UNIVERSITY OF MINES AND TECHNOLOGY, TARKWA

FACULTY OF INTEGRATED MANAGEMENT SCIENCES

DEPARTMENT OF MANAGEMENT STUDIES

A THESIS REPORT ENTITLED

SUSTAINABLE MEANS OF TRANSPORTING MINING GOODS TO A LOGISTICS CONSOLIDATED PLATFORM: A PROPOSITION

SUBMITTED IN FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF THE DEGREE OF MASTER IN ENGINEERING MANAGEMENT

BY

PRINCE KOFI OTCHERE

SEPTEMBER, 2022

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DECLARATION

I declare that this thesis is my own work. It is being submitted for the degree of Master in Engineering Management in the University of Mines and Technology (UMaT), Tarkwa. It has not been submitted for any degree or examination in any other University.

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(Signature of Candidate)

…… day of …...…………….2022

ABSTRACT

The movement of goods and services severely impacts the development of supply chain and urban sustainability. Both scholars and decision-makers have recently given the idea of city logistics and intermodality a lot of attention. City logistics are crucial to maintaining the viability of metropolitan regions in which urban freight transportation also significantly impacts how well people live there. Optimizing urban freight transportation substantially impacts the sustainability and livability of cities and urban areas by lowering traffic congestion, minimizing traffic accidents, and attenuating the effects of CO_2 emissions and noise. The supply chain of mining and sub-contractor companies in Tarkwa is mostly done by road freight which creates massive environmental, safety and traffic congestion. Therefore, this thesis evaluates creating a new transport network to haul mining goods and services to a consolidated logistics platform. To achieve this, a wide range of literature assessments relevant to peripheral logistics platforms' impact on cities' sustainability were examined. It appears that there aren't any well-defined models that can provide a thorough and quantitative evaluation of sustainability for the rerouting of transport networks. Field traffic flow observation and a case study on Goldfields Damang were used to perform additional research. A mixed-methods study using both a qualitative and quantitative component was conducted based on all the data gathered from the pertinent sources. This thesis created a methodical technique using google Maps and Jupyter notebook to evaluate the significant elements that affect a move in the context of all three sustainable aspects: social, economic, and environmental growth. These effects include traffic congestion, travel time and distance, increased emissions, cost-effective transportation, and improved mobility. The simulation revealed the necessity of having new transport link to the consolidated platform to enhance

intermodality. Research must be done into how government and other stakeholders can partner to build an intermodal logistic platforms with well enhanced transport networks, and the use of GIS in location selection to create smart city concepts.

DEDICATION

This study is dedicated to my late Parent, Mark Otchere and Rosemond Arthur, for their tutorship, guidance, and care for me to get this far. I also dedicate this thesis to my beloved Le-El Ruby Ekuba Otchere for her commitment and support throughout the period of my study in UMaT.

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ABBREVIATIONS

UMaT	University of Mines and Technology
TBL	Triple Bottom Line
CSV	Comma Separated Value
UCCs	Urban Consolidated Centres
BSS	Binnen Stad Service
CO_2	Carbon Dioxide
ECR	Earning Credit Rate
GDP	Gross Domestic Product
HTML	Hypertext Markup Language
CSS	Cascading Style Sheets
JS	JavaScript
GPS	Global Positioning System
Min	Minute
Kg	Kilogram
Lit	Liters
Lon	Longitude
Lat	Latitude
Coord	Coordinates
PHDA	Prestea Huni-valley Municipal Assembly
DHL	Dalsey, Hillblom and Lynn
WCED	World Commission on Environment and

	Development
OECD	Organization for Economic Co-operation and Development

CHAPTER 1

INTRODUCTION

1.1 Background of the Study

Mining contributes significantly to the economic growth of most developed and emerging economies, including Ghana, which is among the top ten producers of numerous critical minerals internationally. Recently, as the industry keeps expanding, mining companies also tend to increase their production line. In this vein, well-organized systems in the supply chain, such as building the right transportation and distribution network, should be encouraged (Zadeh et al., 2014). Accordingly, high-quality transportation, processing facilities, and storage in the halls must all be highly important for economic and social advancement. In this line, the construction of multi-modal logistics systems could help diversify the region's industries and lay the groundwork for a competitive and innovative business that can quickly adjust to changing economic conditions in the global economy (Jumaniyazov 2010).

The transportation sector is beset by traffic congestion, local air pollution, fossil fuel exhaustion, carbon emissions, and the dangers of accidents that affect cities (Geels et al., 2011). Because smaller mines are typically located in remote rural locations, transportation for their equipment and other products is a crucial concern for the mining business (Gupta et al., 2018). The mining companies use several pieces of equipments, including heavy and light duty, for their operations. Most notably, the heavy-duty to their remote sites usually causes several environmental and safety issues. According to Gupta et al. (2018), delivering a total volume of produced coal from mines to destinations, exporting by-products to dumps, and transporting commodities with maximum speed, minimum cost, and higher traffic safety are the key transportation activities in the mining business.

Today, the mining industry's most significant challenges are its effects on the environment and social life and economic and commercial factors. As a result, sustainability and sustainable development have arisen as critical requirements that the mining industry should prioritize. The increased intensity of mining truck traffic on specific routes hurts the surrounding areas, affecting the road network and residents' quality of life while also wreaking havoc on the natural environment (Institute for Territorial Development 2012; Supreme Audit Office 2011). While most problems have environmental and social consequences, they also have economic consequences (Markard et al., 2012), exacerbated in times of financial crisis and public budget overruns (IEA, 2009). With the growing problem of urban traffic congestion in large and medium cities, transportation must be coordinated utilizing various tactics such as city logistics (Morana, 2014).

Therefore, as economic growth accelerators, cities will continue to thrive and promote a country's much-needed economic development. Indeed, urban logistics has become a critical component of a city's expansion and development. An innovative and well-developed city logistics system can boost economic growth, minimize high transaction costs, improve economic efficiency, improve the investment climate, stimulate foreign direct investment, eliminate urban unemployment, and promote regional economic development (Rao et al., 2015).

According to Gajšek et al. (2012), to save time and resources, it is significant to think in the direction of establishing a joint resource base whose assets could be deployed, if necessary, to execute the exchange of information, goods, financial support and intangible re-sources with business partners to overcome distances within or between regions through external logistics activities. As transportation and logistics systems continue to integrate, their impacts on the ecology, especially air, water, and land resources, will become more complicated soon (Rondinelli and Berry, 2000). Firms must therefore realign their competitive priorities by focusing on accessibility, routing constraints, types of transportation modes, delivery time, reliability, and cost (Banomyong, 2004; Rodrigue, 2008). The mining industry in Tarkwa can achieve this by collaborating and building a consolidated platform where large volumes of goods can be kept and distributed evenly to the mining sites.

According to Rimienė and Grundey (2007), a consolidated platform is also known as the logistics center concept, which is widely merged with knowledge of distribution centers, central warehouses, freight/transport terminals, transport nodes, logistics platforms, freight villages, logistics depots, and distribution parks, among other things to satisfy customers needs. Cambra-Fierro and Ruiz-Benitez (2009) also highlighted how creating a logistics platform where different supply chain agents can be integrated into the exact physical location can reduce transportation costs and cycle times, improve overall customer service, and contribute to a critical competitive advantage. Great multimodal logistics platforms may be found in Spain's Zaragoza Logistics Platform (PLAZA) and Italy's Padua Cityporto (Hamid and Rozario, 2018).

The identified issue is essentially a beginning point for a conversation about how to effectively balance the effects of mining transportation on the environment while maintaining industrial functionality and development. This issue is significant in every city's development goals, and local governments, in collaboration with the mining industry, in the Tarkwa municipality, should modify the transportation infrastructure to limit its negative effects.

Crainic et al., 2016; Nathanail et al., 2017; Franceschetti et al., 2017; Groß et al., 2017 are examples of recent research on sustainable city logistics and urban transport systems, but there are minimal studies based on finding solutions for mining transport traffic jams using simulation tools which has a wide range of characteristics to consider. As a result, this thesis is a little attempt to bridge the gap between the limited methods to identifying the benefits of locating mining transport jams. This thesis will also seek to determine the benefits that the community and the mining industry can achieve as a result of using sustainable means to transport mining materials by employing a mixed methods technique and doing both qualitative and quantitative research.

1.2 Statement of the Problem

Tarkwa, as a regional mining hub in Ghana, boasts of several top mining companies and sub-contractors. Almost all these companies procure and transport major equipment, machinery, and other products weekly or monthly. Over 90% of the transportation means for conveying them is road freight, specifically using long vehicles. This tends to create massive environmental, safety, and traffic congestion problems for the residents of Tarkwa and nearby communities. According to Allen et al. (2012), the urban freight transportation system has detrimental effects on the ecological and social elements such as fuel consumption, greenhouse gas emissions, air pollution, traffic congestion, noise pollution, and an increase in the frequency of accidents. To control and overcome this problem, an effective inter-modal transportation network linked to a consolidated platform has to be promoted. This will help reduce the burden on road transportation in Tarkwa, reducing the release of carbon emissions, traffic congestion, and unwanted accidents to help achieve the UN's sustainable goal 11 of sustainable cities and communities.

In the past few years, sustainability in advanced nations has become an absolute priority in major industrial cities and emerging ones due to shifts in technologies (Geels, 2005; Hekkert et al., 2007; Markard et al., 2012;). Decarbonizing energy and effective transport systems are the most notable examples of sustainability transition (Verbong and Geels, 2007).

In order to achieve significant transitions with regards to sustainability, a systematic and well-planned approach should be developed to suit city logistics. This approach can go a long way to ensure significant decision making with regards to the selection of a location, transportation means or modes to ensure: reduction of road freight transports in busy city areas, reduction of accidents, air and noise pollution, reduction of transportation travel and transit times and promotion of intermodal transportation (Aljohani and Thompson, 2016).

1.3 Research Objectives

The specific aim of the study is to:

1. Examine key factors necessary for the developing an effective means of transporting mining goods to a consolidated platform by mining companies.

2. To investigate the economic, environmental and social benefits for developing an effective transport network to a consolidated platform.

1.4 Research Questions

1. What are the factors that encourage mining companies to develop an effective means of transporting goods and services to a consolidated platform?
2. What economic, environmental and social benefits can be gained from developing an effective transportation network to a consolidated platform?

1.5 Justification of the Study

Research into the area of assessing the effective means of transporting mining equipment and goods is essential for numerous reasons. First, it is going to help determine the best transportation network to transport mining equipment and products to ensure smooth flow and delivery of products, secondly, reducing traffic congestion in city centers, prevent road accidents and deaths, air and noise pollution and thirdly, for the company to enjoy economies of scale.

The study is expected to reveal the importance of having another route to argument the existing route in use and also increase transport mobility to be a vital driver of both economic and social development which determines access to jobs, goods and services. This optimization of freight movement is deemed to aim at the urban logistics as it has a great influence to increase the city mobility among other environmental and economic benefits.

Furthermore, it will lead to the invention of Intermodal transport facilities which will further increase the logistics prospects of the community to create more job opportunities. The intermodal transportation system is a typical hub consisting of finely distributed collection systems, a practically distributed long-haul system and more than one transportation modes (Flodén, 2007). Finally, another significant contribution the study will bring is the reduction of traffic congestion. The idea of applying the simulation tool on this thesis is to demonstrate the traffic flow of the city to know the most affected areas to use it as a basis to plan new transportation routes which will reduce travel and transit times, fuel consumption and cost and to ensure a sustainable and environment-friendly city.

As a result, management can utilize the findings to identify the optimum way to convey mining equipment and goods as well as contributing towards UN's sustainable goals.

1.6 Scope of the Study

This study focuses on assessing the significant means of transporting mining equipment and goods to a consolidated platform. The study will cover the transport network used by the mining companies of Tarkwa and their major mine sites. It is therefore relevant that the required assessment is done with the assistance of the simulation model to identify the traffic points for analysis. Data will be acquired from top personnel in the mining industry of Tarkwa, with a particular focus on the officers in charge of Supply Chain and Transport.

1.7 Limitations of the Study

There will always be limitations in research, and this study is no different. These limitations will undoubtedly have an impact on how the investigation is carried out. The researcher must contend with tremendous time pressure. Due to the researcher's need to balance his professional and research responsibilities, time was severely limited. This was due to the fact that it constrained the type of work that would otherwise have been done if the researcher had the most time.

1.8 Organization of the Study

The study is organized along five main chapters. Chapter one introduces the study which composes the background to the study, problem statement, study objectives, research questions, the study area, significance of the study and the chapter organization. Chapter two contains relevant literature on the subject under study. Chapter three is research methodology, highlighting sources of data, study population, sample size, sampling technique, data gathering instrument, data collection procedure, data analysis procedure and limitations of the study. Chapter four covers the results presentation and data analysis. And the fifth chapter covers discussions, recommendations and conclusion.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

The topic, context, problem statement, objectives, and research question were all introduced in the previous chapter and served as the general introductory chapter. Additionally, it examined the thesis' organization and the study's importance and expectations. Finally, it aimed to put the subject covered by the research into context. Finally, it offered a few insights that contributed to development of an understanding and purpose, as well as an expectation for the conduct of this research.

This chapter, however discusses the pertinent annotations, overviews, and theories that examine the sustainable means of transporting goods to a consolidated platform. The chapter will also examine in detail the empirical research as well as the current contextual and conceptual framework, which presents a critique on the on-going inquest of transporting goods to and from the consolidated platform.

Concerning the current trends and topics about the research issue, it sought to situate the subject within the body of pertinent literature and provide the necessary framework. This also made it possible to follow up on citations to crucial sources in the research field to gain further context for the subject. By doing this, the contributions of these critical sources were made public while also highlighting any potential gaps that needed to be filled. For a more in-depth understanding and practical application, a thorough examination of the ideas and concepts behind the topics was also done. This examined the definitions and comprehension of different academics in the field of study on the crucial terminology from their diverse points of view.

To understand the historical and present state of knowledge about the subject, the review identified, described, and examined connected scholarly works in the research area. An adequate discussion was then established using the understanding gained from what was found to be existing knowledge in the literature to help answer the research question. The following categories of literature reviews were done: a conceptual, theoretical, empirical, and conceptual framework.

2.1 Conceptual Review

This section entailed assessing writings by authors on ideas connected to the topic matter. The section defined terms such as sustainability, urban freight transport system, sustainable urban freight transport system, urban freight consolidation, sustainable strategies for their implementation, and the importance of consolidated urban centers in the present scenario.

2.1.1 Sustainability

The terms sustainability and sustainable development have grown much more important in academic studies of environmental problems, environmental management laws, and industrial and agricultural output, among other topics (Ruggerio 2021). It incorporates two major concepts: the concept of 'needs,' particularly the essential needs of the world's poor, to which top priority should be given; and the idea of restrictions imposed on the environment's ability to supply existing and future requirements by the state of technology and social structure

(Behrends et al., 2008). This concept emphasizes three critical elements of sustainable development: (1) economic growth, (2) social fairness for fulfilling today's and future generations' needs, and (3) environmental protection for meeting today's and future generations' requirements. It also disproves the widely held belief that some environmental and societal repercussions are trade-offs for economic development.

Lozano (2012) defines these characteristics as activities that proactively contribute to the maximum assurance of sustainability in his research on corporate sustainability.

Elkington (1999) also created the Triple Bottom Line (TBL) concept, which considers various bottom-line characteristics beyond legal perspectives, such as social and environmental assessments. Lozano (2008), on the other hand, highlighted and introduced a new perspective on sustainability based on the World Commission on Environment and Development (WCED) concept, which includes: (1) the traditional economists' perspective, (2) the social perspective, (3) the integration perspective, which encompasses economic, environmental, and social dimensions, 4) the inter-generational perspective, which focuses on time, and 5) the holistic perspective, which is intended to help the public understand sustainable development and raise awareness.

2.1.2 Urban Freight Transport System

The OECD (2003) defined urban freight transport as the delivery of consumer goods (not only by retail but also by other sectors such as manufacturing) in city and suburban areas, including the reverse flow of used items. From an actor's standpoint, Dablanc (2008) defines urban freight transport as transporting commodities by or for professionals in an urban context. Urban freight transportation allows citizens to access products consumed and used daily (food, clothing, furniture, books, cars, computers, and so on) wherever and whenever they need them, thus playing an essential role in meeting citizens' needs. Still, it contributes significantly to the 12 unsustainable effects on the environment, economy, and society (Behrends et al., 2008). Researchers, scholars, and professionals have attempted to apply sustainable development ideas in urbanisation, and metropolitan nations since Brundtland's study in 1987 brought global attention to the notion (Goldman and Gorham, 2006). In the progression of sustainable urban development, urban transportation plays a critical role (Russo and Comi, 2012). Based on the generic principles of sustainable development, May et al. (2001, p.26) identified six sub-objectives of a sustainable urban transportation system. These principles include: 1) economic development, 2) livable and healthy roads, streets, and neighborhoods, 3) ecological protection, 4) equity and social inclusion, 5) safety and 6) economic swing contribution.

Safety, fuel consumption, road access, congestion, and car emissions are also five critical factors for sustainable transportation, which are particularly relevant in urban environments, according to Richardson (2005).

2.1.3 Sustainable Urban Freight Transport System

According to Behrends et al. (2008), a sustainable urban freight transport system achieves all of the following goals: to ensure that the transportation system is accessible to all types of freight transportation; to reduce air pollution, greenhouse gas emissions, waste, and noise to levels that do not harm citizens' or nature's health. To improve the resource and energy-efficiency, as well as the cost-effectiveness of goods transportation, while accounting for external costs; to contribute to reducing global warming. The transportation system is a significant contributor to the unsustainability of urban regions, as well as many negative social, environmental, and economic aspects of urban freight transportation that policymakers can target to enhance sustainable circumstances (Browne et al., 2012). While freight transit accounts for approximately 10% to 18% of all cars in cities, it accounts for roughly 40% of air pollution and noise emissions (European Commission, 2006). When it comes to urban locations, it's also vital to consider if a place is attractive or suitable for living, as well as issues such as traffic, noise, and safety (European Commission, 2011).

On both the provider and user sides, freight transportation is regarded as a private sector phenomenon driven by commercial imperatives, causing traffic conditions in cities worldwide to worsen (Behrends et al. 2008). According to Crainic et al. (2004), official authorities are unconcerned about private-sector operations leading to the number of vehicles of all types rapidly expanding. As a result, traffic congestion and pollution levels are rising, harming the city's quality of life. The vast majority of cities, particularly in Europe, have yet to come up with suitable methods to optimize urban commodities mobility. All players appear to be anticipating initiatives from the opposing side. On the one hand, city governments expect businesses to establish new logistics services tailored to the evolving needs of customers and retailers; on the other hand, logistics providers wait for municipalities to initiate (and subsidize) new services before launching a business, which could be unprofitable and risky (Dablanc, 2007a). This has therefore made it difficult to design clear logistical standards that account for all traffic congestion (Behrends et al., 2008).

2.1.4 Urban Freight Consolidation

The freight transportation industry is a significant employer and frequently contributes to regional and national economic development, and traditionally, operating businesses are in charge of urban freight transportation planning (Morana et al., 2014). However, due to congestion and other factors, freight transportation is also a source of environmental disruption, especially in cities (Crainic 2008). For more than fifteen years, city logistics has been developed in urban contexts, providing solutions and approaches to assist public authorities and other stakeholders in the planning and administration of urban freight transportation (Taniguchi et al. 2001). These solutions are aimed at better understanding and quantifying these phenomena. They are the first step in forming new science that various writers have dubbed City Logistics Urban Logistics or Consolidation centers (Morana et al., 2014). According to Morana et al. (2014), Urban Consolidation Centers (UCC) are one of the most common solutions for freight transport conundrums. Several city logistics actions are organized around the concept of the urban consolidation center (UCC), which is defined by Allen et al. (2010) as a logistics facility located in relatively proximity to the geographic area that it serves, which many companies deliver goods destined for the site, from which consolidated deliveries are made within that area. According to Cidell (2010), freight transportation has shifted from historical central sites to peripheral suburban regions in recent decades due to: the massive growth of suburban zones that accommodate inter-modal logistics centers; changes in global logistics industries' requirements; the need for diversity in transportation modes; easier or shorter distances to the main road, rail, and air transportation; and new infrastructural developments. Technological advancements force businesses to consolidate their operations on a single platform, which usually necessitates more space (Glasmeier and Kibler, 1996).

According to (Morana et al., 2014), in as much as UCCs have several positives, they have their limitations as well. They highlighted that UCC requires significant upfront investments in infrastructure, facilities, and human and technical resources (including delivery vehicles), frequently augmented by public funding. This assistance is insufficient, as the UCC's overall income does not always meet operational costs. Furthermore, under certain circumstances, transport operators are still hesitant to employ UCCs because the schemes associated with these logistics platforms require at least one additional transshipment. Ville et al. (2010) also emphasized the following as the primary drawbacks to employing UCC systems:

1. Legislation: Although it can be viewed as a positive component in UCCs but legislation can be a stumbling block when it comes to freight compatibility, i.e., the rules and regulations that prohibit the transport of hazardous materials, loading a truck with a variety of things (for example, hazardous materials) when dealing with commodities, fresh food, garbage, raw materials, and so on) or when dealing with competitors.
2. Organization: The physical and organizational requirements for freight compatibility can stifle the growth of a UCC. This means dimensions, type of packaging, stock unit, and the necessity for specific loading and unloading equipment will always limit the coexistence of two shipments on the exact vehicle or consolidation platform.
3. Cost: If a transshipment necessitates organizational change, it also requires an increase in prices. Although some UCCs have devised optimization strategies to lower these expenses

and impute equivalent fees to transportation providers, the issue remains concerning when planning and creating these platforms.

4. Responsibility. The criteria relating to the transport operator's duties are spelled out in the contract between the various parties. It will not interfere with sharing if the collaboration between UCC distribution system partners and customers is governed by an agreement or charter that clearly defines accountability issues.

2.1.5 Sustainable Strategies for Urban Consolidation Centers

According to Allen et al. (2012), the economic benefits of urban freight transportation represent alleviating some of the challenges they face, such as a shortage of room for loading/unloading, handling, delivery, and client collection time. Sustainable city logistics, whose goal is to establish the best logistics operation for the freight distribution system that can be taken into account for both environmental and economic benefits of the enterprises, could play a vital part in overcoming these issues (Taniguchi et al., 2003).

Research, such as Rao et al. (2015), He et al. (2017), and Liu et al. (2012), the parameters for selecting the site of UCCs are as follows

A. Economic criteria: land cost, where adequate space will allow for smooth operation; flexible delivery, where a suitable location will allow for a reduction in lead-delivery time; transportation condition, where the availability of various forms of transportation will make freight operations easier

B. Environmental criteria: Environmental concerns relevant to environmental protection, such as reducing air pollution and greenhouse gas emissions; impact on the ecological landscape to be protected from harm; climatic conditions such as temperature, rainfall, and floods.

C. Social criteria: Infrastructure availability, such as roads and communication facilities; safety and security; adherence to public authority roles and rules; impact on adjacent neighborhoods, such as disruption of life quality and public health.

2.1.6 Importance of UCCS in Logistic Centres

In terms of functions and performance, the word "logistics center" is used in a variety of ways: a distribution center, a central warehouse, freight or transportation terminal, a logistics center, a distribution center, the central warehouse, an urban consolidation center, a transit node, freight village, logistics depot, distripark, etc. (Rimien and Grundey, 2007). Paddeu (2018) highlighted further case study analyses by concentrating on the stakeholders' perspective to identify the significant successes of a UCC program. He demonstrated how the case of SMILE in Malmo was successful. SMILE enabled receivers and suppliers to collaborate to shorten the distance fresh food traveled. Additionally, Binnenstadservice (BSS) in Nijmegen is an excellent example of UCC success, prioritizing receivers over carriers. This project included small and independent retailers where deliveries are provided free of charge by ecologically friendly delivery vehicles. The strong results of the BSS project in Nijmegen prompted other franchise attempts in other Dutch towns (for example, BSS has already begun operations in Den Bosch without any subsidies). As a result, BSS becomes a more exciting partner for carriers by expanding the concept to additional Dutch cities, which could result in new revenue for the company. Morganti and Gonzalez-Feliu (2015) also investigated Parma's consolidation center known as Ecocity, which was established because 55% of the pollution produced by road vehicles is related to freight transport. The implementation of the Ecocity resulted in Suppliers and transport operators delivering to the freight consolidation center, where the items are subsequently returned to receivers in the city center by 14 vehicles, aligning with the local authorities' aims of:

1. Avoiding harmful effects on citizens' health, air pollution, greenhouse gas emissions, waste, and noise.
2. Improving resource and energy efficiency, as well as the cost-effectiveness of products transportation, when external expenses are taken into account
3. Improving the beauty and quality of the urban environment by reducing accidents and traffic congestion while maintaining citizen mobility.

Sheffi (2013) also highlighted several distinctive aspects and advantages that are linked with industrial logistics platforms like UCC: a lower cost of transportation; a higher volume of freight transportation; a higher frequency of transit; shared assets in the vehicle, numerous enterprises using the same platform; faster and better customer service; the flexibility of the platform growth of logistics network capabilities; shared workforce; employment generation and increased diversification; employment; modern and creative operation and management system the terms of technology and innovation, as well as the other way around. Cambra-Fierro and Ruiz-Benitez (2009), also in their study about the Zaragoza logistics platform, emphasized how logistics platforms like the UCC create intermodalism. According to them, intermodalism has emerged as a critical idea in freight transportation due to changing business trends. Effective transportation connectivity and the capacity to combine many modes of transportation in a single coordinated freight movement are essential for managers. Furthermore, Intermodalism can lead to the outcomes of alliances, joint ownerships, networks, or the share of modes or terminals, which usually enhances economies of scale (Olivier and Slack, 2006).

2.2 Theoretical Review

Varpio et al. (2020) define a theoretical framework as a rationally created and integrated collection of concepts and premises advanced from one or more theories by a researcher to support a study. According to Trochim (2006), there are two areas of research: theory and observation. He defines theory as what is happening inside the researcher's head, whereas observation refers to what happens in the real world where data is being* gathered. An effective theory or combination of ideas can direct every step of your study, from developing your problem statement and research questions to presenting the results of your data analysis and writing your conclusions (Simon and Goes 2011). In light of the aforementioned and to respond to the research question, this study would be influenced by the theory of change.

Theory of Change

Reinholz and Andrews (2020) defined theory of change as a diagram or written description of strategies, actions, conditions and resources that facilitate change and achieve outcomes. It has explanatory power that is it should be able to tell why you think a particular activity or action will lead to a particular result. A good theory of change can give a program rationale that is based on best available research and practice evidence while also clarifying any assumption made by achieving success.

From Church and Roger (2006), theory of change is very useful in evaluation by explaining how you will plan to get from program delivery to achieving outcomes.

Creating city logistics is an act of organizational change, and the question is how it emerges, develops, grows, or dies (Van de Ven and Huber, 1990). Four theoretical change kinds are briefly provided here to connect change process theories to city logistics.

Change Perspective	Explanantion
City logistics from a life cycle perspective	City logistics is viewed as a single organizational unit with principles for constructing city logistics and a path to follow. The municipality regulates the organization and its operations. Citizens and the municipality will recognize the results over time. Still, new solutions will outperform the present solution - it will "die" (disappear), but "seeds" for new and improved ways of managing delivery in the city will be developed. After that, a new life cycle will begin.
City logistics from an evolutionary standpoint	The expectation is that there are multiple city logistics models and that the ones that adapt best to the environment would survive and develop through natural selection; in the business world, this is called competition. The interaction of self-organizing interdependent elements in complex adaptive systems then produces more and newer versions of city logistics (Nilsson and Gammelgaard, 2012; Van de Ven et al., 2013).
City logistics from a dialectical standpoint	The "thesis and antithesis" of numerous separate organizational bodies colliding into a conflict indicate different viewpoints and perspectives on city logistics. When the process has a beneficial end, this conflict may be addressed by a so-called synthesis, a new solution that captures the best of the conflicting perspectives. The synthesis might be an entirely new model of city logistics that emerges from a process of conflict in which not just compromises but also new ideas arise. However, the process does not necessarily result in synthesis; for example, the coercive power of one of the agents may be used to ensure that this agent's solution eventually triumphs over the others.
City logistics from a teleological standpoint	The term "teleology" is used here to denote that the action has a purpose and that humans create it. This area includes management theory, which provides for logistics and supply chain management. The process is put in motion by dissatisfaction with the current condition, such as too many vans transporting goods in the inner city's narrow streets, congestion, and emissions of various greenhouse gases. Then management seeks and decides on new options. When all of the stakeholders in the company agree on a solution, the new solution is implemented. With innovative solutions, Problems are resolved, but new ones may arise, and the process repeats itself. It's worth noting that change processes can take various forms (Van de Ven and Sun, 2011).

Table 2.1: Change Process Theories

Source: (Nilsson and Gammelgaard, 2012; Van de Ven et al., 2013 and Van de Ven and Sun, 2011).

2.3 Empirical Review

This section aims to review research projects completed by authors in areas connected to this field of study. It is intended to provide empirical findings that will help the study's chosen topic area. Empirical Literature reveals extant literature on the trends and perspectives of city transportation.

An examination of seventy City Logistics initiatives by Benjelloun, Bigras, and Crainic (2008) reveals many significant tendencies and issues. A review of practice and literature indicates that: 1) after an initial period of "experimentation," several concepts in terms of business models and system organization appear to emerge; 2) from 2000 on, many new initiatives and innovations have been introduced that open new perspectives and challenge research; 3) the "optimization" and utilization of advanced information technologies (e.g., ITS) components of City Logistics are not significantly developed yet; 4) not all co-location services are available; and 5) not all co-location. The field is new and rapidly changing. As a result, the paper serves as an invitation to join in the endeavor to address these concerns and challenges, develop these models and methodologies, and contribute to making our transportation systems more efficient and our cities more livable.

Rudskaia and Eremenko (2020) investigated and presented conceptual principles and practical recommendations for establishing public-private partnerships in urban transportation logistics.

The following findings were obtained after the study: - the necessity of changing the format of transportation and logistics services for urban economic relations is established; - the efficacy of founding a city network of interceptive logistics sites for trucking based on public-private partnerships is justified, and parameters for choosing locations for such logistics facilities are developed, and their attributes are formulated; - recommendations on advanced transportation are made.

Rozario and Hamid (2018) also devised a method for evaluating the most important elements in deciding whether or not to relocate logistics enterprises to an integrated logistics platform. The thesis also emphasized the relocation's favorable impact on the triple bottom line of sustainable development, which includes reduced traffic congestion, CO_2 emissions, shorter transportation distances, shorter travel times, lower costs, and more mobility. Furthermore, DHL will benefit from this thesis because it will allow them to use the systematic method as a tool to examine the elements that influence the decision to relocate to the Tolvfors Logistics Park. There is a scarcity of mixed methods research on this topic with a case study. Moreover, employing FlexSim-6 software that contributes to traffic flow optimization is also an advantage in this thesis. The research contributes to the literature on sustainable city logistics in theory. Practically, this research gives some motives for internal and external stakeholders at the strategic and operational levels to relocate logistics enterprises from the city center to a suburban logistics platform to take advantage of transportation intermodality's benefits.

Based on the authorial SLIM-PREF model, Kiba-Janiak (2016) identified the major success elements for city logistics and their importance from the perspective of various stakeholders.

In addition, the findings of work done using the Juptyer technique among professionals from around the world are provided in this thesis. The results suggest that depending on the expectations of different stakeholders, the list of important success indicators for city logistics should be other.

Boudoin et al. (2014) illustrated the stakes of urban goods transport integration in city development through a supply chain and platform approach. The topic of urban logistics was examined from both a public and private sector perspective. Various logistics platforms are presented as feasible solutions for improving goods distribution within urban regions by identifying the structure of current and hypothetical future demand in urban goods flows. They concluded with suggestions for new organizational forms, technology, and governance.

Morana (2014), in her work, “Sustainable Supply Chain Management in Urban Logistics,” presented a conceptual framework for urban green logistics planning and evaluation to link urban logistics to green supply chain management, i.e., the government's perspective on the vision of the business. As a result, a dashboard and the conceptual framework are proposed and shown through a case study: the Cityporto urban logistics system of Padua, Italy.

Lindholm and Ballantyne (2014) also highlighted how local governments in Sweden, the United Kingdom, and the Baltic Sea Region see urban freight difficulties to drive a complete transportation planning process. In these nations, interviews were performed and analyzed to determine the elements influencing local government and freight operator perspectives of urban freight transportation difficulties. Also covered are the links between municipal governments and freight stakeholders. The findings of the study demonstrate that, despite local governments having begun to recognize freight transportation more frequently, the difficulties that the freight business faces are still not fully understood. This study aimed to show local governments the potential benefits of incorporating freight stakeholders in the transportation planning process by assisting in the development of a better knowledge of how to approach urban freight stakeholders. The study promoted more in-depth interactions with key freight stakeholders early in the transportation planning.

2.4 Conceptual Framework

Conceptual framework as a collection of connected ideas that, when taken as a whole, offer a thorough explanation of a phenomenon or set of facts (Jabareen 2009).

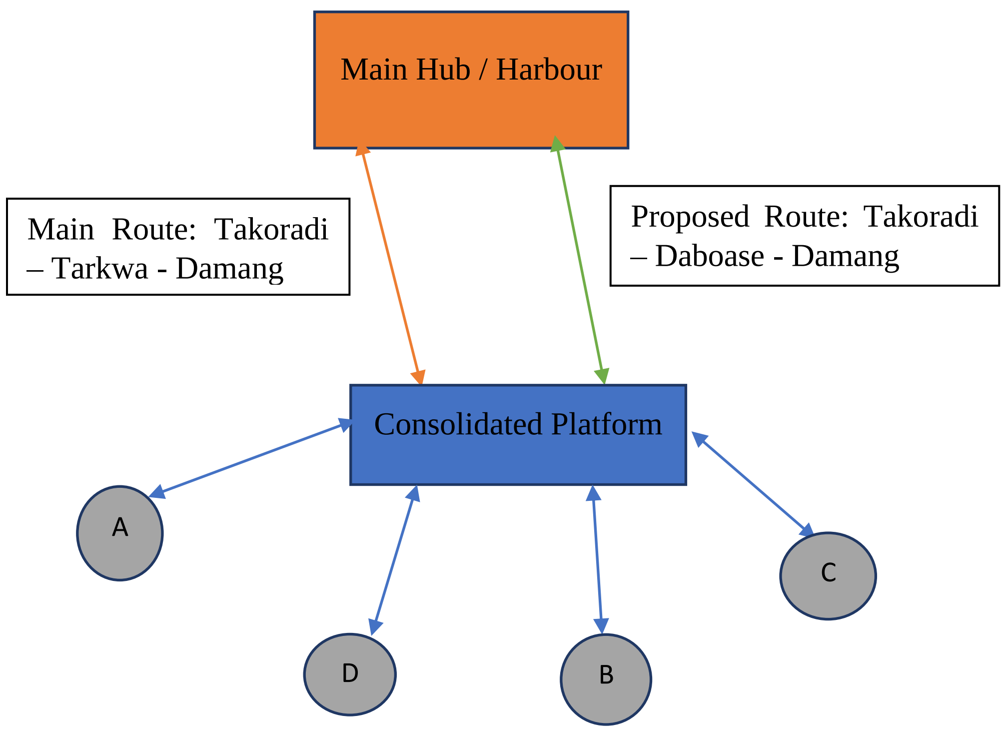


Figure 2. 1 Last-mile delivery in a hub-and-spoke network of a consolidation center

Source: Author Consturct (2022)

The framework refers to using considerable vehicles to move products from shipping terminals or the harbour. The terminals are where trans-shipment operations take place. Long-distance transportation from the sending depots are conveyed on the routes to the consolidated platform. The last-mile delivery allows the many companies whose goods have been consolidated at the plateform to pick up and distribute the commodities to their various sites and stations for operational needs. It's about short-distance transportation with small trucks.

According to the literature, city logistics policies are often adopted in medium-sized cities. In truth, city logistics systems are more challenging to develop and administer due to the complexity and size of commercial sectors in large cities.

In addition, when other rules (such as access regulation, limited traffic zones, and so on) are implemented, this type of system is more successful. As depicted in the conceptual framework, the Urban Consolidation Center (UCC) is the most well-known example of city logistics intervention. Multiple shipment deliveries meant for specific destinations are unloaded at the UCC, which is usually located in the city's immediate vicinity. Here, goods are received, consolidated by a third-party logistics provider or in-house logistics created through a collaboration between several companies, and then delivered to the sites using environmentally friendly full-load vehicles, to optimise deliveries and lower transportation costs. Thus, the UCC program underpins the logistics collaboration concept by sharing resources such as warehouse facilities and vehicle capacity with other prospective competitors for the last mile.

2.5 Chapter Summary

For operational and consumer purposes, this chapter tried to study empirically the sustainable means of conveying, consolidating, and moving commodities and services to their final destination. The chapter began with a definition of sustainability, followed by an overview of urban freight transportation and its sustainable aspects. The concept of an urban consolidation center and its functions, importance, drawbacks, and long-term strategies were then discussed. Second, it reviewed four perspectives on city logistics: city logistics from a life cycle perspective, city logistics from an evolutionary standpoint, city logistics from a dialectical viewpoint, and city logistics from a technological standpoint, as well as the theoretical framework that underpins the subject matter Theory of Change.

In addition, implications of the stated aims in section 1.3 were discussed in the empirical literature review. The helpful literature review outlined above demonstrates that different research produces different outcomes while all are attempting to attain the same goal. In section 2.4, you'll find a conceptual framework that illustrates the topic's depiction.

CHAPTER 3

METHODOLOGY

3.0 Introduction

This chapter discusses the procedures and the analysis of the data. It goes into great detail about the study's sources, statistics, and design. This chapter also includes a full explanation of the empirical methodology that identifies sustainable urban freight transportation and its consolidation for delivery. The processing and analysis of data is another theme in this chapter.

3.1 Research Strategy

Research is typically divided into mixed, quantitative, and qualitative methodologies. The quantitative research approach is frequently employed in the natural sciences and is usually founded on data that can be numerically measured (Leppink, 2016). The quantitative approach may use surveys, personality tests, and standardized research tools (Creswell & Creswell, 2017). A formal objective, a systematic procedure in which numerical data are employed to obtain knowledge about the world, according to Gawlik (2016), is what quantitative research is.

On the other hand, the qualitative research approach is based on systematic processes and procedures and incorporates the researcher's unique perspectives into the findings and recommendations. Because it may recount and characterise a relationship in a particular context, this approach aids in understanding why and how a phenomenon occurs (Parkinson and Drislane, 2011). Additionally, qualitative research seeks to comprehend a social phenomenon and its practises, typically providing words rather than figures for data analysis (McCusker and Gunaydin 2015).

However, the mixed-method involves using both quantitative and qualitative approaches, which entails collecting and analysing both types of data for a single study or many studies (Creswell and Clark, 2011). According to (Leppink, 2016), mixed-method research is justified since, in comparison to utilising only one approach, it provides a more explicit knowledge of the study challenges. As a result, the mixed approach (both quantitative and qualitative) research design was adopted in this study. Furthermore, combining the two improved the study since it took advantage of each approach's benefits to clarify the study's goals.

3.2 Research Approach

Researchers can employ three alternative tactics to attain the intended goal, according to Andreewsky et al. (2000): i) deductive approach, in which the research moves from a general law to a specific case to test the developed theories or hypotheses; ii) inductive approach, in which the research moves from facts to theories in the opposite direction of the deductive approach; iii) abductive approach, which is a creative method for finding a reasonable hypothesis to match with a given phenomenon. As a result, the study in this thesis uses a blend of deductive and inductive methods. Deductive in the sense that the thesis aims to build a systematic method based on current literature and by examining its consistency with theories relating to city logistics and sustainable urban freight movement and consolidation. The data was gathered from Google Maps, observation, and interviews.

According to Malhotra and Malhotra (2012), exploratory, explanatory, and descriptive are the three main research designs adopted by researchers when carrying out research. Experimental research aims to discover more about the research questions and is not intended to offer final and conclusive results to prevailing research problems. Explanatory research examines the relationship among the various variables used for a study. Similar to descriptive research, explanatory research provides a quantitative analysis of data.

Descriptive research describes the sample population using numbers that usually provide a conclusive answer to the research problem. In addition, the descriptive analysis defines various elements' attitudes, opinions, and behaviours concerning the subject under study (McCombes, 2019). The research designs employed for this work were exploratory and explanatory since they had to explore and observe a phenomenon and required quantitative analysis.

3.3 Research Design

The study's case study approach is based on the chosen research design. "A case study is an empirical inquiry that analyzes a contemporary phenomenon inside its real-life environment," according to Yin (2009), "particularly when the borders between phenomenon and context are not readily visible." Case studies can show the intricacies of real-life circumstances that experiments and survey research may not be able to portray (Zainal, 2007).

3.4 Research process

This study began with preliminary research to better understand the subject matter and identify and explore the best options to collect data. Voss et al. (2002) also stressed the importance of exploration in developing research questions and ideas. This was further highlighted by Peters et al. (2012), who offered a quick outline of the research process: 1) Planning; 2) Broadway identification of the study area; 3) Research topic selection; 4) Approach decision; 5) Formulation of the action plan; 4) Data and information collection; 5) Data analysis and interpretation, and 6) Presentation of the findings and results.

This thesis is based on a proposition which will aid in creating a means of a link or route to lease off pressure from the main Tarkoradi – Tarkwa - Damang route, which has already been discussed with the Prestea-Huni Valley Municipal Assembly and the mining companies in the municipality. The main reason for the move is to create a new transport network to link the assumed logistics platform that would house existing and new mining companies' goods and services, reducing traffic congestion and increasing employment opportunities in the municipality. By conducting the case study, an attempt was made to find answers to the research questions to build a systematic strategy for assessing the proposed transport network to the logistics platform.

3.5 Data Collection and Sources

The study used secondary data from the different sources below:

- Observation: to measure the average number of vehicles and actual time count for the roads under study

- The Prestea-Huni Valley Municipal Assembly: The information about regulations needed to ensure practical completion of the proposed consolidation center.
- Google map: The traffic flow of the roads, routes, distance measurements, and time counts by digitizing the main route and the proposed route.
- The data obtained was exported as a comma-separated value (CSV) format to the Jupyter Notebook for analysis. The fields within the table consisted of the Point ID and the Coordinates.

Primary data was also gathered through interviews. According to Saunders et al. (2009), there are three types of interviews: structured, semi-structured, and unstructured. The fundamental approach in a semi-structured interview is to act and reflect upon the nature of the interchange of the expressions between the researcher and the participant, where the researcher or interviewer can prompt the interviewee, rephrase the questions or make changes according to the situation or demand of the time and interview (Galletta, 2013). As in this case, it was found that a semi-structured interview would be perfect and would be based on the questions of this thesis. The interviewees were the Logistics managers of the companies Gold fields Damang and Golden Star Resources Ltd, who have been working there for several years. The interviewees were selected from these companies because they are the largest employers and operators in Damang and other nearby areas. Therefore, the operations of these mining companies positively or negatively affect the communities socially, economically, and environmentally. A schedule was booked before the semi-structured interview. Then the interview was conducted to get information about the company's transportation system and routing process for the inbound and outbound transport in their warehouses.

3.6 Model Specification

For the model specification in assessing the sustainable means of transporting goods to the consolidated center, the study adopted a traffic simulation model to establish the relationship.

The application size of the network or the size of the junction, demonstration of process behaviour, or the size of the independent variables has all been used to create traffic flow simulation model theories (Mihăiţă et al., 2014).

3.7 Definition and Description of Variables

- **Macroscopic**: this kind of model considers the overall traffic flow and utilises variables such as average speed, flow, and density
- **Microscopic**: these models give attention to the individual drivers and the interaction between vehicles
- **Mesoscopic:** these models have less level of detail or precision like the microscopic model, but more than the macroscopic, where the objectives of these models are to obtain the traffic simulation that can observe the congestion phenomenal

3.8 Conceptual Model

So here, in this part of this thesis, the problem will be described, the system and its boundaries will be defined, and schematization of the real system will be performed. Then the processes and data to be simulated will be determined and described concerning their functionalities, details of inputs, and results.

Traffic data from google maps for the study area was used and compared for different times within the day, specifically 7:30 AM, 1:30 pm, and 7:30 pm. In addition, the observation was done on random days to check for data anomalies such as unusual traffic due to road works or broken-down vehicles or trucks. Below is a google map depicting the traffic movements of the study routes.

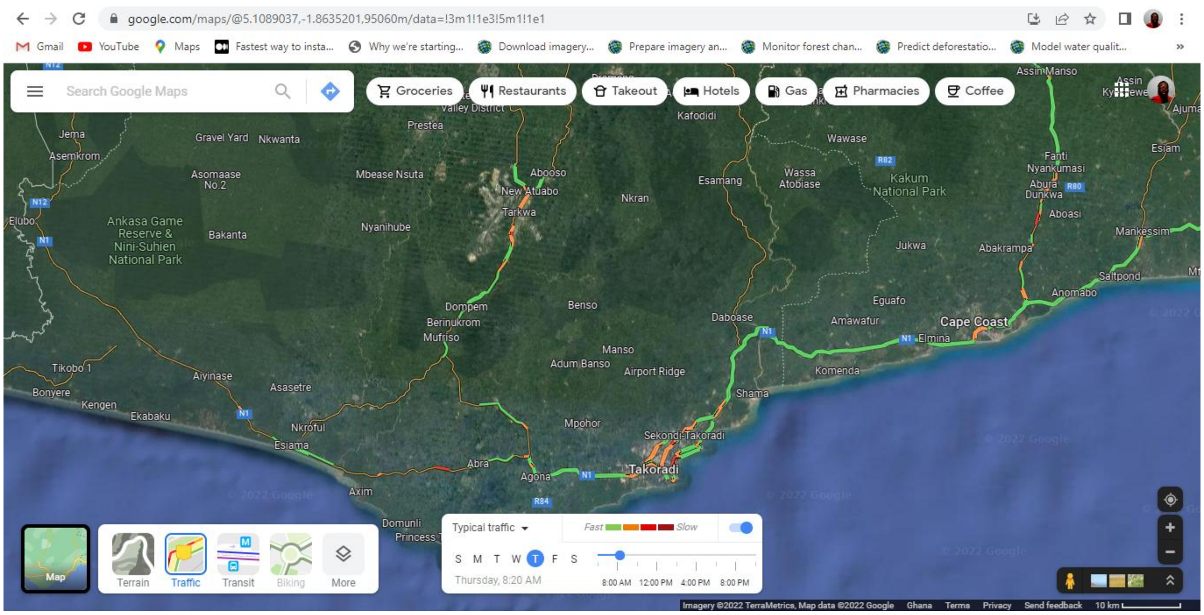


Figure 3. 1 Typical Google Traffic Data Dashboard for the Study Area

Source: Goggle Map

A web-based interactive dashboard app was developed in the Jupyter Notebook using the popular Folium plugin. An empty web map was first created with a default Open Street base map. Then, map control widgets such as zoom, overview map, and a map group layer were added to the map to organise the base maps and map layers.

The route data was added onto the map as two different layers representing the main route, the Takoradi – Tarkwa – Damang route, and the proposed route, the Takoradi – Daboase -

Damang route. The layers were organized under the map group layer control. In addition, an editor tool widget was added to the map to allow users to draw to create features such as points, lines, and polygons on the map. An export tool was also added to allow users to export the components they make on the map in a geojson format.

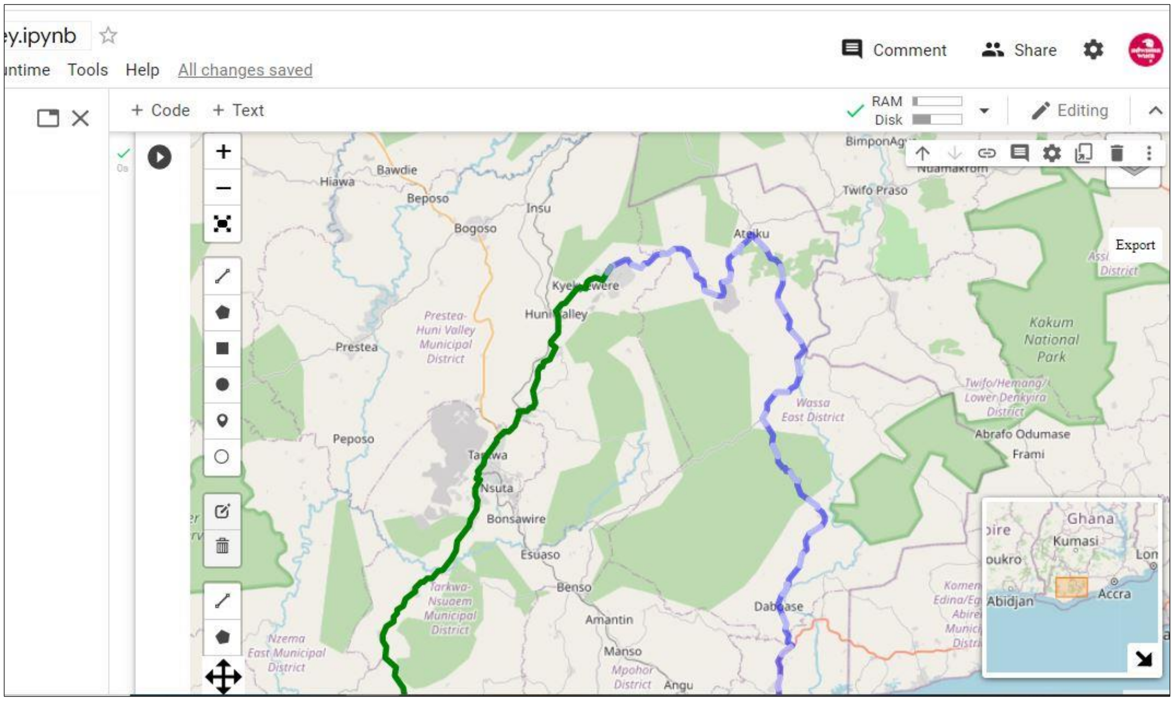


Figure 3. 2 The Dashboard App in the Jupyter Notebook

Source: Jupyter Notebook Simulation Tool

The project codebase was exported as a web page with all the various assets, such as the HTML, CSS, and JS files. The final edit of the app was done in visual studio code. The default base map of the app was sent to Google Maps. The last app was packaged and published to a web hosting provider. A domain name was pointed to the app on the host, and the app was served on the internet.

3.9 Data Analysis

According to Miles et al. (2014), data analysis consists of three activities: data condensation, display, and conclusion. According to Voss et al. (2002), data analysis includes presentation and conclusion. Sorting and editing data into written field notes, interview transcripts, documents, and other formats is called data condensation (Miles et al., 2014). After collecting data, one of the most important components of the research process is data analysis, carried out by researchers in qualitative and quantitative studies (Menter et al., 2011). Selected mediums are utilized to collect and analyze data in responding to the findings and making suitable suggestions for future research (Tomal and Hastert, 2010).

The goal of collecting data for this study was to understand the route of transportation to sustainably convey goods and services of mining companies within the city of Tarkwa, Damang, Akyempim, Bogoso, and other nearby locations to a consolidated platform and to look at the various ways they can benefit from the such initiative, based on the data analysis process. In this scenario, qualitative data was gathered through a semi-structured interview with Goldfields Ghana ltd and abstracted using an inductive data strategy (Menter et al., 2011). Based on a comprehensive literature review, the research approach was utilized to generate qualitative data for conducting a semi-structured interview. A semi-structured interview with the Prestea-Huni Valley Municipal Assembly was also done to support the findings. As Yin (2009) advised, the discussion and meeting were well supported by taking notes, which were later digitally transcribed and archived. The data was then sorted, filtered, and identified to obtain answers to the study questions using both primary and secondary sources.

Figure 3.3 illustrates the classification of the simulation model, where the shstochastic system depends on more than one random variable and can be dynamic or static. In this theise, the stochastic path of simulation was used in other for the Jupyter Notebook to show the route we will propose to the consolidated platform. This then gave a dynamic feature for us to have a clear view of the engineering, economical and social view of the route.

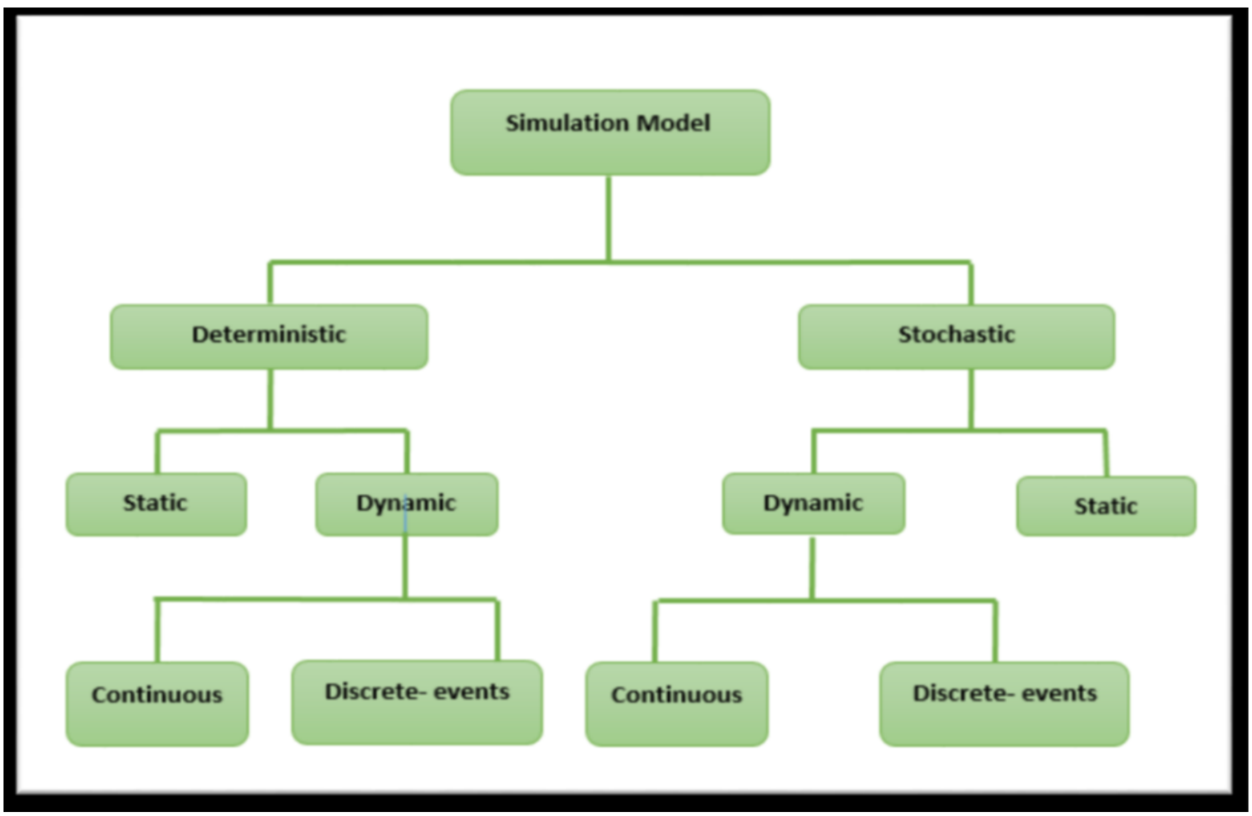


Figure 3. 3 Classification of Simulation Model (Shawki et al., 2015)

Source: Shawki et al.., 2015

3.10 Chapter Summary

The chapter presented the research methodology and discussed the various methods used to collect the appropriate data for analysis. The researcher discussed the research strategy, design, approach, process, data collection method, data sources, data processing and analysis, reliability, and validity. However, for the analysis, this research used a jupyter notebook to clean the data derived from google map and simulated it with the jupyter for analysis and discussion. The subsequent chapter looked at the results and discussions of the study findings.

CHAPTER 4

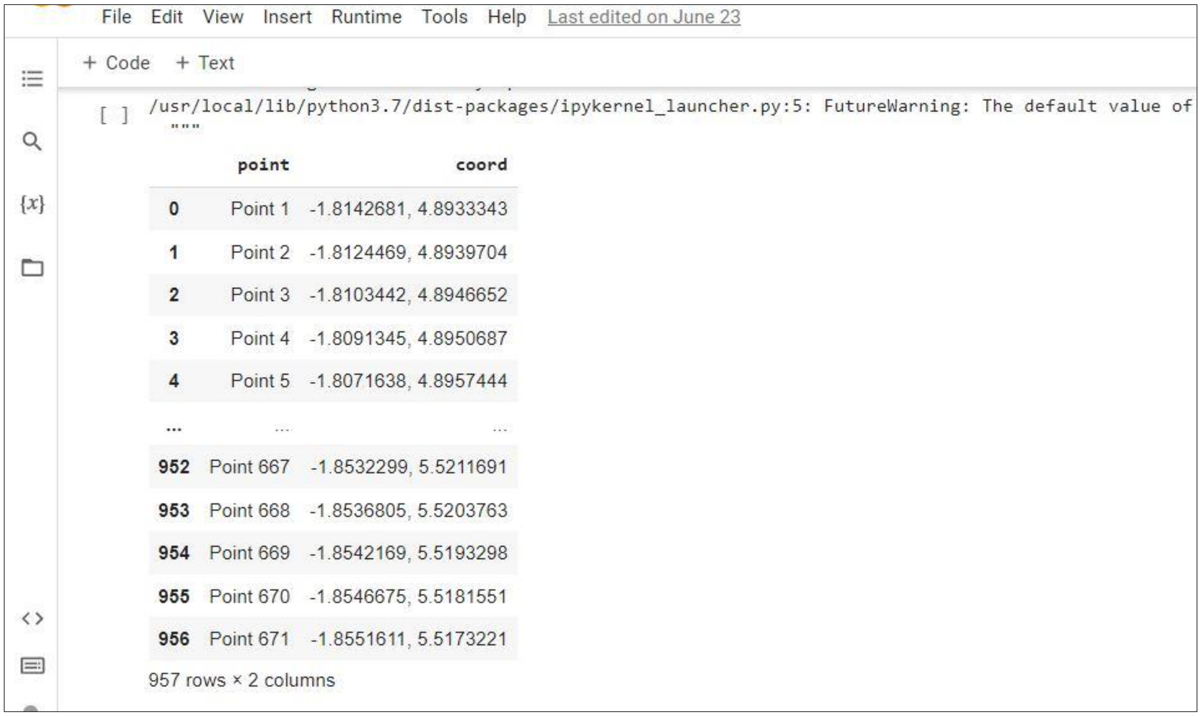
RESULTS AND DISCUSSIONS

4.0 Introduction

This chapter exists to address the findings and discuss them. It encompassed the distance and traffic data derived from Google Maps and observation, presenting how the proposed route can help reduce the burden on the existing route to contribute toward sustainability. It analysed the data obtained and shown the results for discussion.

4.1 Data Presentation

The data was imported into Jupyter Notebook, a data science and machine learning tool that allows several python plugins to be installed and used. Since the data was imported into the notebook was not in the desired format, it was essential to clean it up into the desired format. Figure 4.1 and 4.2 below show the raw data extracted from the google map regarding the study routes and exported to the Jupyter Notebook to be cleaned for the simulation process.



File Edit View Insert Runtime Tools Help Last edited on June 23

+ Code + Text

[ ] /usr/local/lib/python3.7/dist-packages/ipykernel_launcher.py:5: FutureWarning: The default value of

"""

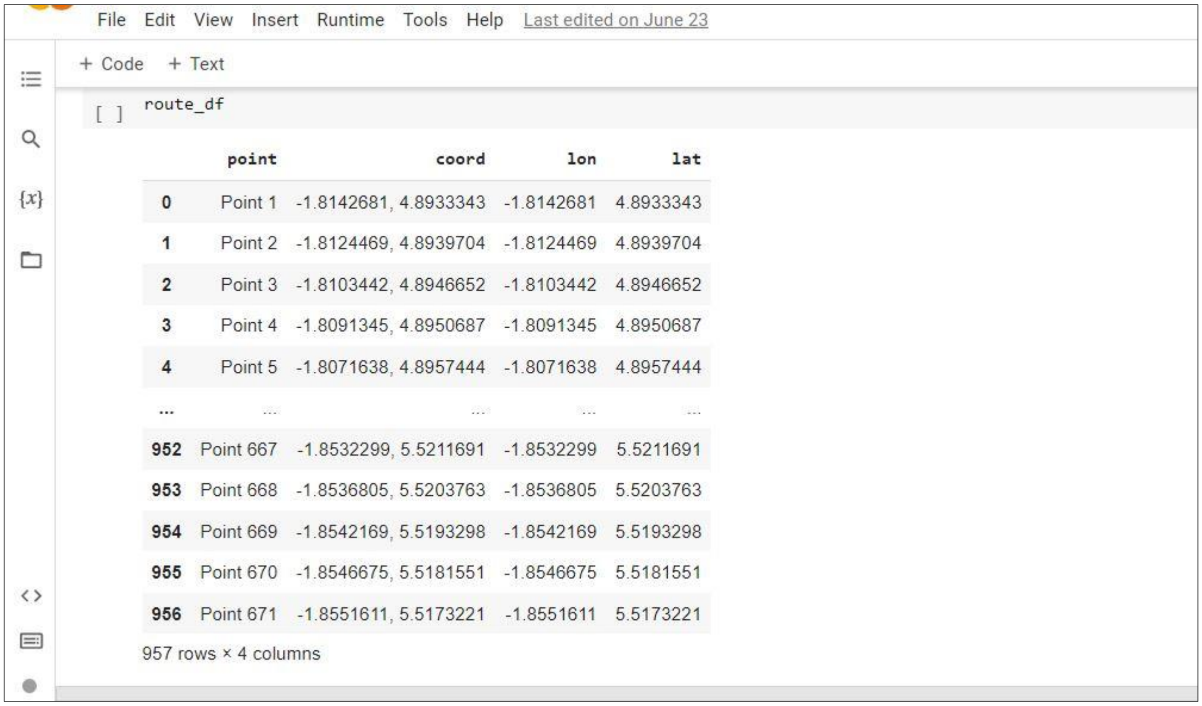
	point	coord
0	Point 1	-1.8142681, 4.8933343
1	Point 2	-1.8124469, 4.8939704
2	Point 3	-1.8103442, 4.8946652
3	Point 4	-1.8091345, 4.8950687
4	Point 5	-1.8071638, 4.8957444
...	...	...
952	Point 667	-1.8532299, 5.5211691
953	Point 668	-1.8536805, 5.5203763
954	Point 669	-1.8542169, 5.5193298
955	Point 670	-1.8546675, 5.5181551
956	Point 671	-1.8551611, 5.5173221

957 rows × 2 columns

Figure 4. 1 The Data before Cleaning

Source: Goggle Map

The Pandas and Geopandas modules were used to achieve the desired results. The first step in the data cleaning process was splitting the coordinate (coord) field into two different fields, latitude (lat) and longitude (lon), using the split function in python. The next stage in the data cleaning process was converting the latitude and longitude fields from text into float (decimal) to be usable during the data simulation process. The final step in the data cleaning process is to store the latitude and longitude fields in a list.



	point	coord	lon	lat
0	Point 1	-1.8142681, 4.8933343	-1.8142681	4.8933343
1	Point 2	-1.8124469, 4.8939704	-1.8124469	4.8939704
2	Point 3	-1.8103442, 4.8946652	-1.8103442	4.8946652
3	Point 4	-1.8091345, 4.8950687	-1.8091345	4.8950687
4	Point 5	-1.8071638, 4.8957444	-1.8071638	4.8957444
...	...	...	...	...
952	Point 667	-1.8532299, 5.5211691	-1.8532299	5.5211691
953	Point 668	-1.8536805, 5.5203763	-1.8536805	5.5203763
954	Point 669	-1.8542169, 5.5193298	-1.8542169	5.5193298
955	Point 670	-1.8546675, 5.5181551	-1.8546675	5.5181551
956	Point 671	-1.8551611, 5.5173221	-1.8551611	5.5173221

957 rows × 4 columns

Figure 4. 2 The Data after Cleaning

Source: Goggle Map

This chapter discusses how data was obtained for the route simulation and analyses for the two routes: Takoradi – Tarkwa - Damang and Takoradi - Daboase – Damang. The consolidation center, as shown in the figure below, is located at Damang, the case study where both routes will link

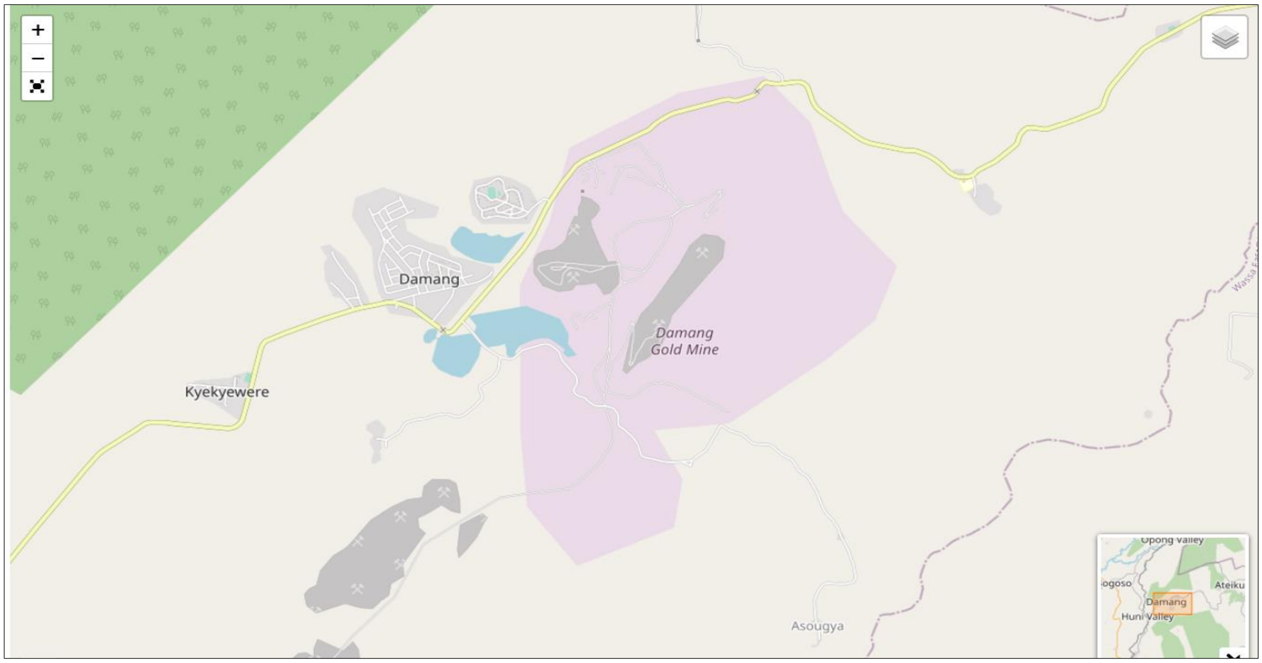


Figure 4. 3 The Consolidation Centre location

Source: Jupyter Notebook Simulation Tool

The data consists of GPS points along each route. This research focuses on identifying an alternative route to the existing Takoradi - Tarkwa – Damang road, which can be developed for mining trucks to haul goods and services to a shared platform to reduce traffic congestion, and carbon emissions and increase productivity. First, the data for the two routes were simulated on a dashboard on a google map. Then, the alternative route was analyzed and compared to the route based on factors like distance, traffic, and travel time to ascertain if it could be a good alternative for redevelopment. A standard departure, Apowa Junction, and destination point, Damang, was used to ensure a good analysis.

4.1.1 Travel Distance and Time Analyses

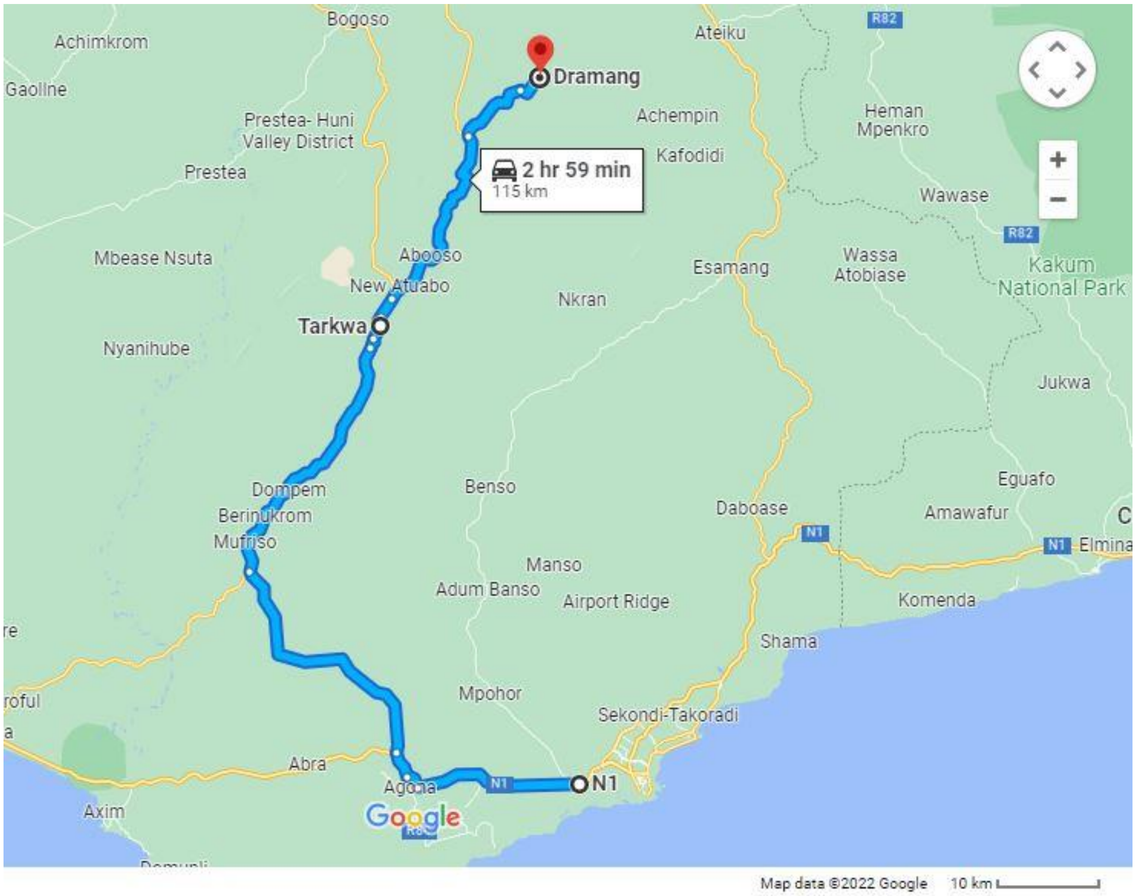


Figure 4. 4 Time and Distance for the Takoradi – Tarkwa- Damang Road

Source: Goggle Map

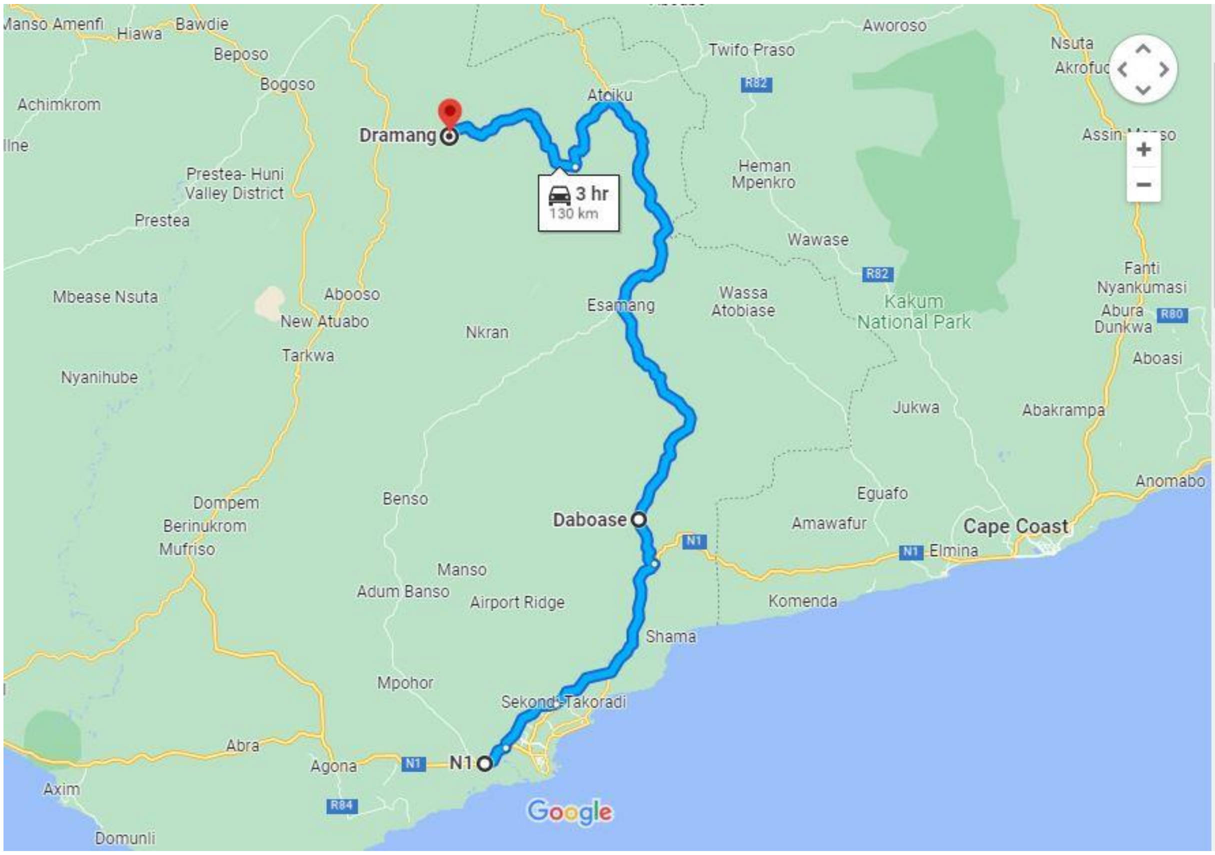


Figure 4. 5 Time and Distance for the Takoradi – Daboase-Damang Road

Source: Goggle Map

Figures 4.4 and 4.5 above analyzed the two roads under study as depicted on Google Maps. From the figures, the distance of travel on the Takoradi - Tarkwa - Damang route is 115km, whereas that of the Takoradi – Daboase route is 130km. This means that on a typical day, it will take 15km more to travel to the destination if the proposed route is adopted for the mining companies. However, the difference in the distance may not be significant if it is compared to other factors such as road cut that will cause motorist to go move round towns that link to the main.

However, the average travel time for both routes is approximately the same (three hours) even though the travel distance differs significantly from that of the main route, the Takoradi – Tarkwa – Damang road being fifteen kilometres lesser. This could be attributed to traffic or congestion caused by heavy human activities, road tolls, and checkpoints on the main route compared to the proposed route.

4.1.2 Traffic Analyses

This section discusses traffic distribution within the study area compared at specific times, their causes, their effect on travel time, and why they need to utilize the proposed route to maintain balance and increase productivity.

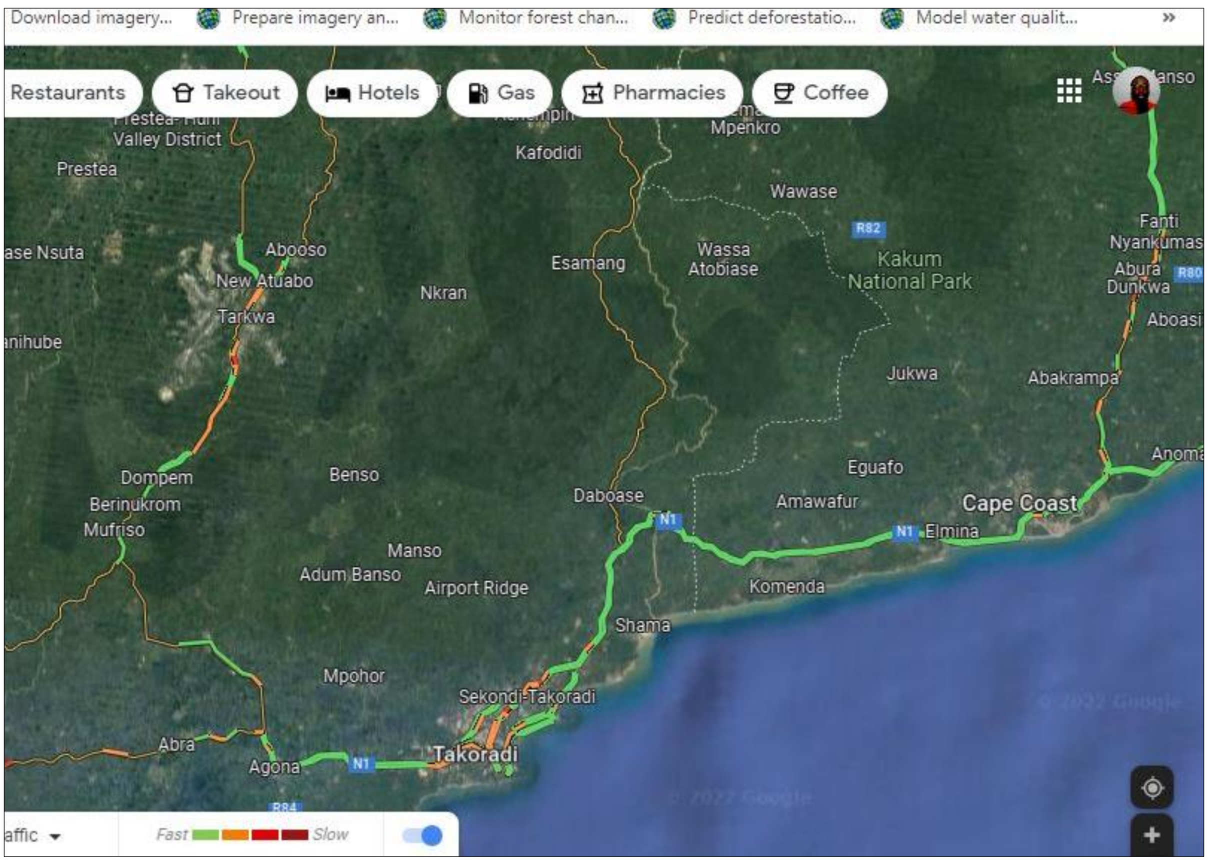


Figure 4. 6 Traffic condition in the Study Area at 7:30 AM

Source: Goggle Map

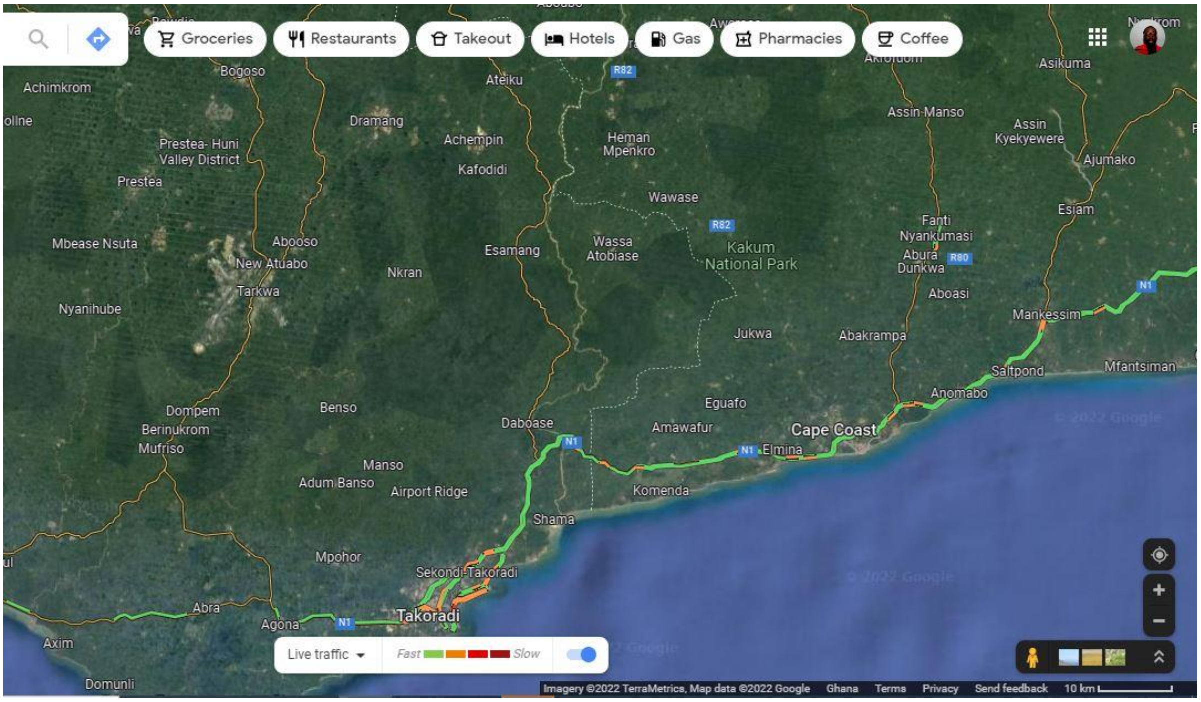


Figure 4. 7 Traffic condition in the Study Area at 1:00 PM

Source: Goggle Map

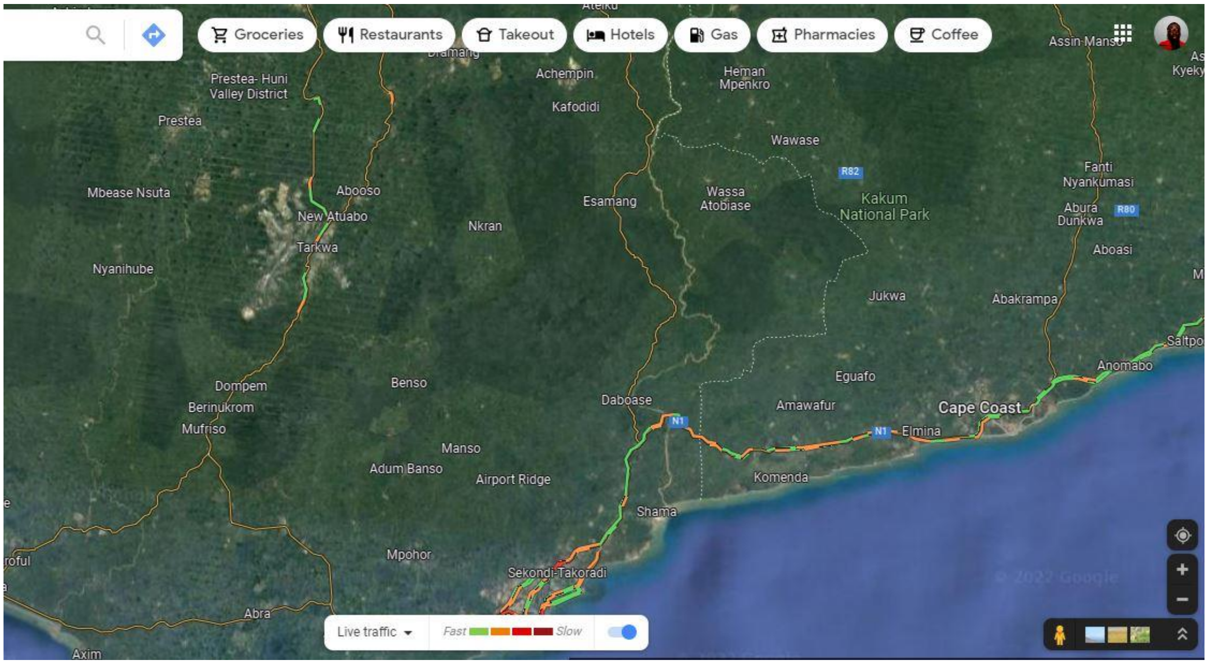


Figure 4. 8 Traffic condition in the Study Area at 7:30 PM

Source: Goggle Map

The figure above shows the traffic condition depicted on Google Maps at six hours intervals, 7:30 am, 1:30 pm, and 7:30 pm within the study area.

Figure 4.6 above shows significantly higher traffic conditions within the study area, specifically in areas such as Tarkwa, which is a significant route for trucks operating at the Damang mines. The proposed route, however, has a lower traffic volume and could thus serve as a good option for the mine vehicles. In addition, the traffic data was captured at 7:30 am, which is rush hour for business and other social and economic activities, increasing traffic congestion. This could negatively affect productivity for the trucks operating within those hours and public life within the area.

Figure 4.7 above shows significantly lower traffic, especially within Tarkwa, compared to areas within Takoradi. This could be attributed to reduced human activities as most people are already within their offices, schools, and other business operating sites.

Figure 4.8 above shows significantly higher traffic, mainly within Takoradi and Tarkwa. This can be attributed to the dense human activities within these areas as people are returning to their homes after late work amidst the numerous night businesses and activities in these townships.

Therefore, the traffic data presented from the map clearly shows that the distance of both routes is almost similar, with 15km separating them. But the proposed route of Takoradi-Daboase-Damang shows a meager traffic rate on the map at three different times of the day compared to the Takoradi-Tarkwa-Damang. This will significantly increase the travel time for trucks using the main road, Takoradi – Tarkwa – Damang, during that hour. Therefore, adopting the development-006t and utilization of the proposed route will ensure balance and reduce the traffic and congestion on the main route by encouraging other drivers, especially mine drivers, to utilize the alternative route.

4.2 Route Simulation Dashboard

The figure below shows the two roads simulated on the web app. The Takoradi-Tarkwa-Damang road uses a static polyline to depict the main or existing route. In contrast, the proposed route, the Takoradi-Daboase-Dabang road, is depicted using an ant-hill line. The map uses google as the base map; however, additional base map options are provided in the layer list widget for the users' benefit, as shown in the figure below.

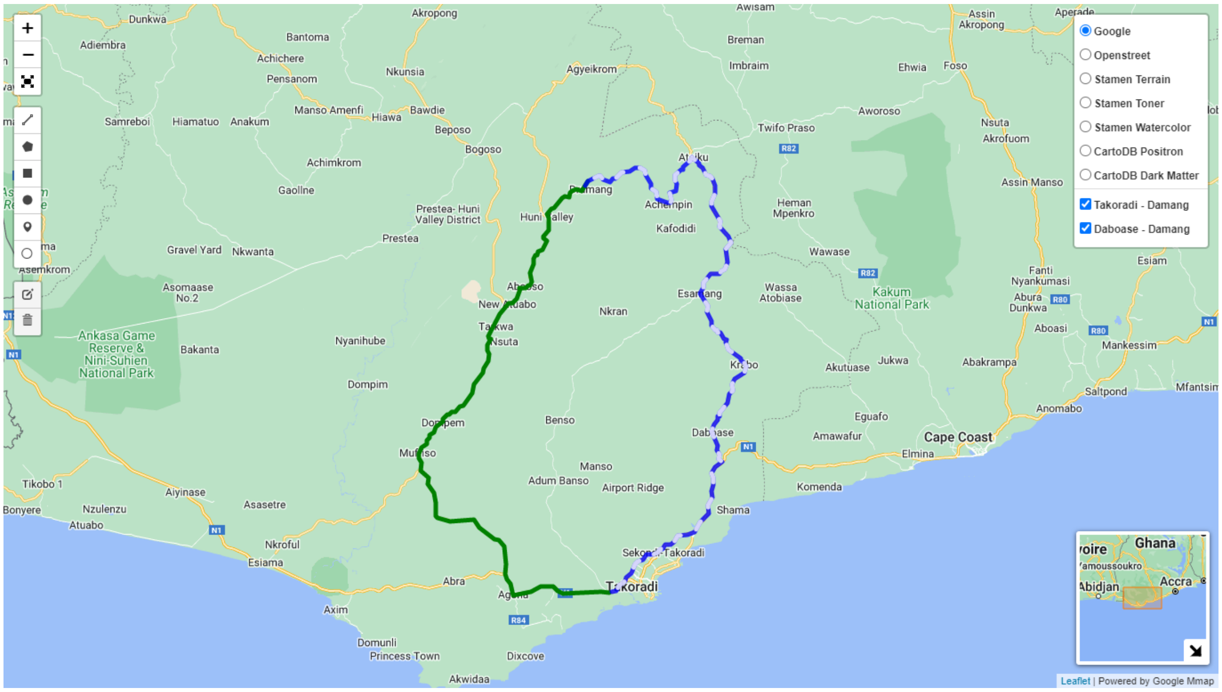


Figure 4. 9 The Layer Tool

Source: Jupyter Notebook Simulation Tool

The draw toolset has widgets that allow the user to add different shapes such as points, lines, circles, and polygons which can be exported as a geojson file format using the export tool. This toolset can be handy for daily planning for the movement of mine vehicles within and outside the mine, as shown in the figure below. These diagrams can be saved and used as indicated earlier.

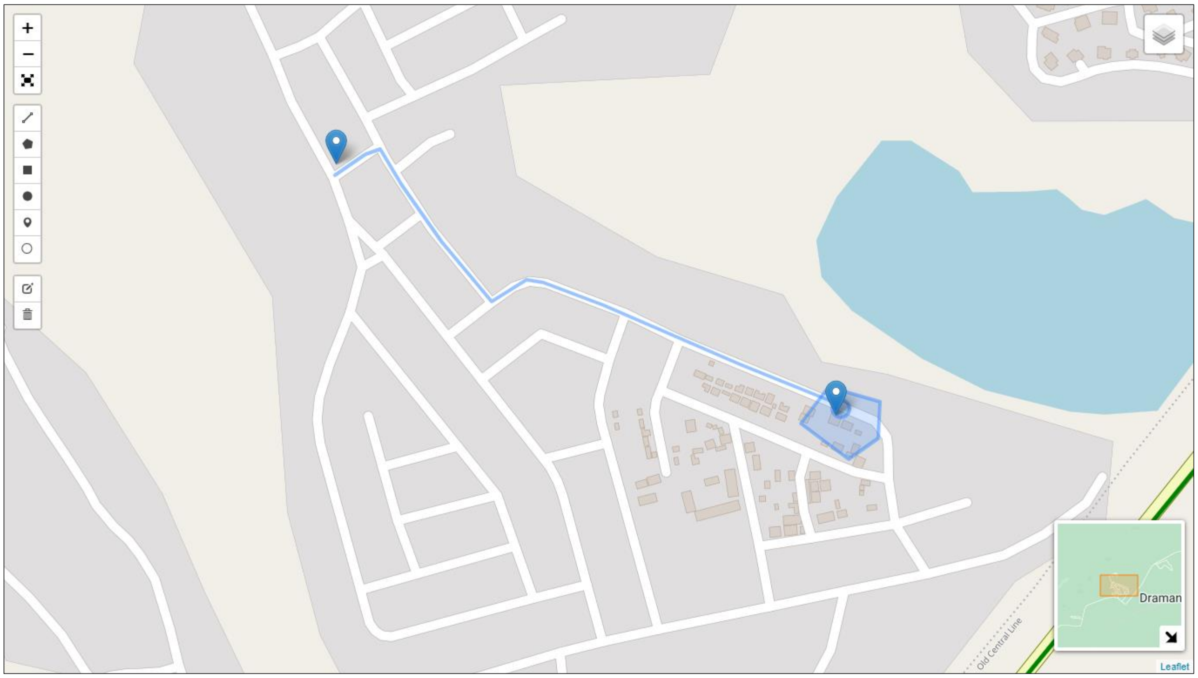


Figure 4. 10 The Editor Tool

Source: Jupyter Notebook Simulation Tool

The dashboard can serve as a centralized portal for planning transport routes for the daily operations of the mines and developing alternative routes with time.

4.3 Measurements

The field observation and measurements extracted from Google Maps enabled the calculation of the distance, time, emission, and fuel consumption, as shown below in table 4.

1. Reduction in travel distance and time: Takoradi to Tarkwa to Damang transportation distance and time will be significantly reduced by building a different transport route to the consolidated center. According to the calculations, the distance and time will be decreased from Takoradi to Tarkwa to Damang's present route by about 0.57% and 0.9%.

2. Emission: Constructing a new route to connect to the consolidated center can reduce carbon dioxide emissions by about 0.23% compared to the current route.
3. Fuel usage: If a different route is built, mining companies might save up to over 0.57% on fuel because the less time spent in traffic, the less fuel consumed.
4. Cost optimization: The new planned route will result in a 50 percent reduction in fuel consumption, translating into a 50 percent reduction in fuel costs. In addition, due to the bad nature of the Takoradi to Tarkwa road, the mining companies spend a lot on maintaining their trucks. Therefore, building a new sustainable transport route will also reduce maintenance costs.

Table 4.1 Calculation of Mileage, Time, Emission, and Fuel Consumption

Description	Takoradi-Tarkwa	Tarkwa-Damang	Total	Takoradi-Daboase	Daboase-Damang	Total	Reduced value	Reduced %
Distance (Km)	80.8	34.2	115	38.5	91.5	130	15	0.57%
Time (Min)	150	60	210	70	120	190	20	0.90%
CO2 (Kg)	72.32	30.61	102.93	34.46	81.89	116.45	13.52	0.23%
Fuel (Lit)	283.61	120.04	403.65	135.14	321.17	456.31	52.66	0.57%

Source: Authors' Construct (2022)

Stay Time = No. Of Vehicles X Travel Distance

CO_2 = No. Of Vehicles X Mileage X conversion factor:

Conversion factor = 0.895 (kg CO_2 Per vehicle-km (DEFRA, 2008)

Fuel =No. Of Vehicles X Mileage X consumption factor;

Here, Consumption factor= 0.35 l/km

Note: If, on the average of the day, about two thousand (2000) use only the Tarkoradi – Tarkwa - Damang route with the proposed;

1. Too much Carbon dioxide (CO_2) will be in the atmosphere.
2. The fuel consumption rate will be high

Therefore, if the proposed route is developed, the table above shows how the parameters will improve.

4.4 Discussion

Numerous linked elements play a role in the evaluation of transport networks and the location of freight consolidation centers. However, since the qualitative and quantitative measures of the elements are not always evident, and there are not enough appropriate resources to identify and evaluate all factors, assessing business transport networks and migration is not easy. Nevertheless, the significant influences on business transport networks and migration that were chosen for this thesis can be summarized as follows:

1. Location
2. Sustainable development
3. Stakeholder involvement
4. Infrastructure

Damang, a town closer to Tarkwa, is a leading commercial city for gold mining in Ghana. It has a significant value in city logistics and supply chain because it is situated at a vantage point to link major cities such as Takoradi, Kumasi, and Accra. Most mining companies haul their products via Damang. Therefore, the best location to build a freight consolidation center that will be easily accessible using the proposed new route. Once this consolidation center is established, the mining companies currently placed in Tarkwa, Damang, Bogoso and other nearby areas can easily access it via the proposed route to be developed. This chapter will therefore try to discuss the answers to the research questions for this thesis below;

What factors encourage mining companies to develop an effective means of transporting goods and services to a consolidated platform?

1. Intermodal transport facilities.

Intermodal transportation, a specific type of multimodal transportation in which freight is transported from an origin to a destination in a fixed intermodal transportation unit, has evolved into an integral part of international/intercontinental cooperation as a result of the growing demand for modular construction in a global environment (SteadieSeifi et al., 2014). Intermodal transportation is typically advised when the weight of the freight is less than 25,000 kg and the travel distance is more significant than 500 km (Crainic and Kim, 2007). According to Flodén (2007), the intermodal transportation system is a typical hub of finely distributed collecting systems, a practically spread long-haul system, and many modes of transportation.

The entire intermodal transportation process is divided into four main components, according to Liu et al. (2018): (1) a composition stage, which entails gathering, strengthening, packaging, and storing via road transportation; (2) a connecting or transferring stage, which is primarily utilized by freight trains for long distances; and (3) an interchange stage, which aims to prevent interruptions during transportation (4) A decomposition step, which depicts the distribution of the freight from the terminal to other locations, is included. As a result, the terminal acts as an intermodal link between the local, regional, and global distribution networks. The indicators can provide information about the intermodal transportation facilities, using the Zaragoza Logistics Park as an example. Since the government of Aragón invested in it, Sheffi (2013) reports that between 2002 and 2008, the unemployment rate was somewhat higher than Spain's average unemployment rate. In addition, he noted that whereas overall production increased by around 83 percent in Spain between 2003 and 2008, it increased by nearly 87 percent in Aragón. Therefore, the proposed Takoradi-Daboase-Damnag route linking the consolidated center shall also benefit the region regarding employment, production, transport mobility, shared assets, etc.

2. Sustainable transportation facility

According to Jacnya et al. (2014), unsustainable transportation has a number of negative effects on the environment and the economy. This proposed route to the consolidated center can address these issues by offering a sustainable transportation system similar to "Cityporto Padua," an operational service for goods delivery in an urban area in Italy. This freight system is concentrated in an urban distribution center and uses hybrid and compressed natural gas (CNG) vehicles to alleviate the pollution and freight transport issues. It is located inside the logistics platform "Interporto Padova," which also serves as the freight town. Owners of the 55 carriers transport their cargo to the logistics platform, which is loaded into all the green vehicles and then delivered to the City Center. The project's favorable environmental and financial outcomes were made possible by its strategic location, the availability of a logistic platform, the impartiality of all freight firms, a dedicated IT system, and the support of all stakeholders (Morana, 2014). Additionally, using electric vehicles such as the Cubicycle (used by DHL in the Netherlands), electric tricycles (like those used by San Sabestian for cargo cycle distribution), and electric tricycles (like those used by Correos for the Spanish Postal 50 service) can help cut down on CO_2 emissions, improve pedestrian safety, and cut down on fuel consumption and traffic congestion.

3. Shared platform

Creating the consolidated center via the proposed route may offer the mining companies many benefits, including the opportunity to pool resources, improve customer service, and change their business volume. In this situation, Gajsek et al. (2012) talk about saving time and resources through this initiative. Furthermore, to interchange materials, information, and assets between nearby business partners, it is also essential to construct a general and shared resource center. Finally, employing a shared platform can be another reason to use external logistics operations to bridge distances inside or between areas. Involved companies, facilities, and the entire material or information flow from the supplier to the end users can all be included in external logistics activities (Aldin and Stahre, 2003). As they build strong bonds and work together to achieve and benefit from a common logistical platform, many companies, whether in the service or commercial industries, are arranged in the same venue to efficiently produce high-quality products or services (Porter, 2000). In this context, the proposed consolidated center at Damang can also assist the mining companies to gain enormous benefits ranging from having a shared infrastructure that can increase productivity, reduce travel and transit times, and bring innovative and value-added final products.

4. Transport mobility

This freight movement optimization is thought to enhance urban logistics since it significantly increases city mobility and positively affects the environment and the economy (Crainic et al., 2009). Access to jobs, products, and services is determined by adequate mobility, which is one of the best drivers for both economic and social development. In this regard, it is anticipated that the execution of the Takoradi to Daboase to Damang route will significantly impact both sustainable mobility and the reduction of emissions.

What can economic, environmental, and social benefits be gained from developing an effective transportation network to a consolidated platform?

1. Reduction of congestion

Before new policies are implemented on the road network, traffic simulations can make it easier to make the necessary improvements to the network's infrastructure. The purpose of this thesis's simulation tool is to show how building a new route used by mining companies to haul their goods to a shared platform affects network traffic flow positively. Fig. 4.3a, b, and c display the typical usage of each route daily to confirm the simulation's behavior in the current scenario where all traffic flows—including trucks— appear. Although the distance traveled on the Takoradi to Daboase to Damang route is 15km longer than Takoradi to Tarkwa to Damang, it can be seen that the inbound and outbound traffic on the former is far less crowded than the latter. Therefore, drivers can escape traffic and save time whether the distance is short or long. The thesis assesses how a new route from Takoradi via Daboase to Damang will alter the behavior of traffic on the already busy and congested Takoradi to Tarkwa route. To reduce congestion to a significant percentage leading as well as other connected effects like reduction in emissions, fuel consumption, and travel time. While there has been a constant increase in automobiles on the road, the traffic situation is getting worse, which causes congestion and pollution. Reducing traffic congestion has various advantages (Crainic et al., 2004). The congestion phenomenon in urban areas is complex and tied to several factors that may affect its demographic, social, and economic characteristics, the accessibility of public transportation, and the activities involved in the movement of urban freight. These factors, which go beyond people's control when deciding where to live and work, affect the demand for travel-related activities and cause congestion. To reap the rewards that enhance communities' quality of life, lowering the amount of congestion has thus become a crucial goal. The advantages include; better air quality, safer traffic, and time savings.

2. Increased employment opportunities

The development of a new sustainable transport route to a logistics consolidated center is viewed as a long-term project that could take years to complete, resulting in numerous job possibilities and helping to lower the unemployment rate. Long-term employment prospects might be anticipated after creating the consolidated center. For instance, the Interporto Padova in Italy, with its 2 square kilometers of space, is home to about 80 logistics businesses and 3000 workers (Morana, 2014).

3. Provision of port services

The decision to build a consolidated logistics center via a new route for the mining companies will serve as the impetus for creating a shared platform. This will allow them to take advantage of the platform's services, which include on-site custom facilitation and customs clearance, efficient transportation infrastructure, and warehousing infrastructure. In addition, such services can also be provided to the city, which will use the chance to expand port services to neighboring towns by taking advantage of its advantageous geographic location.

4. Reduction of noise

Noise pollution is mainly created by traffic, industry, and other recreational activities. Noise pollution is a central problem in urban environments that impact human behaviour (European

Commission, 2017) and animal behavior (Raimbault and Dubois, 2005). Moreover, road traffic is considered the highest contributor to noise pollution in the urban environment. As per ECR (2017), noise affects people's health directly or indirectly and costs the EU not less than 0.35% of its gross domestic product (GDP). So, by rebuilding a new transport network for the haulage of mining goods and services, a certain percentage of the heavy traffic vehicles will be removed from the main inner-city route of Takoradi and Tarkwa and definitely will reduce the noise and improve the quality of life of city inhabitant.

4.5 Chapter Summary

This chapter presented the study's findings, whose data was obtained from google maps and observations from the study areas and routes considered. First, it presented the distance and traffic data and later discussed the findings within the context of the objectives of this study. Finally, it answered the research questions to answer the factors that encourage mining companies to develop an effective means of transporting goods and services to a consolidated platform and the sustainable benefits that can be derived from such initiative.

CHAPTER 5

SUMMARY OF FINDINGS, RECOMMENDATIONS, AND CONCLUSION

5.0 Introduction

Following the preceding chapters, which presented the results and their discussions, this chapter concluded the research outcome. Then, it reviewed what the study was about, its objectives, and the analysis results within the research objectives. Finally, based on the outcome and the possible impact of the study, it subsequently gave recommendations that may suit diverse interest groups in their decision-making and other purposes like future research direction.

5.1 Review of Research Objectives

1. Assess the key factors that can encourage mining companies to develop an effective means of transporting their goods and services to a consolidated platform.
2. To investigate the economic, environmental, and social benefits of developing an effective transport network to a consolidated platform.

5.2 Summary of Findings

There has been very little research using mixed methods and a case study. The use of the traffic flow simulation optimization program (Jupyter Notebook) is another benefit to this thesis. The traffic simulation model highlighted the selected routes of this study and weighed the pros and cons of both routes using data generated from google maps and observation for comparison.

5.3 Conclusions

After a critical analysis, the Takoradi to Daboase to Damang proposed route had the edge over the existing Takoradi to Tarkwa to Damang route. The study also adds theoretically to the literature on sustainable city logistics. Practically speaking, this particular study offers various incentives for internal and external stakeholders at strategic and operational levels to develop a new transport network to take advantage of the benefits of transport intermodality.

5.4 Recommendations/Policy Implications

Platforms for multimodal logistics can be quite helpful in overcoming organizational and operational challenges by using many modes and numerous linkages in the transportation chain. Therefore, aside from consolidated platform developments, intermodal transportation must also be looked into critically to help boost operations in the mining sector. These logistics shared platforms with the right transport network, and modes can link freight marketplaces, freight forwarders, and other types of transportation. These platforms can undoubtedly offer some critical advantages over several dispersed businesses situated in non-industrial locations if they are managed optimally and appropriately. It can also develop other basic facilities such as housing creation in nearby environments. The housing problem can be alleviated by constructing homes in those regions that can benefit society.

Therefore, supply chain management experts, Government, and other stakeholders may evaluate this very good option to develop innovative transport networks linked to logistics platforms in today’s age of globalization to enjoy all of its facilities with increased supply chain efficiency and advanced competitive advantages.

5.5 Future Research Direction and Limitations of the Study

Initially, the research was intended to be done from a holistic point of view on different routes other than the two alternatives selected for this study. Still, later on, for time constraint, the study was limited to two road networks: Takoradi to Tarkwa to Damang (Existing route) and Takoradi to Daboase to Damang (Proposed route). Other locations and their laws and government regulations could influence the answers and lead to different perspectives in developing transport routes; logistics consolidated centers, stakeholders' involvement and participation, urban freight transportation and city logistics and infrastructure facilities, etc. Furthermore, as the information and data were collected and based only on two road networks, the results could somewhat differ if some more road network locations were included. There were also some discrepancies in the data for calculating the emissions released and fuel consumption as there were no fixed and latest data, so we had to use field observation.

However, because of this case study, researchers may draw analytical generalizations about it. Most aspects of urban freight transport and consolidated centers have been covered in this study, although others are still unexplored and merit additional studies. How should the government and project stakeholders work together to build an intermodal logistics platform in the case of consolidated logistics centers or platforms? What guidelines could there be for efficient and contemporary management and operation? How can GIS help with location selection to create the smart city concept?

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APPENDICES

Appendix1: Interview

FACULTY OF INTEGRATED MANAGEMENT SCIENCES

DEPARTMENT OF MANAGEMENT STUDIES

INTERVIEW

I am Prince Kofi Otchere, a student from Ghana studying for a master's degree in Engineering Management at the University of Mines and Technology, Tarkwa, under the supervision of Dr Akyene Tetteh. The purpose of this study is to propose a **"sustainable means of transporting mining goods to a logistics consolidated platform".** I am, therefore, appealing for your support to complete the questionnaire below. The study is purely for academic purposes, and the information will be confidential. Interviews conducted for this study will not be personalised, and as such, the names of individual respondents will not be mentioned in any way during and after the analysis. The strict confidentiality of the respondent is assured. You qualify to participate in this study based on your experiences on the issue under investigation. It will take you approximately 10 minutes to complete the whole interview.

You may kindly contact me on 024 726 5001.

Thank you very much for your time and effort in answering this questionnaire.

Prince Kofi Otchere

(Student)

Part 1

Semi-Structured Interview with Goldfields Ghana Ltd and Golden Star Resource Ltd

1	Can you brief us about the logistics and freight operations of your company?
2	What are the most common routes used by your vehicles to go to highways?
3	What is the average number of inbound and outbound trucks for your delivery?
4	What are the total number and size of vehicles operated by the company including subcontractors')?
5	What is the loading/ unloading time?
6	Do you have any big volume of goods transaction from the port of Tema or Takoradi?
7	What are the destination zones away from Tarkwa or Damang?
8	What is your preferred time in the whole day for loading and unloading of goods?
9	Have you been approached by the Prestea-Huni valley Municipality for a future building of logistics center?
10	What is your take on to move to the link a proposed route to a consolidated platform?

Part 2

Semi-Structured Interview with Prestea-Huni valley municipality

No.	Questions
1	Can you tell us a brief on infrastructure planning?
2	When will the proposed route to the consolidated platform take effect (the year it will start and end)?
3	What is the infrastructural development that can be established in the logistics center?
4	How will the project be subsidized?
5	What is the plan of municipality regarding the allocation of the land?
6	What kind of incentives the municipality will offer to the mining companies?

Appendix B:

DABOASE ROUTE MODEL

Line wrap

```
<!DOCTYPE html>
<head>
    <meta http-equiv="content-type" content="text/html; charset=UTF-8" />
    <script>L_PREFER_CANVAS=false; L_NO_TOUCH=false; L_DISABLE_3D=false;</script>
    <script src="https://cdn.jsdelivr.net/npm/leaflet@1.4.0/dist/leaflet.js"></script>
    <script src="https://code.jquery.com/jquery-1.12.4.min.js"></script>
    <script src="https://maxcdn.bootstrapcdn.com/bootstrap/3.2.0/js/bootstrap.min.js"></script>
    <script src="https://cdnjs.cloudflare.com/ajax/libs/Leaflet.awesome-markers/2.0.2/leaflet.awesome-markers.js"></script>
    <link rel="stylesheet" href="https://cdn.jsdelivr.net/npm/leaflet@1.4.0/dist/leaflet.css"/>
    <link rel="stylesheet" href="https://maxcdn.bootstrapcdn.com/bootstrap/3.2.0/css/bootstrap.min.css"/>
    <link rel="stylesheet" href="https://maxcdn.bootstrapcdn.com/bootstrap/3.2.0/css/bootstrap-theme.min.css"/>
    <link rel="stylesheet" href="https://maxcdn.bootstrapcdn.com/font-awesome/4.6.3/css/font-awesome.min.css"/>
    <link rel="stylesheet" href="https://cdnjs.cloudflare.com/ajax/libs/Leaflet.awesome-markers/2.0.2/leaflet.awesome-markers.css"/>
    <link rel="stylesheet" href="https://rawcdn.githack.com/python-visualization/folium/master/folium/templates/leaflet.awesome.rotate.css"/>
    <style>html, body {width: 100%;height: 100%;margin: 0;padding: 0;}</style>
    <style>#map {position:absolute;top:0;bottom:0;right:0;left:0;}</style>

    <meta name="viewport" content="width=device-width,
        initial-scale=1.0, maximum-scale=1.0, user-scalable=no" />
    <style>#map_e073e275369e0137d14f50175d5d81d8 {
        position: relative;
        width: 100.0%;
        height: 100.0%;
        left: 0.0%;
        top: 0.0%;
        }
    </style>
    <script src="https://cdnjs.cloudflare.com/ajax/libs/leaflet-minimap/3.6.1/Control.MiniMap.js"></script>
    <link rel="stylesheet" href="https://cdnjs.cloudflare.com/ajax/libs/leaflet-minimap/3.6.1/Control.MiniMap.css"/>

                <style>
                    #scroll_zoom_toggler_1acf4652ac97ba0d460f60ed44f432ca {
                        position:absolute;
                        width:35px;
                        bottom:10px;
                        height:35px;
                        left:10px;
                        background-color:#fff;
                        text-align:center;
                        line-height:35px;
                        vertical-align: middle;
                        }
                </style>

    <script src="https://cdnjs.cloudflare.com/ajax/libs/leaflet.fullscreen/1.4.2/Control.FullScreen.min.js"></script>
    <link rel="stylesheet" href="https://cdnjs.cloudflare.com/ajax/libs/leaflet.fullscreen/1.4.2/Control.FullScreen.min.css"/>
    <script src="https://cdn.jsdelivr.net/npm/leaflet-ant-path@1.1.2/dist/leaflet-ant-path.min.js"></script>
    <script src="https://cdnjs.cloudflare.com/ajax/libs/leaflet-minimap/3.6.1/Control.MiniMap.js"></script>
    <link rel="stylesheet" href="https://cdnjs.cloudflare.com/ajax/libs/leaflet-minimap/3.6.1/Control.MiniMap.css"/>
    <script src="https://cdnjs.cloudflare.com/ajax/libs/leaflet.draw/1.0.2/leaflet.draw.js"></script>
    <link rel="stylesheet" href="https://cdnjs.cloudflare.com/ajax/libs/leaflet.draw/1.0.2/leaflet.draw.css"/>
    <style>
        #export {
            position: absolute;
            top: 5px;
            right: 10px;
            z-index: 999;
            background: white;
            color: black;
            padding: 6px;
            border-radius: 4px;
            font-family: 'Helvetica Neue';
            cursor: pointer;
            font-size: 12px;
            text-decoration: none;
            top: 90px;
        }
        </style>
</head>
<body>

    <div class="folium-map" id="map_e073e275369e0137d14f50175d5d81d8" ></div>

            <img id="scroll_zoom_toggler_1acf4652ac97ba0d460f60ed44f432ca" alt="scroll"
                src="https://cdnjs.cloudflare.com/ajax/libs/ionicons/2.0.1/png/512/arrow-move.png"
                style="z-index: 999999"
                onclick="map_e073e275369e0137d14f50175d5d81d8.toggleScroll()">
            </img>

    <a href='#' id='export'>Export</a>
</body>
<script>

```

```
    var bounds = null;

    var map_e073e275369e0137d14f50175d5d81d8 = L.map(
        'map_e073e275369e0137d14f50175d5d81d8', {
        center: [5.380473, -1.691968],
        zoom: 10,
        maxBounds: bounds,
        layers: [],
        worldCopyJump: false,
        crs: L.CRS.EPSG3857,
        zoomControl: true,
        scrollWheelZoom: true,

        });



    var tile_layer_86938f5d1aaadf9a714f4e85d6c2ad7c = L.tileLayer(
        'http://{s}.google.com/vt/lyrs=m&x={x}&y={y}&z={z}',
        {
        "attribution": null,
        "detectRetina": false,
        "maxNativeZoom": 18,
        "maxZoom": 18,
        "minZoom": 0,
        "noWrap": false,
        "opacity": 1,
        "subdomains":['mt0', 'mt1', 'mt2', 'mt3'],
        "tms": false
}).addTo(map_e073e275369e0137d14f50175d5d81d8);


        var tile_layer_f354474fe76894dfc0fc4ac941974574 = L.tileLayer(
            'http://{s}.google.com/vt/lyrs=m&x={x}&y={y}&z={z}',
        {
        "attribution": null,
        "detectRetina": false,
        "maxNativeZoom": 18,
        "maxZoom": 18,
        "minZoom": 0,
        "noWrap": false,
        "opacity": 1,
        "subdomains":['mt0', 'mt1', 'mt2', 'mt3'],
        "tms": false
} );

        var mini_map_dd4989beea1426c545cde1bf31369cb5 = new L.Control.MiniMap( tile_layer_f354474fe76894dfc0fc4ac941974574,
         {
  "autoToggleDisplay": false,
  "centerFixed": false,
  "collapsedHeight": 25,
  "collapsedWidth": 25,
  "height": 150,
  "minimized": false,
  "position": "bottomright",
  "toggleDisplay": true,
  "width": 150,
  "zoomAnimation": true,
  "zoomLevelFixed": null,
  "zoomLevelOffset": -5
});
        map_e073e275369e0137d14f50175d5d81d8.addControl(mini_map_dd4989beea1426c545cde1bf31369cb5);
```

```
                    map_e073e275369e0137d14f50175d5d81d8.scrollEnabled = true;

                    // map_e073e275369e0137d14f50175d5d81d8.toggleScroll = function() {
                    //     if (this.scrollEnabled) {
                    //         this.scrollEnabled = false;
                    //         this.scrollWheelZoom.disable();
                    //         }
                    //     else {
                    //         this.scrollEnabled = true;
                    //         this.scrollWheelZoom.enable();
                    //         }
                    //     };

                    // map_e073e275369e0137d14f50175d5d81d8.toggleScroll();


            L.control.fullscreen({
                position: 'topleft',
                title: 'Full Screen',
                titleCancel: 'Exit Full Screen',
                forceSeparateButton: false,
                }).addTo(map_e073e275369e0137d14f50175d5d81d8);
            map_e073e275369e0137d14f50175d5d81d8.on('enterFullscreen', function(){
                console.log('entered fullscreen');
            });



            var feature_group_e478bae783b0c45e1e26a072e1bb62d9 = L.featureGroup(
                ).addTo(map_e073e275369e0137d14f50175d5d81d8);


                var poly_line_56f1bb2340a475df5ec23dcb83f60a00 = L.polyline(
                  [[4.8921171, -1.818851], [4.892844, -1.8245588], [4.8936137, -1.8303953], [4.8930151, -1.8435274], [4.8923737, -1.8578182], [4.
                    {
  "bubblingMouseEvents": true,
  "color": "green",
  "dashArray": null,
  "dashOffset": null,
  "fill": false,
  "fillColor": "green",
  "fillOpacity": 0.2,
  "fillRule": "evenodd",
  "lineCap": "round",
  "lineJoin": "round",
  "noClip": false,
  "opacity": 1.0,
  "smoothFactor": 1.0,
  "stroke": true,
  "weight": 5
}
                        )
                        .addTo(feature_group_e478bae783b0c45e1e26a072e1bb62d9);


            var popup_d598fd6a12f1a8c517a68f4b5dabfec8 = L.popup({maxWidth: '100%'

            });
```

```

                var html_1864b42503d48c3942f0369b9758e286 = $(`<div id="html_1864b42503d48c3942f0369b9758e286" style="width: 100.0%; height: 100.0
                popup_d598fd6a12f1a8c517a68f4b5dabfec8.setContent(html_1864b42503d48c3942f0369b9758e286);


            poly_line_56f1bb2340a475df5ec23dcb83f60a00.bindPopup(popup_d598fd6a12f1a8c517a68f4b5dabfec8)
            ;




        poly_line_56f1bb2340a475df5ec23dcb83f60a00.bindTooltip(
            `<div>`
            + `Takoradi - Damang` + `</div>`,
            {"sticky": true}
        );


            var feature_group_03b6ab3235c415bdcf08e72b854d2e4d = L.featureGroup(
                ).addTo(map_e073e275369e0137d14f50175d5d81d8);


                ant_path_0baa9efa6eed5cf40c6ce0e90fd4ba2f = L.polyline.antPath(
                  [[4.8933343, -1.8142681], [4.8939704, -1.8124469], [4.8946652, -1.8103442], [4.8950687, -1.8091345], [4.8957444, -1.8071638], [
                  {
  "bubblingMouseEvents": true,
  "color": "#0000FF",
  "dashArray": [
    10,
    20
  ],
  "dashOffset": null,
  "delay": 1000,
  "fill": false,
  "fillColor": "#3388ff",
  "fillOpacity": 0.8,
  "fillRule": "evenodd",
  "hardwareAcceleration": false,
  "lineCap": "round",
  "lineJoin": "round",
  "noClip": false,
  "opacity": 0.8,
  "paused": false,
  "pulseColor": "#FFFFFF",
  "reverse": false,
  "smoothFactor": 1.0,
  "stroke": true,
  "weight": 5
}
                )
                .addTo(feature_group_03b6ab3235c415bdcf08e72b854d2e4d);


            var popup_6ae3f7e818a3e93f00c502bbff4fd0d3 = L.popup({maxWidth: '100%'

            });


                var html_d7a6ce2a780b28265d881f846b6ea92f = $(`<div id="html_d7a6ce2a780b28265d881f846b6ea92f" style="width: 100.0%; height: 100.0
                popup_6ae3f7e818a3e93f00c502bbff4fd0d3.setContent(html_d7a6ce2a780b28265d881f846b6ea92f);


            ant_path_0baa9efa6eed5cf40c6ce0e90fd4ba2f.bindPopup(popup_6ae3f7e818a3e93f00c502bbff4fd0d3)
            ;




        ant_path_0baa9efa6eed5cf40c6ce0e90fd4ba2f.bindTooltip(
            `<div>`
            + `Daboase - Damang` + `</div>`,
            {"sticky": true}
        );
        var tile_layer_830670dcc55e125f6db7798e8b761111 = L.tileLayer(
            'http://{s}.google.com/vt/lyrs=m&x={x}&y={y}&z={z}',
            {
            "attribution": "Powered by Google Mmap",
            "detectRetina": false,
            "maxNativeZoom": 18,
            "maxZoom": 18,
            "minZoom": 0,
            "noWrap": false,
            "opacity": 1,
            "subdomains": ['mt0', 'mt1', 'mt2', 'mt3'],
            "tms": false
    }).addTo(map_e073e275369e0137d14f50175d5d81d8);
    var tile_layer_cee87b1391f1eac989fa71ca55820cde = L.tileLayer(
        'https://{s}.tile.openstreetmap.org/{z}/{x}/{y}.png',
        {
        "attribution": null,
        "detectRetina": false,
        "maxNativeZoom": 18,
        "maxZoom": 18,
```

```
        "maxZoom": 18,
        "minZoom": 0,
        "noWrap": false,
        "opacity": 1,
        "subdomains": "abc",
        "tms": false
}).addTo(map_e073e275369e0137d14f50175d5d81d8);
    var tile_layer_aac2c385fea14304097c18ac2a686930 = L.tileLayer(
        'https://stamen-tiles-{s}.a.ssl.fastly.net/terrain/{z}/{x}/{y}.jpg',
        {
        "attribution": null,
        "detectRetina": false,
        "maxNativeZoom": 18,
        "maxZoom": 18,
        "minZoom": 0,
        "noWrap": false,
        "opacity": 1,
        "subdomains": "abc",
        "tms": false
}).addTo(map_e073e275369e0137d14f50175d5d81d8);
    var tile_layer_2bb1526357c214503e094b00428984e1 = L.tileLayer(
        'https://stamen-tiles-{s}.a.ssl.fastly.net/toner/{z}/{x}/{y}.png',
        {
        "attribution": null,
        "detectRetina": false,
        "maxNativeZoom": 18,
        "maxZoom": 18,
        "minZoom": 0,
        "noWrap": false,
        "opacity": 1,
        "subdomains": "abc",
        "tms": false
}).addTo(map_e073e275369e0137d14f50175d5d81d8);
    var tile_layer_5bdee70a67167924b44e587aa2b9c798 = L.tileLayer(
        'https://stamen-tiles-{s}.a.ssl.fastly.net/watercolor/{z}/{x}/{y}.jpg',
        {
        "attribution": null,
        "detectRetina": false,
        "maxNativeZoom": 18,
        "maxZoom": 18,
        "minZoom": 0,
        "noWrap": false,
        "opacity": 1,
        "subdomains": "abc",
        "tms": false
}).addTo(map_e073e275369e0137d14f50175d5d81d8);
    var tile_layer_3ad72312991ffb69259ca7b71773f428 = L.tileLayer(
        'https://cartodb-basemaps-{s}.global.ssl.fastly.net/light_all/{z}/{x}/{y}.png',
        {
        "attribution": null,
        "detectRetina": false,
        "maxNativeZoom": 18,
        "maxZoom": 18,
        "minZoom": 0,
        "noWrap": false,
        "opacity": 1,
        "subdomains": "abc",
        "tms": false
}).addTo(map_e073e275369e0137d14f50175d5d81d8);
    var tile_layer_837d139a07403b9389085c4006a7316d = L.tileLayer(
        'https://cartodb-basemaps-{s}.global.ssl.fastly.net/dark_all/{z}/{x}/{y}.png',
        {
        "attribution": null,
        "detectRetina": false,
        "maxNativeZoom": 18,
        "maxZoom": 18,
        "minZoom": 0,
        "noWrap": false,
        "opacity": 1,
        "subdomains": "abc",
        "tms": false
}).addTo(map_e073e275369e0137d14f50175d5d81d8);

            var layer_control_8cd74b73125a22e3d6c1a0331d5610ef = {
                base_layers : { "Google" : tile_layer_830670dcc55e125f6db7798e8b761111,"Openstreet" : tile_layer_cee87b1391f1eac989fa71ca55820cde,
                overlays : { "Takoradi - Damang" : feature_group_e478bae783b0c45e1e26a072e1bb62d9,"Daboase - Damang" : feature_group_03b6ab3235c41
                };
            L.control.layers(
                layer_control_8cd74b73125a22e3d6c1a0331d5610ef.base_layers,
                layer_control_8cd74b73125a22e3d6c1a0331d5610ef.overlays,
                {position: 'topright',
                 collapsed: true,
                 autoZIndex: true
                }).addTo(map_e073e275369e0137d14f50175d5d81d8);
```

```
                tile_layer_cee87b1391f1eac989fa71ca55820cde.remove();
                tile_layer_aac2c385fea14304097c18ac2a686930.remove();
                tile_layer_2bb1526357c214503e094b00428984e1.remove();
                tile_layer_5bdee70a67167924b44e587aa2b9c798.remove();
                tile_layer_3ad72312991ffb69259ca7b71773f428.remove();
                tile_layer_837d139a07403b9389085c4006a7316d.remove();


            var options = {
              position: "topleft",
              draw: {},
              edit: {}
            }
            // FeatureGroup is to store editable layers.
            var drawnItems = new L.featureGroup().addTo(map_e073e275369e0137d14f50175d5d81d8);
            options.edit.featureGroup = drawnItems
            var draw_control_87b5f5575af0e3e50f4871211335119f = new L.Control.Draw(options).addTo(map_e073e275369e0137d14f50175d5d81d8)
            map_e073e275369e0137d14f50175d5d81d8.on(L.Draw.Event.CREATED, function (event) {
              var layer = event.layer,
                  type = event.layerType,
                  coords;
              var coords = JSON.stringify(layer.toGeoJSON());
              layer.on('click', function() {
                alert(coords);
                console.log(coords);
                });
               drawnItems.addLayer(layer);
             });
            map_e073e275369e0137d14f50175d5d81d8.on('draw:created', function(e) {
                drawnItems.addLayer(e.layer);
            });

            document.getElementById('export').onclick = function(e) {
              var data = drawnItems.toGeoJSON();
              var convertedData = 'text/json;charset=utf-8,' + encodeURIComponent(JSON.stringify(data));
              document.getElementById('export').setAttribute('href', 'data:' + convertedData);
              document.getElementById('export').setAttribute(
                'download',
                "data.geojson"
              );
            }

</script>
```

```
import fiona
import folium
from folium import plugins
import pandas as pd
import geopandas as gpd

import ipywidgets
import os
import json

import datetime

import matplotlib.pyplot as plt
%matplotlib inline


route_df = pd.read_csv("https://webmucho.com/trans_simul/daboase_damang.csv")
route_df["coord"] = " "
route_df['coord'] = route_df['WKT'].str.replace(r'POINT ', '')
route_df['coord'] = route_df['coord'].str.replace(r')', '')
route_df['coord'] = route_df['coord'].str.replace(r'(', '')
route_df['coord'] = route_df['coord'].str.replace(r' ', ', ')
route_df.rename(columns={"name": "point"}, inplace=True)
del([route_df["WKT"], route_df["description"]])
route_df
```

```
/usr/local/lib/python3.7/dist-packages/ipykernel_launcher.py:4: FutureWarning: The
  after removing the cwd from sys.path.
/usr/local/lib/python3.7/dist-packages/ipykernel_launcher.py:5: FutureWarning: The
  """
```

	point	coord
0	Point 1	-1.8142681, 4.8933343
1	Point 2	-1.8124469, 4.8939704
2	Point 3	-1.8103442, 4.8946652
3	Point 4	-1.8091345, 4.8950687
4	Point 5	-1.8071638, 4.8957444
...	...	...
952	Point 667	-1.8532299, 5.5211691
953	Point 668	-1.8536805, 5.5203763
954	Point 669	-1.8542169, 5.5193298
955	Point 670	-1.8546675, 5.5181551
956	Point 671	-1.8551611, 5.5173221

957 rows × 2 columns

```
tkd_df = pd.read_csv("https://webmucho.com/trans_simul/takoradi_damang.csv")
tkd_df["coord"] = " "
tkd_df['coord'] = tkd_df['WKT'].str.replace(r'POINT ', '')
tkd_df['coord'] = tkd_df['coord'].str.replace(r')', '')
tkd_df['coord'] = tkd_df['coord'].str.replace(r'(', '')
tkd_df['coord'] = tkd_df['coord'].str.replace(r' ', ', ')
tkd_df.rename(columns={"name": "point"}, inplace=True)
del([tkd_df["WKT"], tkd_df["description"]])
tkd_df
```

```
/usr/local/lib/python3.7/dist-packages/ipykernel_launcher.py:4: FutureWarning: The
  after removing the cwd from sys.path.
/usr/local/lib/python3.7/dist-packages/ipykernel_launcher.py:5: FutureWarning: The
  """
```

	point	coord
0	Point 1	-1.818851, 4.8921171
1	Point 2	-1.8245588, 4.892844
2	Point 3	-1.8303953, 4.8936137
3	Point 4	-1.8435274, 4.8930151
4	Point 5	-1.8578182, 4.8923737
...	...	...
1122	Point 1123	-1.8538727, 5.5199997
1123	Point 1124	-1.8533229, 5.5210051
1124	Point 1125	-1.8526724, 5.5221367
1125	Point 1126	-1.8521105, 5.523077
1126	Point 1127	-1.8515145, 5.5240285

1127 rows × 2 columns

```
# split column and add new columns to df
route_df[["lon", "lat"]] = route_df['coord'].str.split(',', expand=True)
# display the dataframe
route_df
```

	point	coord	lon	lat
0	Point 1	-1.8142681, 4.8933343	-1.8142681	4.8933343
1	Point 2	-1.8124469, 4.8939704	-1.8124469	4.8939704
2	Point 3	-1.8103442, 4.8946652	-1.8103442	4.8946652
3	Point 4	-1.8091345, 4.8950687	-1.8091345	4.8950687
4	Point 5	-1.8071638, 4.8957444	-1.8071638	4.8957444

```
# split column and add new columns to df
tkd_df[["lon", "lat"]] = tkd_df['coord'].str.split(',', expand=True)
# display the dataframe
tkd_df
```

	point	coord	lon	lat
0	Point 1	-1.818851, 4.8921171	-1.818851	4.8921171
1	Point 2	-1.8245588, 4.892844	-1.8245588	4.892844
2	Point 3	-1.8303953, 4.8936137	-1.8303953	4.8936137
3	Point 4	-1.8435274, 4.8930151	-1.8435274	4.8930151
4	Point 5	-1.8578182, 4.8923737	-1.8578182	4.8923737
...	...	...	...	...
1122	Point 1123	-1.8538727, 5.5199997	-1.8538727	5.5199997
1123	Point 1124	-1.8533229, 5.5210051	-1.8533229	5.5210051
1124	Point 1125	-1.8526724, 5.5221367	-1.8526724	5.5221367
1125	Point 1126	-1.8521105, 5.523077	-1.8521105	5.523077
1126	Point 1127	-1.8515145, 5.5240285	-1.8515145	5.5240285

1127 rows × 4 columns

```
route_df["lat"] = route_df["lat"].astype(float)
route_df["lon"] = route_df["lon"].astype(float)
route_df
```

	point	coord	lon	lat
0	Point 1	-1.8142681, 4.8933343	-1.814268	4.893334
1	Point 2	-1.8124469, 4.8939704	-1.812447	4.893970
2	Point 3	-1.8103442, 4.8946652	-1.810344	4.894665
3	Point 4	-1.8091345, 4.8950687	-1.809135	4.895069
4	Point 5	-1.8071638, 4.8957444	-1.807164	4.895744

```
tkd_df["lat"] = tkd_df["lat"].astype(float)
tkd_df["lon"] = tkd_df["lon"].astype(float)
tkd_df
```

	point	coord	lon	lat
0	Point 1	-1.818851, 4.8921171	-1.818851	4.892117
1	Point 2	-1.8245588, 4.892844	-1.824559	4.892844
2	Point 3	-1.8303953, 4.8936137	-1.830395	4.893614
3	Point 4	-1.8435274, 4.8930151	-1.843527	4.893015
4	Point 5	-1.8578182, 4.8923737	-1.857818	4.892374

	point	coord	lon	lat	coords
0	Point 1	-1.8142681, 4.8933343	-1.814268	4.893334	[4.8933343, -1.8142681]
1	Point 2	-1.8124469, 4.8939704	-1.812447	4.893970	[4.8939704, -1.8124469]
2	Point 3	-1.8103442, 4.8946652	-1.810344	4.894665	[4.8946652, -1.8103442]
3	Point 4	-1.8091345, 4.8950687	-1.809135	4.895069	[4.8950687, -1.8091345]

```
tkd_df['coords'] = tkd_df[['lat', 'lon']].values.tolist()
tkd_df
```

	point	coord	lon	lat	coords
0	Point 1	-1.818851, 4.8921171	-1.818851	4.892117	[4.8921171, -1.818851]
1	Point 2	-1.8245588, 4.892844	-1.824559	4.892844	[4.892844, -1.8245588]
2	Point 3	-1.8303953, 4.8936137	-1.830395	4.893614	[4.8936137, -1.8303953]
3	Point 4	-1.8435274, 4.8930151	-1.843527	4.893015	[4.8930151, -1.8435274]
4	Point 5	-1.8578182, 4.8923737	-1.857818	4.892374	[4.8923737, -1.8578182]

...	...	...	...	...	...
1122	Point 1123	-1.8538727, 5.5199997	-1.853873	5.520000	[5.5199997, -1.8538727]
1123	Point 1124	-1.8533229, 5.5210051	-1.853323	5.521005	[5.5210051, -1.8533229]
1124	Point 1125	-1.8526724, 5.5221367	-1.852672	5.522137	[5.5221367, -1.8526724]
1125	Point 1126	-1.8521105, 5.523077	-1.852110	5.523077	[5.523077, -1.8521105]
1126	Point 1127	-1.8515145, 5.5240285	-1.851514	5.524029	[5.5240285, -1.8515145]

1127 rows × 5 columns

```
# the latitude and Longitude coordinates
centre_location = (5.380473, -1.691968)
map = folium.Map(location = centre_location, zoom_start = 10) # max zoom: 18

# mini map, scroll zoom toggle button, full screen

# plugin for mini map
minimap = plugins.MiniMap(toggle_display=True)

# add minimap to map
map.add_child(minimap)

# add scroll zoom toggler to map
plugins.ScrollZoomToggler().add_to(map)

# add full screen button to map
plugins.Fullscreen(position='topleft').add_to(map)
```

```
# Creating feature groups
f1=folium.FeatureGroup("Takoradi - Damang")
f2=folium.FeatureGroup("Daboase - Damang")

# Adding lines to the different feature groups
line=folium.vector_layers.PolyLine(tkd_df["coords"],popup='<b>Takoradi - Damang</b>',toolt

ant_path = folium.plugins.AntPath(route_df["coords"], popup="Daboase - Damang", tooltip="D
#folium.plugins.AntPath(tkd_df["coords"], popup="Takoradi - Damang", tooltip="Takoradi - D

#folium.GeoJson(data=gdf["geometry"]).add_to(map)


f1.add_to(map)
f2.add_to(map)

# add tiles to map
folium.raster_layers.TileLayer('Open Street Map').add_to(map)
folium.raster_layers.TileLayer('Stamen Terrain').add_to(map)
folium.raster_layers.TileLayer('Stamen Toner').add_to(map)
folium.raster_layers.TileLayer('Stamen Watercolor').add_to(map)
folium.raster_layers.TileLayer('CartoDB Positron').add_to(map)
folium.raster_layers.TileLayer('CartoDB Dark_Matter').add_to(map)

folium.LayerControl().add_to(map)
map
# draw tools
# export=True exports the drawn shapes as a geojson file
draw = plugins.Draw(export=True)

# add draw tools to map
draw.add_to(map)

# display map
map
#map.save("transport_simulation.html")
```