookshops and the telecommunications' head offices may not be the primary activity points that motivate trips to Accra Central by GAMA trip makers. This finding also supports the earlier one that the Makola Market and the Ministries Area are the main attractive activity points for trip makers. However, upon accessing these two important activity points, the majority of trip makers may decide to use the other notable activity points as well. It also underscores the assertion that the concentration of several activity points within the same geographical area called Accra Central offers a 'one-stop-shop' experience, thus making the visits attractive, and in most instances, inevitable.

Another major finding that was made in this present study is that GAMA's functional interactions are not necessarily uni-directional. To put it differently, this study contests the conventional theory (Yeboah, 2003; Abane, 1993) that appear to suggest that all traffic that originates in the peri-urban areas finds a destination at the city core. GAMA's present functional linkages have been characterised by the presence of intervening activity points, particularly with respect to commercial activity points. The Kaneshie Market, for instance, is found directly along the highway that connects Kasoa to Accra Central. Thus, it serves as a major direct intervening activity point in the functional interaction between the city core and its peri-urban neighbourhood. Surveyed residents of Madina and Teshie also indicated their frequent visits to the Kaneshie Market. The Kaneshie Market, in particular, was designed purposefully for the very reason of taking some of the congestion and pressure off Accra

Central, a point that has been noted by Grant and Yankson (2003). Between the Madina town and Accra Central, one identifies the location of the Airport City which is a newly developed business district that is characterised by formalised, high class and high-density commercial cum- office activities. However, its role as a major intervening activity point was not found in this present study. Perhaps, the perceived high-class status which may mean that goods are priced relatively higher than in other commercial centres, as well as congestion and parking space constraints at the Airport City, may be some of the reasons why the majority of surveyed GAMA residents still find Accra Central a preferred destination. It may also be due to the reason that trip makers are more familiar with the informal commercial activity points in the latter and that goods are generally perceived as competitively priced.

Another major revealing finding made in the study was the phenomenon of peri-urban to peri-urban functional interaction in GAMA. Existing knowledge on GAMA functional linkages (example, Yeboah, 2003; Abane, 1993) largely paint a picture of peri-urban to urban pattern. However, as was found in this study, the Madina Market, located in a peri-urban area was accessible to peri-urban dwellers in Kasoa and Teshie. Thus, from the foregoing, one could describe the present functional interlinkages in GAMA as complex and multi-directional.

In the next section, the researcher discusses how the multi-directional and complex functional interlinkages and indeed GAMA's present urban form influence modal use among trip makers.

6.3. The Influence of the Geographical Distribution of Residences vis-à-vis Activity

Points on Transport Modal Use in GAMA

Drawing on previous studies (van Acker & Witlox 2005; Wegener & Furst, 1999), it has been shown that the geographical pattern of land use is a major determinant of modal use among urban trip makers. There has always been the need for urban trip makers to connect to various activity points that provide them with their livelihoods, shopping, social and recreational

opportunities, among others. Earlier in the literature review as well as in the Systems conceptual framework, it was found that the need for urban trip makers to connect has created a strong functional relationship between locations of activity points and residences of trip makers (Yeboah, 2003; Abane, 1993). It is in line with the above that the second research question was formulated to drive the study. In answering the second research question, the present study examined, from a theoretical perspective, various spatial factors found by earlier researchers to influence the interactions between activity point locations and transportation behaviour, particularly modal use. From an empirical perspective, the present study conducted statistical and geospatial (Proximity/Buffering) analyses to test the hypotheses that the locations of land use activity points, whether far or near to residential locations of urban trip makers influence their modal use.

Long distance trips in GAMA were found to be directly associated with an almost exclusive use of motorised transport modes. The most common motorised transport modes are trotro paratransit services which were the most dominant public transport mode patronised by the majority of trip makers who make long distance trips, notably from peri-urban localities to Accra Central. This finding is in consonance with earlier studies that revealed that trotros are by far the most dominant form of public transport in Ghana (Amoh-Gyimah & Aidoo, 2013; Abane, 2011; 1993; Adarkwa, 1991; Lartey, 1977). The study found that females, the youth, the less educated class of trip makers (which also means income levels are low) together with trip makers resident at distant locations from activity points were the main identifiable groups that mostly relied on trotros. Taxis were another form of public transport that was found to be common among older female trip makers, especially those in the wholesale trade and those with second cycle education, had smaller household sizes and lived relatively closer to nearby activity points. Long distance trips in GAMA are also made with cars. Mostly males and some large-scale female traders, senior level government employees and users of public services, trip makers with relatively larger

household sizes as well as those further away from activity points were the main group of car users in GAMA. The high use of motorised transport modes, as opposed to non-motorised modes, as was found in this study is quite understandable and in sync with earlier studies that have consistently found a strong relationship between long distance trips and the use of public transport and private cars (Cobbinah & Amoako, 2014; Cervero, 2013; van Acker et al., 2007; Boapeah, 2005; Schwanen, 2002; Gordon et al., 1989).

In contrast to long distance trips, the study found a relatively high use of non-motorised transport modes, especially walking for short distance trips. Non-motorised transport modes were found to be high in dense mixed neighbourhoods where residences of trip makers were located relatively near activity points. This finding may be explained by the relatively short commuting distances for trip makers. This is consistent with findings of earlier studies conducted in American and Western European cities (Naess, 2012, van Wee, 2002; Meurs & Haijer, 2001; Cervero & Kockelman, 1997) as well as in some cities in developing countries, including Santiago, Taipei and Hong Kong (Cervero, 2013; Zegras, 2012; Lin & Yang, 2009; Zhang, 2004). Similar to Cervero and Golub (2007), walking was basically a female-dominated activity. It was also found in the sampled population that the aged walked, similar to an earlier finding (van Acker et al., 2007) that show that most old people in Europe walk to their activity point locations.

In short, the geographical distribution of activity points for shopping, work and accessing government services relative to residential locations of trip makers, largely determines the type of modes, whether motorised or non-motorised, that trip makers use. However, other possible factors, besides distance, may account for modal use differences among trip makers. The next section takes a closer look at these factors.

6.4. Modal Choice Determining Factors of GAMA Trip Makers

Following after van Acker et al., (2007), in order to fully account for modal use among trip makers, it was necessary to consider also their personal circumstances. This justified the third research question underpinning the study. As already explained in the Systems conceptual framework, trip makers had the desire to reach destinations where activity points are located. However, they were largely constrained by what van Wee et al., (1997) call 'travel resistances' which may include their socio-economic and demographic circumstances as well as personal trip motivating factors. Specifically, age, gender, education, occupation type, and car ownership status of trip makers have been found in the reviewed literature to influence modal use. But, it is almost impossible to make universal conclusions on the role of socio-economic and demographic factors on modal use due to the fact that societies differ from one another. Again, trip makers' personal circumstances and preferences are constantly changing. Hence, there is that need to constantly update our knowledge on how these socio-economic and demographic variables influence modal use. The literature has demonstrated that the decisions of trip makers to travel by different transport modes are also very much a function of how they perceive the utility factor of individual transport modes. This is based on the perception that particular modes offer maximum utility in terms of service quality compared to other modes. To illustrate this point, most women in the developed countries, perhaps by reason of improved economic circumstances are generally known to drive cars (Boarnet & Sarmiento, 1996). Their counterparts in Ghana have been found to rely on public transport, particularly those who are engaged in distribution and marketing activities (Abane, 2011).

However, the dynamics might have changed such that in recent times, not all women distributors and marketers rely on public transport. By reason of their improved economic circumstances and their desire to gain maximum utility from transport, some women distributors and marketers may be using cars instead of public transport. Therefore, the conventional knowledge on gender and modal use and indeed all the other socioeconomic

factors are re-examined in the context of this present study with the aim of fully understanding modal use by trip makers in GAMA. In doing this, the present study thoroughly reviewed arguments espoused by various authors on the influencing roles of socioeconomic and demographic factors as well as individual perceptions of utility on modal use by trip makers. These views have been empirically tested through statistical and geospatial analyses to come up with a recent contribution to the debate on what factors actually influence modal use of trip makers. The findings made in this present study partly support and partly contends with earlier studies that have examined how spatial, socioeconomic, demographic and personal motivation of trip makers influenced travel behaviour.

6.4.1. The Role of Spatial Factors on Modal Use

Commuting distance from the residential locations of trip makers to locations of activity points has been found to be a major explanatory factor for modal use in GAMA. Motorised transport modes were high for long distance trips, especially by trotros and cars. The use of trotros at distant locations by trip makers may be as a result of low income earners being forced out of urban areas where their livelihoods are located due to high rent and into the peri-urban areas where rent values are relatively cheaper. The relatively cheaper fares charged by trotros, compared to taxi fares, may help explain why the former are used at increasingly longer distances away from the city centre. Besides, formal transit (bus) services which are comparatively cheaper than trotros are limited and where they are found, they only make route-specific journeys. The high use of cars for long distance trips could be explained by the large number of middle and high-income trip makers who find it convenient to live in the emerging gated communities dotted across the peri-urban areas with all its health and aesthetic benefits, but also the possibility of commuting back to the city centre to work, shop or access government services on improved transportation networks, as have been found in

earlier studies (Doan & Oduro, 2012; Bryceson, 2006; Grant & Yankson, 2003). Taxis were used mostly for shorter distances. This is understandable given that at longer distances, trip makers will be required to pay comparatively higher fares.

Short distance trips had a high representation of non-motorised transport modes, particularly walking. Walking was high especially for suburbs which are found closer to the community markets such as Zongo and Adakope (in Kasoa); Zongo (in Madina) and Maami (in Teshie). In reverse, walking becomes less and lesser among trip makers who live at an increasing distance away from the various community markets. This also makes sense in that commuting distances are relatively shorter between homes and activity points. The role of distance in influencing modal use is consistent with earlier studies (Cobbinah & Amoako, 2014; Cervero, 2013; van Acker et al., 2007; Boapeah, 2005; Schwanen 2002; Gordon et al., 1989). The above notwithstanding, the Multinomial Logistic Regression of the long-distance trip data did not show that distance statistically influence modal use. This could be due to a possible correction for multicollinearity in that distance could have been related to other socio-economic and demographic variables in influencing modal use. In other words, distance on its own was not found to influence modal use among long distance trip makers. A further statistical analysis of the data on short distance trips also could not establish any statistically significant relationship between distance and modal use for one out of the three localities. A similar reason may explain why distance was not found to be statistically significant.

6.4.2. The Role of Socio-Economic and Demographic Factors on Modal Use

With respect to the personal circumstances of trip makers in explaining modal use, the Multinomial Logistic Regression modelling of the data on long distance trips found a positive correlation between modal use and a trip maker's age, education and car ownership status (see Table 5.20).

This finding supports earlier studies that found that age (van Acker et al., 2007; Schwanen, Dieleman & Dijst, 2004; Dargay & Hanly, 2004; Rajamani et al., 2003; Stead, 2001; Boarnet & Sarmiento, 1996) and levels of education which invariably determines a person's occupation type, income and car ownership status greatly influenced modal use (Amoh-Gyimah & Aidoo, 2013; Abane, 2011, 1993). The implication of this finding is that with increasing age, trip makers find it difficult to cope with the inefficiencies of GAMA's present paratransit services, including waiting in long queues at bus stops and lorry parks while exposed to the vagaries of the weather, and the constant struggle with other commuters for a seat on a public transport. Also, the attainment of high education generally results in better job opportunities and better working conditions which include the possibility of owning a personal car or having access to official cars. As demonstrated in the Systems conceptual Framework, trip makers who own cars are more likely to use them for trips in GAMA due to the cultural attachment to cars as status symbols bearing in mind that the prevailing informal public transport system in GAMA is generally perceived as inefficient and woefully inadequate.

An earlier study (Abane, 1993) had argued that the disproportionate disparities in formal education between males and females, with the latter preferring instead to opt for trading activities which offered quick turnovers, has resulted in their inability to rise to highly paid job opportunities. This therefore reduces their chances of commuting by car. However, the data on long distance trips partly contradicts this view in the sense that large-scale traders (who are mostly females) may not necessarily be among the most highly educated, but were found to commute to Accra Central mostly by car. Perhaps, the scale of their economic activities, rather than their educational status, provided them with enough resources to own their personal cars. It is also understandable that taxi users were largely made up of older female trip makers with relatively high levels of education and who were also engaged in wholesale trading.

This is because, while taxis fares may be relatively higher than those of trotros, the turnover from large-scale wholesale trading activities and the possibility of hiring taxis to transport bulky products make taxi use worthwhile.

In all three localities, non-motorised transport modes, especially walking was common among female trip makers. The high association of females with walking to activity points in these localities may not be explained by health and fitness concerns as well as environmental consciousness on the part of trip makers. Relatively high illiteracy rates of Ghanaian females, compared to males and female poverty may partly explain the high prevalence of walking among females. This is because in all three localities, walking corresponded with trip makers who are resident in the low-income neighbourhoods. Walking was relatively less among trip makers who live in the middle and high-income neighbourhoods.

An unusual finding made in this present study is the low cycling rates (only 2.1% of all short distance trip makers) particularly in neighbourhoods with high representation of Ghanaians of Northern descent. This is because while cycling is generally unpopular in the southern parts of Ghana, it is a very popular non-motorised transport mode in Northern Ghana. Thus, it was surprising to find that in the two Zongo neighbourhoods both in Kasoa and Madina, cycling use was minimal. This surprising finding contradicts an earlier study (Grieco, Turner & Kwakye, 1994) that sampled GAMA residents in Nima, the majority of whom had migrated southwards from Northern Ghana, which concluded that cycling was not only high but was also seen as a culturally acceptable means of transport patronised by men, women and children of all ages. The low use of bicycles to activity points in GAMA may be accounted for by the fact that in Northern Ghana, motorised transport modes are relatively few than in Southern Ghana. Thus, fatalities and injuries arising from collisions between cycle riders and fast moving cars are much lower. However, in the highly urbanised southern parts of Ghana, the high use of motorised transport modes makes cycling very risky.

This comes against the backdrop of a woefully inadequate infrastructure and appropriate legislation for non-motorised transport mode operations in GAMA. It must be pointed out that dedicated cycle lanes are now being added to newly constructed roads, for instance along the Madina-Tetteh Quarshie corridor. However, these are fairly new introductions which are not even properly integrated into the overall mobility master plan of the city. During peak hour trips, some recalcitrant motorists can be seen driving on the shoulders of the road which are primarily reserved for non-motorised transport use.

6.4.3. The Perception of Utility of Transport Modes on Modal Use

With respect to effects of mode-specific characteristics on modal use, trip makers were found to consider a number of factors in their use of various modes. Among trotro users who embark on long distance trips in GAMA, issues of availability and affordability were identified as the key determinants of modal use. This is expected in view of the fact that trotros are generally found in most places. They also provide the widest para-transit services even to the remotest routes that are not easily accessible by the formal transit system. Comments of a social scientist explain how trip makers' perception of trotros being available (even on routes abandoned by formal bus operations) as well as being relatively affordable has served to popularise this paratransit service in GAMA:

The trotro in the local Ga dialect means 'Three Pence'. This was the initial fares charged by the privately owned Bedford mummy trucks. So typically in those days, they were operating between smaller nodes. The trotro system has been in existence since before independence (Social Scientist 2).

This finding confirms earlier studies (Abane, 2011, 1993; Adarkwa, 1991) which had found that most trip makers were motivated to travel by trotros due to their availability and affordability. The high availability of trotros in GAMA could be accounted for by the sheer lack of viable competition, particularly from the formal transit (bus) system in GAMA.

It should be noted that prior to Ghana's independence, Accra was served by a formal transit (bus) system, as seen in the comments of a social scientist who was interviewed:

During the early 1950s, there was an adequate urban transport system known as the Accra Municipal Transport system. The bus system was there, the drivers were disciplined, they wore khaki uniforms, we had ticket inspectors who wore their helmets and virtually everybody knew the buses by numbers. So you knew that Bus 8 is an Achimotan bus, Bus 9 is a Korle Bu bus etc. These buses moved at a regular interval (Social Scientist 2).

As was noted in the Systems conceptual framework, as well as in the section that described how GAMA's present transport system had evolved (in chapter four), the high availability of trotros may be accounted for by the decline in formalised bus services in GAMA. In terms of affordability, most respondents perceive the fares charged by trotros as affordable. The lack of proper regulation of the trotro system, in some instances, have led to unapproved fares being arbitrarily charged by trotro operators during peak hours, after heavy rains when most passengers are stranded, and immediately following the announcement of fuel price hikes by the National Petroleum Authority (Agyemang, 2015).

In the analysis of modal choice through Multinomial Logistic Regression model, the study found a strong statistical relationship between demand for trotro paratransit services and trip makers' perception of utility measured in terms of the convenience of alighting at a choice location. Also, compared with car use, the data surprisingly showed that trip makers perceived trotros as having higher departure rates. A possible explanation could be due to the fact that while the survey instrument made it possible for respondents to compare their favourite mode with any other mode they chose as their reference category, the final analyses of the data was performed using only the most commonly used modes (i.e. trotro, taxi and car). Thus, while for instance, a respondent might have used say bus as his/her reference category when commenting on his/her preference for a trotro, the analyses considered car

instead as the reference category. Trip makers did not perceive trotros to be the safest or the most comfortable means of transport. In view of the poor road safety record of commercial vehicle drivers that has resulted in road traffic fatalities in Ghana, one could have imagined that safety, in particular, would have been a key modal use determinant among trip makers.

During the multi-participant interview, drivers were given the opportunity to respond to the perceived poor safety and lack of comfort in their services to trip makers. In the comments below, the drivers appear to lay the responsibility for safety and comfort on their passengers, arguing that ...

They [passengers] will not feel comfortable simply because this is a public transport. It is similar to several people sharing the same bowl or plate at a 'chop-bar' [public eating place/restaurant]. Excuse me to say that if a fat person occupies more than one seat reserved for four passengers in a row, the others will complain that the ride was not comfortable but we cannot take the blame. If you ask that individual to push and make room for the others too, he/she will also complain that the ride has not been comfortable (Member 2, GPRTU).

Some of the passengers might have offended someone. Due to the perceived retribution awaiting them for their offence, when they board our cars they are naturally afraid they are going to die through accidents. At the slightest mistake on the part of the driver, these passengers become extremely terrified, as if they are about to die in the next minute! [All discussants burst into laughter]. However, I know of a particular neighbourhood whose residents are elated when we drive at top speed. If you are known to be a slow driver, they will not board your car. They have a clear mind-set that accidents will not kill them (Member 4, GPRTU).

Each driver has his own personal habits which influence how safely or otherwise he drives. There are some drivers who get infuriated when a passenger shouts at him or insults him. In that case, due to the anger, the driver might drive recklessly. As for me, I do not allow negative comments to influence my driving style. My priority is to drive you safely to your destination (Member 5, GPRTU).

The comments above (particularly from Member 4, GPRTU) illustrate the belief generally held by some drivers in divine punishment as a major determinant of safety or the lack of it, similar to an earlier finding in Ivory Coast (Kouabenean, 1998).

This has the tendency for people to be resigned to fate and to be less careful on the road (Lund & Rundmo, 2009; Sjøberg, Kolarova, Rucal, Bernstrøm & Flygelholm, 1996). However, comments from a senior GPRTU official reveal the acknowledgement of the challenge of lack of safety and comfort on-board their vehicles as well as measures being implemented to address them.

I admit that the majority of the vehicles we use to run our transport business are indeed old. Therefore, what I normally do is to organise regular meetings with the other executives and station masters to conscientise their drivers on the need to do regular maintenance. Occasionally, we partly finance our drivers to do vehicle maintenance and offer them flexible terms for repayment of the loan. Again, we have instituted strict punitive measures including suspensions for a period and/or payment of fines to keep our drivers in check. Whenever we receive complaints from passengers on misbehaviour or carelessness of a driver or his mate, we ensure that appropriate sanctions are applied (Senior Official, GPRTU).

In the light of the above, some trip makers prefer to rely on the services of shared taxis which they perceive to be relatively comfortable even though they may be required to pay several times the amount being charged for commuting in a trotro. The desire for comfort while travelling may explain why taxis were used principally by relatively older female trip makers with some form of high education and who are engaged in wholesale activities. This is understandable in that female trip makers may find the scrambling for available seats on trotros, particularly during peak hour trips, too strenuous to participate in. Trotros may also overload, particularly during peak hour trips. This may also be seen by some female trip makers as making them uncomfortable, hence, their decision to travel by a more comfortable option.

The possibility of enjoying door-to-door services was also ranked high among taxi users and this is very much expected, especially for traders who may be carrying heavy items for sale or for storage. For car users who are mostly government employees and users of public services, the need to get to one's workplace or attend to an appointment on time was paramount. Thus, having a car at one's disposal allows the flexibility of moving out as at when one wills. The added advantage for car users was its low loading factor which permitted frequent departures, compared to public transport modes.

In short, distance, as well as some personal circumstances of trip makers, together with perceptions of service quality of the various modes to a large extent, account for modal use. In the next section, the study considers the implications of GAMA's present spatial and transportation patterns on energy use and emissions of Greenhouse gases.

6.5. The Nexus between Land Use and Transportation Patterns and Energy Use and Greenhouse Gas Emissions in GAMA

Following after Sperling et al. (2009) who argue that the achievement of substantial climate mitigation in urban transport is possible through the densification and integration of land use and transport systems, the fourth research question was aimed at finding answers to the energy and emissions implications of GAMA's present spatial and transportation patterns. In doing this, the study relied on empirical field data obtained through surveys, interviews as well as observations. Secondary data on vehicular energy use and emission in Ghana is also used.

A major implication of GAMA's present land use and transportation patterns on energy use and emissions relates to long journey durations, particularly for long distance trips made to Accra Central from various residential locations in GAMA. This is to be expected given the long commuting distances between residential locations, most of which are found in the peri-urban areas and Accra Central, due to urban sprawl, in consonance with earlier studies (Boapeah, 2005; Abane, 1993).

In addition, high traffic densities as a result of more people and cars moving simultaneously to work, shop or access government services in Accra Central result in traffic congestion during the peak hours. See Appendix 29 on population densities found in the three localities, for instance. Thus, trips which ordinarily should have taken less time end up taking much longer time due to congestion.

Evidence gathered from the multi-participant interviews, and also confirmed through observations, shows that there are quite a number of important hot spots where delays and long queues are most commonly observed during morning rush hour trips. Along the Kasoa-Accra corridor, the major ones occur around Tuba Junction, the Toll booth plaza, Bortianor and the West Gate Shopping Mall. The rest are the Sakaman Traffic Light, Kaneshie First light, Kaneshie Roundabout and along the Graphic Road. On the Teshie-Accra Central corridor, major congested spots include the Lascala Market area, the Bush Road junction, the Regimanuel Area, La and at the Polyclinic Junction. On the Madina-Accra Central corridor, severe congestion builds up along the Madina to Legon stretch, the Legon to 37 stretch as well as the Airport 1st Traffic light through Opeibea to 37. The congestion hot spots identified on the Madina-Accra Central corridor, in particular, is in tandem with an earlier study (Agyemang, 2013) which made similar findings.

A careful observation of congested hotspots on all three major corridors linking Accra Central to the peri-urban localities indicates serious physical bottlenecks in the road environment. They include poor traffic management particularly at traffic light locations due to the programming of the signage systems to give access to all vehicles coming from particular directions for a time period without cognisance of the intensity and volume of traffic. This often results in long queues for lanes with heavy traffic flow. At times, the traffic signage system breaks down due to power outages. Occasionally the traffic police step in to direct traffic. This intervention by the police could hasten and slow down traffic flow even further depending on the officers in charge of directing the traffic.

Along the major corridors linking the peri-urban areas to Accra Central, a number of activity points which attract traffic, including shopping malls are also found. The siting of toll booths, particularly on the Kasoa-Accra Central corridor all creates conditions for traffic congestion. One could also make a case that the inadequate road infrastructure capacity to meet peak hour demand explains the regular occurrence of congestion at the above noted hot spots.

In a multi-participant interview, an interesting revelation that emerged was that the expansion of road infrastructure by building new ones or upgrading existing ones rather resulted in generated traffic. In other words, new roads that were meant to ease congestion rather encouraged more driving and more congestion in the end. This is illustrated in the comments below of two interviewees who ply the Madina-Accra Central corridor:

Occasionally when the traffic situation is bad, we re-route through East Legon, go through the bridge under the Tema Motorway and connect to the Spintex road. Then we may go through the *newly constructed road* [emphasis mine] connecting the Polo Grounds to the Airport. Otherwise, when we get to the Accra Shopping Mall Area, we then use the Tetteh Quarshie Interchange to join the main Madina-Accra Central corridor once more (Member 5, GPRTU).

However, there are no local access routes we can use beyond this point [Tetteh Quarshie Interchange], so we just have to drive at low gears until we pass these areas. Congestion on the Madina-Accra road, to me, is as a result of the traffic lights, especially the one at the Shiashie area. This is the point where many cars, especially those coming from Adjiringanor and American House try to join other cars on the main corridor. This situation slows vehicular movement (Member 6, GPRTU).

Two further observations are made based on the comments above (i.e. Member 6). First, the lack of alternative secondary access roads and second, the presence of just too many low occupancy vehicles (i.e. trotros, taxis and cars) often resulting in an inefficient use of the road space, causing or exacerbating the problem of congestion on the main corridors.

When vehicles are stuck in traffic, they tend to use more energy, burn fuel inefficiently and emit far more pollutants into the air, as was found in earlier studies (Armah et al., 2010; Nerquaye-Tetteh, 2009; GoG, 2008). The study found that long-distance trips usually last longer, due to traffic congestion. Also, the secondary data on energy use and GHG emissions in GAMA revealed that the majority of vehicles that are usually used for such long distance trips are based on an old vehicle technology that may not be fuel and GHG-efficient. The implications of these findings are critical for rising energy use and GHG emissions in GAMA, for four reasons. First, the longer the trip duration, the higher will be the amount of CO₂ that is emitted. This is because, during the combustion process, the amount of carbon content in the fuel is directly related to the amount of CO₂ which is emitted. Second, in the multi-participant interview, it emerged that some commercial drivers were in the habit of switching off their engines to save fuel when traffic congestion builds up. The practice of turning a vehicle's ignition on and off under congested conditions generates extra emissions which are largely avoided under normal driving conditions. Third, given the relatively limited seats available in vehicles used for long distance trips, per capita energy use and GHG emissions can be understandably high. Fourth, the minimal use of high occupancy formal transit/bus services, as well as the non-use of rail services by survey respondents for long distance trips, may have further compounded per capita energy use and GHG emissions in GAMA.

Aggregate energy use and emissions in Accra, as illustrated in Table 5.25, is expected to have become worse in recent times than what was found in 2005 by the Environmental Protection Agency of Ghana. This is in view of the continuous use of vehicles that are old and in a poor state of repair for intra-urban public transport in GAMA, as has been found in an earlier study (Kwakye, Fouracre & Ofosu-Dorte, 1998). Also, the generally poor performance of the Ghanaian economy and the associated financial hardship may keep the possibility of buying relatively newer as well as fuel and GHG efficient personal cars out of

the reach of many trip makers. Hence, one can expect that the continuous use of fairly used imported cars for long distance trips, with its negative impacts on fuel use and GHG emissions in GAMA.

In terms of short distance trips made to access nearby community activity points, the use of motorised transport modes was still high. However, travel times were comparatively lower. The implication of this finding could be that given the relative shorter commute time, energy use and emission per kilometre of vehicle travel could be lower compared to long distance trips. A counteracting mechanism may also be in place in that the relatively short commute time could be offset by several trips being made by drivers at shorter intervals. This then results in more GHG emissions into the atmosphere. Again, the use of these low occupancy vehicles has implications for per capita energy use and emissions, as noted above. Short distance trips promoted walking, particularly for trips made within a walkable distance of 1000 metres in the three surveyed localities. This is understandable or even expected in view of the relatively short distances involved, as well as other local factors such as the hot weather which may make walking less desirable for some people and the lack of dedicated infrastructure to make walking safer.

The relatively high percentage of trip makers who were found to walk to activity point locations found at 1000 metres from their homes could have a major impact on energy and GHG mitigation. This finding lends support to the overwhelming evidence that has shown that the integration of a spatial planning and transportation system in a manner that enables trip makers to be located closer to activity point locations could have significant climate mitigation benefits (Cirilli & Veneri, 2014; Cervero, 2013; Abane, 2011; UN-Habitat, 2011, Dulal et al., 2011; Zhao, 2010; Handy et al. 2006; VandeWeghe & Kennedy, 2007; van Wee, 2002; Boarnet & Crane, 2001, Newman & Kenworthy, 1999; Naess et al., 1996).

6.6. Stakeholders' Views on the Adoption of a Climate Efficient Transport System in GAMA

Drawing from Gilbert (2008) on how to ensure a successful implementation of mass transit in cities of the developing countries, the fifth research question, as noted above, delves into the potentials and challenges for the implementation of an energy and emission efficient bus rapid transit (BRT) system for GAMA. Earlier in the reviewed literature, it was found that mass transit resulted in less per capita energy use and emissions, besides other co-benefits (Deng & Nelson 2011; Trans-Africa Consortium, 2010; GoG, 2008; Fouracre, Dunkerly & Gardner, 2003; IEA, 2002; Wright, 2002; Akoena & Twerefou, 2002). Thus, the BRT system has received policy attention in GAMA (Finn et al., 2009; Hesse, 2008; Nuworsoo, 2006). However, an earlier study found a litany of constraining factors that conspired to collapse a BRT system that had been piloted on some selected road corridors in GAMA almost a decade ago (Agyemang, 2015). Empirical evidence obtained in this present study underpins the relevance of the fifth research question. The research question is answered based on a review of earlier studies as well as statistical and thematic analyses of quantitative surveys and qualitative interviews.

The study found a number of important enabling factors for a successful implementation of the proposed bus rapid transit system in GAMA. First, the functional link that has been found in earlier studies and also confirmed in this present study, that exists between Accra Central and its peri-urban areas present a good opportunity for sustaining mass transit. This is because the large number of peri-urban dwellers who regularly commute to activity points in Accra Central offer a high population threshold that could serve as a potential customer base to make transit operations sustainable, particularly during peak hour trips. In an interview with government officials tasked with the implementation of GAMA's BRT system, it came to light that feasibility studies were done on some selected road corridors in GAMA to identify and select the ones with high traffic densities for piloting the

proposed transit system. An interesting observation made in their feasibility study which also resonates well with this present study is that the road corridors that satisfied the conditions for the proposed pilot BRT system were the very ones that linked Accra Central to Kasoa, Teshie and Madina. It must be noted that the Accra Central-Kasoa pilot BRT system has been shelved temporarily, according to the government officials interviewed, due to project under-costing and insufficient funding. However, the Accra Central-Adenta corridor (which passes through Madina) and the Accra Central-Beach Road corridor (which passes through Teshie) are expected to kick start very soon. If and when they become operational, it is envisioned that the high population of trip makers who reside in Madina and Teshie respectively will make such a high customer base for the transit service to be successful.

Second, the study further found that a large number of trip makers surveyed who at present rely on their own personal means of transport, as well as those who patronise the existing paratransit services had the desire to switch to mass transit services. The conditions under which this switch will be possible were hinged on the transit system providing a comfortable and time-conscious service to trip makers. The researcher concedes that the tastes, lifestyles and preferences of trip makers are ever-dynamic and subject to change. However, what stands out clear is that trip makers who were surveyed wished that the inefficiencies in GAMA's present urban transportation are addressed. The implication is that if transit services are improved to meet the demands of trip makers, they are more likely to use such novel transit services. Respondents were not specifically asked to indicate the reason(s) for their willingness to switch from their present means of transport to a proposed transit system. However, the reason(s) may not be far-fetched. Obviously, as rational beings, trip makers will always want to go for a transport mode that will offer them maximum utility in terms of comfort, timeliness, safety, convenience and cost-effectiveness, just to mention a few. If these attributes are judged to be missing in their present transport modes, then one can make an intelligent guess that an alternative mode that promises to provide these qualities

will be the most preferred option. This view is similar to an earlier argument by Amoh-Gyimah and Aidoo (2013) even though Abane (2011) provides a counter-argument. Thus, one would have to be cautious and adopt a ‘wait-and-see’ approach while commenting on the response of trip makers on a yet-to-be implemented mass transit.

Third, interviews with government officials revealed a strong political will on the part of successive governments that had undertaken institutional reforms to ensure the smooth take off of the proposed BRT system in GAMA. This includes the establishment of an inter-district coordinating body known as the Greater Accra Passenger Transport Executive (GAPTE) with members drawn from all thirteen metropolitan and municipal assemblies in GAMA to plan, manage, regulate and coordinate urban transport services and transport infrastructure development in GAMA. Also, bus suppliers and financial institutions have been contacted by the GAPTE for the acquisition of modern buses for use in the BRT system. The interviews also revealed that steps have been taken to incorporate existing public transport operators so as to ease possible agitations, as seen in the comments below by a senior government official:

All the major actors in the industry, including the GPRTU have fully endorsed the idea with the creation of their own limited liability company to participate in the day-to-day running of bus services on the piloting corridor. Initially, the existing operators were not fully informed as to exactly how they were going to be involved. This misunderstanding resulted in their decision not to support the new project. A committee was thus formed to have regular meetings with the existing public transport operators. A memorandum of understanding committing them to the new urban transport project has been signed. The existing operators have also gone to inspect and approved of the new buses to be used for the project (Government Official 2).

However, in the interviews with some members and a senior official of the GPRTU, which is the largest trotro operator union in GAMA, it emerged that the incumbent paratransit operators had some misgivings about the proposed BRT system for GAMA. The comments below of a senior GPRTU official appear to contradict the earlier comments from the government officials on the involvement of incumbent public transport operators:

Initially, when they [GAPTE] proposed the idea, we [GPRTU] unanimously opposed the idea simply because we realised that it was going to kick us out of our business. Then all of a sudden, we are told GPRTU has agreed! Our national executives have agreed with the government. I cannot say for sure whether they have been induced with promises of personal favours or not, but what I can say is that we the members on the ground, those of us at the branch level are not happy with the idea (Senior Official, GPRTU).

The implication of the above comment is that while the government officials responsible for the implementation of the proposed BRT system have had some understanding with the national executives of the largest trotro operator union on a possible involvement of their members, the regional and branch level executives who appear not to have been involved in the discussions have some reservations. The comments below of some drivers who were involved in the focus group discussions suggest possible suspicions that the real motive of the proposed BRT system was to kick them out of business, contrary to the comments of the government officials who were interviewed:

Don't you think that this policy is a ploy to destroy the transport business run by private individuals like us? (Member 2, GPRTU).

When the Metro Mass [Limited] was introduced, passengers could queue to join those buses. Now, they depart virtually empty and therefore, they have had to scale down their operations. It will not work. It will not help us. It is simply to serve someone's parochial self-interest (Member 5, GPRTU).

Contrary to the views of the majority, the comment of a discussant below, suggests that the proposed BRT system was bound to succeed on condition that their union leaders were involved and that the business model should be mutually beneficial to them:

Well, if our leaders have agreed then when the information gets to us [drivers], maybe the project will work. That is if and only if there is a mutual understanding by all the parties involved. I need to also add that GPRTU members have in the past been given such bigger buses to operate, I think some Tata buses and OSA buses as well. If that is the model they are trying to re-introduce, then I think it will work (Member 6, GPRTU).

The involvement of the existing paratransit services operators in the proposed BRT system for GAMA is critical for its success. Evidence drawn from cities that have successfully implemented BRT systems through the active involvement of incumbent public transport operators, such as Mexico City, Bogota, Sao Paulo and Jakarta as well as cities that suffered initial setbacks to their BRT system implementation due to the non-involvement of existing operators such as Quito and Johannesburg, provide useful experiences for GAMA (Dugger, 2010; Gilbert, 2008; Ardila-Gomez, 2004).

6.7. Chapter Summary

In a nutshell, this chapter has discussed the major role Accra Central plays towards the generation of trips from across the country principally due to the apparent failure of regional planning policies of both colonial and post-colonial governments. Also, the concentration of GAMA's trip makers in peri-urban residential locations has been a function of rapid population growth and uncontrolled sprawl-like development. This has been attributed to the implementation of neo-liberalistic policies that led to the influx of capital and human resources, investments in housing estates, the creation of dormitory towns to serve residential purposes, expansion of road networks and the lack of foresight and institutional capacity to

tackle urban growth by relevant authorities. In the face of the above land use inefficiencies, functional linkages are established between the city centre and its peri-urban localities with respect to work, shopping and accessing government services and also among peri-urban localities with respect to shopping-related trip patterns. Long distance trips in GAMA were found to be directly associated with an almost exclusive use of motorised transport modes, particularly trotro paratransit services, as well as taxis and cars. This pattern has been established thanks to the long commuting distances between residential locations and locations of activity points in GAMA, the lack of infrastructure for non-motorised transport modes.

The relative short commute distance was found to have influenced the use of non-motorised transport modes to activity points in GAMA. Based on trip makers' personal circumstances, spatial factors as well as mode-specific attributes of various transport modes, different groups of trip makers were found to use one form of transport mode or the other. Mixed land use patterns that fostered the siting of residential locations closer to activity points explained the relatively high use of non-motorised transport in some instances. Evidence of climate mitigation was found to be the result. Urban sprawl and concentration of activity points at distant locations encouraged motorised transport use for long distance trips, traffic congestion, with its associated high per capita energy and emissions of Greenhouse gases. The strong functional link between the city centre and its peri-urban areas, the preference of a high-quality mass transit service among surveyed trip makers, the institutional support and the willingness to involve incumbent public transport operators are factors that could ensure the successful implementation of a future energy and emissions efficient public transport system. Agitations of incumbent operators are however found to be a major constraining factor that could potentially derail the smooth implementation of the proposed new urban public transport system.

**CHAPTER SEVEN:
SUMMARY OF KEY FINDINGS, CONCLUSIONS & POLICY
RECOMMENDATIONS**

7.1. Introduction

In Ghana, as in most developing countries, climate mitigation strategies in the transport sector appear to be much focused on improvements in vehicle technology and fuel efficient mechanisms. This is in spite of the numerous studies that have consistently argued that the full integration of land use and transport planning in developing countries has a significant impact on fossil-based energy use and climate mitigation in the transport sector (Cervero, 2013; Abane, 2011; Zegras, 2012; Li, 2011; Zhao, 2010, Lin & Yang, 2009, Newman & Kenworthy, 2006; Zhang, 2004). Earlier studies have generally highlighted urban land use and transportation challenges in Ghana, including urban sprawl and the existence of functional linkages between the urban and peri-urban areas. There is also the challenge of a high use of low occupancy, energy-inefficient motorised transport modes over longer commute distances, with negative ramifications for high per capita fuel use and GHG emissions. Unfortunately, national and urban policies and development strategies have not focussed on or included the climate mitigation potential of an integrated land use and transport system which among other things allow residential and activity point locations to be sited close to each other.

In view of the above, this present study set out to investigate GAMA's land use-transport system and its ramifications for energy use and emissions of Greenhouse gases. While the focus of this study is on GAMA, the study outcome may have general application for climate mitigation in Ghana's transport sector, as well as in other developing countries that are also considering appropriate, permanent and substantial climate mitigation in their transportation system.

The overall research objective aimed to examine the land use and transportation system of GAMA and their implication for climate change mitigation in the transportation sector. This was broken down into four specific objectives. These are as follows:

1. To identify land use patterns with respect to geographical locations of residences and activity points in GAMA;
2. To identify and examine patterns of transportation behaviour in GAMA;
3. To analyse and discuss the extent to which geographical distributions of residences vis-à-vis places for shopping, working and public service provisions influence patterns of transportation behaviour, energy use and GHG emissions in GAMA;
4. To examine the extent to which climate mitigation could be attained through an efficient transport and land use system in GAMA.

The research objectives were achieved through a complementary mixed methods design involving a mixture of quantitative and qualitative methods. The quantitative research entailed an interview-based questionnaire survey of an initial 400 trip makers who were non-residents of Accra Central but who regularly access activity points found there. This initial survey was augmented with a second survey comprising another 400 trip makers who accessed community activity points and in addition commute to other activity points found all over GAMA, including those found in Accra Central. The survey sought among other things to identify the residential locations where trip makers have travelled from, the transport modes that were used for such trips as well as the energy and Greenhouse gas implications of trips made to activity points in GAMA.

The qualitative research comprised opinions of relevant stakeholders in the land use-transport system of GAMA, including 6 public transport operators and a high ranking official, 2 government officials and 2 social scientists who were sampled on their perceptions of GAMA's present land use-transportation system and what mechanisms could be put in place to promote an efficient land use-transport system. Observations were also conducted to obtain, at first hand, some of the inefficiencies currently associated with GAMA's

transportation which has been the outcome of the city's spatial distribution of residential locations and activity points.

Secondary data sources on national vehicular energy use and associated emissions from transportation and national transport policy documents were also considered useful in achieving the research objectives. A Systems conceptual framework of land use and transport system was adapted to guide the description of the symbiotic relationship between GAMA's spatial and transportation patterns and the extent to which this relationship impacted on energy use and Greenhouse gas emissions. The Systems conceptual framework conceptualised that the adherence to a fully integrated spatial and mobility planning principles has the benefits of producing an efficient land use and transport system characterised, among other things, by low emphasis on motorised transport modes, the promotion of non-motorised transport modes over shorter distances and a mass transit which ultimately result in substantial mitigation gains in the transport sector. On the other hand, where policies that regulate spatial planning and transport systems are not fully implemented, an inefficient land use and transport system emerges. This is reflected by urban sprawl and siting of urban residences at distant locations away from the locations of activity points which are usually found concentrated at the city centre. Thus, transport patterns are characterised by a high use of motorised transport modes over longer distances, traffic congestion, the virtual absence of non-motorised transport modes, which ultimately leads to high per capita energy use and Greenhouse gas emissions which are known to lead to climate change.

In line with the literature review, three complementary alternative hypotheses were established to guide the study. The first two sought to establish the statistical relationships between trip distances (i.e. whether long or short) and modal use by trip makers. The last sought to examine the statistical relationship between the personal circumstance of trip makers and their modal use. In the next section, a summary of major findings based on the stated research objectives and hypotheses are presented.

7.2. Summary of Major Findings

The first research objective sought to identify land use patterns with respect to geographical locations of residences and activity points in GAMA. The study, based on the quantitative survey, showed that residential locations of trip makers who visited Accra Central were geographically widespread in Ghana. The majority of residential locations of trip makers were, however, found in the peri-urban areas surrounding the Accra Metropolis, providing an indication of urban sprawl in GAMA. The location of activity points for shopping, work and accessing public services in GAMA was demonstrated to have established a strong functional linkage between the city centre (i.e. Accra Central) and its urban and peri-urban localities. The functional linkage was with respect to accessing specialised and non-specialised commercial activity points in the Makola Market for work as well as competitively priced and convenient shopping opportunities. Also, the possibility of accessing specialised public services and formal sector employment in the Ministries Area further served as a magnetic attraction for GAMA trip makers. The majority of trip makers who visited Accra Central, however, did so for non-work related reasons. In addition, evidence of multi-purpose trip making was found as trip makers simultaneously accessed other major activity points in Accra Central but which are not located inside the Makola Market and the Ministries Area. Outside of Accra Central, locations of activity points for shopping, notably the Kaneshie and Madina Markets respectively, were shown to create other functional linkages in GAMA, especially for residents in the peri-urban areas. Aside these activity points, a number of important activity points for work, shopping and accessing local public services were identified in relative proximity to trip makers in GAMA's peri-urban areas.

The second research objective sought to identify and examine patterns of transportation behaviour in GAMA, particularly with respect to modal use, and factors accounting for modal use among sampled trip makers in GAMA.

The study showed that the functional linkages between activity point locations, especially those found in Accra Central and the surrounding residential areas, were characterised by relatively long commuting distances. Thus, given the present transport system of Accra, it made sense that the majority of long distance trip makers were found to rely almost exclusively on motorised transport modes, notably trotro paratransit and taxi services in addition to cars. The personal circumstance of long distance trip makers, including their demographic and socio-economic status largely explained the variance in modal use. Also, spatial factors, and in particular commuting distances as well as trip makers' perception of service quality were major determinants of modal use. A substantial number of trip makers were found to rely on non-motorised transport modes, particularly walking, when embarking on short distance trips to nearby activity point locations. Again, the personal circumstances of trip makers as well as the relative commuting distance were key determinants of non-motorised modal use.

The third research objective sought to analyse and discuss the extent to which geographical distributions of residences vis-à-vis places for shopping, working and public service provisions influenced patterns of transportation behaviour, energy use and GHG emissions in GAMA. The study shows that the high use of low occupancy motorised transport modes had major adverse consequences for per capita energy use and its associated GHG emissions. Energy use and emissions from long distance trips are worse under congested driving conditions. In contrast, land use density patterns that fostered the siting of residential locations closer to activity points which promoted relatively high use of non-motorised transport resulted in substantial climate mitigation gains.

The fourth research objective aimed to examine the extent to which climate mitigation could be attained through an efficient transport and land use system in GAMA. In particular, the fourth objective aimed to bring to the fore the perspectives of relevant stakeholders towards the adoption of a climate efficient public transport system.

The study found an indication of the desire among potential end users to use GAMA's proposed energy and emission-efficient bus rapid transit (BRT) system. The study also suggests that the GAMA's functional linkages were key enabling factors for the success of the proposed BRT system. Although some challenges still exist, the public-private partnership in the introduction of GAMA's BRT system could provide an enabling environment for a successful BRT system implementation.

Three alternative hypotheses were formulated and empirically tested to examine the statistical relationship between residential locations vis-à-vis distance to activity point locations (whether near or far) as well as between socio-economic and demographic variables on modal use. In this study, the researcher used the one-tailed directional hypotheses. Earlier studies (see Cho & Abe, 2013; Gravetter & Wallnau, 2007) have argued that usually when researchers lack adequate knowledge on the directionality of the research hypotheses, the research hypotheses may take the form of non-directional ones. Under such circumstances, the use of two-tailed non-directional hypotheses testing is appropriate. The use of one-tailed directional hypotheses is therefore justified in the sense that given the extensive literature survey, the researcher had a fairly good knowledge that there will be a directional difference between the dependent and independent variables. Consequently, the first alternative hypothesis 1 (H_1) was stated as: long trip distance to activity points in Accra Central for working, shopping and accessing government services has a statistically significant effect on the transport modal use of GAMA trip makers. This hypothesis was confirmed by a statistical test of significance which showed that as trip distances increase further and further away from activity point locations in Accra Central, the majority of trip makers travel by motorised transport modes, notably trotro paratransit services and cars respectively. However, the output from a re-run of the statistical analysis on the data on long distance trips to include other personal attributes of trip makers and the transport modes did not support the first

alternative hypothesis, implying that other factors were far more important to long distance modal use than the distance per se.

The second alternative hypothesis 2 (H_1) that guided the study was stated as: short trip distance to community activity points for shopping has a statistically significant effect on the transport modal use of GAMA trip makers in their community of residence. This hypothesis was supported in all three localities in that one of the major findings in the study was the high use of non-motorised transport modes among trip makers whose residential units were found much closer to the main community commercial activity points. Increasing distance away from these local activity points resulted in more trip makers resorting to motorised transport modal use. The output from a re-run of the statistical test of the data on short trips to include other possible moderating variables partly confirmed and partly rejected the alternative hypothesis. For the Kasoa and Teshie sub-samples, results of significance in the re-run confirmed a strong statistical relationship between short commute distances on modal use. For the Madina sub-sample, the re-run rejected the second alternative hypothesis, suggesting that perhaps other socio-economic and demographic considerations were more important for trip makers when deciding on which transport modes to use.

The third alternative hypothesis 3 (H_1) was an amalgamation of several socio-economic and demographic predictor variables which are known in the literature to influence modal use. It was stated as: gender, age, education, household size, occupation type and car ownership status have statistically significant effects on the transport modal use of GAMA trip makers who visit Accra Central. Among long distance trip makers, the hypothesis was generally supported, except for variable household size which was not found to be statistically related to modal use. A second test of statistical significance based on the inclusion of other attributes, including perceptions of service quality of different modes, partly supported the hypothesis. This is because a major finding in this study was that age, level of education and car ownership status were key determining factors for motorised

transport use among long distance trip makers. Among short distance trip makers, the third alternative hypothesis was generally supported in the sense that the data showed that the above-named predictor variables (age, education, occupation, household size and car ownership status) were statistically related to modal use in the three communities surveyed with some notable variations.

7.3. Conclusion

This work has made a number of important contributions to the study of human geography, climate mitigation science and provided input to improving climate change mitigation policy. In terms of the contribution to the advancement of the discipline of human geography, this study has answered the ‘what, where, when, how and why’ questions usually asked in the discipline. For urban (human) geography, in particular, while earlier studies have focused on urban sprawl and its negative impacts on long distance trips, including high energy use, traffic congestion etc., growing emissions which have characterised the functional linkages between the city centre and its peri-urban areas (Cobbinah & Amoako, 2014; Abane, 2013; Owusu, 2012; Yeboah, 2003), emphasis have not been placed on the climate mitigation benefits that could be attained in an integrated land use and transport system that will reduce car dependency and promote non-motorised transport modes. This present study has demonstrated that the functional linkages are not necessarily uni-directional, as they were thought to be. Rather multi-directional functional linkages have been established due to the siting of activity points for work, shopping and accessing public services at various locations in GAMA. This study has further benefitted urban geography by pointing out various locations where these functional linkages are presently taking place.

For transportation geography, the pattern of transportation behaviour, particularly modal use among trip makers which derives from GAMA’s existing urban spatial structure, has been established in this study.

Also, the importance of various transport modes in addressing the mobility needs of commuters throughout GAMA and the factors that have accounted for modal use among trip makers have been demonstrated in this study. Again, factors that could promote or derail attempts at improving public transport (with its climate mitigation co-benefits) have been highlighted in this present study.

Towards the advancement of a climate mitigation science, the benefits of this present study are two-fold. First, with respect to the formulation of a theory in climate mitigation science, this study has drawn attention to the Systems conceptual framework which enables researchers to conceptualise the interconnectedness and feedback mechanisms associated with land use and the transportation system, so as to effectively mitigate rising Greenhouse gas emissions. Secondly, this study has answered the call (Rowland, 1998) for developing countries to develop their own capacity to deal with the global challenge of climate change. This comes against the backdrop that the science of climate change mitigation in transport is predominantly an American, European and Nordic affair (Naess, 2012). Thus, this present study presents current evidence from a developing country context that supports earlier international studies (e.g. Cervero, 2013; Zegras, 2012, Zhao, 2010, Lin & Yang, 2009, Zhang, 2004) on the need for cities in developing countries to take the integration of land use and transportation systems seriously so as to reverse the high emphasis on motorised transport modes and its attendant high energy use and growing GHG emissions.

With respect to the policy contribution, this study has produced evidence that challenges Ghana's policy on climate mitigation in the transport sector through an almost exclusive emphasis on improvements in vehicle technology and fuel efficiency to the neglect of reducing car dependency through an integrated land use and transport system. The study has demonstrated that spatial planning mechanism that caters to the mobility needs of urban dwellers could potentially mitigate climate in developing countries as noted in earlier studies (Abane, 2011; Scheiner, 2006).

The methodological contribution of this study is found in the use of the complementary mixed methods epistemological principles. Schwanen et al., (2011) have endorsed the mixed methods approach by arguing that it potentially produces richer and more textured understandings of effective climate mitigation in transport than presently exist.

Again, given the present focus on mass transit, which for policy actors are primarily to improve public transport delivery and address traffic congestion, loss of productive man-hours, social inequity, road safety issues, among others, there is also a climate mitigation co-benefit as well, as has been demonstrated in earlier studies.

Going forward, this present study has added fresh perspectives for the consideration of policy actors on possible enabling and constraining factors they should take note of when implementing mass transit systems.

7.4. Recommendations

Based on the research findings, the following are recommended to policy actors, city authorities and other relevant stakeholders as well as future researchers on improving the efficiency of land use and transport systems to achieve climate mitigation in the transport sector.

7.4.1. Re-organisation and Re-development of Low-Density Areas in and around Accra

Central

There is the need to develop high density, high rise residential apartments on vacant lands in and around Accra Central to accommodate urban dwellers who have the regular need to visit Accra Central. It is acknowledged that while city authorities, on behalf of the central government, have complete control over 'state' and 'vested' lands, the fact still remains that large tracts of 'customary' lands in GAMA are owned by traditional authorities on behalf of their subjects. These customary lands are usually leased out to individuals and estate developers.

Thus, the active involvement and support of traditional authorities and private people who own such vacant lands towards the re-development and in-filling of urban Accra cannot be over-emphasised. Specifically, this study recommends that city authorities search for and identify vacant lands at the following areas: La, Kaneshie, Chorkor, Bubuashie, and Laterbiorkorshie. These are localities which were found in the data on long distance trips to accommodate large numbers of Accra Central visitors. Again, the commute distance between Accra Central and these areas are relatively short, averaging 5 kilometres. Therefore, if city authorities could invest, or at least encourage some public-private participation in the development of low-cost, high density, high rise apartments on vacant lands available in the above areas, it is possible that the majority of regular visitors to Accra Central who presently commute over longer distances from the peri-urban areas in motorised transport modes will relocate to these new apartments.

To this end, policies should be put in place to deliberately target formal sector employees in the Ministries Area and traders in the informal economy at various locations in Accra Central and at the Makola Market in particular. The benefits of this recommendation are four-fold. First, it will boost the local economy such that the original land owners will appreciate the tangible benefits as well. Second, it will promote a balanced re-distribution of the urban population and curtail urban sprawl. Third, the relative proximity to activity points may encourage the use of non-motorised transport modes as was found in the data on short distance trips. Fourth, the dense population will make it easier and more cost-effective for city authorities to effectively cater to the mobility needs of its citizens, for instance through the proposed bus rapid transit system. In addition to the above, the Makola Market, for instance, as well as some major commercial activity points in Accra Central have for some time been experiencing regular fire-outbreaks. As unfortunate as this is, city authorities are presented with the rare opportunity to re-organise and redevelop the markets, with prior

engagements with all relevant stakeholders, to resemble the vertical land use development happening around the Airport City business district area.

7.4.2. Effective Decentralisation Policies of Accra

The establishment and promotion of regional markets may contribute to breaking the unrivalled status of Accra Central. In this study, the Kaneshie and Madina Markets featured prominently as some of the major commercial activity points often visited by surveyed trip makers. It is interesting to note that as part of the Strategic Plan for the Greater Accra Metropolitan Area (GoG, 1993), plans are afoot to encourage the decentralisation of economic activities from the traditional central business district to new growth points particularly the Madina town through a multi-city structure to redistribute the population. However, the fact that these trip makers still found it imperative to visit Accra Central is indicative of the fact that perhaps more needs to be done in terms of promoting the transaction of specialised trading activities, including bulk trading in textiles and food produce in these competitive activity points.

With the exception of a few core ministries, agencies and departments of state whose relocation outside of Accra Central might be counter-productive, it is recommended that most of these public service agencies are moved out of their present locations. The government can take a cue from new high-rise office development initiatives being led by the private sector away from the congested city centre. To this end, the local district assemblies should be well-resourced and staffed with well-trained professional to perform some of the specialised functions so as to bring public service activities much closer to the residential locations of urban dwellers. In order to minimise the high emphasis on Accra Central, particularly for the formal sector employees and users of public services, the full potential of using information, communication and technology should be utilised. Workers could for instance work from home and submit deliverables or work outputs electronically.

Users of public services could also be encouraged to submit their applications online. Already, it is heart-warming to note that most government agencies have up and running websites which the public are encouraged to utilise. However, the extent to which patrons know of the availability of these websites, how serviceable and user-friendly they are and also, how effectively they are utilised by the agencies involved in producing quick and satisfying feedback to consumers could be the subject of a future study.

In light of the above recommendations, the study finds the Ghana National Urban Policy Framework (NUPF) which has been effective since 2012 and the Land Use and Spatial Planning Bill (LUSPB) which is seeking parliamentary deliberation and approval as laudable. As such, these comprehensive urban governance and regional planning policies must be encouraged to succeed. In particular, this study endorses the NUPF policy objectives which include the establishment of new growth points to serve as counter-magnets to the fast-growing cities such as Accra and Kumasi and the promotion of accelerated growth of small and medium-sized towns, including district and regional capitals. This will ensure that long distance trips from various Ghanaian towns to primate cities, such as Accra, could be reduced drastically. Other laudable policy initiatives are: ensuring that investments and development will consistently and increasingly be directed towards targeted counter-magnet growth areas; ensuring the adoption of spatial planning framework and strengthening the use of remote sensing and Geographic Information Systems (GIS) in planning.

7.4.3. Full Integration of Land Use and Transportation Systems

The study has underscored the need for a full integration of land use and transportation, which among other benefits could significantly mitigate energy use and growing GHG emissions. The cooperation and active involvement of various government agencies tasked with land use and transportation are critical in this regard. To this end, the Ministry of Local Government and Rural Development, working through its decentralised metropolitan,

municipal and district assemblies should harmonise their activities with the Ministry of Transportation and its allied departments to integrate the mobility needs of urban dwellers with spatial planning. Closely tied to this point is the need to adequately resource and empower the National Development Planning Commission to carry out its oversight mandate of coordinating development activities in the various government agencies.

7.4.4. Pedestrianisation and the Promotion of Mass Transit Operations in GAMA

As has been noted in this study, trips made into Accra Central are largely based on low occupancy motorised public and private cars, with their high energy and emission implications. To reverse the trend, it is recommended that vehicular trips in the city centre in these low-occupancy transport modes are discouraged. Specifically, the city authorities must ensure that all pedestrian walkways and bicycle lanes are clearly marked and segregated from fast-moving cars. These pedestrian facilities must be well-lit to make walking for instance at night, safer. The erection of billboards and the invasion of pedestrian facilities by commercial interests should be nipped in the bud. These pedestrianisation measures are also relevant in the local community of residences of urban dwellers, particularly around community activity points to ensure high patronage of non-motorised transport modes.

Also, policy actors should look into the issue of congestion and parking pricing whereby users of these low-occupancy modes are charged a fee to use the congested roads and limited parking spaces in Accra Central. There are ten identifiable major arteries leading to Accra Central. The city authorities must encourage investments in the construction of secure, high-rise car parks and temporary holding points at these major entry points where car users will be encouraged to park and continue the rest of their journeys in the bus rapid transit system buses. After transacting their businesses, car users join the buses back to pick up their cars. However, for car users who may still find it necessary to drive into the city centre, a fee could be charged to them for their use of the roads and parking space.

The proceeds from this tolling exercise could be channelled back into subsidising the operations of the bus rapid transit system to make it very affordable for the travelling public. The BRT system buses when they become operational should offer targeted bus services to reflect user needs. For example, special bus services with adequate comfort, safety and security which will stop only at a few designated bus stops could be introduced exclusively for top government officials and formal sector employees to encourage patronage and sustainability of the mass transit.

Again, as was found in the study, the city authorities must do more to engage the incumbent public transport operators in the proposed BRT system. It is good to note that some executive level negotiations have taken place, particularly between city authorities and incumbent public transport operators, notably the Ghana Private Road Transport Union (GPRTU). The newly inaugurated Greater Accra Public Transport Executive (GAPTE) must ensure that the executives of the GPRTU communicate the benefits of the proposed project to their members, including the fact that they are part-owners of the project and that the introduction of the formal bus operations will improve their working conditions. Following this education and sensitization exercise, the GAPTE must be bold to implement the mass transit project tactfully.

7.4.5. Areas for Future Studies

The present study focused attention on land use and the transportation system of GAMA as a climate mitigation strategy. It is highly recommended that future studies explore the extent to which Information Communication Technologies could mitigate climate change given its de-emphasis on physical mobility and car dependency. In an earlier study, Segbefia (2000, p.180) had found that in addition to reducing transaction costs, the substitution of physical mobility with mobile telephones resulted in ‘change in travel patterns, and energy savings’.

Overå's (2006) study on the use of mobile telephones among Ghanaian traders further revealed a change in their travel patterns as well as a significant reduction in their cost of doing business. In the light of these earlier studies, and against the backdrop of findings made in this present study, future studies can closely examine the extent to which the digitisation or the use of the internet/websites to provide government services to the public influence mobility patterns and energy use of urban dwellers. An important research question might be: does the implementation of ICT, particularly the use of websites in the public sector influence modal use in urban areas in Ghana? To what extent does this relatively new development of websites for the public sector impact on climate mitigation?

The 'systems thinking' inspired much of the philosophy and methods adopted in this study. The study further demonstrated that when seen as a system, much of the present challenges associated with GAMA's urbanisation could be resolved, instead of the present piecemeal approach to solving urban challenges in Ghana. To this end, the full potential of the 'urban systems dynamics' as was developed by Jay Forrester (1969) and applied in various cities across the globe, should be explored in future studies.

Finally, this study could have benefitted immensely from the primary data on the income of respondents as well as public transport energy use and its associated GHG emissions. However, the income data was full of uncertainties and had to be discarded. Perhaps, future studies could benefit from Abane's (1993) approach of estimating incomes of respondents based on their expenditure, rather than on their stated incomes, as was initially used in this study. Again, the lack of predictability of paratransit services introduced errors in the primary data and had to be discarded and replaced with secondary data. While the secondary data offered useful baseline information, the findings in the secondary data were very general and not specifically connected to the three specific road corridors of interest. Thus, it is recommended for future studies to develop appropriate data collection tools and techniques that will largely minimise potential uncertainties due to the unpredictable nature

of the informal paratransit services. Specifically, sampled commercial drivers could be trained and provided with simple trip diaries in which they record their circulation and fuel consumption over a specified period. Future researchers should make it a point to follow their subjects at regular intervals to monitor progress being made as well as addressing potential challenges which may arise in working with the research instrument.

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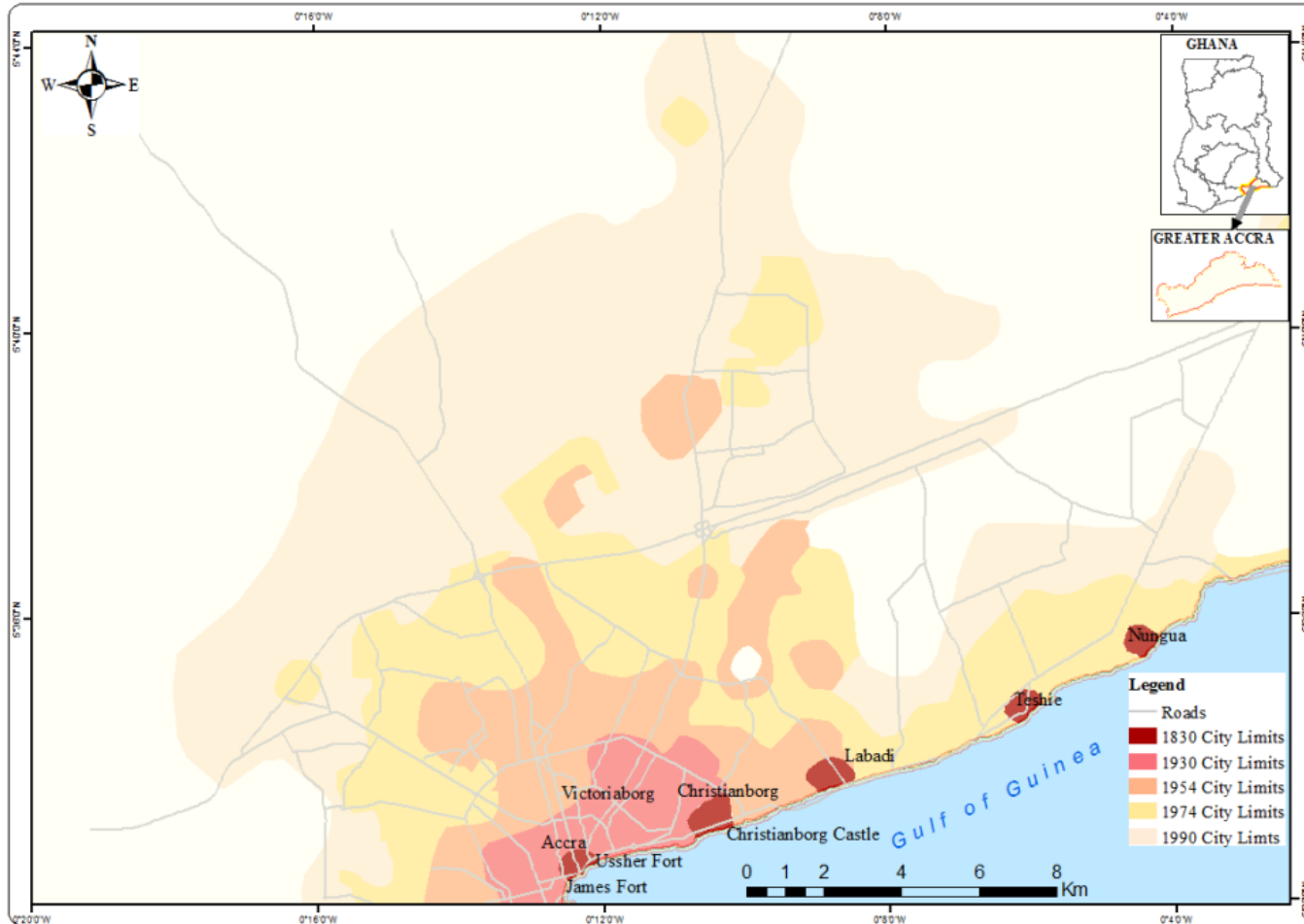
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APPENDICES

Appendix 1: The expansion of Accra in the pre-colonial, colonial and post-independence era



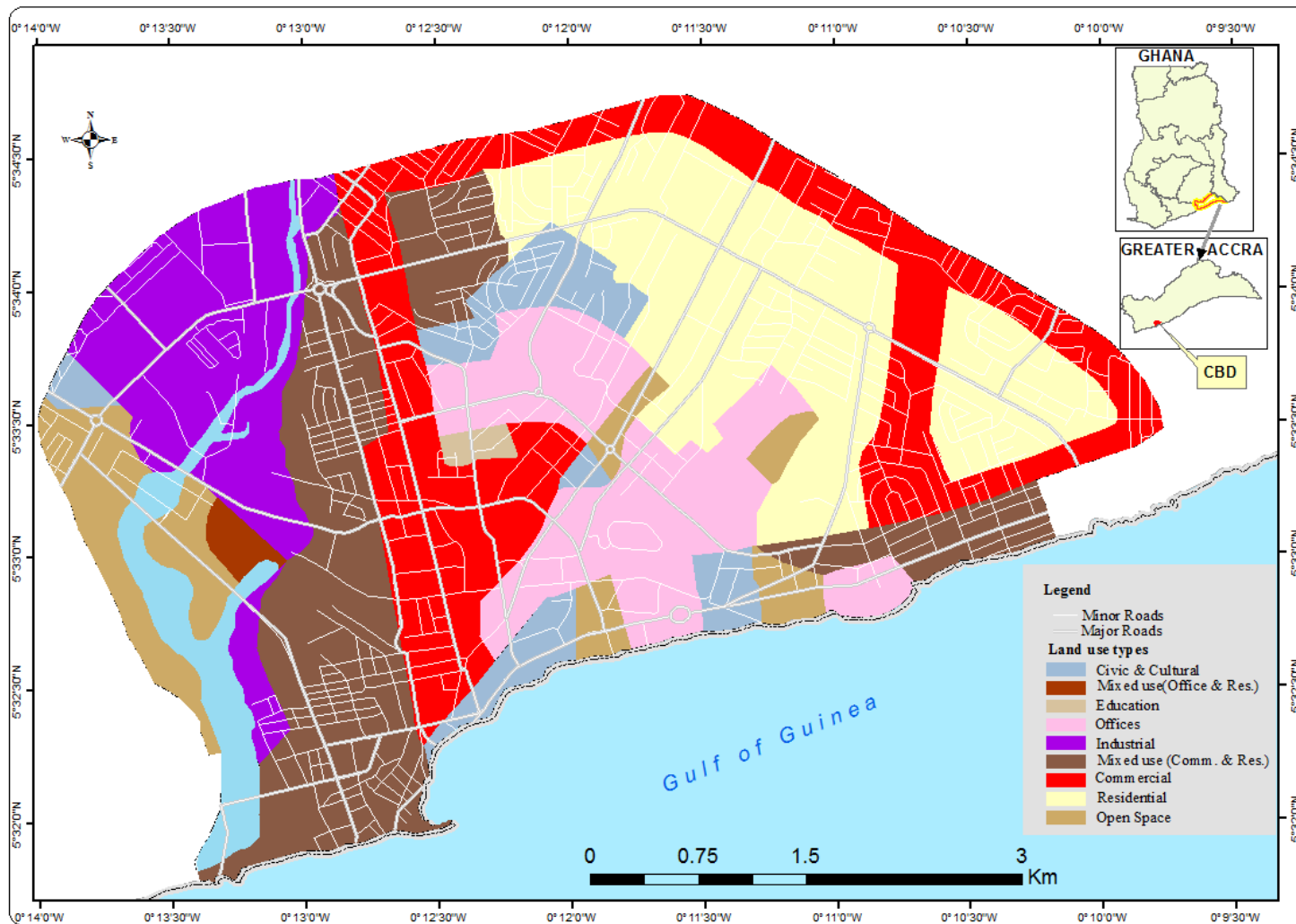
Source: Adapted from Accra Planning and Development Programme (1991) by Author

Appendix 2: Accra Central; home to GAMA's high value formal and informal activity points



Source: Field data, 2014

Appendix 3: Land use types in Accra Central that serve as activity points for GAMA's trip makers



Source: Adapted from Accra Planning and Development Programme (1991) by Author

Appendix 4: A government provided modern public transport terminal at Achimota showing some types of vehicles typically used for Trotro services in GAMA.



Source: Field data, 2014

Appendix 5: Lack of shelter at Tema Station in Accra Central exposes passengers (queuing under umbrella) to the hot sun while waiting to board a Mercedes Benz Sprinter Trotro



Source: Field data, 2014

Appendix 6: Lack of shelter at Tema Station in Accra Central exposes passengers to the rains as they run helter-skelter during a heavy downpour



Source: Field data, 2014

Appendix 7: A 45-seater and 20-free standing high occupancy Metro Mass Transit bus readying for passengers in Accra Central.



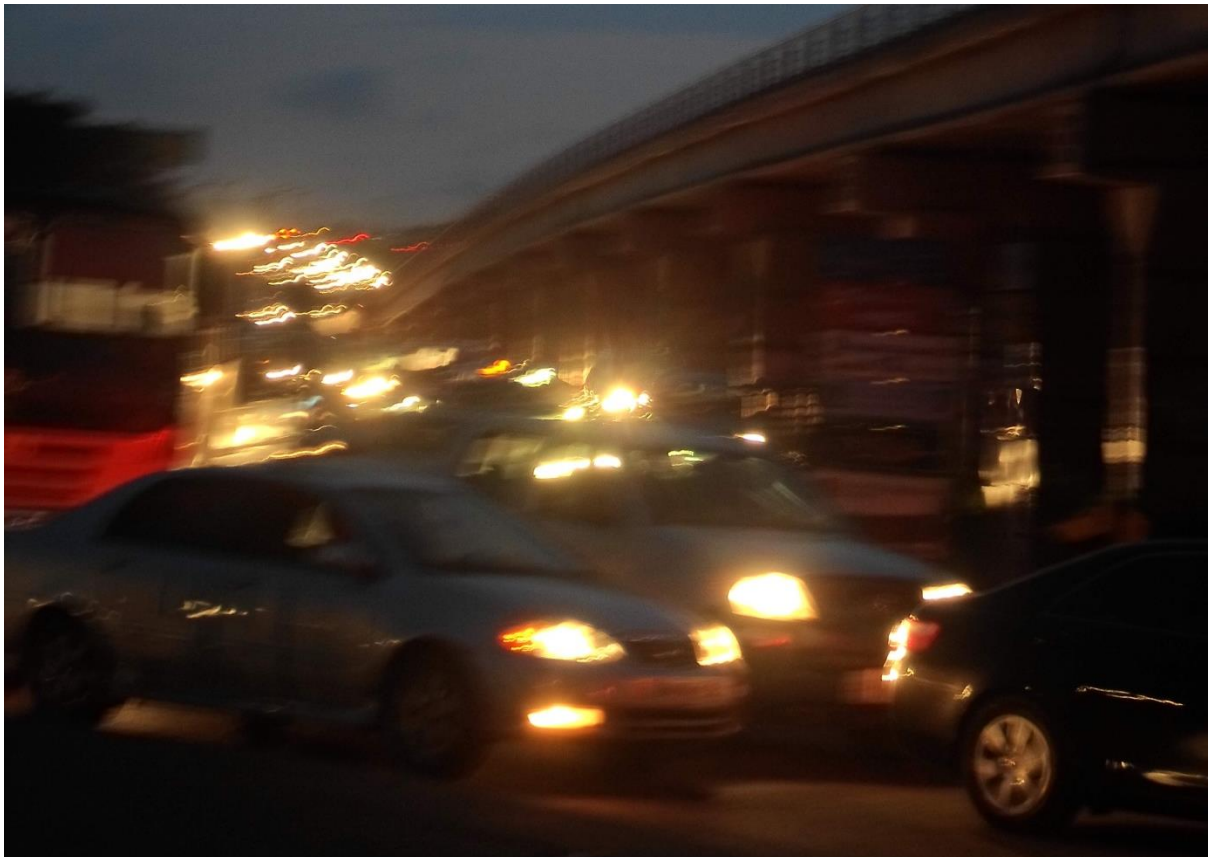
Source: Field data, 2014

Appendix 8: Several single occupancy cars are observed during morning rush hour on a heavily congested major corridor leading to Accra Central.



Source: Field data, 2014

Appendix 9: An ocean of car headlights, primarily from single occupancy cars, are observed during an evening rush hour on a major corridor leading out of Accra Central



Source: Field data, 2014

Appendix 10: Stopping patterns for a proposed BRT on the Adenta to Tema Station corridor in GAMA

Inbound	Outbound
Adenta Terminal	Tema Station Terminal
Adenta Barrier	National Theatre
SDA	Ridge
Reese Junction	Immigration
Madina Zongo Junction	Sankara
Atomic Junction	Flagstaff House
Legon	Waterworks
Okponglo	37 Hospital
Shaishe	37 License Office
Spanner	Opeibea
Shangrilla	Airport 1 st
Airport 2 nd	Airport 2 nd
Airport 1 st	Shangrilla
Opeibea	Spanner
37 License Office	Shaishe
37 Hospital	Okponglo
Waterworks	Legon
Flagstaff House	Atomic Junction
Sankara	Madina Zongo Junction
Immigration	Reese Junction

Ridge	SDA
National Theatre	Adenta Barrier
Novotel	Adenta Terminal
Tema Station Terminal	

Source: Field data, 2014

Appendix 11: Composition and demographic characteristics of GAMA

Political Administrative Areas	Capital	Total Population	% Share of Total Population	% Urban	% Rural	No. of households
Accra Metropolitan Area (AMA)	Accra	1848614	46.1	100	-	501956
<i>Sub-Metros in AMA</i>						
• Ablekuma South		213914	5.3			57913
• Ablekuma Central		268424	6.7			72230
• Ashiedu Keteke		117525	2.9			34964
• Osu Klotey		121723	3			35508
• La		183528	4.6			51155
• Ayawaso East		183498	4.6			43755
• Ayawaso Central		142322	3.5			39116
• Okai Koi South		121718	3			34800
• Ablekuma North		197024	4.9			53039
• Okai Koi North		228271	5.7			64567
• Ayawaso West		70667	1.8			14909
Wuogon						
Tema Metropolitan Area (TMA)	Tema	402637	10	97	3	97597
<i>Sub-Metros in TMA</i>						
• Tema West		127807	3.2			31154
• Tema East		160213	4			38508
• Kpone Katamanso		114617	2.9			27935
Ga South Municipal Area (GSMA)	Gbawe	485643	12.1	89	11	118846
Ga West Municipal Area (GWMA)	Amasaman	262742	6.6	69	31	66706
Ga East Municipal Area (GEMA)	Abokobi	259668	6.5	87	13	66286
Adenta Municipal Area (AdMA)	Adenta	78215	2	64	36	20478
Ledzokuku / Krowor Municipal Area (LEKMA)	Nungua	227932	5.7	100	-	60859
Ashaiman Municipal Area (AshMA)	Ashaiman	190972	4.8	100	-	49936
La Dade-Kotopon Municipal area ⁹	La	-	-	-	-	-

⁹New municipality carved from AMA in 2012. The 2010 Population & Housing survey however enumerated it as part of the AMA; ³New municipality carved from TMA in 2012. The 2010 Population & Housing survey however enumerated it as part of the TMA; ⁴New municipality carved from Ga East in 2012. The 2010 Population & Housing survey however enumerated it as part of Ga East district; ⁵New district carved from Ga South in 2012. The 2010 Population & Housing survey however enumerated it as part of Ga South district.

Kpone Katamanso Municipality ³	Kpone	-	-	-	-	-
Table 3.1 continued						
La-Nkwantanang-Madina Municipality ⁴	Madina	-	-	-	-	-
Ga Central District ⁵	Sowutuom	-	-	-	-	-

Source: Generated from the 2010 Population and Housing Census (GSS, 2012)

Appendix 12: Questionnaire on long distance trip survey



SURVEY OF LAND USE, TRANSPORTATION & CLIMATE CHANGE IN THE GREATER ACCRA METROPOLITAN AREA (GAMA)



Preamble: This questionnaire is meant to provide reliable information on GAMA’s land use & transportation system and their impacts on the environment/climate. This research is being conducted by a PhD student at the Department of Geography and Resource Development, University of Ghana, Legon. Please note: Your responses will be used strictly for the purposes of the study and your information will be held in utmost confidentiality.

Form No.....

GPS Coordinates:
Lat.....
Long.....

A. CONCENTRATION & ATTRACTION OF ACTIVITY CENTRES IN ACCRA**CENTRAL**

Please Note: the word ‘activity centres’ as used in this survey refer to the place where you usually go to work, shop or engage in other social activities which are beneficial to you. They may include your work place; market centres; government/public offices, recreation etc.

1. Do you live outside of Accra’s city centre (i.e. Accra Central)? Yes No
2. Which of the activity centres have you assessed in Accra Central?

No.	Activity Centres/Facilities	Tick if you have used this in Accra Central	Please specify the number of times or how often you visit these activity centres
1	Markets (e.g. Makola, Okaishie, Agboghloshie)		
2	Drugstore retail shops		
3	Electronic repair shops		
4	Auto repair (fitting) shops		
5	Industries/factories		
6	Banks		
7	Micro finance firms		
8	Insurance firms		
9	Telecom companies head offices		
10	Ministries; Agencies & Dep't of State		
11	Other Public offices		
12	Schools		
13	Libraries		
14	Bookshops		
15	The Arts Centre		
16	The National Theatre		
17	Int. Conference Centre/ The Dome		
18	Ga King’s Palace		
19	Efua Sutherland Childrens’ Park		
20	Accra Sports Stadium		
21	Independence (Black Star) Square		
22	Kwame Nkrumah Mausoleum		
23	Mantse Agbona Park		
24	Event places (for funerals, outdoring etc)		
25	Transport terminals/ Lorry stations (e.g. Tema Station/ regional bus stations		

3. What in your opinion is/are the reason (s) for accessing activity centres located at Accra Central?

Reasons for visiting Accra Central	Please tick ALL that applies to you
The location of several retail & commercial goods together at Accra Central makes it easy for me to access all that I need at the same time and place.	
The location of highly specialised services (e.g. government businesses at the Ministries Area & wholesale of certain goods and services at Makola) which cannot be obtained in my local community of residence makes Accra Central attractive for me to visit.	
The location of several service centres, e.g. banks, insurance firms, telecom companies & major bookshops) compared to my local community of residence makes Accra Central attractive for me to visit.	
My work place is located at Accra Central	
Others (please write)	NOT APPLICABLE

B. TRANSPORTATION PATTERNS OF RESIDENTS USING ACTIVITY CENTRES LOCATED IN ACCRA CENTRAL

4. Which of the following means of transport do you personally own?

Means of Transport	Tick if you personally own any of these transport means	How many do you own? (please specify)
Cycle		
Motor bike		
Moped		
Car		
None		NOT APPLICABLE

5. In the last 2 months, what has been your *main transport mode* to activity centres located in Accra Central? [Note: The term ‘*main transport mode*’ as used in this survey refers to the transport mode that covers the longest distance of your journey].

Main transport mode used	Please tick ONE mode only	How often do you use this main transport mode?
Walk		
Cycle		
Motor bike(as a rider)		
Motor bike(as a passenger)		
Train		
Moped(as a rider)		
Moped(as a passenger)		
Trotro		
Taxi		
Private Car (as a driver)		
Private Car (as a passenger going with friends & family)		
Government/Company vehicle		
Metro Mass Transit bus		
Other (please specify).....		

6. What are the main reasons for using this particular transport mode when accessing activity centres in Accra Central?

Reasons	Please tick ALL that applies to you	
	Agree	Disagree
This particular mode is the most available		
This particular mode is the most comfortable		
This particular mode allows me to alight/stop at any place I want		
The fares charged for using this mode is very affordable		
This particular mode is the fastest		
This particular mode depart frequently		
This particular mode easily dodges traffic easily		
This particular mode is the safest		
This particular mode is the least polluting		
The distance is too far to use any other mode apart from this particular mode		
The distance is too short to use any other mode apart from this particular mode		
I do not have any other options apart from this particular mode		
Other reason(s) (Please specify).....	NOT APPLICABLE	

7. In addition to your main transport mode, do you usually travel by *other transport modes* from your home to activity centres which are located in Accra Central?
 Yes No
8. If ‘Yes’ to question 7, which of the following transport modes do you often use together with your main transport mode?

Other transport modes used	Please tick ALL modes that apply to you	How often do you use this main transport mode?
Walk		
Cycle		
Motor bike(as a rider)		
Motor bike(as a passenger)		
Train		
Moped(as a rider)		
Moped(as a passenger)		
Trotro		
Taxi		
Private Car (as a driver)		
Private Car (as a passenger going with friends & family)		
Government/Company vehicle		
Metro Mass Transit bus		
Other (please specify).....		

C. ENERGY USE & GREENHOUSE GAS EMISSIONS IN ACCRA

9. Kindly fill in the table below about your journey from your home to Accra Central:

Total journey duration or travel time from home to Accra Central (in main transport mode)	Total journey duration or travel time from home to Accra Central (combining main & other transport modes)	Average distance travelled from home to Accra Central	Fares charged (ONLY for public transport users e.g. Trotro; taxi; bus, train & motor bike)

NOTE: ONLY people who travel from home to Accra Central by ‘private car (as a driver)’ could answer Questions 10 & 11. If you’re not a private car driver, kindly skip these questions and continue from Question 12.

10. Kindly fill in the table below with information about the car you normally use in travelling from home to Accra Central

Fuel type used in car (e.g. Diesel; Petrol/Gasoline; LPG)	Car's manufacturing date OR total kilometres travelled (as recorded by car's odometer)	Size of car's engine (e.g. in cubic centimetres (CC))	Average fuel bought/ used in a month (e.g. per 'gallon' or 'litre' or 'cash paid')

11. Kindly fill in the table below with information about the maintenance schedule of the car you normally use in travelling from home to Accra Central

How often do you service your car's engine (e.g. engine oil & oil filter change; fuel & air filter change; engine coolant checks, brake & power steering fluid levels). Please tick ONE only	How often do you do general servicing of the car(e.g. tire rotation, tire pressure & wheel alignment checks) Please tick ONE only
Weekly <input type="checkbox"/>	Weekly <input type="checkbox"/>
Monthly <input type="checkbox"/>	Monthly <input type="checkbox"/>
Quarterly <input type="checkbox"/>	Quarterly <input type="checkbox"/>
Yearly <input type="checkbox"/>	Yearly <input type="checkbox"/>

12. To what extent do you agree with the following statements about the location of activity centres, transportation & climate change in Accra? Tick in the boxes below.

	Strongly disagree	Dis-agree	No Idea	Agree	Strongly Agree
The presence of more cars on our roads leads to high emissions of smoke or gases from cars into the atmosphere					
The unusual rainfall and high temperatures occurring in Accra in recent years is due to the emission of smoke or gases from cars into the air					
In order to reduce the emission of smoke/gases from cars into the atmosphere, it is important to provide more train and big buses to serve Accra					
If new, fuel-efficient and comfortable express buses or train services are introduced in Accra for commuting between home and Accra Central, I prefer to use them even if I have my own car.					
If pedestrian walkways and bicycle lanes are provided, and the activity centres which attract me to Accra Central are located about 45 minutes away from my home, I would prefer to walk or bike in order to access them					

D. SOCIO-ECONOMIC CHARACTERISTICS OF RESPONDENTS

13. Gender: Male Female

14. Age of respondent.....

15. What is your highest level of educational attainment?

Highest level	No formal education	Prim.	JSS/JHS/	SSS/SHS/ Mid. Sch.	Voc./Tech./ Comm.	Tertiary
Please tick box only						
Years of formal education or level of completion						

16. Which specific neighbourhood or place in Accra do you live?.....

17. For how long have you lived at this particular place?.....

18. At your place of residence, how many people do you live with as members of your own family, including househelps?.....

19. What is your primary occupation or main source of income?.....

20. If you have employment with pay, what is your income level? (NOTE: Please fill in the column which represent the time-period you receive pay for your work.)

Daily	Weekly	Monthly	Quarterly	Yearly

Thank you for making time to fill in this questionnaire.

Appendix 13: Questionnaire used during household quantitative data collection



**SURVEY OF LAND USE, TRANSPORTATION & CLIMATE CHANGE
IN THE GREATER ACCRA METROPOLITAN AREA (GAMA)**



Preamble: This questionnaire is meant to provide reliable information on GAMA's land use & transportation system and their impacts on the environment/climate. This research is being conducted by a PhD student at the Department of Geography and Resource Development, University of Ghana, Legon. Please note: Your responses will be used strictly for the purposes of the study and your information will be held in utmost confidentiality.

Form No.....

GPS Coordinates:
Lat.....
Long.....

A. USE OF COMMERCIAL & PUBLIC FACILITIES IN METROPOLITAN ACCRA

Please Note: the word ‘activity centres’ as used in this survey refer to the place where you usually go to work, shop or engage in other social activities which are beneficial to you. They may include your work place; market centres; government/public offices, recreation etc.

1. Have you accessed commercial activity centres such as markets, banks and insurance firms which are found nearer (i.e. within a walking/biking distance) to your *community of residence*? YES NO

2. If ‘Yes’, kindly indicate the particular commercial activity centre you have used

No.	Facilities/Activity Centres	Tick if you used this in your community	How often did you visit these activity centres
1	Main community market		
2	Banks within community		
3	Insurance companies within community		
4	Micro-finance firms within community		
	Other (specify)		

3. Have you accessed government/public offices which are found nearer (i.e. within a walking/biking distance) to your *community of residence*? YES NO

4. If Yes, kindly indicate the government/public offices you used

No.	Facilities/Activity Centres	Tick if you used this in your community	How often did you visit these activity centres
1	Local District Assembly office		
2	Ghana Revenue Authority office		
3	Local Judiciary Service office		
4	Police Station		
	Other (specify)		

5. Have you travelled in a motor vehicle (e.g. car, motor cycle, trotro etc.) in order to use commercial activity centres such as markets, banks and insurance firms which are found in *Accra Central*? YES NO

6. If Yes, kindly indicate the commercial activity centres in *Accra Central* you used

No.	Facilities/Activity Centres	Tick if you used this in Accra Central	How often did you visit these activity centres
1	Makola Market		
2	Agbogboshie Market		
3	Okaishie Market		
Others (specify facility & frequency of use)			

7. Have you travelled in a motor vehicle (e.g. car, motor cycle, trotro etc.) in order to use/work in government offices which are found in *Accra Central*? YES NO

8. If 'Yes', kindly indicate which of the following government offices you visited or worked in?

No.	Facilities/Activity Centres	Tick if you used this in Accra Central	How often did you visit these activity centres
1	Ministries, Departments & Agencies of Ghana		
2	Judiciary Service		
3	Police offices		
Others (specify facility & frequency of use)			

9. Have you travelled in a motor vehicle (e.g. car, motor cycle, trotro etc.) in order to use commercial and public activity centres which are found in *other parts of the city of Accra*? YES NO

10. If 'Yes', kindly indicate the commercial activity centres in *other parts of Accra* you used

No.	Facilities/Activity Centres	Tick if you used this in other parts of city of Accra	How often did you visit these activity centres
1	Kaneshie Market		
2	Madina Market		
3	Teshie Market		
Others (specify facility & frequency of use)			

11. In the past year, I accessed commercial and public offices located in Accra Central and other parts of Accra more than the ones found nearer to my community of residence

Agree Disagree No idea

12. What in your opinion is/are the reason (s) for accessing activity centres located at Accra Central and other parts of the city of Accra?

Reasons for visiting Accra Central & other parts of the city	Please tick ALL that applies to you
The location of several retail & commercial goods together at Accra Central makes it easy for me to access all that I need at the same time and place.	
The location of highly specialised services (e.g. government businesses at the Ministries Area & wholesale of certain goods and services at Makola) which cannot be obtained in my local community of residence makes Accra Central attractive for me to visit.	
The location of several service centres, e.g. banks, insurance firms, telecom companies & major bookshops) compared to my local community of residence makes Accra Central attractive for me to visit.	
My work place is located at Accra Central	

**B. TRANSPORTATION PATTERNS OF RESIDENTS ACCESSING
ACTIVITY CENTRES IN METROPOLITAN ACCRA**

13. Which of the following means of transport do you personally own?

Means of Transport	Tick if you personally own any of these transport means	How many do you own? (please specify)
Cycle		
Motor bike		
Moped		
Car		
None		NOT APPLICABLE

14. In the last 2 months, what has been your *main transport mode* to activity centres located nearer to your community of residence?

[Note: The term ‘*main transport mode*’ as used in this survey refers to the transport mode that covers the longest distance of your journey].

Main transport mode used	Please tick ONE mode only	How often do you use this main transport mode?
Walk		
Cycle		
Motor bike(as a rider)		
Motor bike(as a passenger)		
Train		
Moped(as a rider)		
Moped(as a passenger)		
Trotro		
Taxi		
Private Car (as a driver)		
Private Car (as a passenger going with friends & family)		
Government/Company vehicle		
Metro Mass Transit bus		
Other (please specify).....		

15. What are the main reasons for using this particular transport mode when accessing activity centres located nearer to your community of residence?

Reasons	Please tick ALL that applies to you	
	Agree	Disagree
This particular mode is the most available		
This particular mode is the most comfortable		
This particular mode allows me to alight/stop at any place I want		
The fares charged for using this mode is very affordable		
This particular mode is the fastest		
This particular mode depart frequently		
This particular mode easily dodges traffic easily		
This particular mode is the safest		
This particular mode is the least polluting		
The distance is too far to use any other mode apart from this particular mode		
The distance is too short to use any other mode apart from this particular mode		
I do not have any other options apart from this particular mode		
Other reason(s) (Please specify).....	NOT APPLICABLE	

16. In the last 2 months, what has been your *main transport mode* to activity centres located in Accra Central/Other parts of Accra?

Main transport mode used	Please tick ONE mode only	How often do you use this main transport mode?
Walk		
Cycle		
Motor bike(as a rider)		
Motor bike(as a passenger)		
Train		
Moped(as a rider)		
Moped(as a passenger)		
Trotro		
Taxi		
Private Car (as a driver)		
Private Car (as a passenger going with friends & family)		
Government/Company vehicle		
Metro Mass Transit bus		
Other (please specify).....		

17. What are the main reasons for using this particular transport mode when accessing activity centres in Accra Central/Other parts of Accra?

Reasons	Please tick ALL that applies to you	
	Agree	Disagree
This particular mode is the most available		
This particular mode is the most comfortable		
This particular mode allows me to alight/stop at any place I want		
The fares charged for using this mode is very affordable		
This particular mode is the fastest		
This particular mode depart frequently		
This particular mode easily dodges traffic easily		
This particular mode is the safest		
This particular mode is the least polluting		
The distance is too far to use any other mode apart from this particular mode		
The distance is too short to use any other mode apart from this particular mode		
I do not have any other options apart from this particular mode		
Other reason(s) (Please specify).....	NOT APPLICABLE	

18. In addition to your main transport mode, do you usually travel by *other transport modes* from your home to activity centres which are located in Accra Central/Other parts of Accra? Yes No

19. If ‘Yes’ to question 18, which of the following transport modes do you often use together with your main transport mode?

Other transport modes used	Please tick ALL modes that apply to you	How often do you use this main transport mode?
Walk		
Cycle		
Motor bike(as a rider)		
Motor bike(as a passenger)		
Train		
Moped(as a rider)		
Moped(as a passenger)		
Trotro		
Taxi		
Private Car (as a driver)		
Private Car (as a passenger going with friends & family)		
Government/Company vehicle		
Metro Mass Transit bus		
Other (please specify).....		

C. ENERGY USE & GREENHOUSE GAS EMISSIONS IN ACCRA

20. Kindly fill in the table below about your journey from your home to activity centres located nearer to your community of residence:

Total journey duration or travel time from home to nearby activity centres (in main transport mode)	Fares charged (ONLY for public transport users e.g. Trotro; taxi; bus, train & motor bike)

21. Kindly fill in the table below about your journey from your home to Accra Central/Other parts of Accra:

Total journey duration or travel time from home to Accra Central/Other parts of Accra (in main transport mode)	Total journey duration or travel time from home to Accra Central (combining main & other transport modes)	Fares charged (ONLY for public transport users e.g. Trotro; taxi; bus, train & motor bike)

NOTE: ONLY people who travel from home to various activity centres by ‘private car (as a driver)’ could answer Questions 22 & 23. If you’re not a private car driver, kindly skip these questions and continue from Question 24.

22. Kindly fill in the table below with information about the car you normally use in travelling from home to your activity centres

Fuel type used in car (e.g. Diesel; Petrol/Gasoline; LPG)	Car's manufacturing date OR total kilometres travelled (as recorded by car's odometer)	Size of car's engine (e.g. in cubic centimetres (CC))	Average fuel bought/ used in a month (e.g. per 'gallon' or 'litre' or 'cash paid')

23. Kindly fill in the table below with information about the maintenance schedule of the car you normally use in travelling from home to your activity centres

How often do you service your car’s engine (e.g. engine oil & oil filter change; fuel & air filter change; engine coolant checks, brake & power steering fluid levels). Please tick ONE only	How often do you do general servicing of the car(e.g. tire rotation, tire pressure & wheel alignment checks) Please tick ONE only
Weekly <input type="checkbox"/>	Weekly <input type="checkbox"/>
Monthly <input type="checkbox"/>	Monthly <input type="checkbox"/>
Quarterly <input type="checkbox"/>	Quarterly <input type="checkbox"/>
Yearly <input type="checkbox"/>	Yearly <input type="checkbox"/>
Only when necessary <input type="checkbox"/>	Only when necessary <input type="checkbox"/>

24. To what extent do you agree with the following statements about the location of activity centres, transportation & climate change in Accra? Tick in the boxes below.

	Strongly disagree	Dis-agree	No Idea	Agree	Strongly Agree
The presence of more cars on our roads leads to high emissions of smoke or gases from cars into the atmosphere					
The unusual rainfall and high temperatures occurring in Accra in recent years is due to the emission of smoke or gases from cars into the air					
In order to reduce the emission of smoke/gases from cars into the atmosphere, it is important to provide more train and big buses to serve Accra					
If new, fuel-efficient and comfortable express buses or train services are introduced in Accra for commuting between home and Accra Central, I prefer to use them even if I have my own car.					

If pedestrian walkways and bicycle lanes are provided, and the activity centres which attract me to Accra Central are located about 45 minutes away from my home, I would prefer to walk or bike in order to access them					
--	--	--	--	--	--

D. SOCIO-ECONOMIC CHARACTERISTICS OF RESPONDENTS

25. Gender: Male Female

26. Age of respondent.....

27. What is your highest level of educational attainment?

Highest level	No formal education	Prim.	JSS/JHS/ Mid. Sch.	SSS/ SHS	Voc./Tech./ Comm.	Tertiary
Please tick box only						
Years of formal education or level of completion						

28. For how long have you lived in this community?.....

29. At your place of residence, how many people do you live with as members of your own family, including househelps?.....

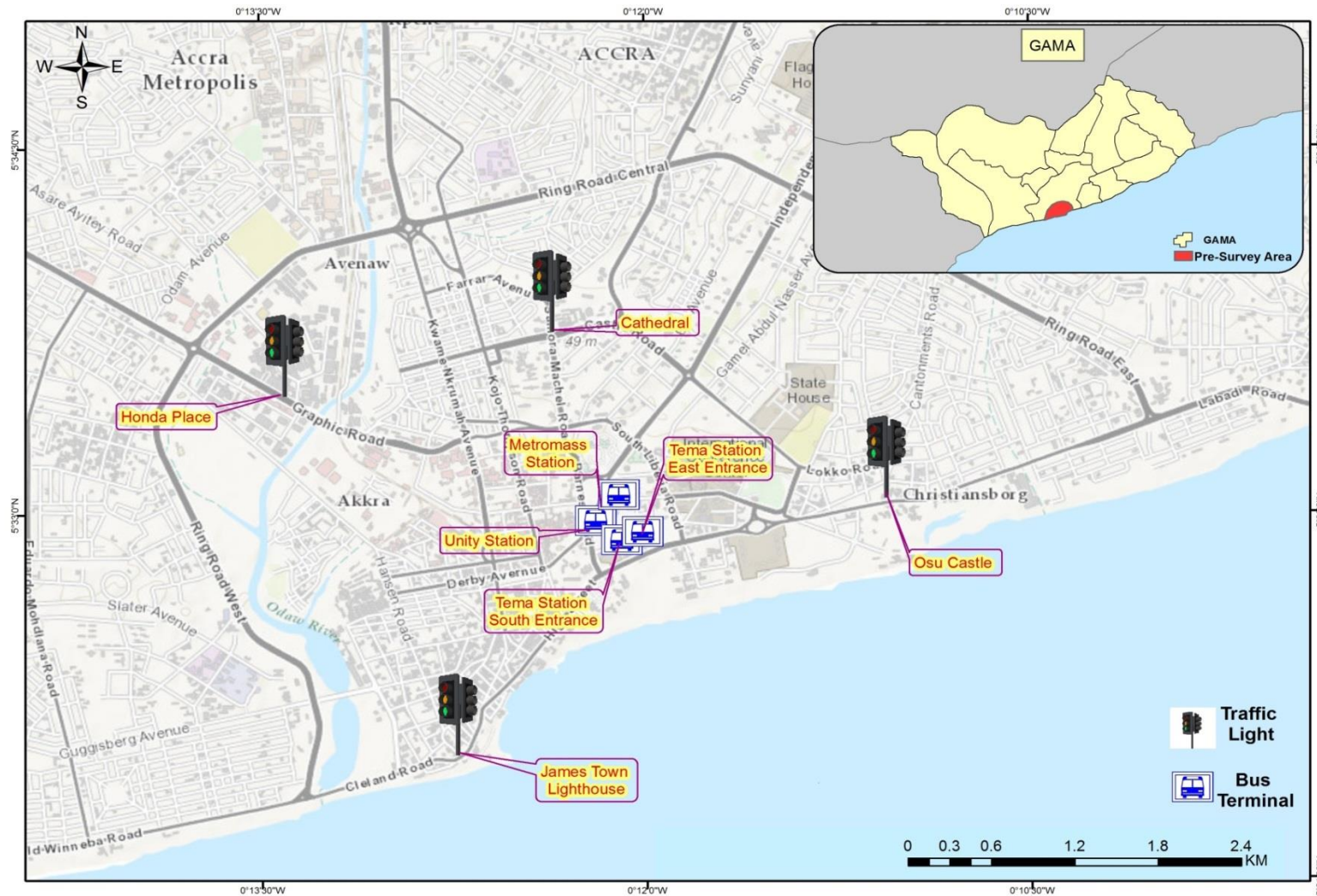
30. What is your primary occupation or main source of income?.....

31. If you have employment with pay, what is your income level? (NOTE: Please fill in the column which represent the time-period you receive pay for your work.)

Daily	Weekly	Monthly	Quarterly	Yearly

Thank you for making time to fill in this questionnaire.

Appendix 14: Map of Accra Central showing various study sites where reconnaissance surveys were conducted



Source: Author's own construct, 2014

Appendix 15: Interview guide for reconnaissance/vox pop surveys

**SURVEY ON THE UTILISATION OF THE CITY CENTRE
UNIVERSITY OF GHANA**

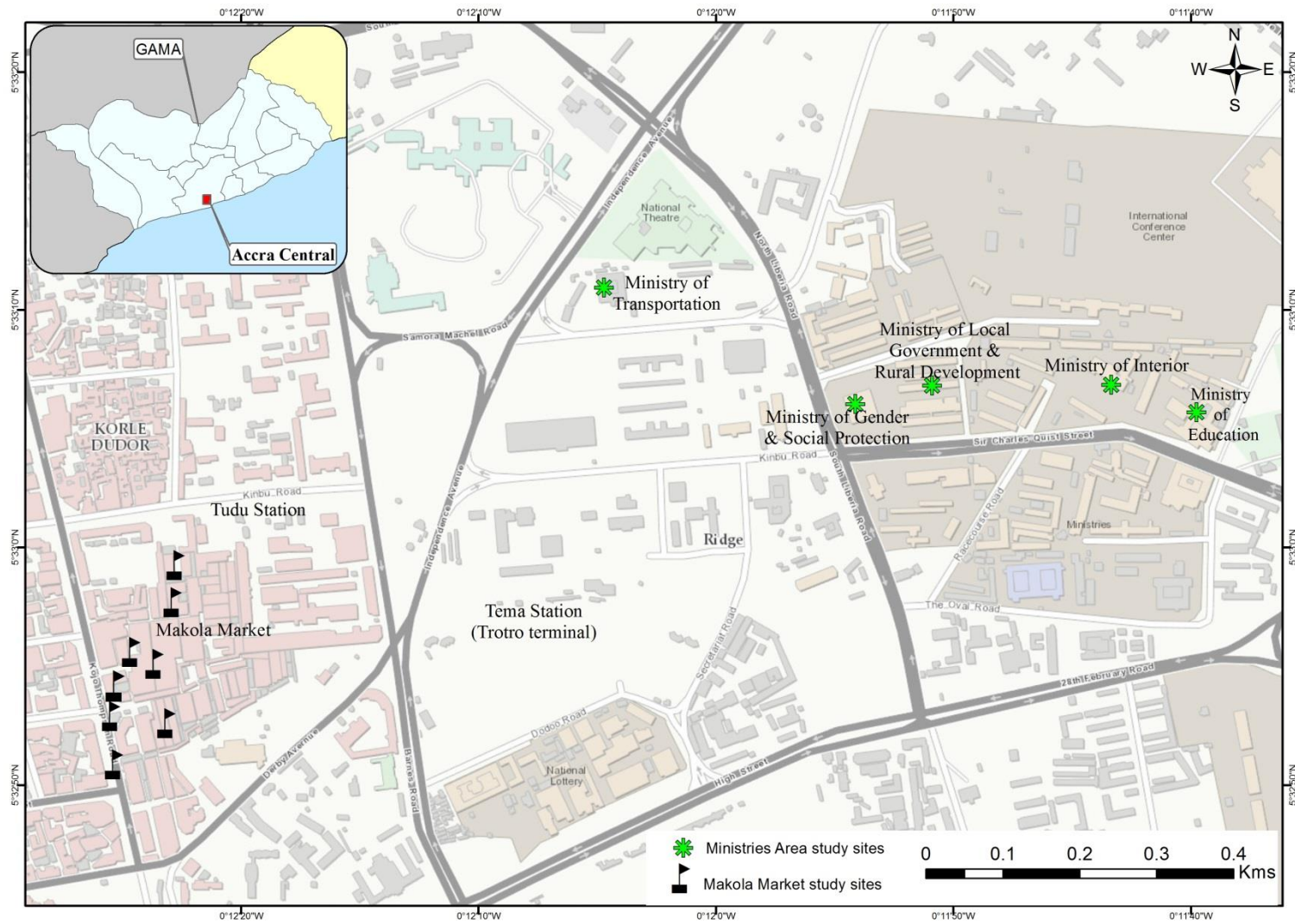


No.	Why respondent visits CBD (B)	Specific Area of Work/Shop (C)	Specific Area (Where 'C' is not defined)
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
13.			
14.			
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28.			
29.			
30.			
31.			
32.			
33.			
34.			
35.			
36.			
37.			
38.			

GPS Coordinates:
 Lat:.....
 Long:.....
 Major landmark:.....

- A. DO you live in the city center?
- B. Why do you visit the city center?
1. Work
 2. Shop
 3. Transit
 4. Recreation
 5. Others
- C. Which specific area of the city center do you work/shop?
1. Commercial (retailing, marketing, finance, insurance)
 2. Industrial(manufacturing companies, electronic repairs, auto repairs, small scale wood work; Construction, Pharmaceuticals)
 3. Educational (library, schools)
 4. Government Use (Ghana Post, Ministries, Agencies & Department; Judiciary, National Lotteries)
 5. Civic & Culture(Arts Centre, National Theatre, Chief’s Palace)
 6. Functional Open Spaces(Stadium, restaurants, Old Polo Grounds, Independence Square, Nkrumah Mausoleum)
 7. Transportation/Circulation

Appendix 16: A map of Accra Central showing long distance survey sites



Source: Author's own construct, 2014

Appendix 17: Characteristics of data on long distance trip makers

Variable	Elements	GAMA (N=338)		NON GAMA (N=62)	
		Total	Percent	Total	Percent
Sex	Female	264	78.1	47	75.8
	Male	74	21.9	15	24.2
Age	18-25	64	18.9	5	8.1
	26-35	97	28.7	22	35.5
	36-45	86	25.4	16	25.8
	46-55	59	17.5	12	19.4
	Above 55	32	9.5	7	11.3
Education	No formal education	43	12.7	11	17.7
	Basic (Primary & Jnr. Sec.)	71	21	24	38.7
	Second cycle (Snr. Sec. & Voc./Tech.)	141	41.7	18	29.0
	Tertiary (Polytechnic & University)	83	24.6	9	14.5
Occupation	Unemployed	14	4.1	1	1.6
	Self-employed	241	71.3	50	80.6
	Salaried/Gov't employee	65	19.2	9	14.5
	Others	18	5.3	2	3.2
Household size	1--5	267	79	44	71.0
	6--10	61	18	12	19.4
	11--15	6	1.8	6	9.7
	Above 15	4	1.2	-	-

Appendix 18: A high density-low income housing type at Teshie (Maami)



Source: Field data, 2014

Appendix 19: A low density high-income housing type at Teshie (GREDA Estates)



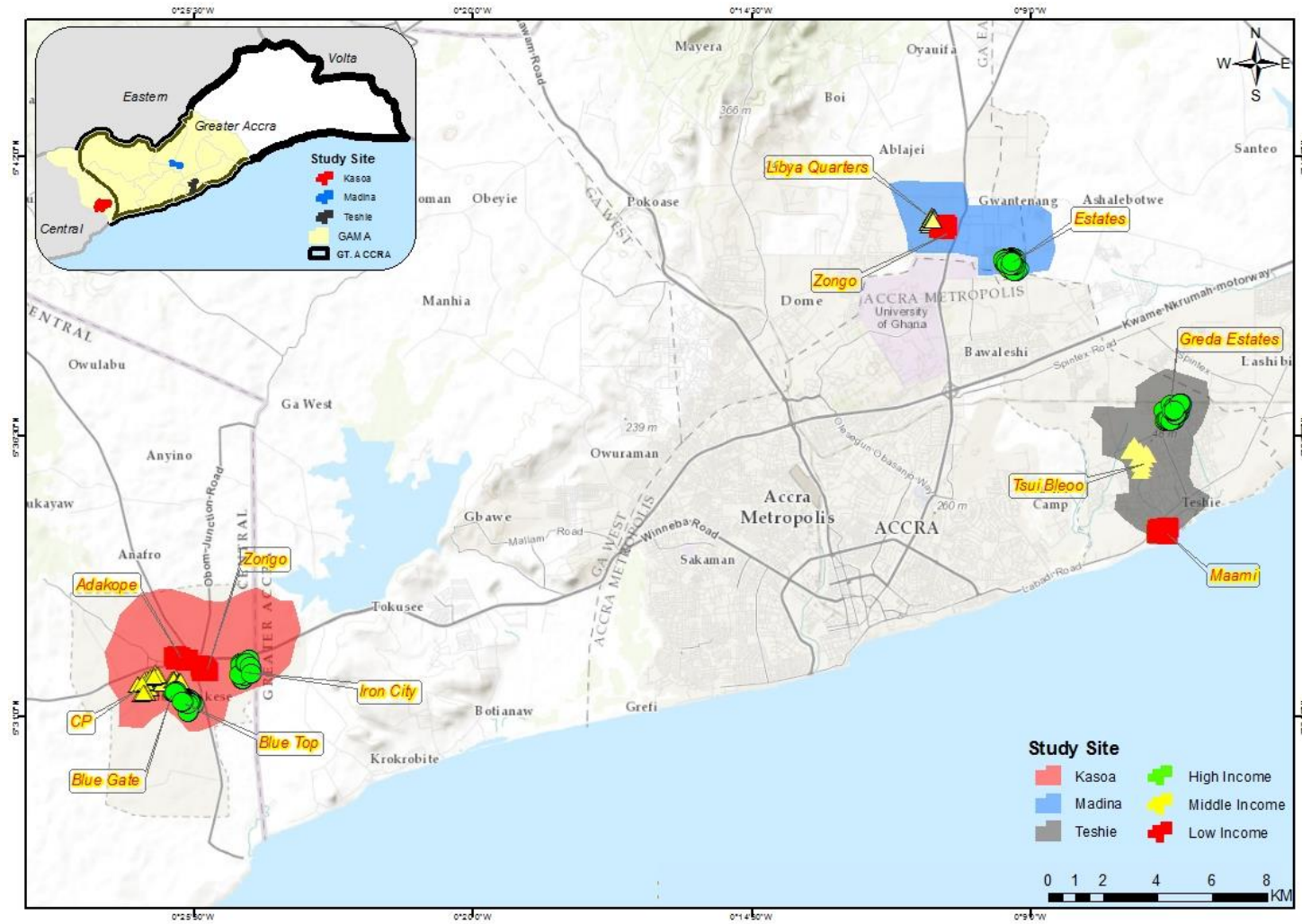
Source: Field data, 2014

Appendix 20: A medium density middle-income housing types at Madina (Libya Quarters)



Source: Field data, 2014

Appendix 21: A Map of GAMA showing household survey sites



Author's own construct, 2014

Appendix 22: Characteristics of data on short distance trip makers

Variable	Elements	KASOA (N=151)		MADINA (N=108)		TESHIE (N=141)	
		Total	Percent	Total	Percent	Total	Percent
Sex	Female	70	46.4	57	52.8	75	53.2
	Male	81	53.6	51	47.2	66	46.8
Age	18-25	24	15.9	6	5.6	13	9.2
	26-35	46	30.5	33	30.6	37	26.2
	36-45	46	30.5	44	40.7	38	27.0
	46-55	23	15.2	16	14.8	30	21.3
	Above 55	12	7.9	9	8.3	23	16.3
Education	No formal education	9	6.0	15	13.9	12	8.5
	Basic	47	31.1	33	30.6	49	34.8
	Second cycle	47	31.1	16	14.8	44	31.2
	Tertiary	48	31.8	44	40.7	36	25.5
Occupation	Unemployed	4	2.6	5	4.6	12	8.5
	Self-employed	97	64.2	77	71.3	93	66.0
	Salaried/Gov't employee	45	29.8	26	24.1	32	22.7
	Others	5	3.3	0	0.0	4	2.8
Household size	1--5	100	66.2	70	64.8	95	67.4
	6--10	47	31.1	35	32.4	41	29.1
	11--15	2	1.3	2	1.9	3	2.1
	Above 15	2	1.3	1	0.9	2	1.4

Appendix 23: Key informant interview participants

	Establishment	Status	Interview date & time
Key Informant 1	Urban Transport Project, Ministry of Local Government & Rural Development	Head of Unit	12/08/ 2014, 10:30-11:46
Key Informant 2	Road Transport Services, Ministry of Transport	Director	12/08/2014; 14:56-15:36
Key Informant 3	Ghana Private Road Transport Union (GPRTU), Tema Station	Branch Chairman	26/08/2014; 14:00-14:38
Key Informant 4	Metro Mass Transport Limited (MMTL), Kimbu Station	Acting Supervisor	27/08/2014; 13:00-13:20
Key Informant 5	Department of Geography & Resource Development, University of Ghana	Professor	10/09/2014; 15:45-17:03
Key Informant 6	Department of Geography & Resource Development, University of Ghana	Professor	12/09/2014; 11:50-13:40

Appendix 24: Interview guide for trotro drivers

Day		Route	
No. of passengers		Weather	
Gross (Weight)		Net (Weight)	
TRIP STARTS		Time	
STOPS			
	1	Comment	
	2	Comment	
	3	Comment	
	4	Comment	
	5	Comment	
	6	Comment	
	7	Comment	
	8	Comment	
	9	Comment	
	10	Comment	
	11	Comment	
TRIP STOPS		Time	

1. What fuel type does your car use?.....
2. How often do you buy fuel?.....
3. How much fuel do you buy daily?.....
4. How many trips do you make in a day?.....
5. How often do you service your car's engine/oil change?.....
6. Do you notice any changes to your car's performance after oil change?.....
.....
7. How often do you do general maintenance of your car?.....
8. Do you only use your car for business purposes?
9. Which time of the day/area of the city do you experience as congested? (most significant ones)
.....
.....

Appendix 25: Interview guide for multi-participant interview

1. Characteristics of Discussants & Operational Information

1. Kindly indicate your name.
2. Which route do you normally ply your trade?
3. How long have you driven on this route?
4. What is the make/model of the car you presently use for your business?
5. Do you only use your car for business purposes?
6. How many passengers do you usually carry per trip?

2. Energy Use and Emissions from Public Transportation

7. What fuel type does your car use? Petrol/Diesel/LPG?
8. Why do we have many commercial drivers using diesel engines for their work?
9. Have you or know any colleague driver who has switched engine from say petrol to diesel type?
10. Can you explain to me how and where the engine switch is done?
11. Why do you think some drivers change their engine?
12. Are there challenges with cars whose original engine has been changed?
13. What do you normally consider first before buying fuel at a filling station?
14. What type of fuel grade do you usually buy at the filling station e.g. Basic: ‘Super/’ Diesel/ Super Effimax/Diesel Effimax / Premium Shell V-Power/ Shell V-Power Diesel/Shell Diesel Extra for trotro
15. How often do you buy fuel? Daily/ every two days etc?
16. How much fuel do you buy?
17. How many trips do you make daily?
18. In these times of regular fuel price increment and fuel shortages, how do you ensure that you minimise your fuel consumption? Drive slow?

3. Maintenance Characteristics of Public Transportation

19. How often do you service your car’s engine/oil change?
20. Where do you normally go to change your engine oil?
21. How much do you normally pay for servicing your car’s engine?
22. Do you observe any improvements in your car’s engine performance/speed/sound after engine service?
How?
23. How often do you do general maintenance of your car?
24. Do you observe any improvements in your car’s performance after general maintenance?

4. Traffic congestion and Productivity

25. Which time of the day/area of the road do you experience as congested? (most significant ones).
26. What is your average travel time from Teshie/Kasoa/Madina to Tema Station?
27. What in your opinion account for congestion on your route?
28. When you reach congested parts of your journey, what do you normally do? Some trotro drivers jump queues. Have you seen this happen before? Have you personally jumped queue before? What motivate them/you to jump queues?
29. Some drivers re-route through other roads apart from the main corridor. Have you seen a colleague driver do that before? Have you tried that before? What motivates them/ you to do that? How do you get to know all of the other routes that connect you to Tema Station?
30. Some drivers turn off their engine in traffic. Have you notice colleague drivers do that before? Have you personally done that before? What motivates them/you to do that? How often, say in a day/week do you turn off your engine in traffic?
31. How does traffic congestion affect your productivity; health (exhaust fumes/scorching heat); car maintenance/operational cost;
32. Are there other strategies you adopt to cope with traffic congestion on your route?
33. Earlier passenger surveys on trotro operation showed varied responses. Do you agree/disagree to the following? What are your reasons?
34. X'tics of discussants
35. Weight of car?
36. Are you an owner-driver; driver of someone's car; drive & pay driver? How did you get the car you drive?
37. Age?
38. Level of education?
39. Income per month?

Appendix 26: Participants in qualitative interviews and fleet characteristics

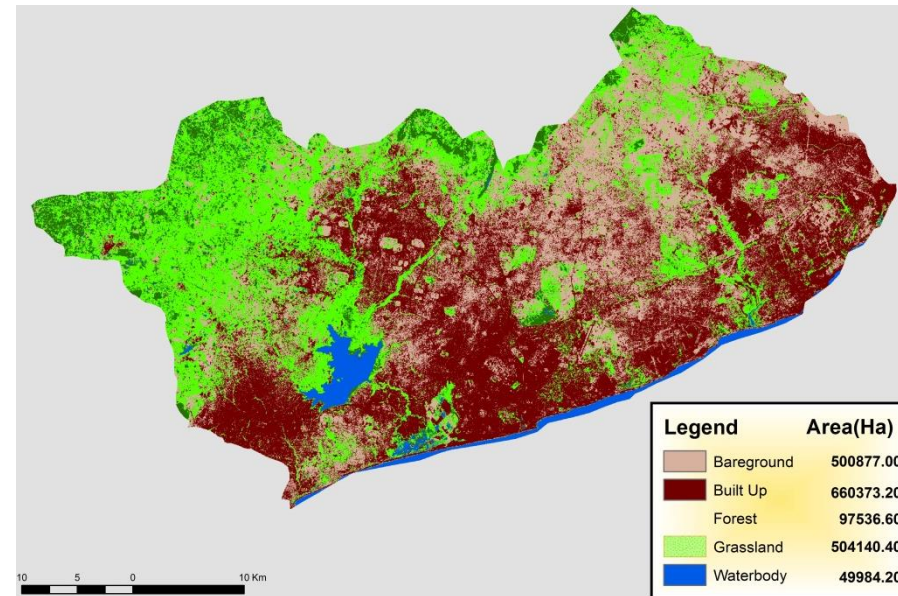
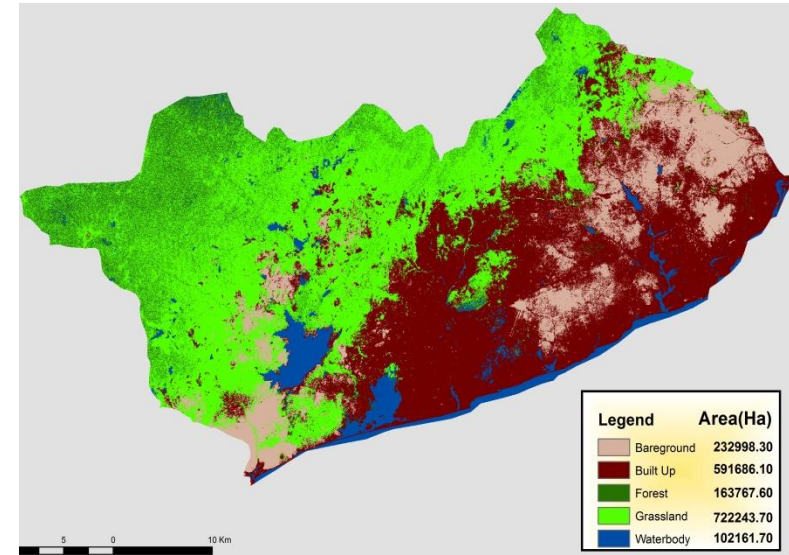
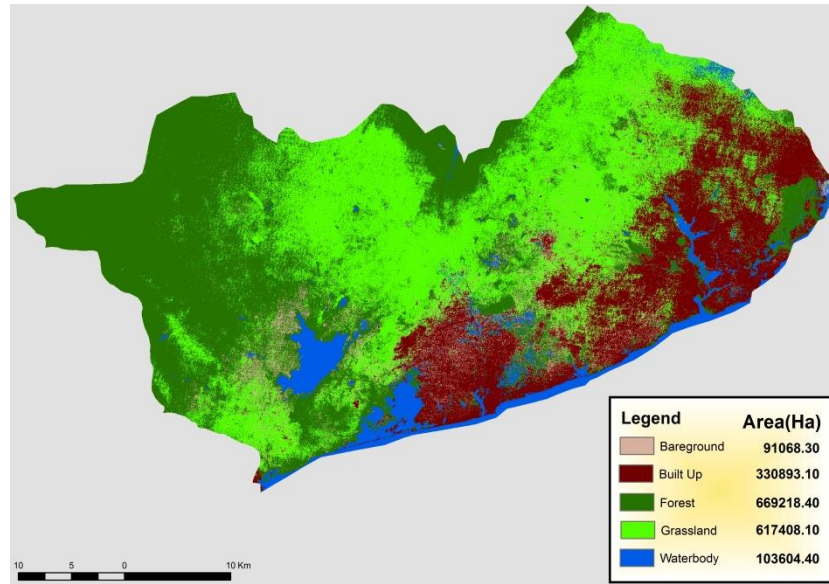
Route	Drivers	Vehicle Characteristics	Interview Type
Kasoa-Accra Central	D1	Mazda Suraj; 26 passengers; Gross 2450 kg; Net 1415 kg;	Interview
	D2	Mercedes Benz 207; 23 passengers; Gross 2450 kg; Net 1450 kg	Interview
	D3	Nissan Civilian bus; 30 passengers; Gross 5100 kg; Net 3100 kg	Interview
	D4	Nissan Civilian bus; 30 passengers; Gross 5100 kg; Net 3100 kg	Interview
	D5	Mercedes Benz Sprinter; 28 passengers; Gross 5500 kg; Net 3500 kg	Interview
	D 6	Nissan Civilian bus; 30 passengers; Gross 5100 kg; Net 3100 kg;	Group Discussion
	D 7	Nissan Civilian bus; 30 passengers; Gross 5100 kg; Net 3100 kg;	Group Discussion
Teshie-Accra Central	D8	Mercedes Benz 207; 23 passengers; Gross 1350 kg; Net 900 kg	Interview
	D9	Ford Van; 20 passengers; Gross 4000 kg; Net2600 kg	Interview
	D10	Mercedes Benz Sprinter; 24 passengers; Gross 4050 kg; Net2650 kg	Interview
	D11	Mercedes Benz bus; 34 passengers; Gross 5190 kg; Net 4550 kg	Interview
	D12	Kia Urvan; 14 passengers; Gross 1830 kg; Net 450 kg	Interview
	D13	Ford Transit; 20 passengers; Gross 4000 kg; Net2600 kg;	Group Discussion
	D14	Mercedes Benz 207; 23 passengers; Gross 4800 kg; Net 2800 kg;	Group Discussion
Madina –Accra Central	D15	Mercedes Benz 308; 23 passengers; Gross 3050 kg; Net 1450 kg	Interview
	D16	Mercedes Benz Sprinter; 24 passengers; Gross 4800 kg; Net 2800 kg;	Interview
	D17	Mercedes Benz Sprinter; 23 passengers; Gross 4800 kg; Net 2800 kg	Interview
	D18	Mercedes Benz Sprinter; 27 passengers; Gross 2450 kg; Net 1450 kg	Interview
	D19	Mercedes Benz 208d; 23 passengers; Gross 4800 kg; Net 2800 kg	Interview
	D20	Mercedes Benz 207; 23 passengers; Gross 4800 kg; Net 2800 kg;	Group Discussion
	D21	Mercedes Benz Sprinter; 27 passengers; Gross 2450 kg; Net 1450 kg;	Group Discussion

Field data, 2014

Appendix 27: Type and description of variables used in the Multinomial Logit Model on mode choice

Variable name	Description
<i>Service Quality</i>	
1 AVAIL	Most Available; 1 if Agree, 0 if Disagree
2 COMF	Most comfortable; 1 if Agree, 0 if Disagree
3 CONV	Convenience in alighting at location of choice; 1 if Agree, 0 if Disagree
4 AFFORD	Most affordable; 1 if Agree, 0 if Disagree
5 FAST	Fastest; 1 if Agree, 0 if Disagree
6 FREQ	Frequently departs; 1 if Agree, 0 if Disagree
7 TRAF	Easily dodges traffic; 1 if Agree, 0 if Disagree
8 SAFE	Safest; 1 if Agree, 0 if Disagree
9 SMOKE	Least Smoking; 1 if Agree, 0 if Disagree
10 DIST_FAR	Distance is too far; 1 if Agree, 0 if Disagree
11 DIST_NEAR	Distance is too near; 1 if Agree, 0 if Disagree
12 OPTIONS	No other transport options; 1 if Agree, 0 if Disagree
<i>Socio-spatial variables</i>	
13 GENDER	Sex; 1 if female, 0 if male
14 AGE	Age of respondent
15 EDUC	Years of formal education
16 HOUSE	Household size; 1 if 1-5, 2 if 6-10, 3 if 11-15, 4 if > 15
17 OCCUP	Occupation type; 1 if unemployed, 2 if self-employed, 3 if salaried/gov't, 4 if other
18 OWN CAR	Effect of car ownership on mode choice; 1 if yes, 0 if no
19 DIST	One-way trip distance (Km); 1 if <5, 2 if 5-10, 3 if 11-15, 4 if > 15
20 DUR	Trip duration
<i>Mode-specific variables</i>	
21 TROTRO	
22 TAXI	
23 CAR	Reference category

Appendix 28: Satellite images of GAMA during (a) 1986 (b) 2000 and (c) 2014 indicating urban expansion



Source: RS/GIS Lab, 2014

Appendix 29: Population and housing dynamics in the three selected localities

Locality	POPULATION					HOUSING		
	2000			1984	1970	Total Houses	Total Households	Average Household size
	Total	Male	Female					
Kasoa	34719	17181	17538	2597	863	3810	7108	4.9
Teshie[1]	92359	45094	47265	-	-	7088	20732	8.9
Madina	76697	37625	39072	28364	7480	6948	16131	4.8

Source: Compiled from Ghana Statistical Service, 2002. Note that the 'Teshie' statistics include both

North and South Teshie enumeration areas